

Durham E-Theses

*An investigation in the east Durham plateau into the
problems of soil survey in relation to agricultural
productivity*

R. F. McKee

How to cite:

McKee, R. F. (1965) An investigation in the east Durham plateau into the problems of soil survey in relation to agricultural productivity. Doctoral thesis, Durham University.

Use policy

The full-text may be used and/or reproduced, and given to third parties in any format or medium, without prior permission or charge, for personal research or study, educational, or not-for-profit purposes provided that:

- a full bibliographic reference is made to the original source
- a <https://etheses.durham.ac.uk/id/eprint/9367/> is made to the metadata record in Durham E-Theses
- the full-text is not changed in any way

The full-text must not be sold in any format or medium without the formal permission of the copyright holders.

Please consult the [full Durham E-Theses policy](#) for further details.

AN INVESTIGATION IN THE EAST DURHAM PLATEAU INTO THE
PROBLEMS OF SOIL SURVEY IN RELATION TO AGRICULTURAL
PRODUCTIVITY

R.F. McKee., B.A.

Thesis presented for the degree of
Ph.D. in
the University of Durham.

Department of Geography
1965



"Certain limestones of high magnesia content
greatly impair the fertility of the land"

(Joseph Black 1728-99. Lect. on the
Elements of Chemistry. 1803 edtn.)

Without the continuous advice and practical assistance of the undermentioned this thesis would not have been completed.

Professor W.B. Fisher
Dr. S.G. Willimott
Dr. V.B. Proudfoot
Dr. I.G. Simmons
Mr. D. Gilchrist-Shirlaw
Mr. G. McWhirter

Special mention must be made in acknowledgement of the patient textual criticism and revision by Mr. K. Atkinson and my wife Janet.

CONTENTS

INTRODUCTION.

	A. Aims	p. 1
	B. Basic requirements of the survey.	p. 10
Section One.	THE REGION.	
Chap.1	A. Selection.	p. 11
	B. Boundaries and area.	p. 14
2	Topography and drainage.	p. 16
3	Geology and Drift.	p. 20
4	Climate.	p. 28
5	Vegetation.	p. 36
Section Two.	METHODOLOGY.	
Chap.1	Soil Survey.	p. 43
2	Site Standards.	p. 49
3	Profile standards.	p. 54
4	Methods of analysis.	p. 78
Section Three	SOILS.	
Chap.1	Parent material.	p. 87
2	Topography.	p. 97
3	Soil movement.	p. 99
4	Weathering.	p.104
5	Grouping the soils.	p.106
6	Higher grouping of the soils.	p.135
7	Profile characteristics.	p.138
Section Four.	AGRICULTURAL HISTORY.	
Chap.1	Before 1912.	p.150
2	1912 - 1945.	p.160
3	1945 - 1960.	p.169
Section Five	SOILS AS APPLIED TO UNITS.	
Chap.1	The Sector.	p.178
2	The Soil Zones.	p.184
3	Sector analysis related to soil zones.	p.202

Section Six. PRODUCTIVITY GROUPING.

Chap1	Land classification.	p.248
2	Land productivity and limitation.	p.268
3	Objections.	p.289
Summary.		p.292
Bibliography 1.		p.294
Bibliography 2.		p.298
Appendix I	Rainfall data	p.305
IIa	Summarised profile descriptions	p.318
IIb	Analysis	p.345
III	Farming system, classification	p.367
IV	Summary of farm studies	p.369

INTRODUCTION

(A) AIMS

The object of the present study is to test the validity of the claim that soil survey can be usefully correlated with agricultural productivity. If the answer is positive the soil surveyor has an important part to play in planning land use, even in highly developed industrial societies of western Europe.

Mapping soils has been called into question in recent years in positive criticism (1) and perhaps more seriously by a negative lack of interest in published soil maps by those not directly concerned in the study of the soil. Three questions must be answered before attempting any soil survey.

1. Why survey soils at all ?
2. Why has soil survey failed to generate more than passing interest in non-pedological spheres ?
3. From a practical point of view, can soil survey be related to agricultural productivity and hence land-use planning ? (2)

1. Why survey soils at all ?

It has been said (3) that any country has but two assets :- its land and its people. Yet the planner has in the past been too often trained only in architecture or pure survey and his efforts have frequently resulted in the sterilisation of large areas of land. Land survey and planning should be set against the background of increasing population and the failure of food production to keep pace. This statement may seem slightly out of place when considering the agriculture of an industrial nation such as Britain but it is an increasingly obvious fact that the



heavily industrialised areas of western Europe are also the areas which have the greatest potential for increased food production on a very intensive and scientific basis. The word 'planning' has been unpopular because of political connotations and the fear of regimentation, but the time has long been reached when a more rational and scientific use of resources has become necessary.

Land-use planning is not an end in itself. It has the somewhat equivocal purpose of 'an improved standard of living for mankind'. Although the great emphasis in this investigation is on the agricultural implications of soil survey and land-use, the total land-use scheme includes several complex and often conflicting elements :-

1. Industrial location.
2. Housing.
3. Food and water.
4. Recreation
5. Communication.
6. Security bases.

There must be a balance between these elements but this can never be easily achieved. Much that has been done by planners needs to be undone. The soil surveyor can have only a small part in the overall balancing of the plan but his voice must be heard. There are of course deficiencies on many counts. There is too little knowledge about mobility of people in the location of industry. There is still an intense fear of allowing town raised people to live in the country, yet this is essential to balance the loss of farm labour if village services and amenities are to remain viable. There is a lack of geological and drift knowledge ; despite the growing need for sand, gravel and clay there are large areas without adequate drift-map coverage. There is a serious

lack of water resource survey and large scale water supply lines frequently cross each other. Meteorology is often criticised but its greatest defects, often ignored, are at the level of microclimatic surveys: at Houghall Agricultural School County Durham, for example, the horticultural section was sited in one of the most reliable frost pockets in the North of England: instruments used are also open to criticism. The Stevenson screen is situated above the level of growing crops and below the level of ripening fruit. The ecologist has not yet mapped the vegetation of the problem areas of the country. Finally soil survey itself has been painfully slow in producing results and when the soil maps are published they are often unintelligible to any other than the man who has produced them. Carried to its extremes the modern emphasis on the soil profile can be of less use to the farmer than the earlier surveys based on soil texture. Many workers have no confidence in the profile as an indication of soil potential or even demarcatable units (4). Some say that the profile can tell everything that is required in knowledge of the soil.

Soil survey is but part of an enormous but neglected field of research that is essential before sound land-use planning can be undertaken. The Geographer's discipline of correlation is not out of place in the organisation of conflicting elements and he has the added qualification of cartographic interpretational techniques. The soil surveyor who has geographical training is perhaps doubly fortunate. The cartographic technique is of great importance. The soil map must be intelligible, and capable of relation to the whole plan. Stamp's pre-war land-use surveys showed the advantage of cartographic representation over statistical methods. The soil surveyor should not necessarily be a pedologist, but he must depend on the latter. There is a misconception amongst planners and certain schools of thought that any land can be upgraded.

They do not realise the great value of limited areas of very good land. There are unchangeable factors such as elevation, slope and microclimate that the sample analyst can underestimate. The surveyor is not then a specialist pedologist. He is a producer and interpreter of maps.

Where does the soil surveyor start ? The simple answer is where he finds himself, with the existing land use. Stamp showed that in a long settled country such as Britain the land use resulting from centuries of trial and error and the interaction of countless factors has remained remarkably stable. Land use on good land has changed little, as has the use of very bad land. Land falling in the intermediate section has responded to changing conditions more severely and it is perhaps in this sphere, the intermediate lands, that the practicality of soil survey can find its most useful testing ground.

Why survey soils ? The product of present planning seems to be aimed at 'new towns to starve in'. (3a) There is room for a detached scientific approach to the whole question of planning land-use, and soil survey must find its logical and important function in this planning.

2. Why has soil survey failed to generate more than a passing interest in non-pedological spheres ?

Classification is the soul-destroying nympholepsy of soil science. There is a confusion of literature from Thaer to the U.S. Seventh Approximation which allows almost any form of classification from texture through properties, to parent material and other soil forming factors to be used as a basis on respected authority (5). It is perhaps not called for to trace the development of different schools of classification here but an indication of principles that have influenced the present survey are offered. Kubiena's 'natural' system despite the controversy with Leeper (6) about what is in fact 'natural' and what 'artificial'

has two main important features. First he preserves continuity with the terminology of past soil workers. Secondly he based his classification on profile properties rather than soil forming factors. He allows the concept of soil maturity and is generally satisfying in theory but perhaps lacking in precision at those lower levels of classification which are all-important to the surveyor dealing with Soil Series and Types. The Seventh Approximation has no clear statement on principles but emphasises the importance of diagnostic horizons a factor of great importance in the region under study. This admittedly provisional work from America could become a satisfactory balance with Kubiena if some of the terminology could be set on a more traditional or even pronounceable basis. Future development in soil classification is not easy to prognosticate. The position of an independent surveyor is therefore at present very unsatisfactory. He has a confusion of principles and terminology to unravel and will always be obsolete in his presentation according to some shade of opinion within the world of soil study. The aim of classification on a world scale and at the local level is correlation on the best genetic principles developing, for example Botany. The best system if it were possible would be some approximation to the periodicity of the chemist (7). At present apart from the various soil manuals and soil memoirs the surveyor has two guiding principles behind his choice of system. There is the natural system which takes all properties and orders them by significance and there is the artificial system which correlates predetermined properties in a predetermined order. Vilenski (8) has added something which has really been obvious for a long time; the fact that most soils are domesticated, and such domesticated soils present perhaps the most urgent call on our investigation. The surveyor is therefore faced with choice and is still in the position of having to define the terms he uses and indicate the methods and system adopted.

The system used is fundamental to the success of the survey

and if it is to be a valuable system, for practical reasons, in the long run its nature must be determined by the purpose of the survey. The idea of a system which can be applied generally is valid only if the criteria required for different purposes are similar or correlate closely. This has proved impossible in practice. Criteria to be used differ according to the purpose of the survey. Soil surveys based on a supposedly general-purpose natural classification are of very limited value as they do not assess soil properties that are significant for different purposes. This is especially true when one classification is used over a wide range of environments.

Two approaches may help to make surveys more valuable than many of them have been in the past.

1. Devise an improved approximation to a general purpose classification by selecting better key criteria from the present limited stock. Its failings could be ameliorated by incorporating it into an ecosystem survey. This would be the best and most scientific approach but the least practical. The Seventh Approximation will take some great time to sort out for key criteria.
2. Adopt a specialist classification for each different purpose of survey e.g. a survey to establish the best areas to grow bananas, pomegranates or rice on the East Durham Plateau. This is not as scientific in principle but is more practical and is the type of system adopted in this thesis. As already indicated one major drawback of this approach is that of standardisation and terminology adopted for the individual survey. Looked at in perspective however there is no disadvantage over the general purpose classification because the literature and terminology create similar problems in both exercises.

Why then is there so little interest in soil survey for example on the East Durham Plateau? First because there is no

published soil map available. Secondly if the farmer could purchase the hand coloured copies of parts of earlier soil survey in the county they would be unintelligible. The unfortunate fact is that English soil survey at present tells the farmer very little about his soil and its productivity.

3. From a practical point of view, can soil survey be related to regional agricultural productivity and hence land-use planning ?

The first farmer was the first soil surveyor (9). The history of land use is not simply that of a gradual occupation of various soils but the history of selected soil suitability under various economic and technological circumstances. Improvement in agricultural technique has, since the middle of the last century, allowed the changing of soil suitability. Because of this there arose the misconception that all soils could be made equally good or at least that most soils could be adapted to various forms of land use. Little attention was paid to those characteristics inherent in soils that had determined how land was used before the turn of the century.

Research lines differ from country to country. Practical experience and advisory rules show wide variation. Today in this country regional data is so insufficient that different fertiliser practice is seen on identical soils. The soil surveyor in cooperation with the fertility expert has a large part to play in the near future in finding better adapted applications of inorganic fertilisers on various soil types.

Present land use is largely the result of former economic and technical circumstances but it is no use to stay at the point of analysing such land use. This doubtless helps the soil surveyor but cannot replace the knowledge of the soils themselves in offering guidance for the best possible use of land now and in the near future. The first essential is an assessment of how far traditional

land use is still sufficiently correlated with soil suitability under the present agricultural system. This applies particularly when considering the intermediate quality soils already mentioned (p.4). Land under pasture may give better returns under arable rotation or the reverse. The soil surveyor cannot solve this problem alone but he must :-

- (a) contribute his knowledge on the difference between soils.
- (b) be able to handle his mapping units as natural entities, which can be used as the basis of research and planning.

The soil survey thus becomes the basis of exchange of knowledge from one region to another.

By extending interest beyond the survey of soils to questions of farm management and productivity it becomes necessary to obtain and analyse a great amount of statistical data. Computer planning of farm capacity in terms of stock and crops, and work study analysis of labour involved and farm layout are immediately thrust upon the surveyor. To select the combination of enterprises which gives the largest possible gross margin over the expenditure on fixed resources is the obvious aim. The relative gross margins per acre of the potential enterprises may be sufficient guides in themselves, but when complexity of factors is multiplied by the inclusion of large poultry or pig concerns, or distinctive soil differences the standard tabular layout of linear programming is by far the simplest and quickest means of analysis and prognostication. A set of figures representing activities in crops and cattle, available quantities in labour, acres and housing, and average margins per enterprise can be fed into an electronic computer. A plan giving the highest profit and suggesting economic ceilings on expansion or the cost of running down an enterprise, can be given in a few minutes. Such analysis can save the multiplication of guess work that is present in any farm community,

but there are difficulties. There is the obvious problem of obtaining the necessary figures for the initial table. The figures must be relevant to the particular farm but need not necessarily come from the farm being programmed. Good records are essential and will represent a lot of field work. In practice during the present survey it was found impossible to obtain anything approaching the right kind of information in quantity. This was not only because of farmers' reluctance to disclose information but also because most farmers just do not keep the necessary records. Similarly work study analysis though desirable is beyond the scope of the present research, time being the limiting factor. Both these aspects are however of increasing use in farm planning, and will perhaps become universal in farming when the necessary statistics become required of farmers.

In conclusion soil survey should not be condemned to its present unpropitious state. The soil surveyor is essential to any land use plan as the one who correlates geographically and corrects misunderstanding by circulating information. Soil science is not the restrictive field of the pedologist. He should make his knowledge available in the simplest manner possible to the surveyor who can translate it into agricultural terms. Theoretical lessons in pedology are not the main end of survey, but the production of subject matter in a readily available form and on a practical level. The present rate of production of soil sheets in Britain is too slow to allow them any significant impact on agriculture, even if their content were designed to that end.

The relation of soil survey to agricultural productivity is quite possible and highly desirable, but for its fullest attainment and exploitation it should be tackled on the basis of teamwork rather than by the individual. The present survey is the product of a single hand and the limitations imposed by time taken in routine soil sampling, laboratory work, farm analysis, interpretation

of results, and final presentation are obviously great.

B. BASIC REQUIREMENTS OF THE SURVEY.

Having stated the aims of the present work some indication must be given of the various steps to be taken to achieve them.

1. Selecting a region for study presents the first problem. The region must demonstrate an established and important emphasis on agriculture in relation to other occupations. It must be sufficiently large to include some variety in the agriculture practised. At the same time it must be small enough for one research student to tackle in the limited time at his disposal. There must be some variety in slope, aspect, climate, geology, vegetation and soil development for the usefulness of this type of survey to be fully tested, but gradation is preferred to sharp distinction. It would be inopportune, for example, to test the validity of the method employed by drawing distinction between the Cleveland Hills and the neighbouring Vale of York. Here physical factors and consequently agricultural practices are too different for any useful transfer of knowledge. The Hills and the Vale would be better studies as separate regions. The citation of these two regions as worthy of study raises a final point. The area chosen should have recognisable boundaries whether physical or artificial. And these must be spatial and within clearly defined and preferably traditional boundaries. The inadequacy of present-day planning is perhaps typified in such obscure 'regional' nomenclature as 'North-East'. No-one is clear what this region includes or where it ends. All that is clear is that Tyneside (or Teeside) is at the centre of this Development Region. For the surveyor himself clear boundaries will be of great convenience and save aggravation of the many existing problems.
2. Having selected the region the soils must be surveyed using adequate but inevitably biased survey methods. Samples must

be analysed and subjected to statistical interpretation. Basic soil sheets on the six inch to one mile scale must be prepared and complete profile records compiled.

3. While the soil survey is in progress a farm by farm survey of land use and management can be made for statistical and cartographic representation.
4. From the above maps, and further survey, various physical limitation maps, soil suitability and soil potential maps will emerge.

SECTION ONE.

THE REGION.CHAPTER 1.A. Selection.

The East Durham Plateau meets most of the requirements listed earlier (p. 10) and has certain added advantages.

Agriculture is the most persistent occupation here and is still a major occupation. Although colliery villages, which in this part of the country have a tendency to twin with older agricultural villages, are larger than their rural counterparts they are less secure. As coal mines close such villages as Wingate and older Cassop Colliery partially assume the appearance of 'ghost towns'. Their twins Old Wingate and Old Cassop having survived the centuries are adding new farms to replace the old although they have themselves shrunk in size with the loss of farm labourers' cottages. Industrial settlement will doubtless become increasingly centralised in such places as Peterlee, Easington, Thornley, and larger towns on the Tyne, Wear and Tees, while smaller industrial villages disappear or amalgamate in new housing estates. Substantial land will be lost to agriculture as new towns and waste heaps spread, but there are signs that some land is returning slowly into agricultural use. The site of the village

Raisby Hill is now largely ploughed up and growing crops. It may be that with increasing industrial centralisation other intervening areas which once supported a scatter of villages may return to agriculture and become increasingly rural in ethos and appearance.

The area of the East Durham Plateau is sufficient to include adequate variety in farming and physical features. It is rather large for one worker to survey in the allocated time but has the advantage of nearness to the University and to departmental laboratories. Access is extremely good, for as the one inch maps of the region show, the plateau is interlaced with a good network of roads and tracks. The largest areas not crossed by public access routes are the increasing number of golf courses to the north of the River Wear.

The boundaries of the East Durham Plateau are as clear as could be wished except in the south where there is something of a gradation into the Tees Basin.

There are, as already mentioned, added incentives to the selection of the East Durham Plateau. In recent years interest in the region has increased on academic, economic and social fronts. No-one has attempted the kind of survey intended in this work, but in 1947 Dougall was actively surveying the soils of the country. The Department of Geography at Durham has shown continued interest in the region. Maling (10) covered part of the geomorphology in 1956. Frisby (11) spent some time looking for Rendzina soils in 1959. Mr. P. Beaumont is at present working on certain aspects of the drift coverage of the region and the Geological survey are currently publishing some six inch geology sheets. Furthermore Dr. S. G. Willimott has for some time been occupied in work on similar soils in the Pontefract area of the West Riding of Yorkshire (12).

The 'North East' has for some years been notorious for its

social and economic problems. Changes in the ship-building and coal-mining industries have led to great unemployment and social unrest. Political attention has therefore been focussed here. The North East is a Development Region. Development and planning have been scanty but the plans continue. Perhaps of more significance than usual is the 'Hailsham Plan' (13). This indicates that the future of the North East lies mainly in its eastern sector, and here development is to be concentrated. The centre of the 'Growth Zone' is occupied by the East Durham Plateau a situation giving added weight to the choice of this region for the present study.

Apart from the planned developments there have been some less publicised regenerations of interest in the plateau. The widening application of magnesian limestone products has led to renewed interest in limestone quarrying throughout the region. Firms such as the Washington Chemical Co., and Steetly Quarries Ltd., both of international reputation and importance, are actively engaged in quarrying and processing magnesian limestone. Once dead quarries are being reopened and even the marly spoil heaps of past extraction are now being quarried. Industrial and agricultural uses of magnesian limestone are numerous and despite periodic recession interest in its quarrying is expanding rapidly. The vast mile-long quarry face, at Raisby Hill Quarry, on the scarp edge is a permanent and impressive indication of the scale of interest in this one resource of the East Durham Plateau.

Coal has since the turn of the century been of increasing importance, proportionally in this eastern part of the county to the detriment of the west, a further factor focussing interest on the region chosen. Finally, to keep pace with the increasing demand for sand, gravel and clay the East Durham Plateau is yielding greater supplies for building purposes and road aggregates. New quarries in kames and other deposits are eating away valuable farmland but these can be reclaimed (14) as for example large areas

south of Hawthorn village 420448. Apart from fluvioglacial deposits sand is obtained from the Yellow Sand below the Lower Magnesian Limestone, Old Magnesian limestone quarries are deepened for this purpose, for example the north end of the Bishop Middleham Quarry, while others supply both magnesian limestone and sand, for example Crime Rigg Quarry, Sherburn Hill.

The above indications add weight to the choice of the East Durham Plateau as a region worthy of study and capable of yielding valuable results. Two additional events; the surveying of the route for the Durham Motorway involving the sinking of many bores on the plateau, and the laying of the deep gas pipe line between Darlington, West Hartlepool and Blyth (Northumberland) provided irresistible and invaluable soil sections.

B. Boundaries and area

The East Durham Plateau is roughly triangular in shape and extends from South Shields in the north to the Ferryhill Gap in the south-west. It is bounded in the east by the sea and in the south less definitely by the Tees Basin. The western boundary is a clear ground feature, the Magnesian Limestone - Coal Measures escarpment., although this feature is less obvious on the O.S. map than on the ground itself. From Trow Point in the north the escarpment trends in a S.S. West direction as far as Coxhoe where it swings S. West, to north of Ferryhill. The Magnesian Limestone outcrops westwards beyond Ferryhill but the Gap forms a convenient boundary to the Plateau. There is no difficulty in determining the eastern boundary but the southern limit has no marked topographical features. The final delimitation of this limit was decided only after considerable field-work in that area and was strongly influenced by the work of Mr. R. Simpson (15) who was then active in the Hartlepool area. The actual boundary line adopted roughly follows a line from 489380 to 300230 on the O.S. sheet number 85. South of this line soils become very complex and new Series, unrelated to those further north, occur under the influence of the Triassic solid geology and different drift accumulations.

Agricultural practice is also radically changed under the influence of slightly milder conditions and the proximity of the expanding Teeside conurbation. The area included within these boundaries is near 100 square miles.

CHAPTER 2Topography and drainage

In general the highest ground is found along the crest of the escarpment. This has significant influences on climate, soil, and cropping practice. North of Coxhoe the dip is to the east allowing but few areas the advantages of the desirable southern sun at a steep angle, an influence of no little importance in such a northerly part of the country. South of Coxhoe the land slopes generally south to the Tees and here the agriculture imposes a more orderly and luxuriant landscape than in the more northerly areas; the absence of industrial villages and the less severe topography are, however, of equal importance with climatic influences in producing this effect.

The escarpment is breached only by the Wear and Ferryhill gaps, but north of the Wear the limestone has been weathered into low rounded knolls as for example Downhill 307' and Beacon Hill 278'. Most of the land in this section of the region is below 250'. Beacon Hill is formed in Upper Concretionary Limestone while Downhill consists of Drift-covered Middle and Lower Limestone. Soils on such knolls obviously differ according to the kind of limestone present, but structural and mineralogical differences within each section of the Magnesian Limestone are so great that Soil Series do not necessarily follow the map of geological exposures.

South of Boldon and Downhill the escarpment is marked by a line of hills most of which rise above the 500' contour. At Warden Law the maximum height of 663' is attained, but here the limestone is topped by a kame-like glacial deposit up to 150' in thickness. The highest summits of exposed Magnesian Limestone are to the west of a line from Thornley to Trimdon Village and are occasionally over 600' in altitude. The climatic effects of such elevation can be clearly seen on the rainfall map (Fig.1.), but even more dramatically in winter when snowfall and the duration of snow cover are regularly more severe here than in the rest of

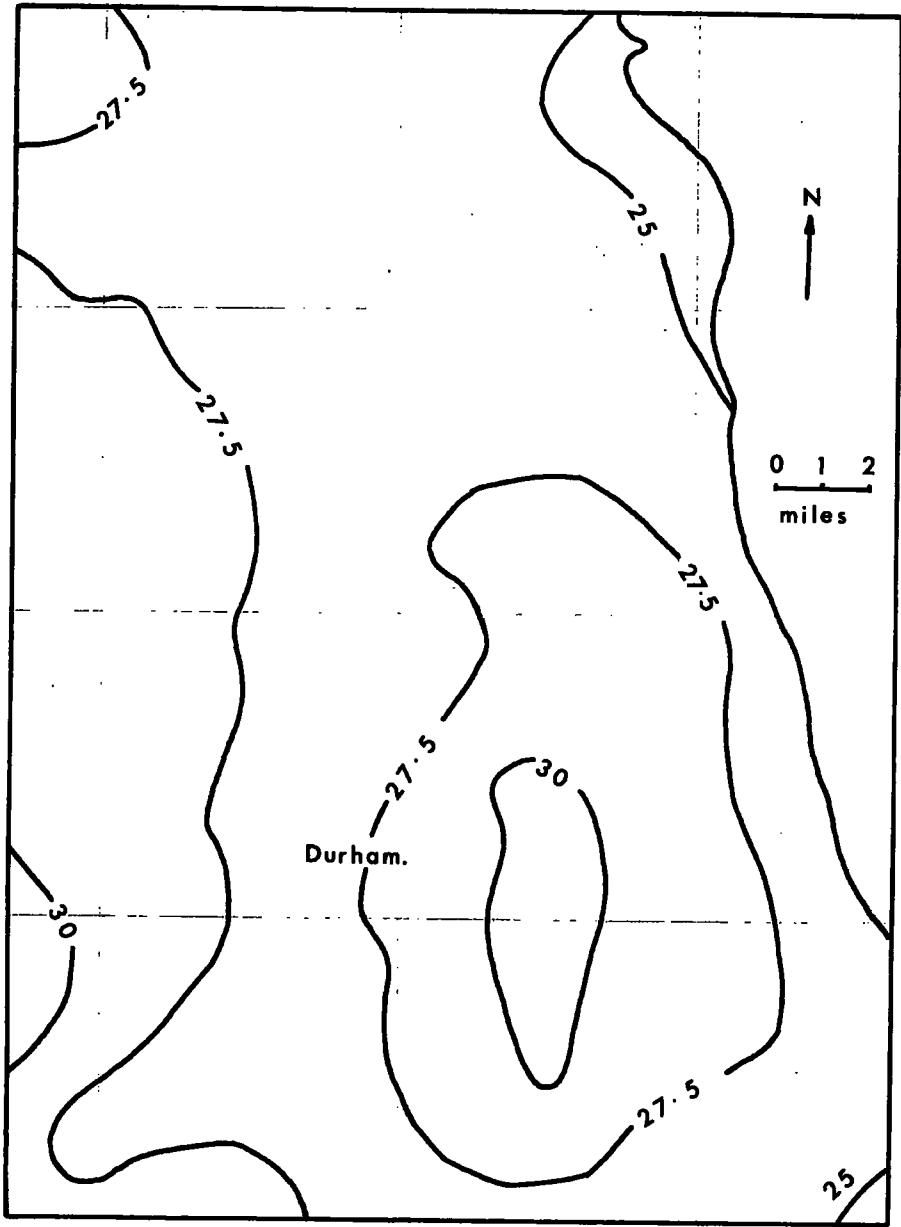


Fig 1 ANNUAL AVERAGE
RAINFALL . (Inches .)

eastern County Durham.

South of the Wear the landscape begins to assume the nature of a true dissected plateau. The western escarpment is much indented but preserves a steep scarp face, while the dip slope is extremely dissected. The land surface of the dip slopes generally falls eastwards to the North Sea, but this certainly does not correspond everywhere to the surface of the Magnesian Limestone beneath. Nor is the general slope itself uniform. It appears to be graded to about 100' above the present sea level. The lower slopes could have been truncated along the line of the present coast as marine erosion of this coast is at present dramatically active. Parts of the cliffs at Marsden for example have receded at least 50 yards in less than a hundred years, leaving Marsden Rock, once connected to the mainland by a bridge, isolated near the low tide mark. On the other hand the one hundred feet gradation above the present sea level cannot have remained constant. Evidence of raised beaches (16) suggests sea levels considerably higher than at present. Frisby (11) notes surfaces on the plateau as follows: A few summits at 600'; principal hill-top surfaces of the Magnesian Limestone between 500 and 550'; the greater part of the middle escarpment between 400 and 450'; a narrow belt running down the east side of the scarp and a broad belt round its southern edge between 300 and 350'; land to the north of the Wear and a thin coastal margin around 200'. These are however almost valueless as geomorphological descriptions as they take little account of the depth and variability of drift cover.

At various places along the escarpment edge, outcrops of Yellow Sand beneath the Lower Magnesian Limestone form minor secondary scarps, for example along the southern edge of the Wear gorge north of Penshaw. Carboniferous material also forms a substantial part of the scarp face, particularly near Old Cassop and Quarrington Hill bank. Here good quality Carboniferous sandstones have been successfully quarried and the limestone cap

is only comparatively thin. The influence of the limestone persists in the soils however even on the Carboniferous fringe of the scarp, because of soil movement down slope which results in a somewhat re-sorted drift cover.

The drainage system of the East Durham Plateau has a general appearance of anachronism and immaturity. It owes this to pre-Drift erosion, an extremely irregular Drift cover and various post-drift erosional influences. Before the Drift was deposited the western edge of the plateau was drained to the west by a series of scarp slope streams which are responsible for the major part of the extreme indentation of the scarp face. These streams were cut back some two or three miles behind the scarp face and must have been formed under the influence of far more water than they dispose of today. At present these valleys, though too large for the present diminutive streams, are greatly infilled with drift-160' at Ludworth Colliery, well behind the scarp, and a similar depth in the valley between Old Cassop and Running Waters, level with the scarp edge. These streams were at some time actively cutting back headwards but are now mostly mere runnels and often intermittent. In the Vale of Cassop there are lateral depressions of undefined drainage along the edges of the valley, while a ridge of drift material rises to the centre. An area of swampy ground on the south side of the valley represents the remains of a post glacial minor lake which has but recently been drained.

To the east the drainage follows partially infilled pre-drift valleys rarely exposing the Magnesian Limestone, but nearer the coast remarkable short but deep denes and gills cut down into the rock and break the continuity of the cliff line. These youthful streams could possibly have been initiated under the influence of melt water from the last glaciation as their headwaters are mainly within the confines of the widest spread of Upper Boulder Clay.

Intefluves between east and west flowing drainages are usually some two to three miles east of the escarpment. The only part of the region drained to the Tyne in the north is the area around Cleadon which is served by the River Don. In this northern section beyond the Wear, there is little marked surface drainage because the Plateau has lost its elevation and breadth. In the extreme south the drainage is erratic over deep Drift but generally in a southerly direction to the Tees. The south west Carr-land has only recently been provided with a semblance of adequate drainage through artificial dykes and modifications to the course of the wandering River Skerne and its erratic tributaries. The Carrs themselves were most probably part of a series of post-glacial depressions and impeded valley lakes, or perhaps one very large lake. They were certainly for the larger part of the last century regularly flooded and had the appearance of marshy fen-like features. They are partially infilled with silty clays, sands and gravels, often overlain with varying depths of peat.

The East Durham Plateau is therefore served with drainage of irregular quality. The eastern and western boundaries have more than adequate ability to dispose of present rainfall. The southern edge, despite improvements is still subject to periodic waterlogging and is mainly devoted to pasture land. Throughout the central sector there are pockets of ill-drained land with permanently marshy appearance or various degrees of soil gleying. There are springs along the foot of the scarp for much of its length as both the Magnesian Limestone and the Yellow Sand are heavy water bearing formations. The settlement pattern and occupation of the land are not in complete harmony with drainage conditions. Regular flooding of roads and water standing in fields are permanent features of life here, particularly in the heart of the plateau around Haswell. Coal mining has also suffered long from the prodigious supplies of unwanted water from the Magnesian Limestone and Yellow Sand, although Sunderland, South Shields and Durham are more than grateful recipients of this water.

GeologyChapter 3 (a)

The areas of Magnesian Limestone outcrop are restricted as inspection of the map (Fig.2) will indicate. Nowhere is there a complete absence of drift influence. Even on the thinnest and most Rendzina-like soils for example outside the northern walls of the Farding Lake Golf Course, near Marsden, traces of coal and other minerals not associated with the insoluble residue of Magnesian Limestone are to be found. Most areas with thin soils over limestone suffer from the sterilising effects of limestone quarrying or are made waste by networks of pitfall chasms. Natural swallow holes are not normally associated with this limestone formation but subsidence sinks have similar effects in isolating small parcels of valuable land and causing loss of life particularly amongst sheep.

Because of the lack of extensive exposure a detailed description of the geology is unnecessary. Some acquaintance with the various forms of Magnesian limestone is however essential as most soils in the region are developed on Drift or moraine and there are varying degrees of fragmented and weathered limestone incorporated within these glacial deposits.

Divisions of the Permian in this part of the country can be conventionally represented as follows:-

	<u>West of the Reef.</u>	<u>East of the Reef.</u>
Red upper		Marls, mainly red false-bedded sandstone, thinly fossiliferous dolomite
Beds		limestone, beds of sale anhydrite and gypsum. Only 300 ft. thick.
	Gypsiferous colites.	Oolites (originally gypsiferous) of Roker and Hartlepool. 100 ft. thick.
	Upper Limestone.	
Upper Limestone.		Concretionary limestone. Bedded concretionary dolomite and calcareous rock. 250 ft. thick.

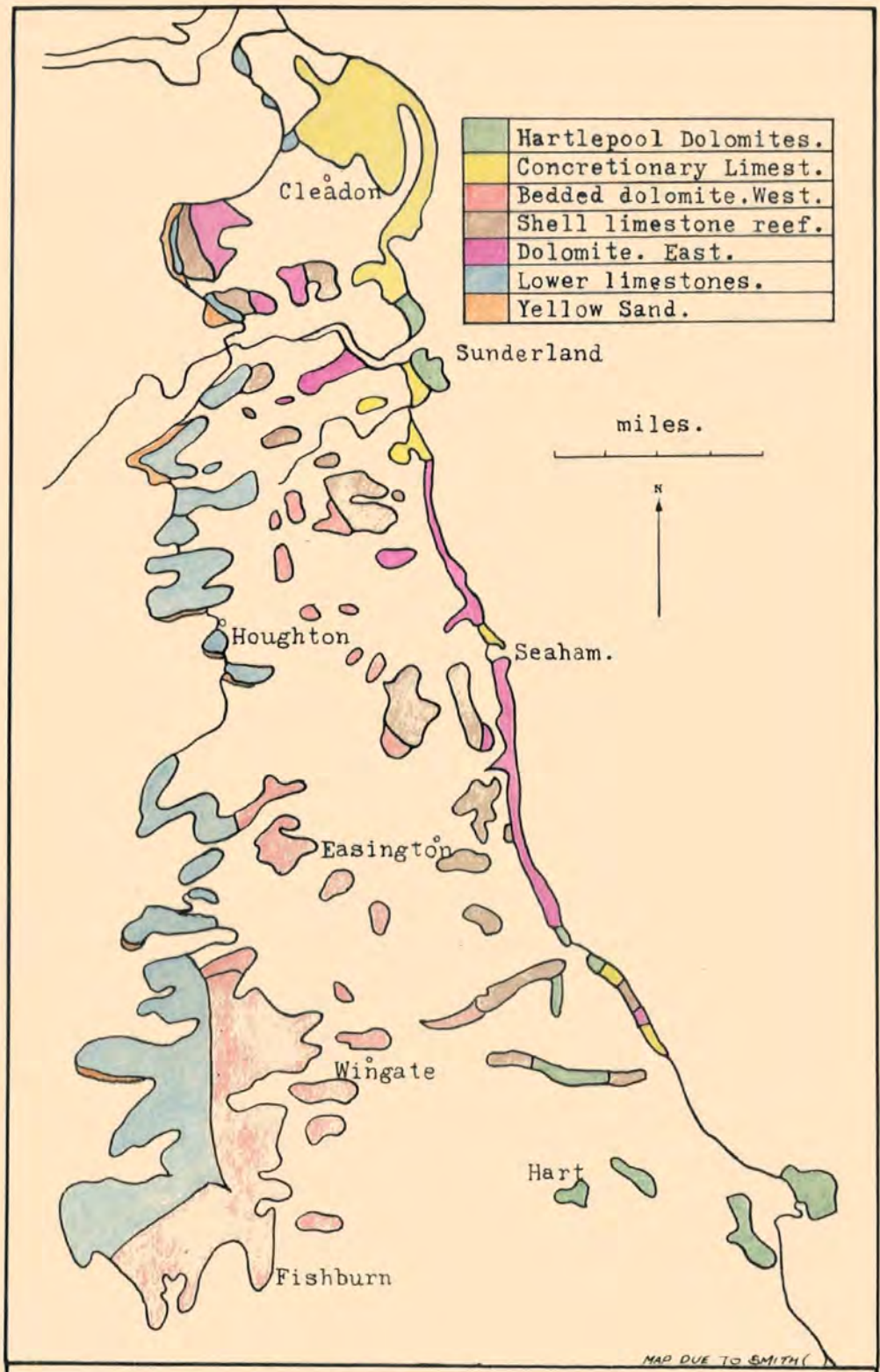


Fig. 2 MAGNESIAN LIMESTONE NEAR THE SURFACE

	<u>West of the Reef</u>	<u>East of the Reef.</u>
Middle limestone.	Segregated limestones. Dolomitic limestones 240 ft. Dolomitic colite. Fossiliferous dolomite Granular colite	Flexible Unbedded dolomite and Lime 12' calcareous shell bank of Yellow Bryzoan Reef. 300 ft. thick. bedded dolomite and segregated limestone
Lower Limestone	250 ft. of yellow bedded dolomites and dolomitic limestones with which are interbedded in the south of the country lenticles of grey calcareous limestone. These beds thin out rapidly north of Sunderland.	
	Marl Slate. 3-8 ft. of thinly laminated dolomitic and calcareous marl.	
	Yellow Sand. Pockets of loose sand varying depths in hollows in the pre-Permian land surface.	

Diagnostic features of the Lower Limestone include its colour which is predominantly yellow, but bands of brown, grey and white occur. Sometimes black crystals of manganese dioxide 'pepper' the surface. The rock is often sub-crystalline, generally compact and not friable.

The Middle Limestone includes highly fossiliferous beds and generally contains the highest content of magnesium carbonate. Some is, however, more calcareous owing to the leaching out of the magnesium carbonate. The colour is usually yellow to brown but manganese dioxide can confer a much darker appearance as for example in the vicinity of Tunstall Hills. More easterly representatives of this series are thinner bedded and less friable.

The Upper Limestone includes soft powdery marls, hard blue-stones and the famous Cannonball Limestone.

The Composition and texture of the Magnesian Limestone exhibit great variety. Calcium carbonate and magnesium carbonate together amount to 90-95 percent of the material. The proportion of calcium carbonate can vary from 38-99 per cent and the magnesium carbonate from 1-50 percent. The rock is generally rich in magnesia but rarely a true dolomite with calcium carbonate at 54.35 per cent and magnesium carbonate at 46.65 percent. Some beds have sufficient

detrital quartz to allow an approach to sandstone characteristics. Great variations occur within the same part of the formation. For example Smith notes the following variations within the Middle Limestone. (17)

1. Massive and very massive, hard, creamy, brown dolomitic limestone presenting many large rounded surfaces and composed of all types of shell debris firmly held in a fine matrix often rich in Bryzoa.
2. Irregular sheets and wedges of talus, often steeply dipping, produced by contemporaneous erosion of the reef.
3. Breccias and breccio-conglomerates probably formed as in 2. and also bedded limestones laid down as an upper surface.
4. Irregular pockets of loosely cemented shell rubble and earthy material and a fauna rich in gastropods and foraminifera.
5. More or less bedded deposits of shell debris which accumulate in hollows on the surface of the reef and which now appear as brown or white crystalline dolomitic limestone.

Elsewhere in the Upper and Lower Magnesian Limestones dolomite and purely calcareous limestones are found side by side in the same quarry face with sharp vertical or horizontal divides. The proportion of calcium carbonate to magnesium carbonate in the limestone is of great importance to the chemistry of the soil and therefore to agriculture. From experience it seems that the more friable and powdery rocks from any part of the limestone have the higher proportion of magnesium carbonate and that when subject to weathering these rocks assume a darker colouring than the more calcareous limestone. As will be noted later the more calcium and magnesium carbonates present in drift soils the better quality of the soil both physically and chemically, a fact clearly reflected in crop responses.

The Limestones contain appreciable but variable amounts of

iron which alter the colouring of the rock considerably. The insoluble residue is rarely above 5 percent and shows derivation from a variety of rock types including acid and basic igneous and metamorphic rocks. Crampton (18) has identified monazite, zircon, apatite, sphene, topaz, tourmaline, rutile, pyroxines, amphyboles, garnets, quartz and feldspar. Secondary minerals found frequently in situ in limestone or in drift include calcite crystals and calcopyrite inclusions.

It will therefore be clear that there is great variety in parent materials and therefore great complexity in the soils developed.

3(b) Superficial Geology

Superficial deposits cover more than threequarters of the Magnesian Limestone in varying thicknesses. Dougall (19) gives the following list of superficial deposits encountered in the North East.

<u>Formation</u>	<u>Parent Material</u>
1. Post-glacial deposits	(a) Brown sand
	(b) Alluvium
	(c) River terraces
	(d) Marine alluvium
	(e) Peat.
2. Glacial deposits	(a) Bedded sand and gravel
	(b) Jurassic and Triassic mixed drift.
	(c) Triassic till
	(d) Triassic and Magnesian Limestone mixed drift
	(e) Permo-triassic till
	(f) Triassic, magnesian Limestone and Carboniferous mixed drift
	(g) Triassic and Carboniferous mixed drift
	(i) Coal Measure till
	(j) Carboniferous till
	(k)-(s) deposits derived from older strata and found mainly in the west of the country.

The only extensive area of blown sand encountered in the region is around Warren House Gill on the coast near Horden Colliery. Trechman terms these dune-like deposits 'loess'. They give rise to shallow soils with excessive drainage and are either waste land or devoted to pasture. The Carr lands of Bradbury, Morden and Mainsforth have extensive areas of basin peat over blue-grey or red-brown silty clay. Some parts of these peat basins have been improved and now support regular cultivation, but mostly they are still regularly waterlogged and used at best for permanent pasture.

While recognising the value of Dougall's classification a simpler division of the drift encountered during the current survey is possible. The north and western parts of the region are covered by what can be conveniently termed Lower Drift. This is a calcareous mixed drift consisting of Carboniferous and Permian materials with diverse mechanical composition and lithological characteristics. Dougall groups the soils formed on this drift into a 'Dalton Association'. They are dominated by his Haswell Series and Improved Haswell Series. Soils of this type are difficult to classify and map because of the great lithological variety within very small areas. Depth of drift over the Magnesian Limestone and the proportion of weathered limestone in the mixture are important but variable factors. The broadest common factors chosen for delimitation are quality of drainage and depth of topsoil in the profile as these correspond best with overall soil quality for agricultural purposes. Generally these soils produce crops of good quality but with very moderate yields, a limitation particularly noticeable in the belt of ill-drained soils around Haswell. Lower Drift occurs in the east of the area and here exhibits significantly different features but as it is covered by later deposits it has very little influence on the soils.

To the south-east of the region, as far inland as Sedgfield, the dominant parent material is a reddish till with Triassic material of great importance. Mechanical composition varies but there is less

vertical complexity than in the Lower Drift. Nevertheless chemical and physical properties are sufficiently diverse to give rise to a wide range of soils. The Place of origin of materials responsible for these soils is not clear but they may have been brought in from the bed of the North Sea.

Further north these reddish deposits have an increasing Magnesian Limestone component which contributes calcareous characteristics and improves structure and depth of top-soil. Such material gives rise to brown or red-brown sandy loams, to red-brown more compacted medium loams. Drainage conditions are important distinguishing factors contributing to recognisable properties in the profiles developed. The poorest soils are shallow, grey-brown medium loams over pale red-brown clay loams with typical rust mottling. There is usually no calcareous reaction in at least the top two feet of soils developed on this material but the pH rises sharply with increased depth and reaches figures around pH8 within the range of root development.

For a short distance north and south of Easington Colliery and stretching inland almost to Shotton Colliery lithological complication becomes even more difficult because of the addition of Carboniferous drift to the mixture of Triassic and Permian material. Brown clays and red clays are seen in close juxtaposition and often wedge out above or below each other. Drainage conditions again distinguish soils on the level of crop response but mapping these differences of drainage with any accuracy is a difficult task. Free drained soils are deep friable sandy loams over brown medium loams. Slightly poor drainage is indicated by rust mottling in the surface horizons while bad drainage is seen in the amount of blue-grey gleying, far shallower topsoil and increased heaviness of texture.

The above is the picture of superficial deposits at their simplest. The general sequence of glacial events may have involved the covering of the whole region with the browner and greyer Lower Drift. In the east this was covered with the redder Upper drift with

the three mentioned divisions. Between the two drifts, vertically come the Middle Sands but these have no surface significance. Between the drifts as seen at the surface is an indeterminate belt of morainic fluvoglacial deposits. They can be found in patches of varying size from South Hetton to Acre Rig, Peterlee, Wingate, Hart Hall and some of the knoll like features around Sheraton. These are sands and gravels mainly, with variable admixtures of clay and large boulders. They are included in the same Series as similar fluvoglacial deposits elsewhere in the region but here they seem to form something of a boundary line between the two drifts. They often have a higher clay component than their counterparts elsewhere.

The Lower drift would seem to have been directed in an easterly direction, while the Upper Drift is from the north. The Lower drift begins to turn south eastwards along the mentioned line of fluvoglacial deposits. This is of more than academic interest because the boundary of moraine is far from adequate and there is frequent mixing of Upper and Lower deposits. Along the Hart road for example an electricity trench revealed bands of Upper clay sometimes over the Lower drift and sometimes underneath. This is typical of much of the junction zone, although at Dalton there is a very clearcut boundary between the overlying Upper Clay and the Lower, wherever an intervening concretionary zone is absent. Soil creep or lake deposition does not seem an adequate explanation as the feature occurs on even land and at the top of hills. Perhaps an explanation can be found in association with another important observation true of most of the drift throughout the region. Everywhere the top foot of drift, or sometimes up to five feet, was distinct from lower parts in that most of the lithological complexity had been removed. Small veins of sand and definite orientation of stones surprisingly seem absent. In fact everything appeared to have been mixed into a homogenous mass, despite subsequent structural developments through weathering and surface cultivation. This feature is so common that normal soil creep will not give a satisfactory explanation. It seems possible that the whole region has experienced periglacial or semi-tundra conditions

during which the surface drift would be subject at times to freezing and at times to sludge conditions. This could produce considerable mobility and can quite easily be visualised as causing the peculiar mixing and distortion notable today. This does not however simplify the task of soil survey because although most of the drift has undergone changes in this way to some extent, these changes are to varying degrees and varying depths, and the profile of course extends into the different drifts beneath. It will therefore be appreciated that survey is not easy in such an area; boundaries are sometimes arbitrary and areas shown as one Series may include many small patches of soil really closer to another series but of too minute spatial development to be represented even on the six inch to the mile scale.

Chapter 4.Climate

There are important differences in climate within this region because of differences in elevation, aspect and proximity to the coast. The whole area to the east of the Pennines has a lower average rainfall than areas of similar latitude to the west. The central escarpment interrupts the pattern of decreasing precipitation from west to east, from the heads of the northern dales to the coast. The mid-Wear Valley has an average of 25-27 inches while the highest lobe of the scarp from Kelloe to Pitkington includes averages of over 30 inches. This central area at 500-600 ft. is surrounded by progressively drier land until the narrow coastal belt between Sunderland and South Shields which receives but 22-25 inches annually on average. Most of the rainfall is cyclonic and orographic rather than convectional but rain received during thunderstorms is not unimportant especially around Sunderland. These storms are evening storms occurring in a period from July to August. Thunder is heard on the Plateau area from ten to twelve times a year on average.

The average number of rain days (more than 0.01" in a twenty four hour period) is around 170 throughout the region but averages conceal great variation. The lowest number of raindays recorded in the period 1943-1957 was 123 at Sunderland (Thornholme) and the highest was 233 at WestHartlepool Waterworks. At each of the fourteen stations shown in Fig.3. the number of raindays are widely scattered between these two limits. Lower totals usually correspond with drier years and higher totals with wet years. Totals for all the stations tend to move up or down in corresponding proportions depending on the wetness of the year, but the range is very great. Stations nearer the higher scarp area always have more rain days in the same year, than stations nearer the coast. There is similar variety in totals of days with over 0.4" of rain, between a minimum of 90 and a maximum of 160. In fact average figures are so rarely achieved that they are almost meaningless. The picture is rather

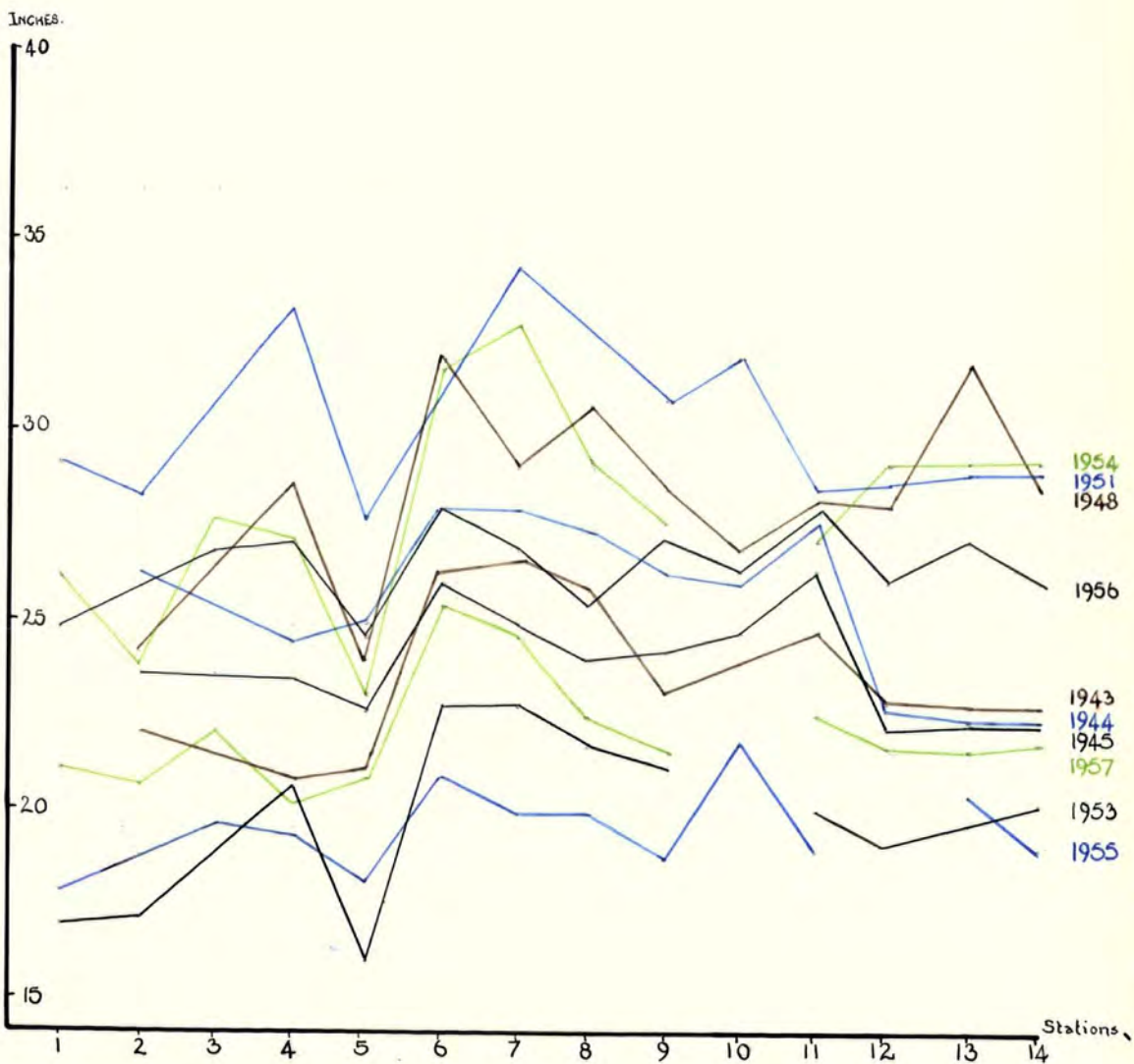
of substantial variation on either side of the average. This applies especially to rainfall totals. Annual totals range from 14" on the coast to over 40" on the central scarp top. The range of totals at any one station is equally dramatic. In each station the maximum annual total of precipitation in the twelve years under study is almost or even more than double the minimum. The range at a dry coastal region of the south (Hart Reservoir) is from 14" to 27.5" (average 21.5"). Further north at Sunderland it is from 16.5" to 33.52" (average 25.5"). Near the scarp at Shotton the range is from 19.9" to 35.1" (average 29.4") and at Easington from 18.3" to 34.4" (average 26.2"). As with rain day totals absolute annual precipitation totals from the different stations fluctuate reciprocally depending on the season. The only station that consistently fails to record patterns of fluctuation corresponding to other places is Sunderland and this may be due to the irregular influence of convectional thunderstorm rain.

The importance of the above rainfall statistics is that the absolute maximum of slightly over 35 inches along the scarp edge is but a moderate precipitation, and there is no guarantee of anything approaching that total. Westerly wetter parts often have less precipitation than the average coastal rainfall. Despite the average totals much of the region frequently has less than 20 inches of rainfall. This shortage would be most serious nearer the coast but here common sea fogs may have a significant mitigating influence. Dry and wet years appear to recur in a regular cycle of alternate years from 1949-1957 but this feature is not persistent throughout the period 1881-1949. When it does occur it is of great significance to local farming. The year 1949 was very dry and the harvests were early. Fortunately it followed a very wet season 1948, and yields were comparatively high throughout the region but more so on the clay soils than on limestone soils. In 1948 and 1950 barley yields were up to the

Fig. 3 Rainfall Data.

Station.

- | | |
|--------------------------------------|------------------------------|
| 1. West Hartlepool Clock. | 8. Seaham Dalton Pumping St. |
| 2. West Hartlepool Waterworks. | 9. Ryhope. |
| 3. West Hartlepool Secondary School. | 10. Washington Glebe School. |
| 4. Hurworth Burn Reservoir. | 11. Sunderland Thornholme. |
| 5. Hart Reservoir. | 12. Cleadon Pumping Station. |
| 6. Shotton Pumping Station. | 13. S.Shields Bents Park. |
| 7. Easington Mill Hill Reservoir. | 14. S.Shields S.Pier Works. |



two ton mark on the thin limestone soils because of the wetness of the season. Normal harvests yield 20-25 cwt. to the acre.

Graph Fig.3 shows that the main feature of precipitation as far as agriculture is concerned is unpredictability, 50-150% deviation from 1881-1915 averages. There is also the tendency to shortage near the coast. Extremes are notable because they usually occur in the same year at most stations. Lowest rainfalls came uniformly in 1949 and the wettest year was 1950 almost everywhere. No year approximated to the average totals but the median of thirteen years closely corresponds with totals for 1952. This correspondence happens only once in thirteen years.

The seasonal incidence of rainfall is also of agricultural importance. Here again averages tend to mislead. Periodicity is very variable. At several stations maximum rainfall has been recorded in every month except May and June, although average monthly records show October as the wettest month (1881-1915). More recently October would appear to have become drier and July, August and December have become 'wetter' months. Drier months include April, March and February and often September. Generally spring is the driest season with late summer and early autumn the wettest, especially away from the coast. This is doubtless partly the reason for the absence of spring wheat in the west of the region.

Snowfall is also unreliable. Its frequency is due to the situation of the region within the influence of polar air and instability showers. Its quantity is due to orography, its duration to altitude and quantity. For every 50 ft. above 200 ft. in the region there is generally an added day of snow cover in the year. Average days of snowfall on the coast are about twenty, but this represents a range from 8-40. in different years. On the scarp the range is from 10-50 days of snow fall. Most of the snow falls between December and March. The greater frequency of instability showers in this period is responsible for its prominence in snow fall over the early winter period. The first fall however is

usually in November and the last in April, although there are sometimes occasional showers in May. At the coast there are often more days of snowfall than of snow lying, but this is not the case higher up on the plateau. Snow lies on average for 7-8 days at the coast and as may be expected this increases inland. Duration of snow cover varies not only with the severity of the winter, but also with local topography and aspect. Snow lies longer on higher ground and on north and east facing slopes. In the severe winter of 1962-63 the contrast between the scarp between Kelloe and Pittington and the mid-Wear Valley or the coast itself was marked. On the central scarp snow was far deeper, drifted more severely and lasted far longer than in neighbouring but lower areas. Especially difficult conditions were experienced in the vicinity of Kelloe where roads were blocked and grazing land deeply covered almost continuously for nearly three months. Even in the valley of Houghall experienced 65 days of continuous snow cover. Winter feed is a very great problem in such a region especially with a large sheep population. The only advantage of such a lengthy duration of snow cover is the protection it affords against frost. This was particularly well demonstrated in 1963. During January and February of that year there were exceedingly low temperatures and occasional strong cold winds over a period of two months. At Shincliffe near Houghall the snow cover was partially cleared during an 'interglacial' and the ground was frozen to a depth of three feet by subsequent frost. This necessitated resowing with spring grain. The scarp fortunately had sufficient snow cover to keep out the frost and the winter wheat came away successfully in the spring despite the extremes of the prolonged winter.

The East Durham Plateau is not generally as cloudy as areas of corresponding latitude in the west of England. In the spring and early summer, however, sea fogs are often sufficiently persistent to be a very bleak feature of local climate. This

weather occurs very suddenly and can persist for several days. It may be clear during the afternoon of the day it first forms only to set in again in the evening or on the following morning. It is caused by easterly winds, common in March to July, but most frequent in April, May and June, and the cooling effect of the sea. It takes the form of shapeless stratus clouds between 300 and 800 feet and is accompanied by intermittent drizzle, poor visibility and chilling easterly winds. Its penetration westwards is irregular but it frequently passes beyond the scarp and the whole East Durham Plateau is affected. Anticyclonic gloom, another North Sea cloud forming at 1500 - 4000 ft. also influences the region with drizzle and cold winds particularly in the spring. Normal cyclonic cloud, is in contrast to the latter forms, more dominant over the scarp edge than at the coast. It loses much of its rain before it reaches the sea and is responsible for the greater rainfall in the higher and more westerly parts of the region.

An alternative form of sea-fret occurs during calm or slightly breezy conditions. This is really a fog and occurs but occasionally in spring, summer and autumn. Inshore breezes may carry it inland and lift it above the land surface giving the appearance of a fret, but its effects are limited to a narrow coastal belt. This region is, however, beyond the main fog belt of Great Britain and because of persistent easterly breezes, the limited agglomeration of dense population, and the undulating topography, dense fogs are rare. Local pools of mist in pockets and hollows are more common. Smoke with all its deleterious effects is however a feature of industrial Tyneside and Teeside and this contributes to the poor visibility during sea frets and anticyclonic gloom. The worst conditions are, however, experienced where there is a northwards drift of Midland and Yorkshire smoke. Considering the infrequency of dense fog chemical pollution of the soil in the region is surprisingly high. One of the reasons given for the lack of malting quality barley over the thin magnesian limestone soils is

Fig. 4a Composite Seasonal Wind Roses.

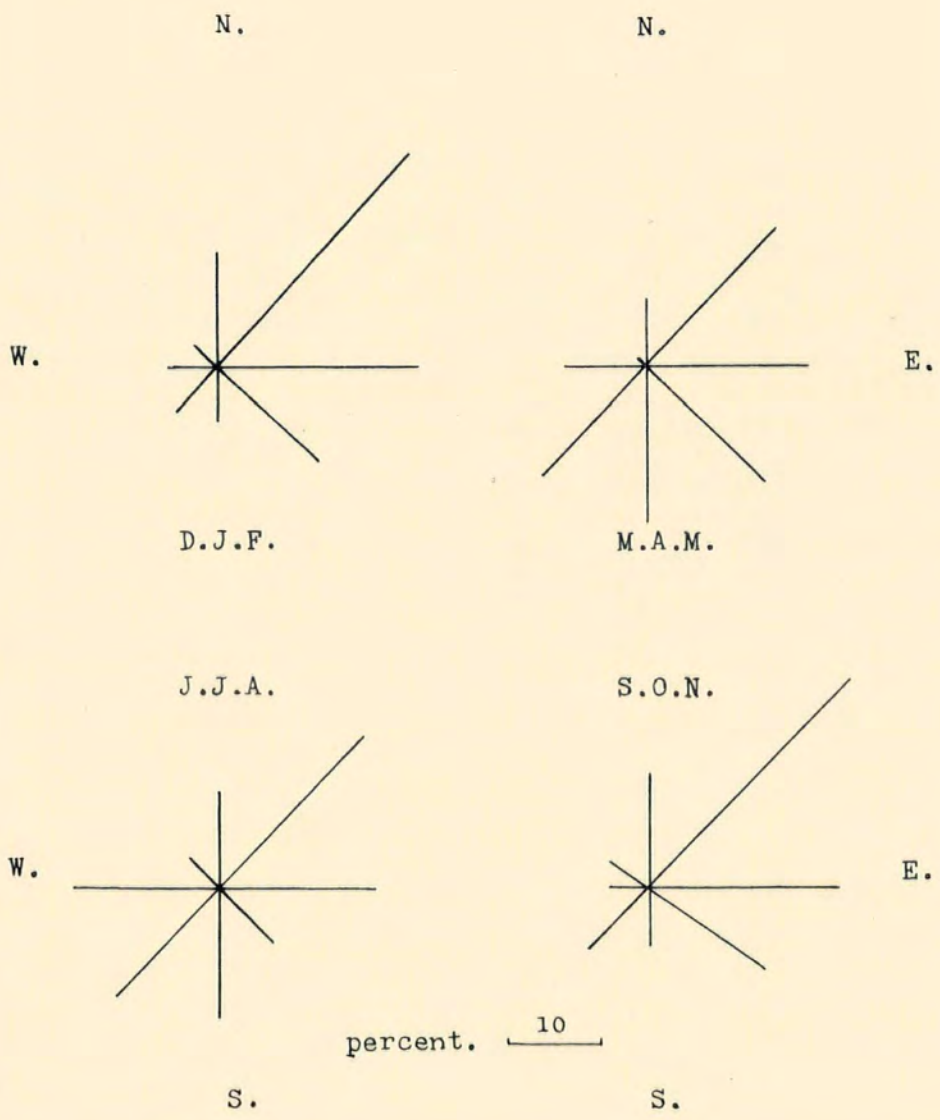
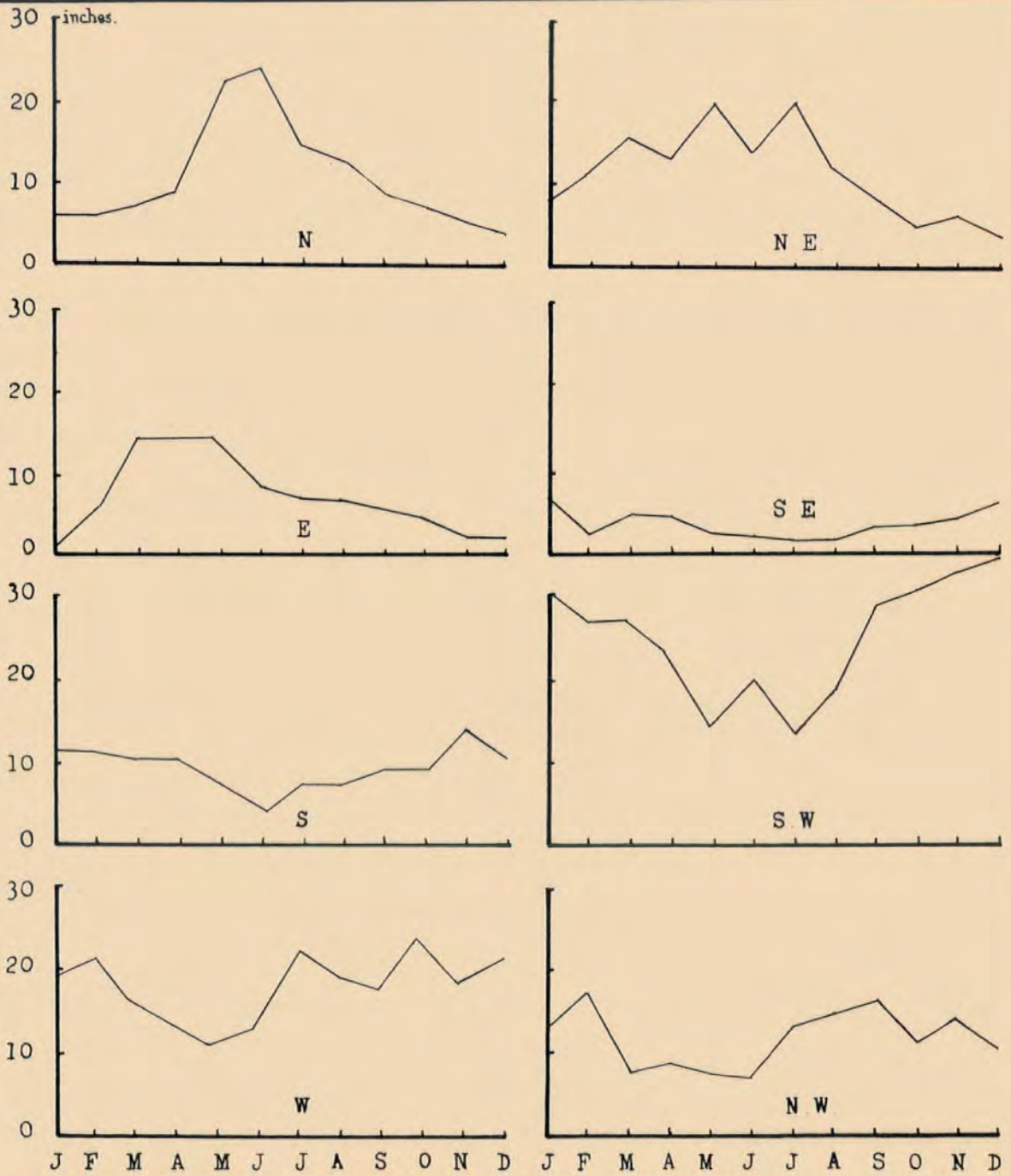


Fig. 4b Wind Direction For Year.
Ten year mean.



that the crops are too dirty. In this context pollution from other sources than industrial smoke must be cited. With prevailing strong winds there seems to be a free circulation of coal dust throughout the region and even worse the spread of Magnesian Limestone dust, especially from the larger quarries. School playing fields in the neighbourhood of Coxhoe have, for example, received severe scorching from such a source in recent years.

From a single station in the region an average of 1383 hours of sunshine in the year has been obtained. The highest month is June followed by May and July. These figures have little agricultural significance except that they are perhaps a little lower than desirable, but most farmers in Britain would make the same complaint. What is certain is that crops are harvested late, because of late ripening, or because the ground is wet and the grain needs drying. Grain driers are essential for efficient arable farming in this region.

Aspect, exposure, altitude and proximity to the sea are obviously the chief influence on temperature in the region. Near the coast temperatures range between 20-80° F and occasionally they fall below 20° F and very occasionally fall below 10° F and rise above 80° F. July and August are the warmest months and January and February the coldest. There is a slight difference in range between coastal and scarp areas, especially in early summer, for mean maxima, and in winter for mean minima. Annual range is from 27° F to 30° F at the coast and 31° F to 33° F at the scarp. Spring is later and cooler on the East Durham Plateau than over much of England. This is partly the reason for the absence of spring wheat over much of the region. The most favoured areas are the coastal denes and the western indentations into the scarp, which are somewhat protected from cold easterly winds. The more westerly valleys are particularly notable for their earlier start and higher yields but this is not a result of temperature alone.

The physical and chemical conditions of these deeper soils with the admixture of magnesian limestone and drift are of great significance. Although spring is two or three weeks later than in areas slightly to the south in the Tees basin the slowness of growth on the plateau has its advantages. One is that plants are less liable to a too early flush and are less susceptible to late frosts. Certain plants are also less liable to bolt. The first air frost is usually in October and the last in May. July and August are the only two regularly frost-free months but even this cannot be guaranteed. Mild air frosts occurred twice in mid-August 1964. The worst frosts occur in January, February and March. The Tyne and Tees estuary areas have a considerably longer frost-free period than the plateau. Katabatic flow is an important influence in the region because the scarp edge seems remarkably free of frost when the mid-Wear valley is locked in frost, and the coastal region to a lesser extent. The influence of the greater snow cover at the scarp is an added advantage. The thin scarp soils do not require the assistance of frost to aid later cultivation as do the heavier clays. These lighter loamy soils at the scarp might be expected to get an earlier start than more easterly clays but except in the valleys elevation and exposure to cold easterlies seems to counteract this. Further east sandy morainic soils do have an earlier start than neighbouring clay but this latter fact is due rather to the dryness of the land and tractor bearing conditions than temperature conditions alone. Over the whole region the growing season can last from mid-April to November or early December.

The coastal belt of County Durham is a markedly breezy region. In all kinds of weather conditions other elements are nearly always accompanied by winds or at least a strong breeze even in an anticyclonic pressure system.

Winds with a westerly component naturally predominate as in the rest of the British Isles, but here winds from the north and east

are of almost equal frequency and they are particularly common in spring and early summer and sometimes winter. Gales are less frequent than on the north-west coast and are usually associated with the frequency of depressions passing over the country. When they occur in winter or spring they are usually from the east and this part of the country certainly has more easterly gales than the rest of England. The average frequency of gales is five to a year but there is variation from two to ten. The occurrence of sea breezes has already been mentioned. Off-shore breezes are very rare. The effect of winds is seen in flattened barley every year in this region but there is usually sufficient growing time after the main summer gales to allow the crops to stand again. Nevertheless winds are responsible for grain losses, difficult to assess but nevertheless significant each year. Late gales in the third quarter of August 1964 for example scattered some of the grain from an early ripened crop and reduced slightly what looked earlier like a very good harvest. There are few windbreaks on the East Durham Plateau.

In conclusion, the climate of the East Durham Plateau is, like the rest of the North-East, severe especially in winter, but here it is somewhat wetter, cloudier, cooler and breezier, though less subject to frost, than the inland valleys.

Vegetation

Chapter 5

The whole of the region has long been cultivated and there is little undisturbed natural vegetation. There are a few quarries, rough areas on the steeper parts of the escarpment, small woods and denes which are of importance in preserving plants of diagnostic significance. The spread of these plants along hedge-sides can be of great use in indicating soil changes, especially in response to varying amounts of Magnesian Limestone in the profile. This was first observed in the vicinity of Bishop Middleham. The Boundary line between a sandy Magnesian Limestone brash soil and a sandy fluvoglacial soil is here very sharp although this is not immediately obvious on a textural basis, by HCl reaction or by topographical features. The line was clearly marked, however, by the purple to blue flower of the Knapweed, which grew in profusion along hedges and paths on the limestone soil but was cut out completely along the edge of the fluvoglacial material. Further investigation led to the simple observation that at that time of year (early summer) soils with a high proportion of Magnesian Limestone in the parent material, including some drift soils, were dominated by blue coloured flowers. This correlation proved so useful that further records of significant plants were made and are summarised below.

Magnesian Limestone soils are often thin and do not form the ideal habitat for woodland. Extensive cultivation has also reduced the number of trees in the region. The denes near the coast preserve the best remaining stands. Hawthorn Dene has the following flora

Upper and Middle Layers

<i>Eunonymus europaeus</i>	<i>Crataegus monogyna</i>	<i>Ligustrum vulgare</i>
<i>Ilex (Acquifolium)</i>	<i>Hedera Helix</i>	<i>Viscum album</i>
<i>Acer campestre</i>	<i>Cornus sanguinea</i>	<i>Ulmus montana</i>
<i>Ulex europaeus</i>	<i>Sambucus nigra</i>	<i>Corylus Aveliana</i>
<i>Prunus institia</i>	<i>Viburnum Opulus</i>	<i>Salix Caprea</i>
<i>Rubus spp.</i>	<i>Lonicera Periclymenum</i>	<i>Salix atrocineria</i>
<i>Rosa spp.</i>	<i>Fraxinus exelsior</i>	<i>Taxus baccata.</i>

Magnesian Limestone soils are often thin and do not form the ideal habitat for woodland. Extensive cultivation has also reduced the number of trees in the region. The denes near the coast preserve the best remaining stands. Hawthorn Dene has the following flora.

Upper and Middle layers

<i>Eunonymus europaeus</i>	<i>Crataegus monogyna</i>	<i>Ligustrum vulgare</i>
<i>Ilex Aquifolium</i>	<i>Hedera Helix</i>	<i>Viscum album</i>
<i>Acer campestre</i>	<i>Cornus sanguinea</i>	<i>Ulmus montana</i>
<i>Ulex europaeus</i>	<i>Sambucus nigra</i>	<i>Corylus Avellana</i>
<i>Prunus institia</i>	<i>Viburnum Opulus</i>	<i>Salix Caprea</i>
<i>Rubus spp.</i>	<i>Lonicera Periclymenum</i>	<i>Salix atrocineria</i>
<i>Rosa spp.</i>	<i>Fraxinus exelsior</i>	<i>Taxus baccata</i>

Ground layer

<i>Anemone nemorosa</i>	<i>Asperula odorata</i>	<i>Ajuga reptans</i>
<i>Caltha palustris</i>	<i>Valeriana officinalis</i>	<i>Viscum album</i>
<i>Helianthemum nummularium</i>	<i>Scabiosa Columbaria</i>	<i>Parietaria diffusa</i>
<i>Viola hirta et spp.</i>	<i>Erigeron acris</i>	<i>Neottia nidus-avis</i>
<i>Polygala vulgaris</i>	<i>Achillea millefolium</i>	<i>Cephalanthera longifolia</i>
<i>Melandrium rubrum</i>	<i>Senecio erucifolius</i>	<i>Listera ovata</i>
<i>Hypericum dubium, humfusium</i>	<i>Carlina vulgaris</i>	<i>Orchis mascula</i>
<i>Linum catharticum</i>	<i>Carduus tenuiflorus</i>	<i>D. Fichsii</i>
<i>Geranium sanguinum,</i> <i>pratense, sylvaticum et</i> <i>robertianum</i>	<i>Dactylorhiza purpurella</i>	<i>Ophrys sphegodes</i>
<i>Oxalis Acetosella</i>	<i>Serratula tinctoria</i>	<i>O. insectifera</i>
<i>Genista tinctoria</i>	<i>Centaurea nigra, Scabiosa</i>	<i>Cymnadenia conopsea</i>
<i>Vicia Cracca</i>	<i>Picris spp.</i>	<i>Coeloglossum viride</i>
<i>Lathyrus pratensis</i>	<i>Lactuca muralis</i>	<i>Allium ursinum</i>
<i>Filipendula Ulmaria</i>	<i>Campanula glomerata,</i> <i>latifolia, rotundifolia</i>	<i>Convallaria majalis</i>
<i>Rubus Idaeus, casius</i>	<i>Primula vulgaris, veris</i>	<i>Lilium Martagon</i>
<i>Gen urbanum, rivale</i>	<i>Lysimachia vulgaris spp.</i>	<i>Paris quadrif</i>
<i>Fragaria vesca</i>	<i>Centaureum umbellatum</i>	<i>Luzula campestris</i>
<i>Agrimonia odorata</i>	<i>Gentiana campestris</i>	<i>Arum maculatum</i>
<i>Poterium Sanguisorba</i>	<i>Myosotis scorpioides</i>	<i>Tamus communis</i>
<i>Sanguisorba officinalis</i>	<i>Solanum Dulcamara</i>	<i>Agrostis stolonifera</i>
<i>Epilobium hirsutum</i>	<i>Veronica montana</i>	<i>Deschampsia caespitosa</i>
<i>Epilobium parviflorum,</i> <i>montanum et palustre</i>	<i>V. officinalis</i>	<i>Holcus mollis</i>
	<i>Euphrasia nemorosa</i>	<i>Helictotrichon pubescens</i>
	<i>Origanum vulgare</i>	<i>Arrhenatherum elatius</i>
		<i>Melica uniflora</i>

<i>Chamoenerion augustifolium</i>	<i>Glechoma hederacea</i>	<i>Brizia media</i>
<i>Circaea lutetiana</i>	<i>Prunella vulgaris</i>	<i>Dactylis glomerata</i>
<i>Sanicula europaea</i>	<i>Stachys officinalis</i>	<i>Festuca ovina. F. rubra</i>
<i>Conopodium majus.</i>	<i>S. sylvatica</i>	<i>F. gigantea</i>
<i>Angelica sylvestris</i>	<i>Teucrium Scorodonia</i>	<i>Galium cruciatum</i>
<i>Brachypodium sylvaticum</i>	<i>Athyrium filix f.</i>	<i>Equisitum Telmateia</i>
<i>Pterodium aquilinum</i>	<i>Dryopteris filix m.</i>	<i>E. sylvaticum</i>
<i>Phyllites Scolopendrium</i>	<i>D. dilatata</i>	

The dene flora is as indicated very rich. By contrast, near Quarrington Hill, again over thin limestone soils, but far more exposed than the denes, the main tree is the ash. Occasional hollies, birches, Rowans and sycamores are present. The shrub layer is composed of hawthorn, elder, guelder rose, hazel and willow. The ground layer is very poor.

<i>Anemone nemorosa</i>	<i>Rubus Idaeus</i>	<i>Stachys sylvatica</i>
<i>Ranunculus auricomus</i>	<i>Sanicula europaea</i>	<i>Urtica dioica</i>
<i>Viola spp.</i>	<i>Conopodium majus.</i>	<i>Orchis mascula</i>
<i>Melandrium rubrum</i>	<i>Angelica sylvestria</i>	<i>Allium ursinum</i>
<i>Oxalis Acetosella</i>	<i>Hedera Helix</i>	<i>Tamus communis</i>
<i>Geranium robertianum</i>	<i>Galium Aparine</i>	<i>Scilla non-scripta</i>
<i>Geum rivale, urbanum</i>	<i>Asperula odorata</i>	<i>Arum masculatum</i>
<i>Fragaria vesca</i>	<i>Crepis paludosa</i>	<i>Athyrium filix f.</i>
<i>Potentilla fragiastrum</i>	<i>Veronica montana</i>	<i>Dryopteris filix m.</i>

Scrubland often develops where rough pasture is allowed to deteriorate. The first invader is usually ash but often hawthorn seems more important, for example, in the embayment into the escarpment south east of Old Quarrington. In recently developed scrubland at Garmondsway shrubs include *Crataegus monogyna*, *Rosa dumalis*, *Rosa mollis*, *Prunus spinosa*, *Rubus spp.*, and *Viburnum opulus*. Ground vegetation includes:

Polygala vulgaris	Primula veris	Succisa arvensis
Viola hirta. V.spp.	Plantago lanceolata	Senecio Jacobea
Hypericum pulchrum	Centaureum umbellatum	Carduus nutans
Linum catharticum	Prunella vulgaris	Cirsium vulgare
Lotus corniculatus	Rumex acetosella	Centaurea nigra
Lathrus pratensis	Trisetum flavescens	Holcus lanatus
Vicia cracca	Arrhenatherum ealtus	Sesleria caerulaa
Fragaria vesca	Agrimonia Eupatoria	Dactylis glomerata
Potentilla reptans	Heracleum spondylium	Briza media
Poterium sanguisorba	Galium verum	Festuca avina.F.rubra
Hiercium pilosella	Knautia arvensis	Bromus erectus
		B. sterilis
		Brachypodium sylvat.

Scrubland varies throughout the region, especially as moisture conditions vary. The above list may, however, be taken as typical of soils with a high Magnesian Limestone content. The scrub encountered in the denes is far richer than that described above, while further west it loses variety with increasing elevation, exposure and rainfall.

Of the rough pasture investigated, areas of particular note are seen at Cleadon, Houghton, Pittington, Strawberry Hill, Hawthorn, Easington, Old Quarrington, East Hetton and Raisby. Cassop vale is of special botanical interest and the following plant list from that site is due to J.W. Heslop Harrison and J.A. Richardson. (20)

Ranunculus bulbosus	Dactylorhiza Fuchsii	Gentiana Amarella
Helianthemum nummularium	Orchis mascula	Veronica Chamaedris
Viola Riviana	Gymnadenia conopsea	Rhinanthus stenophyllus
Viola hirta.V.spp.	Coeloglossum viride	Euphrasia nemorosa
V. Reichenbachians	Luzula campestris	Origanum vulgare
Polygala vulgaris	L. pilosa	Thymus Serpillum
Linum catharticum	Carex caryophylla	Stachys Betonica
Ononis repens	C. flacca	Plantage maritima
Anthyllis vulneraria	Anthoxanthum odoratum	P. lanceolata
Lotus corniculatus	Holcus lanatus	P. media
Fragaria vesca	Trisetum flavescens	Listera ovata
Alchemilla xanthochlora	Senecio erucifolius	Heliotatrichon pubesc.
Agrimonia Eupatoria	S. Jacobea	H. pratense
Poterium Sanguisorba	Carlina vulgaris	Arrhenatherum elatius

Sanguisorba officinalis	Carduus nutans	Sesleria caerulea
Pimpinella saxifraga	C. crispus	Koeleria gracilis
Conopodium majus	Centaurea nigra	Dactylis glomerata
Silaum silaus	C. Scabiosa	Briza media
Galium verum	Crepis virens	Festuca ovons
Knautia arvensis	Leontodon hispidus	Brachypodium sylvaticum
Succisa pratensis	L. autumnalis	Selaginella selaginoides
Scabiosa Columbaria	Hieracium Pilosella	
Bellis perennis	Campanula rotundifolia	
Antennaria dioica	Primula veris	
Achillea Millefolium	Centaureium umbellatum	

In other rough pastures *Bromus erectus* becomes locally dominant, as, for example, at Garmondsway. Other distinctions are clearly drawn in the above-mentioned paper.

In mid and east Durham on soils with regularly impeded drainage, local plant assemblages are similar to the following near Quarrington Hill:

<i>Caltha palustris</i>	<i>Galium palustre</i>	<i>Primula farinosa</i>
<i>Trollius europaea</i>	<i>Valeriana dioica</i>	<i>Scrophularia aquatica</i>
<i>Filipendula Ulmaria</i>	<i>V. officinalis</i>	<i>Mentha aquatica</i>
<i>Geum Rivale</i>	<i>Cirsium palustre</i>	<i>Phalaris arundinacea</i>
<i>Epilobium hirsutum</i>	<i>C. hetero phyllum</i>	<i>Phragmitis communis</i>

The above record shows considerable overlapping of plants in different environments, but with the assistance of the lists it is possible to develop the idea of indicator plants from the point of rudimentary observations mentioned earlier. The following list is invaluable for survey in the region certainly at Soil Series level. The following plants are restricted to soils with a preponderant influence of Magnesian Limestone.

Acer campestre. Denes and hedges in the south of the region.

Agrimonia odorata. Denes

Anthyllis Vulneraria. Throughout the county but more frequent over the Magnesian Limestone.

Aquilegia vulgaris. Mainly found in the denes.

Arabis hirsuta. Rough pasture.

Astragalus danicus. Sporadic mainly coastal.

Bromus erectus. Rough land in the western scarp area.

Cerastium arvense. Not common. Poor bare Magnesian Limestone habitat

Cirsium erphorum. Found in abundance (H-H) Garmondsway.

Clinopodium vulgare. Woods, hedges, bank sides.

Coeloglossum viride. Widely distributed, locally profuse.

Cornus sanguinea. Occasional in denes.

Crepis paludosa. Denes and more western woodland.

Dactylorhys purpurella. Abundant good indicator.

D. Fuchsii. Abundant throughout the Magnesian Limestone region. Flower colour striking purple but in some localities white.

Daucus Carota. Grassy slopes.

Erigeron acris. Abundant in some localities.

Gentiana Amarella. Good reddish purple indicator common.

G. Campestris. Similar but less frequent.

Geranium columbinum. Occasional.

G. Sanguineum. Coastal.

Gymnadenia conopsea. Very abundant flower white to purple-red.

Helianthemum nummularium. General over limestone in pasture, roadside, banks and cliffs.

Hypericum hirsutum Prolific in denes and quarries.

- Hypericum montanum. Similar.
- Lactuca virosa. Denes and mid-Skerne.
- L. muralis. Wider distribution than above.
- Ligustratum vulgare. Denes
- Linum angelicum. Irregular e.g. Penshaw, Tunstall, Marsden, Kelloe.
- L. catharticum. Abundant colonist on disturbed limestone soils.
- Ononis repens Mainly coastal but also at Bishop Middleham.
- O. spinosa. More frequent, inland.
- Orchis Morio. Rough pasture and meadow.
- O. Masculata. Similar. Not good indicators.
- Ophrys apifera. Scattered localities.
- Origanum vulgare. Woods, hedges, bank sides. Great variety in flower colour.
- Paris quadriflora. Denes
- Parnassia palustris. Coastal
- Pimpinella saxifraga. More common in this region than elsewhere in the county.
- P. Major Coastal, not common.
- Plantago maritima. Coastal and scarp area.
- P. Media. Grassland, plentiful.
- Poterium Sanguisorba. Everywhere, early colonist of disturbed Magnesian Limestone soil.
- Primula veris. Abundant
- Rosa spp. Not a useful indicator.
- Scabiosa Columbaria. Useful abundant indicator
- Senecio erucifolius. Common but less frequent towards the coast.
- Serratula tinctoria. Mainly coastal
- Sesleria caerulea. Throughout the Magnesian Limestone region but not common near the coast or the south.
- Tamus communis. Hedges in south and east.
- Viburnum lantana. Raisby Hill and Coxhoe
- Vicia angustifolia. With admixture of boulder clay
- Viola odorata. Denes and frequent at Old Wingate
- V. hirta. Hillsides
- V. calcarea. Restricted to higher scarp edge.

V. Reichenbachiana. Similar environment, but also on the coast.

It will be clear from the above list that there is much to help the soil surveyor in even an elementary study of the wild vegetation. The origins and dispersion of plant life in the Magnesian Limestone region are mentioned in some detail by Heslop-Harrison in the above mentioned paper (20). It is not the purpose of this study to challenge or expand on the arguments there put forward.

SECTION TWOMETHODS ADOPTED IN THIS SURVEYChapter 1Soil Survey

The earliest requirement of any soil survey is a thorough reconnaissance to establish the variety of soils present. The winter period is probably the best time for such a task, when most of the arable land is ploughed and colour changes, stoniness and surface textural variations are obvious at a glance. Exposures in quarries and other disturbances of the surface are useful in reconnaissance, but are not generally good sites for sampling materials for analysis. Having established some pattern in the general spread of soils in the region soil pits are sunk in areas of soil showing some differences from neighbouring soil. This involved, in this survey, the sinking of about one hundred and fifty original soil pits of which only about sixty were finally thought sufficiently representative or well sited to be worthy of laboratory analysis. Towards the end of the survey certain gaps in the spread of soil pits became obvious and several supplementary soil pits had to be dug. This method of digging soil pits on sites previously established because of noted soil changes has certain advantages over a system grid siting or transects. Its main effect is to reduce the number of pits needed. The maximum depth of profile pit sunk in drift material was about seven feet, although widening boreholes on the line of the Durham Motorway and the use of the N.E. Gas Board pipeline trench allowed sampling at greater depth.

From field descriptions and concurrent laboratory analysis distinctive soil Series were established according to the following definition:- 'Soils with similar profiles derived from similar parent material under similar conditions of development are conveniently grouped together as a Series'. Within the Series, Types based on horizontal and Site variation and soil varieties, subdivisions due to variations in texture, stoniness or topographic factors were to be standardised later. The general picture settled, field to field survey followed using the soil auger to a depth of three feet six inches (21) Clark. Full descriptions of each auger recovery were

were made and recorded in code on the six inch O.S. map, with accurate location of the profile pits and the soil boundaries as they became established. The frequency of augering depends on the complexity of the soil pattern encountered but in general follows a systematic radial pattern from the initial profile pit. The survey in such detail of course brings out the need for further profile pits where small areas of distinct soil series are encountered.

System and standardisation are all-important in soil survey and there cannot be too much detail in the original descriptions of soil profiles. It is far better to mention the absence of a factor than to wonder later whether the factor was present or not. To this end a thorough field sheet was prepared. This was tabulated systematically and each factor or property was graded according to rigid standards which could be expressed numerically. The master sheet gives reference to the section of standardisation plan in which the various grades are described. Field description is made possible using a card index system. Two cards were used for each profile. The face of the first card contains a description of the site of the profile pit and the reverse side has a field sketch of the local terrain. The second card includes description of the profile, and the reverse side is sectioned off to allow colour streaks of the soil for each horizon down the profile. All descriptions on the cards was made in numerical or symbolic code and any information not included on the cards was written in longhand in a field notebook. This procedure cut down the business of lengthy field description which is particularly difficult in wet weather. It also helped considerably in the standardisation of reporting. The page references in the field sheet shown below are related to the standards adopted as they occur in this thesis, but they would normally refer to the pages of a small pocket book of standards carried in the field.

Master sheet for field card index system

1. THE SITE

Index Number.....

A. Soil category.

B. Soil Series.....Type.....Phase.....

Site characteristics

- | | | |
|------|-----------------------------------|----------------------|
| 1. | Locality.....p 49) | Map reference..... |
| 11. | Age.....p 49) | Map soil symbol..... |
| 111. | Topographic data: | Map soil colour..... |
| 1. | Altitude.....p 49) | |
| 2. | Slope. Class.....p 49) | |
| | Form.....p 50) | |
| | Symbol.....p 50) | |
| | Unit.....p 51) | |
| 3. | Aspect and exposure. | |
| | Wind direction.....p 51) | |
| | Shelter/shade.....p 51) | |
| | Colonisation.....p 51) | |
| 4. | Surface relief. (micro)....p 51) | |

IV Drainage

- | | | |
|----|---------------------------------------|--|
| 1. | Quality of site drainage.....p 51) | |
| 2. | Possibility of improvement.....p 52) | |
| 3. | Surface run-off.....p 52) | |

V Parent Material

- | | |
|----|-------------------------------|
| 1. | Solid geology/drift type..... |
| 2. | Erratica..... |

VI. Natural vegetation.

- 1. Plant form and association.....(p 52)
- 2. Special indicator plants.....(p 53)

VII. Climatic data

- 1. Rainfall (nearest station)
- 2. Temperature.....
- 3. Frost periods.....
- 4. Prevailing winds.....

VIII. History.

Special reference to human influence.....

IX. Deleterious factors.....(p 53)



The Site card will therefore appear as follows:-

Site Index No.....		A.		B.	
		Map ref.		Symbol	Colour
I.					
II.					
III.	1.	2a	2b	2c	2d
	3.	3a	3b	3c	
	4				
IV.	1.		2	3	
V	1.		2		
VI	1.				
	2.				
VII	1.	2	3	4	

VIII

IX

Arable evaluation

The reverse side of the card shows a sketch diagram of the local topography.

The master sheet continues in the following manner with a systematic description of the soil profile, horizon by horizon.

2. THE PROFILE

1. Horizon.....(p 54)
2. Colour. (Munsell).....(p 61)
3. Texture 1. U.S.D.A.....(p 61)
 2. General.....(p 62)
4. Coarse skeleton. Stones.
 - I. Quantity.....(p 62)
 - II. Chemical nature..(p 63)
 - III. Shape.....(p 63)
 - IV. Size.....(p 63)
5. Structure.....(p 63)
6. Soil constitution.
 1. Porosity, A. aggregate porosity...(p66) B.between aggregates
(p 67)
 2. Soil compactness.....(p67)
 3. Induration.....(p 68)
 4. Consistence (i) Wet.A.Plasticity..(p 68) B.Stickiness... (p 68)
 - (ii) Moist.....(p 69)
 - (iii) Dry(p 69)

7. Organic Matter.
 1. Quantitative.....(p 70)
 2. Qualitative.....(p 70)
8. Roots.
 1. Species of plants present.....(p 70)
 2. Quantity.....(p 70)
 3. Size.....(p)71)
 4. Shape(p 71)
 5. Nature.....(p 71)
 6. Health.....(p 71)
 7. Age.....(p 71)
9. Drainage and water regime.
 1. Class.....(p 71)
 2. Soil moisture distribution in the profile.....(p 71)
 3. Water relationship by texture....(p 72)
10. Faunal influences on the soil.
 1. Intra-soil fauna.....
 2. Extra-soil fauna.....
 3. Dual environment fauna.....(p 74)
11. Secondary chemicals.....(p 72)
12. Soil reaction
 1. pH.....(p 75)
 2. Carbonates.....(a) Relic..... (b) Pedological.
13. Special characteristics
 - (a) Drainage and water regime of the profile
 - (b) Mottling by horizon.

SITE STANDARDSChapter 2

The standards adopted for the coded cards were derived from the following considerations. The sequence correlates with the master sheet (p. 45).

- I. Locality. This is expressed in local terms with the name of the farm and if possible the name of the field, parent parish or village. A grid map reference is also made.
- II. Age. Except for alluvial soils and blown sands the time factor seems to have little significance in describing the soils of the region. This section therefore differentiates between post-drift soils, recent alluvially influenced soils and soils disturbed or otherwise influenced by man.
- III. Topographic data. Altitude is estimated from the nature of the terrain in relation to the nearest contour or spot height on the one inch O.S. map.

The soil map will give some indication of slope by means of contours but it is usual to give more detailed description of landforms and similar units. Class of slopes on which the profile pit is sited is indicated by the use of the U.S. Soil survey system (22)

(Fig.5.)

SLOPE CLASSES

<u>Class A.</u> <u>Limits</u> Lower 0% Upper 1-3%	(0°) ($\frac{1}{2}$ -1 $\frac{1}{2}$ °)	Name:- Level
<u>Class B.</u> <u>Limits</u> Lower 1-3% Upper 5-8%	($\frac{1}{2}$ -1 $\frac{1}{2}$ °) (3-4 $\frac{1}{2}$ °)	Name:- Gentle
<u>Class C.</u> <u>Limits</u> Lower 5-8% Upper 10-16%	(3-4 $\frac{1}{2}$ °) (6-9°)	Name:- Moderate

<u>Class D.</u> <u>Limits</u> Lower 10-16% Upper 20-30%	(6-9°) (12-17°)	Name:- Moderately steep
<u>Class E.</u> <u>Limits</u> Lower 20-30% Upper 45-64%	(12-17°) (24-33°)	Name:- Steep
<u>Class F.</u> <u>Limits</u> Lower 45-60% Upper ----	(24-33°) (90°)	Name:- Very steep

Having classified slope in this manner it is developed into a system of form, which is of far more importance to the soil surveyor (23). Form may be divided into

(a) Uniform or even slopes




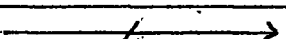
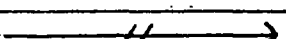
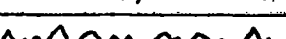
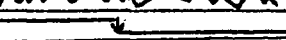
(b) Complex slopes

1. Terrace sequences.
2. Undulations in one direction.
3. Undulations in various directions.
4. Concave.
5. Convex
6. Concave-convex.

All combinations can be used in permutation. When describing complex slopes the upper portion is described first, e.g. 'plane-convex'.

Surface characteristics are further indicated by the use of symbols on the map which add information not clearly available in the Contour system.

(Fig.6.)

Flat or left bank.		Head down the hill. The length of the arrow covers the extent of the slope.
Undulating.		
Slight slope		
Steep slope		
Very steep slope		
Broken and irregular		
"Terraced, lynchets		

The general topographic unit in which the profile pit is sited is also of importance. The Soil Survey of Scotland has adopted the following Canadian system.

1. Depressional to fiat (chiefly 0° - 0.3° slopes.)
2. Very gently sloping to gently undulating (0.3° - 3° slopes of low frequency)
3. Undulating (1° - 3° slopes of high frequency)
4. Gently to moderately rolling (3° - 9° slopes)
5. Mixed undulating and rolling
6. Strongly rolling to hilly (9° - 17° slopes)

All slope angle observations were made with an Abney level.

Aspect is measured as a direction of a compass bearing taken at rightangles to the feature, to $1/16$ of the circle. Slopes of less than 3° are said to have no aspect. Shelter and shade are noted, for example colonisation of cooler and damper north-facing slopes by the ash.

Surface micro-relief is indicated subjectively in single word form, for example hummocky, ridged, ploughed.

IV. SITE DRAINAGE

The following terms are used to indicate the quality of site drainage.

(Fig.7.)

Site Drainage

- | |
|---|
| <ol style="list-style-type: none"> a. Satisfactory. Water from any source is without any deleterious effect. a. Seasonal drought. Water run-off and evaporation exceed supply. b. Seasonal wetness. Water from any source remains on or near the surface for appreciable periods of time. c. Permanent wetness. This is usually associated with basin or valley bottom sites and usually infers some physical impedance to the free flow of water. It is occasionally found at a higher level in the East Durham Plateau region where there are areas of level impervious clay. |
|---|

(Fig. 7
cont.)

- d. Liable to flood. Usually associated with seasonal wetness but is often connected with riverine or lacustrine sites.
- e. Spring line seepage or flushes, found frequently along the scarp face.
- Ir. Irrigated. None in this region.
- Wp. Warp soils. Found only in the extreme south around West Hartlepool.

The possibility of improving drainage is assessed and marked on the card in the following manner :-

- (Local scheme possible.
-) Only regional schemes possible

Surface run-off is of great significance and is indicated as follows :-

(Fig.8)

SURFACE RUN-OFF

SR+++	Surface run-off intense and erosion probable.
SR++	Surface run-off definite but serious erosion improbable.
SR+	Surface run-off is purely local and no abrasives are carried elsewhere.
SRO	No surface run-off detectable.

V. Parent Material

Parent material plays an important part in soil formation by virtue of its porosity and acidity. Next to relief it determines the drainage quality of the soil. Soil developed on local till with no magnesian limestone influence is almost certain to have some degree of gleying within the profile. The presence of quartz in erratics and in the limestone itself can contribute to the reduction of pH from the very high alkalinity usually expected over calcareous solid geology. The influence of geology and the glacial deposits is more fully discussed on pp.

VI. Vegetation

As full a record as is possible is made of the vegetation encountered. This involves the use of a notebook rather than the

index card. Special indicator plants worthy of note are however referred to on the card.

VII. Climate

Adequate climatic observations are impossible to obtain. The most important components of climate which affect the soil are those imparting moisture and energy, precipitation and temperature. The amount of soil moisture is governed by the amount received in precipitation and the amount lost by evaporation and transpiration. The simple subtraction $p - E_t$ represents the water surplus or approximately the amount of water available for soil processes less the amount lost in run-off. This simple formula cannot be applied without the lengthy analysis of lysimeter waters and the establishment of a close network of micro-climatic stations. Only the broadest climatic statements can be at present made in this region, correlating information from the thin scatter of stations recording with varying degrees of trustworthiness throughout the area. Information concerning frost periods can often be assembled from conversation with local farmers and the prevailing winds can be assessed by observing bent shrubs, leaning fences and even telegraph poles.

VIII History

The history of the site includes its recent use for agriculture or other purposes, whether the land has been recently cleared of shrubs or is being allowed to return to scrub, or when the land was in fact ploughed.

IX. Deleterious factors

These may overrule the good characteristics of the soil and include smoke damage, cement works, dust, chemical factory fumes, dust from limestone plants, waste materials blown from neighbouring tips, sludge, spreading from slag heaps, liability to fire and liability to trespass, and the influx of uncontrolled dogs.

PROFILE STANDARDSChapter 3

The profile index card is standardised using the following grades.

1. Horizon

In studies of the distribution of the soils of the world it is found that soils can be arranged in groups having a number of profile features in common, although some would object to this (4). In the region under study groups encountered included Brown Earths, Calcareous Soils, Gley Soils, Podsolised Soils and Organic Soils. Recent work in North America and Europe suggests the possibility of modifying the older established systems to accommodate soils now falling on the boundaries of distinct groups and to introduce new groups (24). There is much controversy surrounding this classification problem which is not the concern of this study. The following system of horizon nomenclature has been adopted and should prove satisfactory for any correlation purposes.

Soil Profile system. (Slightly modified from Kubiena (1953-6))

- L. A superficial layer of relatively undecomposed plant litter generally of the previous year.
- F. A superficial layer of partially decomposed litter with recognisable plant remains.
- H. A superficial layer of decomposed organic matter with few or no recognisable plant remains.
- A₁ Organic matter mixed with mineral soil.
- A₂ Horizon of maximum losses of bases and sesquioxides.
- AB or A(B) Transitional zone between A and B and A and (B) and having something of the characteristics of both horizons. Sometimes designated A₃.
- (B) Horizon between A and C in soils where there is no clear depositional horizon.
- B In podsolised soils the horizon of maximum deposition of sesquioxides and/or humus.
- (B) C, Transitional horizons between B or (B) and C but more closely allied to B or C respectively.
- BC,
- C(B) or
- CB.

- C. The parent material from which the solum has developed.
- CD. Material which has only in part contributed to the development of the solum.
- D. Horizon beneath the soil profile, not being material from which the horizon has developed, but the presence of which is significant in the behaviour of the soil.
- G. Horizon showing the maximum development of the gley conditions.
- AG or (B) G Horizons in which the characteristics of the respective horizons occur but strongly modified by the gley phenomenon.
- Ag or (B) g Horizons where there are slight effects of the gley condition.
- ca. As a subscript to any horizon indicating the presence of free CaCO_3 .

The advantage of adopting a system of symbols for profile horizons is that comparison can easily be made between horizons considered to be similar, in different profiles, regardless of the depth at which they occur in the profile. A comparison of horizons taken at the same arbitrary depth may not be helpful, but comparison of two horizons given the same symbol can be made with confidence. In practice it is more often impossible in the field to designate the appropriate symbols prior to physical and chemical analysis. Simple numerical terms are therefore used on the field card system in sequence down the profile with suggested symbols in brackets.

Of the soils found within the region Brown Earths were perhaps the most common, as most of the area has long been cleared of forest and the land devoted to cultivation. These soils are considered to have no movement of sesquioxides or clay-sized particles down the profile. The solum is uniformly coloured in the freely drained members of the group in shades of brown and reddish brown, indicative of aerobic weathering and of the oxidised state of the iron compounds present. Calcium carbonate or magnesium carbonate is variable. Subdivisions are made into freely-drained Brown Earths of low base status and freely-drained Brown Earths of high base status, the latter having a pH of over 6.5. Heavy applications of limestone or other

liming materials can convert a Brown Earth from low to high base status. Such conversion is usually only temporary however and high base status usually represents a soil that can of itself maintain a pH near neutrality. Within the solum organic matter is completely humified and intimately mixed with mineral soil. The A horizon usually has a good crumb structure while the (B) is weakly cloddy. There is generally a high biological activity and a conspicuous earthworm population.

A further division of the Brown Earths found in this region includes those soils with imperfect drainage. They are classed as Brown Earths with gleying. They may be regarded as transitional to soils of the gley group since typical morphological features associated with poor drainage are encountered but to a minor degree and lower down the profile than in the Gley group. The surface horizon retains to a large extent the characteristics of the freely drained member of the group and agricultural properties are similar. Soil colour at the surface may, however, be slightly duller in tone and the development of fine rusty brown mottles around old root channels is the first indication of poor drainage. The grey colours associated with gleying become dominant features of the profile only beyond 15 inches. Under anaerobic conditions the reduction of ferric compounds to the ferrous state and the loss of ferric oxide from the surface of the clay particles results in the development of grey faces to peds. Yellow, brown, orange and red mottles associated with this feature are caused by the re-oxidisation of the iron when the soil dries out. The greyness and mottled appearance varies in appearance and strength not only with different drainage conditions but also with variations in colour of the parent materials which can seriously mask this diagnostic feature.

Drainage may be imperfect in these soils but there is an adequate depth of cultivable soil before root damaging conditions are encountered. In fact, in drought periods these soils may have

distinct advantages over their more freely drained counterparts, especially where profiles are comparatively shallow. In wet periods however slow drainage and heavy texture render the surface structure liable to damage by poaching.

The usual profile within the freely drained group has horizons A, (B) and C in a deep phase, and A,A(B) and C in shallower phases. In Brown Earths with gleying the profile is A, (B)g, Cg or A, (B)g,C.

Calcareous soils developed on highly calcareous parent material have calcium or magnesium carbonates present in amounts greater than five percent and are often considered as a separate major group. Profile characteristics are controlled largely by the nature of the parent material. Two sub-groups are encountered:- The Rendzina and the Brown Calcareous Soil. In the former the colour of the soil is typically black, very dark brown or grey and the carbonates are finely divided throughout. The Brown Calcareous Soils are reddish brown in colour and the carbonate is present in fragments, weathered but less finely divided than in the rendzina. Crumb structure is usually well developed and a high organic matter content in the surface horizon is characteristic of the uncultivated soils. Brown Earths and Brown Calcareous soil tend to merge into each other in this region and separating boundaries would be difficult to establish.

Gley Soil development has already been mentioned in brief outline. Ball (25) uses three subdivisions for such poorly drained soils.

Waterlogging may occur at or near the surface of the solum due to slow drainage of water arriving at the surface, or to a high ground water table causing water to stand seasonally or permanently high up in the solum. In the first instance water is prevented from moving freely away through the soil by an impervious or poorly permeable horizon that may be of heavy texture or may be heavily indurated.

Surface water gleys have dark grey or dark brown Ag horizons

with strongly marked rust colouring along root channels. The organic matter content at the surface is moderately high and the structure is cloddy. This horizon represents almost the total rooting area during dry spells when, as the water level in the soil falls, small roots can penetrate deeper. These are likely to be killed off with the next rise of water.

A completely gleyed G horizon is usually below the Ag. This is but a few inches thick and passes into an ill-defined set of horizons in which yellow and brown mottles are most prominent in the upper parts. On strongly coloured soils grey gleying may be masked. During drying out shrinkage cracks appear in the BG horizon forming prismatic structure. These cracks allow water and root penetration in drier periods. The faces of prismatic structure units are completely coated with gleyed material and are grey in colour while within the prisms mottles and concretions of rust coloured or black iron or manganese oxides occur.

Typical surface water gleys have profiles of Ag,(B)g,Cg or Ag,G(B)g,Cg. If the soil is practically permanently waterlogged peat begins to accumulate particularly in basins. Representative profiles have A,G,(B)g, and Cg horizons. When peat is deeper than 20 inches the soil is described as an organic soil.

True podsoils are not found within this region but podsolisation is an active process and incipient podsoils are far from uncommon, particularly under conifer stands or above very sandy parent materials. When the biological activity of the soil is so low that the plant litter begins to accumulate on the surface and raw humus develops, intense leaching leads to the mobilisation and translocation of sesquioxides. When the process has been completed the uppermost mineral layer is strongly bleached (A_2). It is succeeded by a rusty brown layer sometimes indurated in which the sesquioxides have in part been deposited - B.

In the early stages of development, when the raw humus layer is still thin, the bleaching may not be very obvious, but the slight movement

of iron oxide that has taken place together with the in situ weathering gives a distinctive yellow, orange brown colour to the B horizon.

Organic Soils with an accumulation of peat to greater than twenty inches are not uncommon in the Carr lands of this region. They are all associated with alluvial deposits and basin topography and are therefore moderate base status peats.

On alluvium and blown sand with little evidence of profile development beyond the darkening of the surface, the Immature Soils are found.

Brown Forest Soils of low base status may have been more extensive than today. Such soil is now almost entirely confined to the denes along the coast or to the steeper unproductive slopes of the plateau. A typical profile is :-

Brown Forest Soil

- L. Undecomposed plant litter.
- F. Partially decomposed litter.
- H. Trace of decomposed organic matter but may be absent.
- A. Brown colour with medium organic matter, moder type. Crumb structure. No differentiation into A₁ and A₂.
- B₂. Brighter brown colour than A. A relatively rich status of free sesquioxides.
- B₃. Less bright than B₂ and nearer the colour of the parent material. May show some degree of induration.
- C. Relatively unweathered parent material.

Brown Forest Soils with gleyed B and C horizons are equally uncommon today but when found have a profile similar to the following :-

Brown Forest Soil with gleyed B and C horizons.

- L. Undecomposed plant litter.
- F. Partially undecomposed litter.
- H. Trace of undecomposed organic matter.
- A. Mixed mineral and organic layer, moder type. No differentiation.
- (B)g. Well defined blocky or prismatic structure. Mottling within and sometimes on the face of peds.
- Cg. Structure usually massive, less mottled than the B horizon

(Fig.10)

Conventional grouping of soils encountered
in East Durham.

<u>Major Soil Group</u>	<u>Sub-group</u>
Brown Earths.	High base status. Low base status. With gleying.
Calcareous Soils.	Rendzinas. Brown Calcareous Soils. Brown Calcareous Soils with gleying.
Gley Soils.	Surface water Gley. Gley developed on alluvium. Peaty gley.
Podsollic Soils.	Incipient.
Organic Soils.	Moderate base status peat.
Immature Soils.	Road cuttings in limestone or drift. Alluvium. Blown sand.
Brown Forest Soils.	Low base status. With gleyed B and C horizons.

On the index card under the 'horizon' section is given the number of the horizon, its depth and the degree of definition of the lower boundary. All other classification based on the previous section awaits complete laboratory analysis. The standards adopted for definition of horizon boundaries are as follows :-

(Fig.11.)

1. Sharp.	Boundary within one inch transition zone. 1½ - 2½ inches. 2½ - 5 inches. over 5 inches.
2. Clear.	
3. Gradual.	
4. Diffuse.	

2. Colour is determined in the field in the fresh state and later in the laboratory in an air-dried condition, in both cases using the Munsell chart.
3. Texture is determined in the field by 'feel'. This is later confirmed by mechanical analysis. The following list of terms has been adopted from the U.S.D.A. System to conform with the International System used in mechanical analysis.

(Fig.12)

Texture	Sand %	Silt %	Clay %
Sand	90+	-10	- 10
Loamy Sand	80-90	-20	- 20
Sandy loam	40+	-50	- 20
Loam	- 52	28-50	10-17
Silty loam	- 50	50+	- 27
Sandy clay loam	45+	-28	20-35
Clay loam	20-45	15-52	27-40
Silty clay loam	-20	40-73	27-40
Sandy clay	45+	-20	35-55
Silty Clay	-20	40-60	40-60
Clay	-45	-40	40+

These categories are designated in the field but mechanical analysis results are plotted on a triangular graph divided into the eleven groups given above. It is often convenient to further distinguish broad groups of textural classes which will represent field texture as it is, as distinct from pretreated and dispersed laboratory samples. These designations are roughly correlated to the power required for ploughing and are of some importance in a study such as this. The broad terms 'heavy' and 'light' can lead to confusion and general terms adopted were those suggested by U.S.D.A. Broad correlation with basic field sample texture terms are given but the general terms will not be altered by the results of mechanical analysis. They are themselves

valid as properties contributing to agricultural potential.

(Fig.13)

General textural terms

General terms.	Basic terms.
Sandy soils.....coarse textured soils....	Sands :Loamy sands.
... moderately coarse soils....	Sandy loams. ..Loams
Loamy soils.....medium textured soils...	Silt loams. ..Clay loams
... moderately fine soils....	Sandy clay loams :Silty clay loams
Clayey soils..... fine textured soils....	Sandy clays. :Silty clays :Clays

4. Stoniness is an important property of a soil horizon. Stones dilute the finer material and make the soil more permeable. They have also marked effects on the ease of cultivation and are the cause of costly wear on cultivation implements. The terms below are estimates and claim no precise accuracy. Quantity appears on the index card simply as numbers.

(Fig.I4)

Stone Quantity

Index No.	Quantity
0.	Stoneless or nearly so. Less than 15% stones.
1.	Slightly stony, not sufficient to interfere with cultivation. 15-20% stones.
2.	Very stony, enough to interfere with cultivation and visibly acts as a diluent to the soil mass fine earth. More than 50% stones.
3.	Occasional boulders.
4.	Live rock exposed.
5.	Rock or stones dominant

The chemical nature of the stones is divided into three groups.

- (a) Residual material which is capable of further weathering and combination to produce fine earth. Characteristic of immature soils this includes carbonates of lime and magnesia, or the more complex silicates and alumino-silicates.
- (b) Residual material not capable of further chemical decomposition while existing conditions prevail. Further comminution is possible but effects on the soil are entirely physical. This includes quartzite pebbles and flints.
- (c) Concretionary material.

The shape of the stones is divided into the following categories :

- (a) Angular
- (b) Subangular
- (c) Rounded
- (d) Shaly
- (e) Tabular

The size of the individual stone is measured along the long axis.

- 1. Gravel $1/8 - 1/4$ "
 - 2. Coarse gravel $1/4 - 1/2$ "
 - 3. Very small stones $1/2 - 1$ "
 - 4. Small stones 1 - 2"
 - 5. Medium stones 2 - 4"
 - 6. Large stones 4 - 8"
 - 7. Boulders 8" and over
5. The structure of a soil is the aggregation of its primary soil particles into compound units which are to some extent independent of each other. Generally soils with aggregates of spheroidal shape have much more pore space between aggregates, have more permeability and are more productive than soils of similar chemistry with massive or blocky structure.

Field description of soil structure includes :-

- 1. Shape and arrangement
- 2. Size
- 3. Distinctness and durability of the peds.

(Fig.15) Structure classification (21)

General form.	Appearance defined	Name	Size
Cubic	Well defined cubes	Large cubic	6" + 15 mm +
		Medium cubic	6-2" 15-5 mm
		Small cubic	2-1" 5-2.5 mm
	Ill defined cubes Angular A Rounded R	Large A/R cloddy	As above
		Medium cloddy	
		Small cloddy	
Concoidal fragments	Large starchy	$\frac{3}{4}" +$ 2 mm +	
	Small starchy	$\frac{3}{4}-0"$ 2-0 mm	
Roughly spaced solids with good air space	Large nutty	1" 25 mm	
	Medium nutty	1- $\frac{1}{2}"$ 25-12 mm	
	Small nutty	$\frac{1}{2}-\frac{1}{4}"$ 12-6 mm	
with few air spaces	Gunshot	$\frac{1}{4}-\frac{1}{8}"$ 6-3 mm	
	Large granular	$\frac{1}{8}-1/16"$ 3-1 mm	
	Small granular	1/16-0" 1-0 mm	
Roughly rounded small aggregate particles with well defined air space	Large crumb	$\frac{3}{8}"-\frac{1}{4}"$ 9-6 mm	
	Medium crumb	same as granular	
	Small crumb		
	Crumb dust		
Prismatic	Well defined prisms	Large prismatic	2x2xH 5x5xH
		Medium prismatic	1x1xH $2\frac{1}{2}x2\frac{1}{2}xH$
		Small prismatic	to 0 to 0

(Fig.15) contd...

General form	Appearance defined	Name	Size
Columnar	Well defined prisms with indefinite tops	Large columnar Medium columnar Small columnar	As for prismatic
	Jointed columns Series of prisms with wide vertical and narrow horizontal cracks.	Large jointed columnar Medium Small	As for prismatic
Laminated	Plates (flat)	Slabby Platy Foliated	$\frac{1}{2}'' +$ 12 mm + $\frac{1}{2}-\frac{1}{8}''$ 12-3 mm $\frac{1}{8}-0''$ 3-0 mm
	Scales (curved plates)	Scaly Flaky	$\frac{1}{8}'' +$ 3 mm + $\frac{1}{8}-0''$ 3 mm-0.
Polyhedral	Polyhedral state number of faces	Large polyhedral Medium Small	$1'' +$ 25 mm+ $1-\frac{1}{2}''$ 25-12 mm $\frac{1}{2}-0''$ 12-0 mm
Single grain or structureless Defined by feel		Single grain Mealy	2-1 mm 1-0.2 mm

Terms used for grades of structure are :-

- 1. Weak. Units barely visible in situ. When disturbed the soil material breaks into a mixture of a few unbroken units and many broken units with unaggregated material.
- 2. Moderate. Well-formed units but not distinct in undisturbed soil. When disturbed there are many distinct units, some broken units and a little unaggregated material.
- 3. Strong. Well formed units distinct in undisturbed soils. Adhere to one another only weakly. When the soil is disturbed the material consists of entire units with few broken and very little unaggregated material.

This classification, based on the Oxford system (21) compares well for correlation purposes with the American system and was found more manageable in the field than the latter.

6. Soil constitution

- 1. Porosity is described under two headings.
 - A. The nature of spaces within the soil aggregates.
 - B. The nature of the spaces surrounding the soil aggregates.

(Fig.16)

A. Aggregate porosity

Size name	Shape	Distribution
Fine porous. 0-1mm diameter	Honeycomb	Horizontal
Porous 1-3mm	Vermiculate	Vertical
Spongy 3-5mm	Rounded	Oblique
Cavernous 5-10mm	Polygonal Dendritic	Ubiquitous

B. The nature of the spaces between the aggregates may be determined by the shape of the aggregates themselves. If this is the case it is noted. If the inter-aggregate porosity is due to the influence of flora and fauna it is described under the following standards.

(Fig.17)

B. Inter-aggregate porosity

Name	Size	Distribution
Very fine fissured	(spiders web)	Horizontal
Fine fissured	Over 1mm wide	Vertical
Fissured	1-3 mm	Oblique
Wide Fissured	3-5 mm	Ubiquitous
Very wide fissured	5-10 mm	

2. Soil compactness is standardised from the following diagnostic features into seven grades.

(Fig.18)

Soil Compactness

Description	Spade	Auger
1. Very compact (dry dispersed clay)	will not enter, pick needed	Virtually unborable
2 Compact	Enters with difficulty much fragmentation	Good bite, fills threads with broken aggregates
3 Loose	Enters easily and spit falls readily into pieces	Particles fall through thread and run through fingers
4 Friable	Digs well with fine fragments	Comes up loosely packed and does not fill threads
5 Mellow	Digs well, clods just hold	Bores easily neatly fills threads
6 Indurated (implies cementation).	Pick needed, then digs easily	Spins and grinds to dust
7 Tenaceous	Clogs and tears away from uncut face	Sucks noisily but comes up full.

3. Induration

This is a handling property of the soil not dependent on moisture content. It can readily be detected in three grades.

1. Weakly indurated. Not usually detected when digging, but diagnosed by stabbing the profile face with a knife. The soil breaks easily in the hand.
2. Moderately indurated. Detected when digging. Soil ped breaks in the hand with moderate pressure.
3. Strongly indurated. Detected when digging, and in fact causes difficulty. The spit is not readily broken in the hand.

4. Soil consistence

Soil consistence is a quality which is expressed by the degree of cohesion and adhesion. It is measured by the resistance of the soil material to deformation or rupture. Structure and consistence are interrelated, the former being the resultant of the forces within the soil, the latter being concerned with the forces themselves.

As consistence is strongly influenced by moisture conditions it is necessary to have a series of terms for each significant moisture state (U.S.D.A. 1951.22)

(Fig.19) Consistence when wet

To evaluate this property the material is rolled between the thumb and the finger.

A. Plasticity.	0. Non-plastic. No wire formable. 1. Slightly plastic. Wire formable and soil mass easily deformed. 2. Plastic. Wire formable and moderate pressure required to deform soil mass. 3. Very plastic. Wire formable and much pressure required to deform soil mass.
B. Stickiness.	(a) Non-sticky (b) Slightly sticky (c) Very sticky

(Fig.20)

Consistence when moist

To evaluate this property attempt to crush moist soil mass in the hand.

0. Loose. Non-coherent.
1. Friable. Soil material crushes under very gentle pressure but coheres when pressed together firmly.
2. Firm. Soil material crushes under moderate pressure between thumb and forefinger, but resistance distinctly noticeable.
3. Very firm. Soil material crushes under strong pressure, sometimes not crushable.

(Fig.21)

Consistence when dry

To evaluate this property break an air dry mass in the hand.

0. Loose. Non-coherent
1. Soft. Breaks to powder or individual grains under very slight pressure.
2. Hard. Can be broken easily in the hand but only with difficulty.

7. Organic matter

Much of the work on organic matter has been standardised under forest conditions. Here all that need be said is that a complexity of factors set in a definite time scale result in a very small number of humus forms. These are very sensitive to the factors controlling their development and are generally the first part of the soil profile to reflect changes in environmental conditions. They are more readily modified than the other features of the soil profile and have important bearings on the condition of the seed bed and on natural regeneration. There is obviously room for practical application of the academics and theory of organic matter. A practical field terminology must be designed from field experience but it should include the relevant results of the considerable laboratory investigation that has already taken place. The importance of humus may never be displaced by inorganic fertilizers, but as yet farmers have very little deliberate control over the establishment and preservation of

desirable humus forms.

In field description it is usual to estimate the amount of humus present in each horizon. If the horizon has over twenty percent organic matter it is considered an organic horizon, if less a mineral horizon. In mineral horizons organic matter varies and its status is indicated thus :-

High.	13-20%
Moderate.	8-13%
Low...less than ..	8%

Organic horizons are divided into:-

- L. relatively fresh litter
- F. fermented litter with origin of the remains still evident.
- H. well decomposed humus with very few recognisable constituents.

When the H layer is more than twelve inches thick the soil is considered to be a peat.

Mull is an intimate mixture of mineral soil and organic matter, in the A horizon, with the constituent parts not identifiable by means of a hand lens.

Silicate moder has similar appearances to mull but its mineral and organic parts can be distinguished with a hand lens.

Mor, or raw humus is usually found where there are well developed L, F, and H layers. There is no intimate mixing of organic and mineral parts, the two remaining distinct. The H layer itself has a very low mineral content.

The most common forms found in the region were variants of mull and silicate moder, although mor forms were common in the denses and under plantation trees.

8. Roots. are classified in the following manner:

1. Name of the plants present.
2. Quantity.
 1. Abundant.... more than 100 sq. ft. of the profile face.
 2. Frequent.... 100-20 per sq.ft. of the profile face.

3. Few.....20-4 per sq. ft. of the profile face.
 4. Rare.....3-1 per sq. ft. of the profile face.

3. Size (diameter)
1. Large... more than 1/2 inch.
 2. Medium.. from 1/2 - 1/8 inch.
 3. Small... from 1/8 - 1/32 inch.
 4. Fine.... from 1/32 inch - 0.

The adjectives long, medium and short are also used.

4. Shape. Free growing, distorted.
5. Nature. Woody, fleshy, fibrous or rhizomatous.
6. Health. Dead, alive, strong or weak.
7. Age. Old, young, past or present vegetation cover.

9. Drainage has several meanings, but in this case the word refers to the morphology of the profiles. In general free-draining soils have bright uniformly coloured B horizons. Mottling, especially grey mottling is considered to be evidence of gleying. Thus drainage classes are distinguished purely on the basis of morphology.

Drainage excessive.....The B horizons are bright and uniformly coloured, although those with a small degree of dullness and slight mottles are permitted within this class.

Drainage imperfect.....The B horizons are not quite so bright as those of well-drained soils and they have appreciable mottling. They are designated $B_2(g)$ and $B_3(g)$ to indicate a moderate amount of gleying.

Drainage poor.....The Bg horizons are dull and mottling is very evident.

The imperfectly drained soil is intermediate between the well and the poorly drained soil, though it is generally closer to the well-drained soil in characteristics and in crop responses.

The poorly drained soils and very poorly-drained soils require tile drainage before they can be successfully cultivated. Both may have an A_2g horizon, which is often a dull grey colour, but it is

usually more evident in the very poorly-drained soils. Degree of wetness in each horizon is also measured.

Dry..... Structural elements are visibly dry and do not further change with exposure to the air. They become darker when moisture is added.

Moist..... Structural elements feel moist and if exposed to wetting they change their colour. Moist soils can be moulded into rods of not more than 1/8th inch diameter and 1/2 inch long.

Wet..... There is visible fluid water between the structural units or water may be squeezed from them. Colour does not change with further wetting.

Water relationships and soil textural classes have been discussed by Glentworth (26). It has been estimated that the amount of water available to the plant in a naturally free-drained soil for the different textural classes is as follows :-

Sandy and loamy sand..... 1/4 - 1/2 inch per foot.
 Sandy loams. 1 inch per foot.
 Fine sandy loams. 1½ - 1¾ inches per foot.
 Loams 2 inches per foot.
 Clay loams. 3 inches per foot.
 Clays. 3½ inches per foot.

Assuming that the roots of agricultural crops reach three feet, the amount of water retained in the three feet column varies from one inch to twelve inches. An eight quarter oat crop will remove over twelve inches of water. In light textured soils water shortage can easily affect the crop adversely in some seasons despite the relatively humid climate of the British Isles.

16. Secondary chemicals

Most chemical deposits are due to the reactions induced by soil water and are therefore mainly precipitative in nature. They are

recognised and classified according to their form and their colour.

Efflorescences occur on the outer edge and faces of the drying-out structural elements. They are extremely finely divided, sometimes resembling a dusty powder and occasionally existing as a bunch of very fine hairs or a bloom.

Dendrites are efflorescences occurring on the faces of elements or stones to give the impression of a picture of a branching tree or plant. Such designs are frequently found produced by manganese in certain of the Brown Forest Soils.

Crusts represent the greater development of efflorescences in both thickness and distribution, but usually they occur in surface deposits resulting from the drying out of a concentrated soil transpiration current.

Veins and tubes are usually well-defined as in-fillings of old root channels. They are frequently found in heavy soil in woodland and meadow conditions. Petrified, fixed or in-filled animal holes may be included.

Concretions occur as extensive zones of grain-like and nodular accumulations. They are found in their greatest frequency in sub-tropical and tropical soils.

Streaks and interlayers occur where the whole of a zone is undergoing induration by the deposition of some cementing agents. Humus columns occur in clays where during drought the soil mass cracks into deep clefts. With rainfall humus drops, or is washed into these cracks and with the subsequent expansion of the clay is sealed in the soil mass as a column. These columns sometimes achieve considerable depth. The most common forms in which the various chemical compounds occur are as follows :-

- (a) Crystals occurring as efflorescences, crusts, interlayers and pockets, include carbonate, chlorides, sulphates and alkalis, all easily soluble and carried into the soil transpiration current. They are found as fine crystals or

crusts in the upper zones. Calcium carbonates such as aragonite and calcite may be observed in the AC horizon of certain limestone soils by deposition from solution of skeletal material in the percolation stream.

- (B) Amorphous powders from deposits of dehydrated silicic acid may be observed as flour of silica and may be distinguished from other white amorphous substances of the soil mass either by means of a drop of indicator or by insolubility or tastelessness on the tongue. Concretions and deposits of irreversible material include compounds of iron, alumina, manganese, titanium and phosphorus and occur in great variety. Iron and alumina sesquioxides occur in the orstein layer of the B horizon of podsoils. Ferruginous compounds frequently develop as black or brown beans, grains, and ore grains, in great variety. Spots of brown-yellow eyes and brown dots of iron and manganese are common in heavy clays with gley horizons. Other ferruginous deposits occur as brown laminae, brown ochreous or brown and crimson spots and patches.

Red and yellow ochreous nodules, ochreous veins and rusty patches often occur in root channels and in interstices of meadow soils of heavy clay origin. Dark purple to brown dendrites of manganese iron are frequently found on the faces of structural elements and stones in soils where oxidation dominates reduction in the gley zone. Calcium carbonate as white 'eyes', nodules or puppets may be found in the lower horizons of Brown Forest Soils of heavy clay origin in which the surface run-off exceeds percolation. Dark grains of limonite and manganese dioxide and sometimes haematite may be recognised by their streak on rough porcelain.

11. Faunal influences

Faunal influences on the soil are divided as follows :-

1. Intra-soil fauna.....protozoa, worms, insects.
2. Extra-soil fauna.....birds, cattle.
3. Dual environment fauna.....burrowing animals, insects and larvae.

12. The distribution of carbonates and pH value, in the profile is noted in the field by adopting the following procedure. A little hydrochloric acid is poured over the face of the profile. The points at which reaction commences and ceases are noted and the intensity of the reaction. Carbonates may be present as relics of weathered parent material or as pedological deposits (carbonates of soda, lime, iron, and magnesia). The size, shape and quantity of the pedological deposits are noted. Differentiation between concretionary and relic parent material is often difficult, but fracturing concretions usually reveals the tendency to concentric formation. Crystalline calcium carbonate as calcite and, less commonly, aragonite is frequently found in the soils of this region, wherever Magnesian Limestone is of importance in the profile. Down-washing of dissolved carbonates, from the surface into lower horizons, results in dehydration to form powders or crystalline forms in pockets in the limestone or on the face of weathered limestone fragments.

The appearance of concretionary or deposited carbonates in the soil profile may always be correlated with the basic ground water and a soil transpiration current. Soil type may often be recognised on the basis of such observations alone. Relic carbonates will resemble the parent material rock in such an areas as this and can be recognised with a pocket lens. Failing this it will be found that new calcium deposits are more soluble in weak acid than the rock and are purer, leaving less insoluble residue of clay, iron compounds or silica. The influence of drift is so strong in most of the soils, however, that limestone erratics from a great variety of sources confuse accurate identification considerably. Estimation of quantity of carbonates and sources should therefore be made in the laboratory and field tests are really limited to delimitation of carbonate distribution. Clark (21) gives the following table to indicate a rough idea of the quantity of carbonates present in the soil, by treating a handful of soil in a basin with an excess of 10 percent HCl.

(Fig.22)

Estimation of soil carbonates

$\%CaCO_3$	Audible effects	Visible effects
Less than 0.1	None	None
0.5	Faintly audible, increasing to slightly	None
1.0	Faintly audible increasing to moderate	Slight effervescence confined to individual grains. Just audible
2.0	Moderate to distinct, heard away from the ear.	Slightly more general effervescence visible at close inspection
5.0	Easily audible	Moderate effervescence. Bubbles to 3mm, easily visible.
10.0	Easily audible	General strong effervescence. Ubiquitous bubbles to 7mm. Clear.

The above information is recorded on the cards for every profile. Hand auger bores are not recorded in such detail but each profile pit and each bore are recorded on the soil map according to the following standards.

1. The Series name given by a two letter symbol e.g. DU = Durham Series.
2. The texture of the surface soil and its depth e.g. SL 9" (Sandy loam)
3. The texture of the second horizon and, if worth comment, the third.
4. The drainage class of the site.

Each pit or bore is marked with a dot on the map and will indicate the above information in the following manner:

• BU
 SL9"
 CL+St.
 s.

Auger interpretation is not simple but soil boundaries are largely based on it. It is necessary to have alternative substantiation wherever possible and change in profile can be expected under the following combined (if possible) conditions.

- (a) Change in lithography (on the auger).
- (b) Change of topography.
- (c) Change in the vegetation or the condition of the crop.
- (d) Change in the colour of the soil (if ploughed).
- (e) Difference in feel and sound underfoot when walking.

Methods of Analysis

Chapter 4

The methods adopted in this survey are basically well-established, but they have been modified to suit the soils encountered and the capabilities of available laboratories.

The avoidance of 'clutter' is the main guide to the final form of reporting, and many analyses that have proved superfluous or that can be combined more simply are not reported individually.

While this conciseness is desirable and while the chemical analytical methods are basically well-established, Soil Science has not yet reached the stage where reports such as this can be made without some description of the laboratory methods adopted and reasons for any modifications to recognised procedure. Full description is therefore offered here to avoid confusion and facilitate correlation.

Analysis was made to estimate the following:- mechanical composition, pH, carbonate content, organic carbon and organic matter, loss on ignition, organic nitrogen, available nutrients, exchangeable cations and m.eq. percentage of the total major metallic cations.

The above analyses were made for every horizon of every profile taken. Samples were always analysed at least in duplicate and often up to six identical analyses were made on the same sample. This is, needless to say, extremely time consuming when the major concern is survey and correlation, but it is essential to give any statistical validity to the interpretation of results. Final reporting has been ruthlessly selective and only typical, significant or cumulative information is offered.

Methods. (a) Sampling.

The profile pit is dug to a suitable depth which will vary according to the depth of solid rock, the nature of the parent material and the depth of organic penetration, and the actual difficulty of digging, but the more usual depth is about five to six feet. The pit is oriented to catch the best light and description is made on the long

face which can be picked and disturbed at will. The appropriate narrow face is then cleaned and samples taken. There are various methods of taking samples. It can be picked and prized from the surface or dug out with a spade. The most satisfactory method however was to cut a block out with a strong knife and slice the outer face from it to avoid contamination. It is then put in a numbered polythene bag. Where the soil is too loose and sandy for this procedure a core sample was obtained by forcing a tube into the face and gently twisting it out with its load of soil. Sampling was always commenced at the deepest horizon to avoid contamination by spill from higher up the profile.

Samples were immediately returned to the laboratory and moist pH and colour recorded. The remaining sample, about fourteen pounds weight per horizon, was air-dried and reduced to a fine earth sample by mortar and pestle and a 2 mm sieve. This was bottled and all further analysis was made on this fine earth sample. Before each analysis a bottle of sample was quartered to obtain a representative sample of the appropriate weight.

(b) Mechanical analysis

In 1927 Bouyoucos (27) introduced the hydrometer method for mechanical analysis which enabled the lengthy procedure used for example in ^{the} pipette method to be reduced considerably. The hydrometer was originally calibrated to read grams of material in suspension by using a sample of known constituents. In 1928 Bouyoucos (28) using Stoke's law suggested that the hydrometer could be used to obtain a more complete accumulation curve. The hydrometer had to be correlated with known soils but settling rates according to Stoke's Law do not correspond with this calibration. It appears that the hydrometer readings at a given time determine an average density of the whole suspension which is empirically related to definite size groupings. Bouyoucos has shown that there are different concentrations in different sections of the suspension but that the hydrometer gives an average reading for the whole column. There have been many

theoretical criticisms of the Bouyouces method. Day (29) made an exhaustive study of the method and derived a new theory which appears to satisfy the demands of the critics. His theory is based on the fact that the density of the suspension is a logarithmic function of depth. Each cylinder used is measured to calibrate the hydrometer on the basis of effective depth. A nomographic chart eases the calculation of results but the method is very lengthy and impracticable when analysing large numbers of samples single handed. Using modifications of the Bouyouces method, derived from the British Standards adopted for soil engineering, the rate of analysis is at least five times as rapid as Day's method. Slight inaccuracies in settling rates will not show when results are plotted on a triangular graph for final textural grouping.

The method adopted was, therefore as follows:- From the fine-earth sample weigh out 60 grams and mix with 150 mls. 20 vols. hydrogen peroxide in a wide necked 500 ml conical flask. Stir for five minutes until the frothing has subsided and then allow to stand overnight under a loose cover. Heat the flask gently until the frothing has subsided and boil the liquid down to 50 mls. Wash the cooled contents onto a grade 50 filter paper and filter through a Buchner funnel using a gentle vacuum. Dry at 50 - 60°C for at least sixteen hours. Weigh the remaining sample to establish loss of humic matter through oxidation. Treat the remaining sample with 100 mls. N/1 HCl and allow to stand overnight. Wash, as before, through a Buchner funnel till completely acid free. Dry and reweigh to establish the loss of carbonates. Transfer the remaining soil to the baffled bucket of a mechanical stirrer and add 100 mls. of warm sodium hexametaphosphate dispersing agent. (50 grams of Calgon and 5.724 grams of sodium carbonate to one litre.) Add a further 110 mls. distilled water after ten minutes and stir for at least twenty-five minutes.

Wash the dispersed sample into a 1,000 ml. measuring cylinder and top up to the litre mark with distilled water. Place in a water bath controlled to a temperature of 20°C and allow to stand for half an hour

to allow the contents of the cylinder to assume the constant temperature. Shake the cylinder end over end for one minute and replace carefully in the water bath. At four minutes thirty seconds slowly lower the Bouyouces hydrometer into the cylinder. (When not actually taking a reading the hydrometer should be kept in a cylinder of water at the same temperature as the sample to be recorded). At exactly five minutes take the first hydrometer reading. This represents the combined silt and clay fractions. Remove the hydrometer and replace in the same manner at exactly five hours. This will represent the clay fraction alone. Results are calculated to percentages of the sample remaining after pretreatment. Correction for temperature differences is not necessary if the water bath functions correctly. A correction factor made necessary by the use of sodium hexametaphosphate is determined by making up 100 ml. of the solution to 1 litre in a cylinder and recording the hydrometer reading at 20°C. This is subtracted from all other hydrometer readings taken.

Most of the liquid, including the clay fraction is poured off and the sediment should be washed through a 72 mesh sieve into 400 ml beakers marked at 10 cm. Using a rubber policeman and a constant flow of water wash the coarse sand that is held on the sieve until it is completely clean. All the water used is retained in the beakers, which are filled to the 10cm. mark and allowed to stand for a time near five minutes. The exact time is governed by the temperature of the water used. After the appropriate time has elapsed the fine sand should have sedimented to the bottom of the beakers. All other contents are carefully decanted. Decantation is repeated until the water in the beakers above the fine sand is absolutely clear after calculated settling time. The fine and coarse sand fractions are filtered separately and even dried before weighing and converting to percentages. The different fractions are totalled and any losses or gains are noted. All fractions, expressed as percentages are plotted on a triangular graph to establish textural classification.

(c) pH

This is determined on a laboratory pH meter before and after drying. The soil:water ratio adopted was 1:2.5. 10 gms of soil and twenty five mls. distilled water are mixed in a beaker for one minute using a low-powered mechanical stirrer with a glass paddle. At the end of this time the sample is transferred to the meter and after leaving the electrodes immersed for exactly forty seconds to allow the instrument to stabilise, the pH reading is recorded. The pH of the distilled water used in the solution is also recorded and supplies with too widely differing measurements are rejected.

(d) Total carbonates

Treatment with N/1 HCl and titration with N/1 NaOH was found to be the most convenient method. The Collin's calcimeter although claiming greater accuracy is far too slow when dealing with a large number of samples. The accuracy of the speedier titration method was tested with pure CaCO_3 and gave very satisfactory results.

Weigh 5gms. of fine earth sample into a tall 150ml beaker. Add 100ml. N/1 HCl and stir several times during one hour. Allow the contents to settle overnight and pipette off 20ml. of the supernatant liquid. Transfer this to an Erlenmeyer flask and add 15-20 drops of bromo-thymol blue indicator solution. Titrate with standardised N/1 NaOH. If the liquid pales during titration so that no colour can be distinguished add more indicator. The end point is a sharp change from yellow to blue. Blanks are run to obtain the titre of the HCl and trial runs with pure CaCO_3 serve as a useful check. The percentage calcium carbonate and magnesium carbonate is obtained from the following expression.

$$\% \text{ carbonates} = (\text{Blank titration} - \text{Actual titration}) \times 5.$$

(e) Organic carbon and organic matter.

The chromic acid method based on spontaneous heating by dilution of sulphuric acid involves essentially the same procedure as Schollenberger (30) except that less heat is produced than when externally applied.

Because of this, less organic matter is oxidised. This is held to be an advantage (31) since the less active organic matter is not measured. The lower temperature produced tends to differentiate soil humus from other sources of organic carbon. Dry combustion includes most of the elemental and near elemental carbon but the Walkley-Black method, from which the procedure adopted here is derived, excludes 90-95 percent of the less important carbons. This merit is of great importance in the region under study where the drift materials contain considerable quantities of coal in various states of weathering.

Procedure is as follows:-

Weigh out 1grm of fine earth sample into a 500ml. conical flask and add 10ml. potassium dichromate, and 20ml. concentrated sulphuric acid. Agitate gently for one minute and allow to stand for thirty minutes. Add 200ml. distilled water 10 ml. phosphoric acid and 20 drops of 0.5 percent diphenylamine indicator. Titrate with 0.5N ferrous sulphate solution until the colour changes through blue to green. The end point is at a one drop colour change. Repeat the procedure with blanks containing no soil.

Results are calculated from the following:-

$$\text{Organic carbon} = \frac{\text{mls potassium dichromate reduced} \times 0.0039 \times 100}{\text{Weight of soil.}}$$

When the number of mls. N potassium dichromate reduced = R
 Blank titration = S
 and Sample titration = T

$$R = \frac{10}{S} (S - T) \quad \text{or} \quad R = 10(1 - \frac{T}{S})$$

The correction factor 0.0039 is derived from the following.

The meq weight of carbon is 0.003 and the recovery factor (Walkley) is 77 percent or $\frac{100}{77}$

$$\text{The factor is therefore } 0.003 \times \frac{100}{77} = 0.0039$$

$$\text{Therefore \% organic carbon} = \frac{10 (1 - T/S) \times 0.0039}{\text{Weight of Soil}}$$

Using the correction factor 1.724 (soil organic matter contains 58 percent carbon) the percentage of organic matter can be obtained.

(f) Loss on ignition.

This estimation was obtained simply by weighing the difference between oven dried sample before and after ignition for thirty minutes at 450°C. As no value can be found in the results of early samples this procedure was abandoned.

(g) Total nitrogen estimation. (Modified Kjeldahl method)

The original Kjeldahl procedure has been frequently modified but the determination of total nitrogen is not as simple as it is often thought to be and modifications should be introduced with caution. Many associated difficulties can lead to very low results. Up to an hour of digestion may be required after the digest has made its significant colour changes, to release the total nitrogen. The most important consideration is the catalyst selected and the digestion temperature. If the temperature is below 360°C the release is slow or incomplete. If it rises to over 410°C there is some loss of NH_3 from the mixture. The soil is more finely ground than normally and soaked for half an hour in distilled water before treating with sulphuric acid. This aids the achievement of complete oxidation. The catalyst chosen was the Kjeldahl tablet manufactured by Boot's. It contains 20 parts copper sulphate, 0.005 parts selenium and 100 parts anhydrous sodium sulphate, total to 2.5 grms.

Digestion is achieved by weighing out 20 grms of ground fine-earth sample into a Kjeldahl flask with 60ml. distilled water. This is allowed to stand for thirty minutes. Eight Kjeldahl tablets and 40 ml. concentrated sulphuric acid are added and the temperature gradually raised on the thermostatically controlled Kjeldahl rack. Digestion proceeds until the colour of the mixture changes to blue, green, yellow or straw colour and then for a further forty five minutes to one hour. The solution is then allowed to cool but not to crystallise and is transferred to 250 ml standard flask and made up to the mark with distilled water. Ten ml. of each sample is distilled

in the Markham still into 10ml. boric acid (and mixed brom cresol green and methyl red indicator adjusted to pH 4.5 and a purple red mid-point colour. The sample is titrated with N/100 HCl back to mid-point and the result is set against a blank. Percentage nitrogen is calculated by simply multiplying ml. acid required by the same less the blank by 0.35. The percentage nitrogen can then be combined with percentage carbon to give the C:N ratio.

(f) Available nutrients.

No modifications were thought necessary and normal leaching and colour or spectrum analysis procedure was followed.

(g) Cationic exchange data.

Because of the high calcium and magnesium carbonate content of most of the soils encountered certain modifications to standard procedure were adopted. A 2.5 gm sample was leached with N ammonium acetate and sodium and potassium cationic status was determined in the normal manner using a flame photometer. Extracting calcareous soils with NH_4OAc dissolves Ca and Mg extensively. The use of 0.2N BaCl_2 - triethanolamine was found satisfactory as the BaCO_3 coats the surface of calcite and dolomite and makes them insoluble, given a satisfactory pH of 8.1. The leachate thus obtained is analysed on the Hilger Watts atom absorption apparatus to obtain calcium and magnesium cationic status.

Total exchange capacity was in the first instance determined as total sodium by leaching the sample after the ammonium acetate leach with sodium acetate. The excess sodium was taken off by leaching with methanol. Results were highly unsatisfactory and did not resemble in total or even proportionally the sum of major metallic cations determined individually. More consistent results were obtained by leaching with sodium acetate after the BaCl_2 - triethanolamine treatment. This measurement should in no way be considered as highly exact, but rather as an equilibrium measurement under the conditions chosen. This led to agreement with the opinion that 'Next to lime requirement no other soil constant perhaps, is so widely used and yet so little understood as "base" exchange capacity.' (32). Considering the

difficulties encountered and the unreliability of even the better results, total exchange capacity determination was not made on many of the soils. A more rewarding estimation was of meq. percentage of individual cations based on total major metallic cations by addition. This enabled full correlation and allowed satisfactory consideration of fertility in relation to individual ion antagonisms. Ratio and proportion are certainly of more value than supposedly exact totals.

SECTION THREESOILS

The soils of the East Durham Plateau are formed under the influence of the following factors and processes:-

1. Parent material
2. Topography
3. Soil movement
4. Weathering and drainage

These factors are interrelated and their relative importance varies in different locations.

Chapter 1Parent material

As already described there are three major sources of parent material: various drifts, the Magnesian Limestone and alluvial deposits.

The glacial drift can be grouped in several ways according to colour, texture, depth or stratigraphic similarities. From the various criteria a four-fold division is found suitable.

(a) Single drift of the west. Where developed to more than four feet in depth these provide soils varying from silty loams through clay loams to clays. The surface horizons vary from loam to clay loam. There is usually some clay movement and accumulation with a resulting (B) horizon which may be Clay. The parent material is within the range Silty-loam to Clay-loam. An example of a typical profile developed on this kind of drift is given.

(Fig.23)

Profile 140

	Clay %	Silt %	Total sand %	Texture
1.	33	13	52	Clay-loam
2.	37	13	50	Clay
3.	27	26	46	Clay-loam

(Note in all cases where percentages do not add to 100 this is because of rounding off to whole numbers, and experimental losses.)

In some cases where there is better limestone, different conditions obtain'. A horizons are usually deeper and more friable falling into the Loam category. There may be some slight movement of clay representing incipient podsolisation, and very slight accumulation at the top of the unweathered parent material or at the surface of the Magnesian Limestone.

(Fig.24)

Profile 9

	Clay %	Silt %	Total Sand %	Texture
1. 1-4"	16	16	54	Loam
2. 4-10"	19	19	59	Loam
3. 10-20"	16	17	64	Loam
4. 20-36"	30	17	46	Clay Loam

Clay accumulation was noted at the bottom of the plough layer in this profile which represents the beginning of a plough-pan an incipience not uncommon in clay soils of this region.

(b) In the east, drifts with a dominant red component in their colour and triassic material identifiable in their mass are encountered. There is a similar division, into heavy and lighter drift materials with associated drainage differences, as in the west but for different reasons. Most of these drifts are deep but some are basically higher in clay status than others. Those with a high clay status, sometimes far higher than clays in the west, fall into the same Soil Series as their Carboniferous-Permian drift counterparts. The lighter drifts form a basis for a separate Series which has local variations according to topography and soil movement.

(Fig.25)

Profile 56

1.	Clay %	Silt %	Sand %	Texture
1. 0-7"	19	13	68	Loam
2. 7-15"	20	17	62	Loam
3. 15-26"	22	19	58	Clay-Loam
4. 26-39"	20	18	62	Loam
5. 39-48"	21	17	61	Loam

(Fig 26)

Profile 57

2.	Clay%	Silt %	Sand %	Texture
1. 0 - 12"	13	12	74	Sandy-loam
2. 12 - 36"	21	12	65	Loam
3. 36 - 48"	24	13	62	Clay-loam
4. 48 - 56"	24	20	55	Clay-loam

The first example represents a flat side and some clay movement with accumulation below the plough level. The second example represents a profile influenced by soil movement, which is more typical of these materials which occur on hummocky and rolling terrain. The fourth horizon in this case, though not texturally distinct is visually the only completely in situ material. Clay content rises from surface to depth, silt is constant and sand percentage falls, as clay increases, up to the abrupt change at the unweathered drift material.

(c) Mixed and re-sorted drifts. There is a morainic belt where the above-mentioned drifts are seen in intimate mixture or varied juxtaposition. In some ways they behave similarly to the heavier drifts of the east and west, but there are several distinctions and they encompass such wide stratigraphic variation that they form the basis of a different Soil Series. They would perhaps be better grouped as a specific Parent Material Association with included Series established as a result of very detailed mapping, but the complexity would be prohibitive of intelligibility. They include variations within very small distances that, were it not for complexity, could be included in other Series. Where larger distinctive areas are developed they are included in their appropriate Series. There is no one typical profile but the following is an example of what can occur.

(Fig.27)

Profile 48

	Clay %	Silt %	Sand %	Texture
0 - 12"	18	14	65	Loam
12 - 50"	37	36	26	Silty Clay-loam
50 - 70"	36	38	25	Silty clay-loam

A more comprehensive picture of the variations encountered can be obtained on inspection of the appropriate parts of Sections I and II. Sorting of drifts by agencies subsequent to the original deposition will be considered later.

(d) Sands, sands and gravels and mixed sandy or sandy and gravelly clays. There are distinct morainic units which result in a lighter soil parent material than found elsewhere in the region. Exact mechanical composition may vary, but the unifying distinction is lightness of texture. Coastal consolidated blown sands and limited exposures of the Middle Sands of the drift sequence are included in this grouping.

An example of a profile on a kame-like feature of water deposited sands and gravel shows stratigraphic variety regardless of soil forming processes.

(Fig.28)

Profile 50

	Clay %	Silt %	Sand %	Texture
1. 0 - 7"	7	7	86	Sand
2. 7 -30"	7	9	84	Sand
3. 30 -40"	9	8	82	Sand
4. 40 -50"	6	1	93	Sand
5. 50 -60"	4	1	95	Sand

An example is given below of the other extreme, a profile with a comparatively high clay content in the fine-earth sample but with sufficient small gravel to ensure good drainage and easy cultivation:-

(Fig.29)

Profile 15

	Clay %	Silt %	Sand %	Texture
1. 0 - 9 $\frac{1}{2}$ "	26	14	60	Clay loam
2. 9 $\frac{1}{2}$ - 15"	35	16	49	Clay loam
3. 15 -30"	28	19	52	Clay loam

Thin soils developed over limestone. Only very rarely do profiles develop in which there is no visible evidence of drift influence and even here the possibility of drift material being discreetly incorporated into the profile cannot be ruled out.. One Rendzina-like profile will serve as an example.

(Fig.30)

Profile 2

	Clay %	Silt %	Sand %	Texture
1. 0 - 4"	19	19	61	Loam

Only one horizon is developed in this form but as drift influence increases a (B) horizon emerges. There is usually a good proportion of clay in the drift.

(Fig.31)

Profile 3

	Clay %	Silt %	Sand %	Texture
1. 1- 5"	10	15	73	Loamy sand
2. 5 -11"	25	15	58	Clay-loam

As depth increases or sometimes even when still very shallow, the profile is more developed and a further horizon appears. This is weathered drift directly over the limestone and limestone fragments and weathered limestone powder is usually intimately incorporated.

(Fig.32)

Profile 34

	Clay %	Silt %	Sand %	Texture
1. 0 - 4"	14	16	65	Loam
2. 4 - 9"	24	21	56	Clay-loam
3. 9 -12"	21	20	56	Loam
4. 12-20"	Brecciated limestone			

It will be noticed that the (B) horizon shows textural signs of clay accumulation and on dried out faces clay coating of individual peds is very clear.

From this depth there is a transition to the better drained deeper drifts of the plateau, as typified by the following profile.

(Fig.33)

Profile 39

	Clay %	Silt %	Sand %	Texture
1. 0- 1½"	7	17	70	Loamy Sand
2. 1½-10"	14	21	63	Loam
3. 10-21"	18	26	53	Silty Loam
4. 21-32"	1	45	52	Silty Loam

There was little sign of clay coating in this profile. Horizon 4 is a highly weathered powdery limestone.

There are variations beyond the simple three-fold pattern of progression described. There may be varying clay content in the parent material. If the clay content increases a profile may develop with similarities to soils on the deeper clays but because of the shallowing of phase, which is probably far more significant agriculturally, it is grouped with these limestone soils. The proximity of the limestone surface is of great importance, particularly to drainage, and while the last profile exhibits some signs of imperfect drainage the following does not.

(Fig.34)

Profile 1

	Clay %	Silt %	Sand %	Texture
1. 2 - 7"	17	17	65	Loam
2. 7 -12"	24	15	60	Clay-loam
3. 12-18"	36	17	48	Clay
4. 18-24"	9	20	71	Loamy sand

Horizon 4 is again weathered limestone and it will be noted that it is neither as far down in the profile nor itself as thick as the corresponding horizon in (39).

There is further variation depending partly on the type of limestone beneath the profile. For example some beds are of a very powdery, easily weathered material. In the profiles already described the drifts have incorporated within their mass varying amounts of platy

or angular limestone fragments with some weathered limestone powder. This solid limestone does not alter the texture of the fine earth and the soils are, especially when deep, comparatively heavy to handle. When the incorporated limestone is entirely weathered powder, however, the texture and cultivation potential is significantly altered.

(Fig.35)

Profile 4

	Clay %	Silt %	Sand %	Texture
1. 0 - 5"	9	18	73	Loamy Sand
2. 5 - 13"	12	18	70	Loam
3. 13-13½"	11	22	66	Loamy Sand
4. 13½-24"	0.4	22	67	Loamy Sand

Horizon 4 is the weathered powdery limestone.

All the above variations were so logically patterned in progression as to be thought validly included as types or varieties within one Soil Series. A variation more distinct and decisive resulted in the establishment of a separate thin-soil Series. In two significant areas in the region the drift is quite thin and has during its deposition ripped the surface of the limestone far more seriously than elsewhere. Instead of normal incorporation of limestone into the drift the whole mass is an intimately mixed amalgam of limestone and clay with the limestone forming the major part. In places bands and wedges of limestone occur within the profile above more balanced soil mixtures. The scraped surface is variably filled with drift and coal bands which pass down cracks and hollows. The resultant parent material and indeed the whole profile is therefore significantly more sandy than the other thin soils of the region. Types similar to the heavier counterparts are discernible. For example, single horizon profiles are common.

(Fig.36)

Profile 32

	Clay %	Silt %	Sand %	Texture %
1. 0 - 15"	9	14	74	Sandy loam

A second horizon is commonly incipient but often not as well developed as in the earlier soils.

(Fig.37)

Profile 31

	Clay %	Silt %	Sand %	Texture
1. 0 - 5"	9	7	80	Loamy Sand
2. Weathering parent material with some crumb structure but mainly pitted limestone fragments.				

Where better developed, the second horizon is still only weakly stable in structure in most cases.

(Fig.38)

Profile 30

	Clay %	Silt %	Sand %	Texture
1. 0 - 2"	7	18	74	Loamy Sand
2. 2 - 4"	5	17	75	Loamy Sand
3. 4" +	Weathered limestone			

There are thicker developments in exact correspondence with the earlier Series but again these are very sandy despite the increased depth.

(Fig.39)

Profile 29

	Clay %	Silt %	Sand %	Texture
1. 0 - 1"	2	25	70	Loamy Sand
2. 1 - 4 $\frac{1}{2}$ "	11	21	62	Loam
3. 4 $\frac{1}{2}$ - 14 $\frac{1}{2}$ "	13	25	62	Loam
4. 14 $\frac{1}{2}$ - 29 $\frac{1}{2}$ "	Weathered limestone			

1.3 Alluvium. There are two forms into which alluvial deposits are differentiated. Valley alluvium is found in bottom land alongside streams and in other depressions. Profiles are very variable as the following example indicates.

(Fig.40)

Profile 47

	Clay %	Silt %	Sand %	Texture
1. 0 - 12"	15	13	72	Loam
2. 12 - 25"	20	5	74	Sandy Loam
3. 25 - 40"	11	7	82	Sandy Loam
4. 40 - 70"	4	11	83	Loamy sand with grave

The other class of alluvial materials show more distinctive features in association with peat, silt, sand and mixed bands in differing sequences. Two examples will show the differences that can occur.

(Fig.41)

Profile 16

	Clay %	Silt %	Sand %	Texture
1. 0 - 5"	23	14	62	Clay-loam
2. 5 -18"	29	10	61	Clay-loam
3. 18-21"	34	9	56	Clay
4. 21-36"	23	7	69	Sandy loam

(Fig.42)

Profile 17

	Clay %	Silt %	Sand %	Texture
1. 0 - 5"	27	17	56	Clay-loam
2. 5 -12"	29	15	56	Clay-loam
3. 12-24"	23	11	66	Clay-loam
4. 24"+	51	30	20	Silty Clay

In both cases horizon 4 is succeeded by laminated clays which persist to at least fifty feet.

In places various forms of drift similar to those in 1.1 occur over the alluvium or perhaps as remnants of islands above at least part of the lacustrine deposition. These show horizon development more consistent with pedogenetic processes but even here resorting of parent material results in non-genetic stratification.

(Fig.45)

Profile 21

	Clay %	Silt %	Sand %	Texture
1. 0 - 7"	23	16	61	Loam
2. 7 -11"	24	14	61	Clay-loam
3. 11-20"	33	16	50	Clay-loam
4. 20"+	31	23	47	Clay-loam

)Fig.46)

Profile 25

	Clay %	Silt %	Sand %	Texture
1. 0 - 6"	21	15	61	Loam
2. 6 -13"	21	15	61	Loam
3. 13-18"	33	15	51	Clay-loam
4. 18-66"	61	24	16	Clay

Most of the alluvium encountered are subjected, depending on topography, to ground-water gleying.

In discussing parent materials emphasis has been laid on texture. Of course texture is not the only factor influenced by parent material but other considerations can be discussed more adequately in the ensuing scheme.

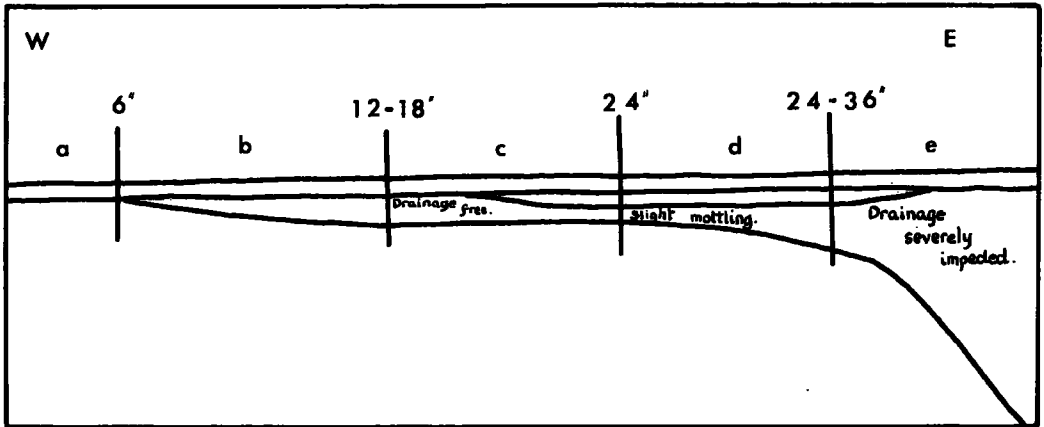


Fig. 43 W E Transect.

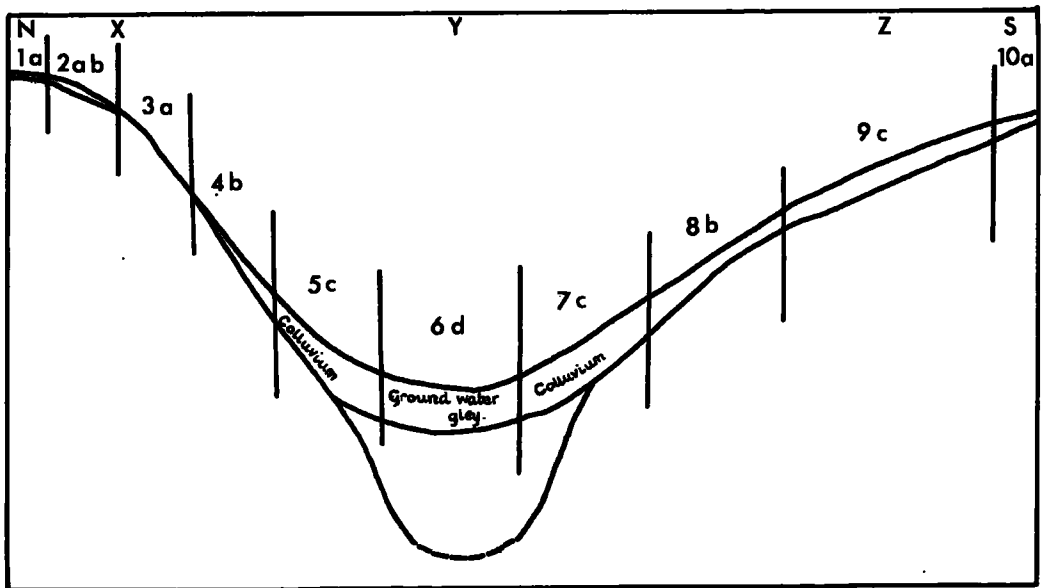


Fig. 44 N S Transect.

Chapter 2Topography

2.I As depth of profile can be visualised increasing on the much simplified diagram (Fig.43), an imaginary E-W transect which helps to demonstrate Series development, so a valley-ridge transect can help to explain topographic influences on the scarp edge, (Fig.44). It is clear that in Fig.44 features of the soil profile very similar to those in Fig.43 are encountered although not in the same sequence. Instead, an irregular topographic Soil Catena is formed. On spur X there is a zone at the top of the hill with thin single horizon profiles directly above the limestone. These are the same soils as at a in Fig.43. Because of topography and the relatively high rainfall at this elevation (500ft+) there is some active soil erosion. This leads to slight thickening in zone 2. The soil may still be moving and still does not exceed 12" so there may be no second horizon. Sometimes however because of lodging in irregularities in the limestone surface there may be a second horizon of weathered material including drift. Often where hollows are filled in this way the vegetation seems to slide over the surface without extending its roots into the lodged material. In other cases mature profiles develop using lodged material as an essential part of the solum. These three forms are so mixed together in small areas that they are grouped together as one transitional type as the ab connotation, which will be developed later, suggests.

Below in zone 3 is a virtual free face where vegetation at best clings to the limestone. In some restricted sites soil persists but native rock is usually exposed. Zone 4 represents a more complicated section which is receiving material from above and shedding material to zone 5. Here depth of profile is increased to 12-18" and apparent material is always present and often a (B)/C or (B) horizon. Where the (B) is particularly well developed and clay coatings on the ped faces begin to alter the drainage regime the soil can be safely grouped with c soils of Fig.43 or zone 9, Fig.44. The reason for this is agriculturally biased. Despite shallowness such well

developed profile characteristics inhibit the frequent summer scorching encountered on a and b soils where there is excessively free drainage.

Zone 5 represents a colluvial zone, which will be dealt with under Soil Movement. Zone 6 alongside the stream bed exhibits all the typical characteristics of a ground-water gley soil. There is some limestone in the drift material and particularly near the stream some alluvial material. The magnesian Limestone surface is either at considerable depth or is breached completely by erosion which took place before Glacial deposition. The surface horizon is usually a humus-rich clay loam. There is a clay (B)g and a G horizon of silty loam texture.

(Fig.47)

Profile 14

	Clay %	Silt %	Sand %	Texture
1. 0 - 13"	33	13	53	Clay-loam
2. 13- 22"	37	13	51 ,	Clay
3. 22-50"+	27	13	55	Silty-loam

Mention of the development of the original valley before post-Glacial times is enforced by the differing forms of slope between north and south-facing facets. The south facing slope is often far steeper than its north-facing counterpart in accord with classic glacial erosion. (This is occasionally reflected in farming practice when advantage is made of the gentler slope which is more congenial to tractor ploughing. More often however the northerly aspect outweighs this advantage and prevents arable use).

The soils in Spur Z are not, therefore, in the same sequence as those on X. Zone 7 corresponds with zone 5. Zone 8 corresponds with 4, but is at a different altitude. There is no free face. Zone 9c is at the same elevation as 1a but the ridge top is more extensive and there is less erosion. Drift influence is substantial and soils identical to c in Diagram 1 are found.

Chapter 3Soil Movement

3.1 One case of soil movement left over from the previous chapter must be described first. In Fig.44 zones 5 and 7 represent colluvial belts circling the foot of many of the scarp spurs. The geological 'soil' is deep and often the solid limestone is not encountered within 24" or even many feet of the surface. Profiles are thus in one way distinct from zone 9 Fig.44 and c soils (Fig.43) but they are grouped with them. As they are collecting sites from zones 1-4 and 9-7 they have large quantities of weather limestone in their mass and they behave in a similar way to other c soils. They have a well defined A horizon, which is usually a loam, over an equally well-defined (B) also a loam. The parent material is a sandy loam dominated by a free-draining structureless mass of weathered limestone fragments.

(Fig.48)

Profile 12

	Clay %	Silt %	Sand %	Texture
1. 0 - 7"	19	10	63	Loam
2. 7 -14"	19	10	65	Loam
3. 14-36"+	Weathered limestone fragments.			

The first indication of colluviation encountered was the collection of material behind an old stone wall on the slope at the bottom of Spur X, Fig.44. An attempt was made to quantify colluviation. In all soils in the region some rounded quartz grains are encountered in the fine sand fraction. A count of these grains in proportion to all other fine sand sized particles was made in level sites of soil stability. In some cases there was less than ten percent variation throughout the profile. On slope sites and other possible colluvial sites similar counts were made but results are by no means conclusive. There are many factors to take into account but it seems reasonable to assume that during soil movement some particles of the same fraction will in some circumstances move more readily than others, depending

on size and shape. A significant disturbance of the control size pattern could be measured. As yet the method has not been successful because of the difficulty of establishing satisfactory control patterns and because of the different forms of soil movement.

3.2 As had already been indicated much of the area has been influenced by post-Glacial surface changes including resorting or homogenisation. This could be through a combination of peri-Glacial frost-thaw action and large scale movement of wedges of clay along slip surfaces. There is also the possibility of great disturbance of the top layers of soil by post Glacial afforestation and subsequent clearing. Most of the profiles on the deep single drift, on the mixed drifts, and to a lesser degree on the heavier Triassic drifts exhibit a stratigraphic depositional horizon still in competition with pedogenetic horizon formation. The thickness of this layer varies from an inch to several feet and is usually a sticky clay to silty clay texture. The effect of the widespread surface disturbance, which must to some degree affect most of the thicker clays, is to make soil survey very difficult. The unifying feature of these soils is bad drainage and a ready source of mobile clay and silt to coat the faces of the lower gley horizon. Soil movement clearly presents correlation of soil type with drift type. At depth drifts may be classified by textural similarity but at the surface there is textural complexity particularly because of factor of movement.

Three examples of the effect of this complex horizon show clear differences.

(Fig.49)

Profile 6

	Clay %	Silt %	Sand %	Texture
1. 1½-5"	18	18	64	Loam
2. 5-21"	23	13	64	Clay-loam
3. 21-36"+	32	12	56	Clay

(Fig.50)

Profile 11

	Clay %	Silt %	Sand %	Texture
1. 0 - 8"	34	22	42	Clay-loam
2. 8 -31"	48	26	22	Silty clay
3. 31-48"	28	13	55	Silty loam

(Fig.51)

Profile 20

	Clay %	Silt %	Sand %	Texture
1. 0 - 6"	30	17	52	Clay-loam
2. 6 -25"	34	22	43	Silty clay-loam
3. 25-30"+	Weathered limestone			

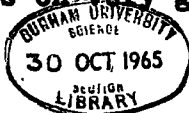
3.3 More recent movement of soil material is evident away from the scarp and especially in the hummocky area around Hutton Henry, Wingate and Hulam. Here there are features related to the colluviation of the scarp but under the influence of far gentler topography. Slight rises and knolls of varying shapes give rise to different soil profiles and particularly to different textures in the plough layer. No hard rule is possible but generally where the slope is steeper, or the convex hill-top is not extensive, soil will have moved to lower levels. The result even in comparatively loamy soils of the lighter Triassic drift is that the surface horizon is shallower, heavier or less rich in organic matter than on more stable sites. An extreme shedding site is where bare clay is exposed but more common would be the following example which can occur either on narrow tops or in shedding bottom land.

(Fig.52)

Profile 52

	Clay %	Silt %	Sand %	Texture
1. 0 - 6"	20	19	61	Loam
2. 6 -36"	38	23	38	Silty clay-loam

A more stable site occurs on very gentle slopes or on the tops of more extensive hummocks.



(Fig.53)

Profile 8

	Clay %	Silt %	Sand %	Texture
1. 0 - 3"	23	18	58	Loam to clay-loam
2. 3 - 6"	25	24	51	Loam to silty-loam
3. 6 - 32"+	26	14	53	Clay

Receiving sites include down-slope and open depressional locations.

(Fig.54)

Profile 101

	Clay %	Silt %	Sand %	Texture
1. 0 - 7"	19	13	68	Loam
2. 7 - 15"	21	17	62	Loam
3. 15-26"	23	19	58	Clay-loam
4. 26-39"	20	18	62	Loam
5. 39-48"+	22	17	62	Loam

This profile has an incipient plough-pan forming at 15 - 15½"

In the last profile humus was present to 15 inches. A more impressive example of a collecting site has humus and plant roots influencing soil colour to 48 inches and there is no plough-pan.

(Fig.55)

Profile 102

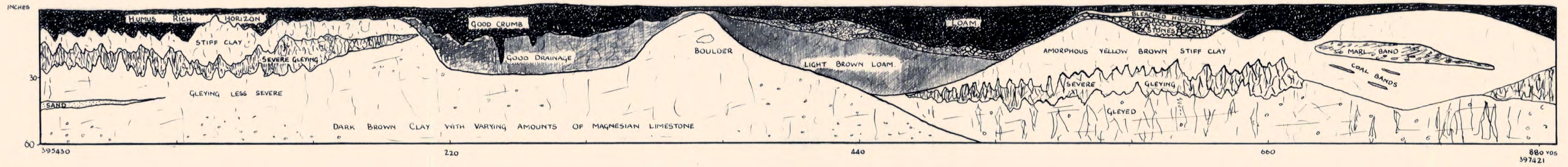
	Clay %	Silt %	Sand %	Texture
1. 0 - 12"	14	12	74	Sandy loam.
2. 12- 36"	22	13	65	Loam
3. 36- 48"	25	13	62	Clay-loam
4. 48- 56"+	24	20	55	Clay-loam

Here there is a marked 'unconformity' between horizons 3 and 4. In colour they are similar as in general texture class, but there are significant differences in the silt and sand fractions. On close inspection of the profile it seems that at some time 4 has been either stripped of its original profile or has in fact never been a parent material. Horizon 3 has moved over it and now forms a related but distinct parent material for the profile.

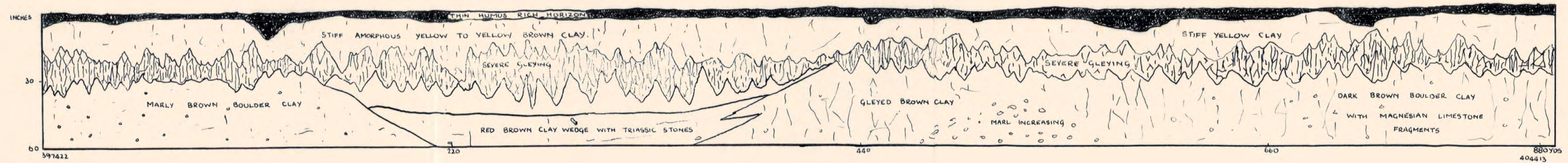
The general picture in this area near Hutton Henry is thus of hummocks and depressions. The hummocks may be shedding sites either depleted in upper horizons or stripped bare. Where more extensive, they may be stable sites. The depressions and down-slopes alongside narrower hummocks are collecting sites, while those below extensive hummocks may themselves be stripped and heavier due to erosion. It is possible to map these differences at six inches to one mile scale but it is not possible to reduce them to smaller scales. Nor are the areas of sufficient extent when mapped to be of use as planning units. As they all occur only on higher drift material and even when depleted do not become uncultivable they are included in one Soil Series.

3.4

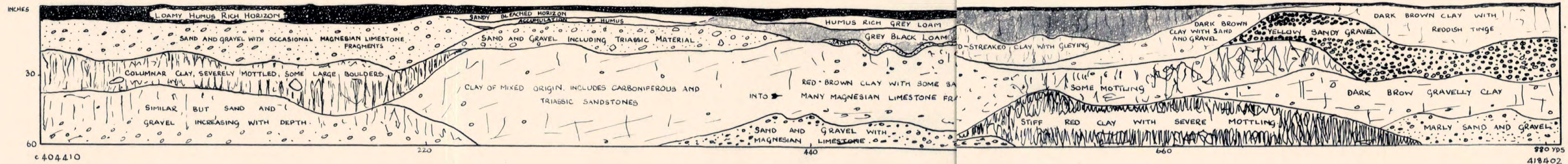
More serious and significant erosion on heavier drift under similar topographic conditions results in the exposure of stiff gleyed clays which take the plough only with difficulty and regularly inhibit crop growth. These conditions occur particularly where unintegrated drainage in one area has resulted in an excess of water flowing over other soils. They are given special distinction on the Soil Limitation map.



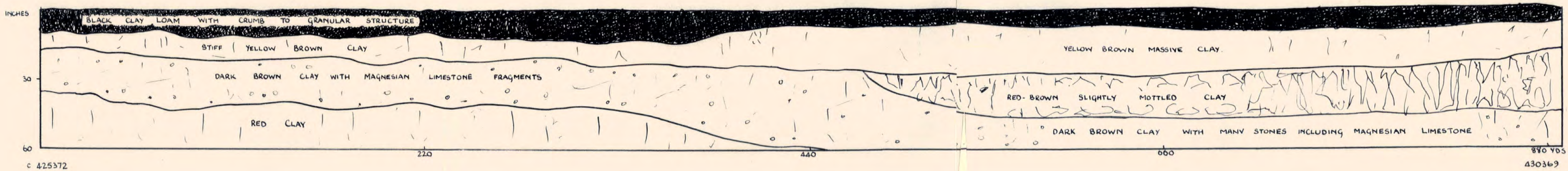
SECTION ONE



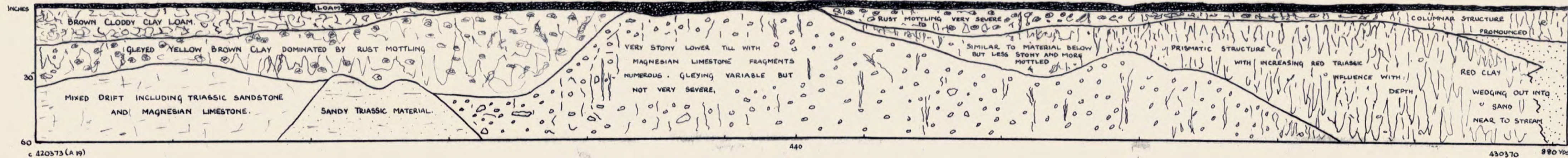
SECTION TWO



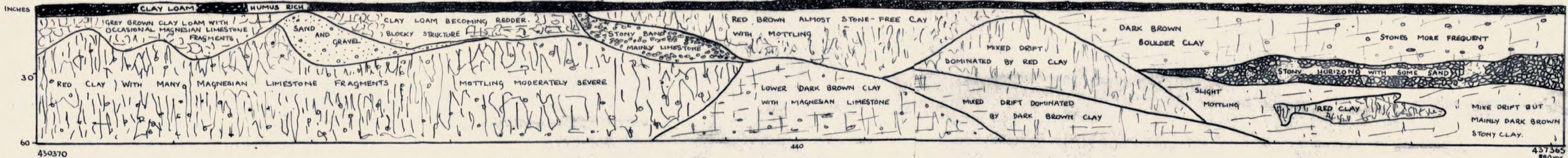
SECTION THREE



SECTION FOUR



SECTION FIVE



SECTION SIX

Chapter 4Weathering

4.1 It is clear that weathering influences will vary on different soil parent materials, and on the same parent materials with some degree of complexity. On the heavier clays, including the deeper single drift weathering is often very shallow, to just a few inches. A consistent gley horizon persists quite near to the surface as seen in long sections one to six. Above, this, horizon gleying may vary in severity to penetrate the individual structural units. Where the drift is mixed or resorted some conditions may lead to more established horizontal development. In long section One bands of gravel are seen to lead to the development of an immature podsol. Wherever drainage is improved significantly, for example by a higher concentration of Magnesian Limestone, a second humus rich horizon usually develops below the A. This is classed as an A/(B) horizon. There is a (B) horizon but the parent material is still sufficiently strong to introduce gleying at depth. The gley line is therefore merely pushed to greater depth, in what is a thicker profile, under the influence of slightly improved drainage conditions.

4.2. Thinner drift soils, as at d in Fig.43, are usually weathered completely to the limestone surface or to a depth of 3ft. 6 inches. Three horizons are commonly well-developed (see Fig.56) an A, a (B) and the weathered parent material. There may be some slight gleying but drainage is not usually a serious factor in cultivation.

(Fig.56)

Profile 6

	Clay %	Silt %	Sand %	Texture
1. 1½ - 5" A	13	18	64	Loam
2. 5 - 21" (B)	23	13	64	Loam to clay-loam
3. 21-36" C	32	12	56	Clay

Sometimes a further horizon develops as in 4.1 particularly in deeper soils over limestone.

(Fig.57)

Profile 9

	Clay %	Silt %	Sand %	Texture
1. 1 - 4" A	18	18	63	Loam
2. 4- 10" A/(B)	19	19	61	Loam
3. 10-20" (B)	16	17	66	Loam
4. 20-36" C	32	18	50	Clay-loam
5. 36"+		Limestone		

This A/(B) is usually texturally similar to 1. but is distinguished by a grey colour due to humus not present in Fig.56, 2.

(Fig.58)

Profile 6

Organic Matter

(6) 1.	4.6%	C/N 10	(9) 1.	5.9%	C/N 10
2.	1.5%	C/N 100+	2.	3.9%	C/N 10
3.	1.5%	C/N 100+	3.	2.0%	C/N 100+
			4.	2.0%	C/N 100+

4.3 Thinner soils of c, b and a (Fig.43) move away from the horizon development above to a single soil horizon. In c there may rarely be four very shallow horizons but agriculturally the shallowness of the whole profile is more important, and in fact more often only an A, a (B) and a C horizon are present. In b there are usually only two horizons:- an A and a C (drift over limestone). In a there is an A horizon directly on limestone. None of these soils (4.3) have any impeded drainage or gleying. Indeed the opposite is the case. Severeburning of most crops and even grass is common in a and b, and potatoes are not successful even in c.

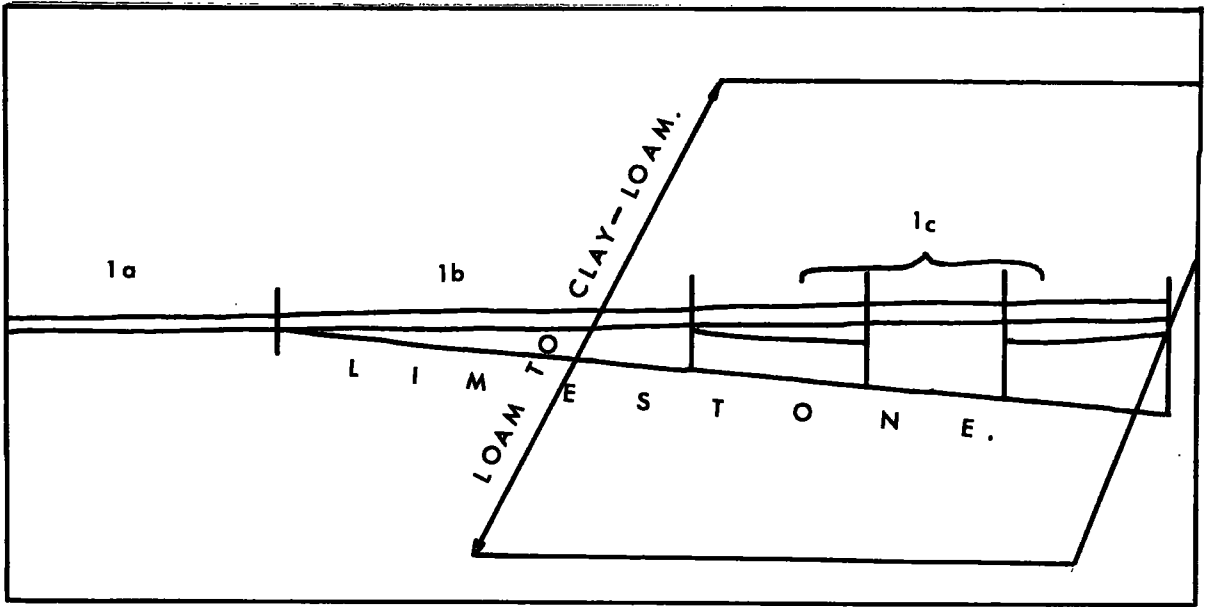


Fig. 59.

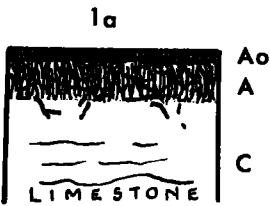


Fig 60

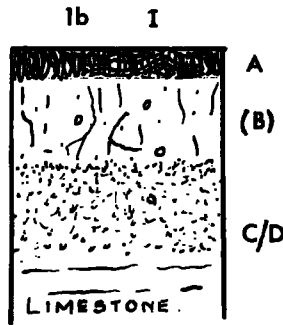


Fig 61

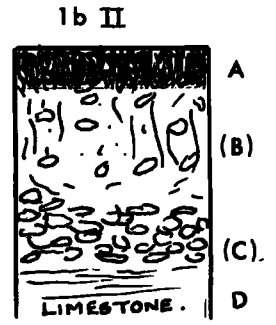


Fig 62

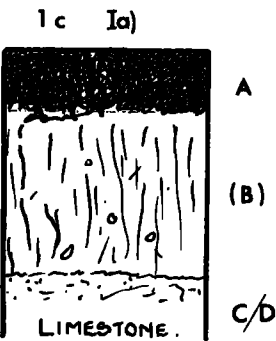


Fig 63

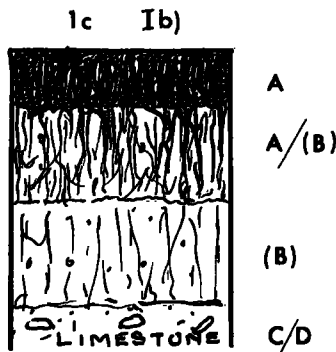


Fig 64

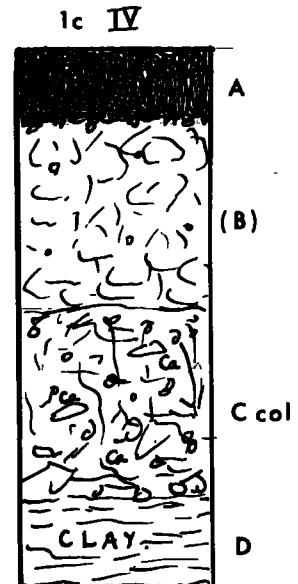


Fig 65

Grouping the SoilsChapter 5

From the above information it is possible to draw together profile similarities and sequences to define the Soil Series and Associations established. Terminology is different from that used by Dougall (19) in order to avoid confusion in what is a different representation of the soil pattern.

I. CORNFORTH SERIES.

This represents the soils developed directly on the limestone surface with drift influence on soil formation ranging from very little to parity with limestone. (Fig. 59) will be useful to understand this Series. A. horizons vary from loamy sand to clay loam and (B) horizons from loam to clay loam. Topography is usually elevated with rolling slopes. Site drainage is always free and profile drainage is free to excessive. These soils are coloured yellow on the map. They are differentiated into three Soil Types.

1a. A.C. Type. (Maximum depth 6-10 inches)

These profiles occur on only the highest parts of the plateau or on shedding sites. Immature soils similar in nature are found on quarry benches, road cuts and sea cliff ledges. An example of an A.C. profile is Profile 2.

1a

Profile 2

- | | | | |
|----|--------|----------------|---|
| 1. | 0 - 1" | A ₀ | Thick mat of roots and humus |
| 2. | 1 - 4" | A ₁ | 10YR 4/3 Dark brown loam with strong crumb to granular structure. Humus-rich and interlaced with roots. Generally stoneless, but occasional fragment of Magnesian Limestone fractured from the rock surface. Reaction calcareous pH 7.6. The whole horizon in places lifts with the turf. |
| 3. | 4"+ | C | Hard limestone in places weathered to a fine yellow powder. |

1b. A.(B). C/D. (Maximum depth 12-18 inches)

These soils occur where the drift influence increases and are distinguished by a (B) horizon which is a shallow weathered drift horizon mixed with limestone and directly upon the limestone surface - C/D. There are three textural varieties depending on the clay percentage in the original drift, and the type of limestone incorporated within the drift and comprising the C/D horizon (Fig.35)

1b. VARIETY I. Light variety (can be stony)

Profile 33

1. 0 - 1½" A. 10YR 3/2 Very dark grey-brown loamy sand with a gritty feel due to presence of large quartz grains. Large crumb structure. Humus and roots throughout. Porosity good. Reaction calcareous. pH 7.6.
2. 1½ - 7" (B) 10YR 3/3 Dark brown loam with quartz grains and occasional small rounded limestone fragments and weathered powdered limestone.
3. 7 - 10" C/D Powdered weathered limestone.

1b. VARIETY II. Stony variety

Profile 37

1. 0 - 4½" A 10YR 3/1 Very dark grey loam with a strong crumb structure and good porosity. Calcareous reaction 7.6
2. 4½ - 7" (B) 10YR 4/3 Brown to dark brown loam with sandstone and coal fragments, but Magnesian Limestone fragments make up to 50 percent of the soil bulk. Very weak crumb structure and some root penetration. Calcareous pH 7.6
3. 7 - 11" (C) 10YR 7/6 Yellow loam with magnesian Limestone fragments dominating the material. Calcareous reaction pH 7.8
4. 11"+ D Bedded limestone

1b. VARIETY III Heavy (B) variety.Profile 36

1. 0 - 6 $\frac{1}{2}$ " A 10YR 4/3 Dark brown loam with strong crumb structure and root mat in the top 1 $\frac{1}{2}$ inches. Calcareous reaction pH 7.0
2. 6 $\frac{1}{2}$ - 14" (B) 10YR 4/4 Dark brown clay to clay-loam with nutty structure and some clay coating of peds. No stones. Calcareous reaction 7.1
3. 14" + C/D Soft friable limestone.

Discussion

Variety I is developed on a soft powdered limestone which is incorporated into the profile to reduce the dominance of the clay fraction. Variety II is developed on a bedded limestone which has been shattered at the surface, possibly by frost or pressure, and incorporated throughout the profile to give an excessively stony soil. Variety III can form when the limestone incorporated within the profile is hard and platy and does not reduce the clay quality of the fine earth (as distinct from Variety I), or by having very little limestone incorporated when developed over a soft limestone as in the example above. This is again quite distinct from Variety I.

- 1c. (a)A. (B). C/D (maximum depth 24") (b) A.A/(B).(B).C/D. (Maximum depth 24")

The unifying feature of these soils is that drainage is not usually excessive. This is either because the soils are sufficiently deep e.g. (a) 18-24", or even when as shallow as 12" the profile has sufficient development in the form of clay accumulation.

There are four varieties, three depending on texture and one depending on its colluvial origin. These can be further grouped around the horizon development as expressed in (a) and (b).

1c. VARIETY I a (Light variety)Profile 4

1. 0 - 5" A 10YR 4/1 Dark grey loamy sand with good crumb to granular structure. Rich in humus and almost stone-free. Calcareous reaction. pH 7.6
2. 5 - 13½" (B) 10YR 4/3.5 Dark yellowish-brown loamy sand with increasing number of weathered Magnesian Limestone fragments at depth. Drainage free. Reaction calcareous 7.7
3. 13½-24½" C/D 5YR/^{7.5/3}Pale yellow powdery limestone. Calcareous reaction 7.7 pH

1c. VARIETY I b (Light variety)Profile 28

1. 0 - 3" A 10YR 4/2 Dark grey-brown loam with good crumb structure. Humus-rich. Some coal fragments at the base. Calcareous reaction pH 7.7
2. 3 - 9" A/(B) 10YR 5/2 Yellow-brown loamy sand with crumbs developed around roots. Small limestone fragments. Calcareous reaction pH 7.8
3. 9 - 13" (B) 10YR 6/4 Light yellowish-brown loamy sand with frequent weathered lime fragments. No strong structure. Calcareous reaction. pH 7.9
4. 13 -24" C/D 10YR 8/6 Yellow sandy weathered limestone.

1c. VARIETY II a (Stony within ploughed depth).Profile 10

1. 0 - 3" A 10YR 4/2 Dark grey-brown clay-loam with numerous stones. Humus-rich. Calcareous reaction pH 7.8
2. 3 - 12" (B) 10YR 4/3 Brown stony clay-loam. Very stony from sand to boulders. Coarse angular nutty structure. Compacted, firm consistence. Not sticky. Moderate humus; frequent, small, free-growing roots. Drainage free but horizon moist. No mottling. Calcareous reaction pH 8.1.

Boundary diffuse.

3. 12 - 24"+ C/D Fissured surface of the limestone, hard and broken.

1c. VARIETY I Ib (Stony within plough depth)

Profile 13

1. 0 - 10" A 10YR 4/2 Dark grey brown loam with crumb to large granular structure. Fine, honeycomb, ubiquitous aggregate porosity helped by stones. Friable; no induration; non-plastic; non-sticky. High in humus. Abundant fine, free-growing roots. Drainage free; no mottling. Reaction pH 6.9 Clear boundary.
2. 10 - 17" A/(B) 10YR 5/2 Grey-brown clay-loam. Stony with coal, sandstone and limestone up to 8". Medium subangular blocky structure. Very fine aggregate porosity. Compact, indurated, plastic, sticky; low in humus but frequent fine, free-growing roots. Drainage very slightly imperfect. Calcareous reaction pH 7.3 Boundary sharp.
3. 17 - 24" (B) 10YR 4/3 Brown sandy clay-loam. Stones dominate and in all sizes and types. Structure determined by stones. Compact, plastic, slightly sticky. No humus. Few fibrous roots. Drainage slightly imperfect with rust mottling. Clay coatings on stones. Calcareous reaction pH 7.6
4. 24 - 31"+ Rock.

1c. VARIETY III a (Heavy variety)

Profile 1

1. 0 - 7" A 10YR 3/2.5 Very dark greyish-brown loam with good crumb structure. Humus rich many roots. Numerous coal fragments and some Magnesian Limestone. Drainage free. Calcareous reaction pH 7.3

2. 7 - 18" (B) 10YR 4/3.5 Dark yellowish- brown clay loam with nutty structure. Less humus and less roots. Stones generally infrequent. Drainage slightly imperfect. Calcareous reaction pH 8.0
3. 18 - 24"+ C/D 10YR 5/4 Yellowish-brown to 10YR 7.5/4.5 very pale brownish-yellow clay transitional to yellow powder and platy limestone.

1c. VARIETY III b (Heavy variety)

Profile 34

1. 0 - 4" A 10YR 4/3 Dark brown loam with occasional sandstone and limestone gravel. Well-developed crumb structure. Mat of roots and humus throughout. Drainage free. Calcareous reaction pH 7.4 Clear boundary.
2. 4 - 9" A/(B) 10YR^{5/4}/Yellow-brown clay-loam with a weaker crumb structure but roots and humus throughout. Drainage adequate. pH 7.5 Boundary clear.
3. 9 - 12" (B) 10YR 5/6 Yellow-brown clay-loam with nutty structure. Few stones or roots. No humus. Slight clay coating. Calcareous reaction pH 7.5
4. 12 -20" C/D 10YR 7/4 Very pale brown mixture of clay with yellow limestone fragments.

1c. VARIETY IV (Colluvial variety)

Profile 12

1. 0 - 7" A 10YR 3.5/2 Dark grey-brown loam, slightly stony - limestone and coal up to $\frac{1}{2}$ ". Large crumb structure; porous honeycomb, ubiquitous

aggregate. Fissured. Mellow compactness. No induration; non-plastic; non-cohesive; non-sticky. Humus-rich. Few fine, free-growing roots. Free drainage through moist. Calcareous reaction pH 7.7 Boundary clear.

2. 7 - 14" (B) 10YR 4/4 Dark yellowish-brown loam. Stony with Magnesian Limestone fragments and some coal. All sizes. Cloddy (moist) structure. Porous, honeycomb and vermiculate inter-aggregate; ubiquitous within the aggregates. No induration. Loose consistence, non-sticky. Free drainage. No humus but some fine dead roots. Calcareous reaction pH 7.8 Boundary clear.
3. 14 - 24"+ C/Col 10YR 5/7 Yellowish-brown sandy loam with stones dominant. Soft weathered Magnesian Limestone of all sizes, shapes and stage of rotting. No structure. Fine ubiquitous porosity, especially open around stones. No induration. Non-plastic; non-cohesive. No humus. No roots. Free drainage but moist.

1c. Discussion

Variety and sub-variety vary for the same reasons as in 1b. Examples of each variety and sub-variety (except varieties for 1c IV where not differentiated) are given to illustrate the great variety of soils encountered within this Type. Obviously characteristics of varieties I and III will be seen in variety II and, correspondingly, the stoniness of variety II can occur in I and III. Variety IV can include characteristics of varieties I, II and III in both (a) and (b) forms. The description is valid as it is important for agricultural

purposes to know the variety of conditions one might encounter. The varieties are not mapped in this Series however (although Types are) because they are not sufficiently extensive units. They are indicated only where of supreme importance on the Limitation maps for example where stoniness prohibits ploughing.

2. MIDDLEHAM SERIES.

These soils are in some respects similar to those in the Cornforth Series, but they are brash-like throughout because of severe scraping of the limestone surface. They are subdivided into three similar Types but because they are uniformly sandy loams due to their mixed parent material they are not sub-divided into textural varieties. Nor are they usually divided according to varying horizontal development within the Type because structural development is far weaker. Type 2a/b is given as a rare example. These soils are developed on rolling slopes with satisfactory site drainage, and profile drainage is free.

2a. A.C/D (Maximum depth 5-15")

Profile 32

1. 0 - 15" A 10YR 4/3 Dark brown sandy loam with a mass of roots, mineral soil and weathered limestone fragments intimately mixed. Large crumb structure and stones give very open porosity. Drainage free. Calcareous reaction pH 7.6 Boundary diffuse.

2. 15"+ C/D Brown limestone

2a/b .A.A/(B).C/D

Profile 31

1. 0 - 5" A 10YR 4/3 Dark brown loamy sand with a mat of roots and numerous small limestone fragments. Some crumb structure weakly developed. Open porosity. Free drainage. Calcareous reaction pH 7.8 Boundary distinct.

2 a

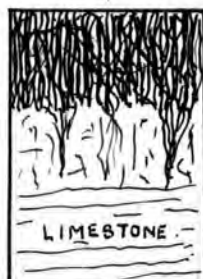


A

C

Fig 66

2 a/b



A

A/(B)

C/D

Fig 67

2 b



A

(B)

C/D

D

Fig 68

2 c



A

A/(B)

(B)

C/D

Fig 69

2. 5 - 7" A/(B) 10YR 6/6 Brownish-yellow sandy mixture of stones and mineral soil. Crumb and grains of soil and organic matter passing down from 1.

3. 7"+ C/D Weathered broken limestone.

2b. A.(B).C/D

Profile 30

1. 0 - 1½" A 5Y 5/2 Grey-brown loamy sand with mat of roots holding structure. Many small limestone fragments. Open porosity. Free drainage. Calcareous reaction pH 7.7

2. 1½ - 4" (B) 2.5Y 6/2 Light grey-brown loamy sand containing small limestone fragments. Roots present but no humus. At the base of the zone limestone bands. Calcareous reaction pH 7.6 Boundary clear.

3. 4 - 14"+ C/D 2.5Y 8/4 Pale yellow silty loam. Weathering limestone with small proportion of mineral soil.

2c. A.A/(B).(B).C/D.

Profile 29

1. 0 - 2" A 10YR 4/2 Dark grey-brown silty loam tending to loamy sand. Humus-rich. Structure held by roots. Limestone fragments and quartz grains numerous. Open porosity. Free drainage. Boundary clear. Calcareous reaction pH 7.7

2. 2 - 4½" A/(B) 10YR 4/3 Brown to dark brown loam with crumb structure and granular tendencies. Stones increasing in frequency. Roots and humus throughout. Calcareous reaction pH 7.7 Boundary clear.

3. $4\frac{1}{2}$ - 14" (B) 10YR 5/4 Yellow brown loam with more limestone fragments, up to 2". Crumb structure only round roots. No humus. Calcareous reaction pH 7.8 Irregular boundary.
4. $14\frac{1}{2}$ - $29\frac{1}{2}$ " C/D 2.5YR 8/4 Pale yellow silty loam with large plates of limestone up to 6". Few roots. No humus. Transitional to limestone powder and stones. At 30" broken limestone.

3. KELLOE SERIES

This widespread Series is in some respects transitional from Series I Type c to Series 4, but it is clearly distinguishable from both. It is distinguished from lc by increased depth over the limestone and by the introduction of impeded drainage seen in rust mottling and some slight grey gleying on the ped surfaces. It is distinguished from 4 in that it is usually shallower and does not have a strong gley horizon near the surface, nor the serious drainage impedance of that Series.

The A horizon is usually a loam but below this there is increasing clay content. Topography is variable from level to undulating while site drainage may be seasonally wet. Depth to the limestone can vary from within a common range of 24-36 inches although some very much deeper soils are included because of profile similarity and particularly because of better drainage quality than in Series 4.

The soil can be separated into three Types depending on horizon development. These types range from a light to a heavy textural variety. The agricultural implications of these variations are negligible and their juxtaposition so chaotic that they are not differentiated on the soil map.

3a. A.(B)/C. Over 24" in total depth.

Unlike Series 1, Types in this Series do not vary according to total depth of the profile. They rather represent transitional stages

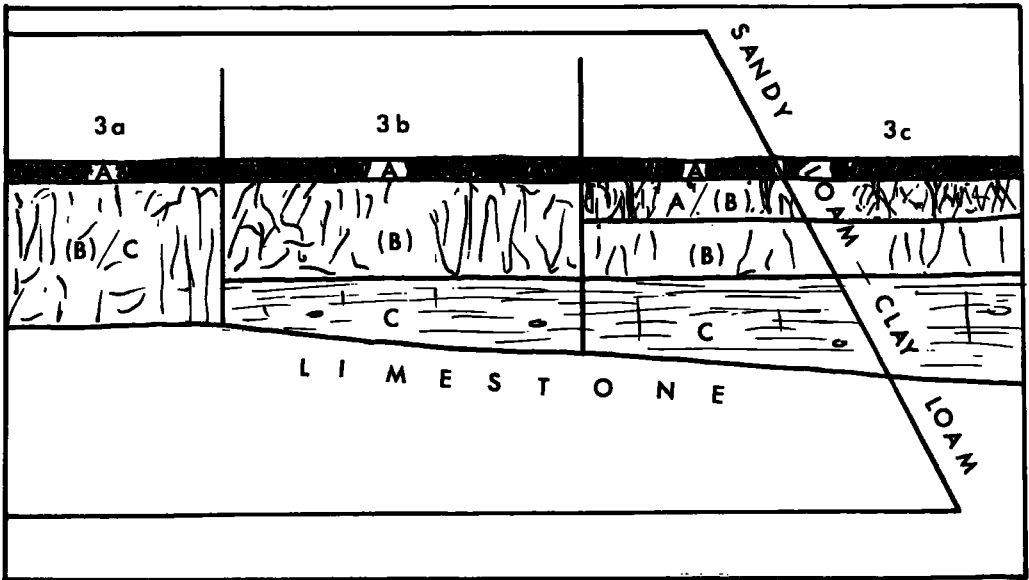


Fig 70

under the influence of varying pedogenetic factors. No claim is made here that they are moving towards one horizon pattern nor is any attempt made to assess why they are not all exactly the same in profile morphology. They are merely seen as very closely related soils and described as they were at the one moment of time when they were sampled.

3a. VARIETY I Light textured
 Profile 53.

1. 0 - 7" A 10YR 3/3 Dark brown loam containing very few stones. Crumb structure with tendency to clod. Friable and non-plastic. Good porosity. Free drainage. No mottling. Boundary sharp. Calcareous pH 7.6
2. 7 - 43" (B)/C 10YR 5/4 Brown silty loam with some very small limestone gravel. Cloddy to massive structure. Compact, slightly sticky. Surface gleying at depth. Calcareous reaction pH 7.6

3a. VARIETY II Heavier texture
 Profile 54

1. 0 - 5" A 10YR 3/3 Dark brown clay-loam with occasional stone up to 2" and some coal fragments. Cloddy structure. High in humus. Slightly sticky. Porosity very fine to none. Drainage along roots. Calcareous reaction pH 7.8 Boundary sharp.
2. 5 - 58" (B)/C 10YR 6/4 Light yellowish brown with grey mottling. Silty clay with some coal fragments. Blocky to prismatic structure. Compact, plastic, sticky. Porosity structural. Drainage impeded. Reaction calcareous pH 7.8

3a Discussion

These soils are, like those in 1a and 1b, comparatively immature

in not showing more development of horizons. They are quite distinct from 1a and 1b however in having far greater depth and unlike all soils of Series I they do not have the same quantity of limestone from the solid rock below incorporated within their parent material. Also these soils (3a) with the least horizontal development are encountered on the deepest soils of the Series unlike the immature shallow soils of Series I.

3b. A.(B) Cg. Over 24" in total depth.

These soils are distinguished from 3a because they now have a distinct (B) above a weathered and slightly gleyed Cg or (B)/Cg horizon.

3b. VARIETY I light texture

Profile 6

1. 0 - 5" A 10YR 4/2 Dark greyish-brown loam. Crumb to granular structure. Rich in humus. Porous and friable. Drainage good but some rust mottling along the root channels. Calcareous reaction 7.5 Boundary sharp.
2. 5 - 21" (B) 10YR 5/4 Yellowish-brown loam to clay-loam. Cloddy structure (damp). No humus. Porosity restricted to roots and structure faces. Impeded drainage with frequent surface gley coatings. Calcareous reaction pH 7.6 Boundary irregular.
3. 21 - 36"+ C 10YR 5/6 Yellowish-brown clay with more frequent mottling, more larger stones. Organic matter still present as roots penetrate to this depth. Tenaceous, sticky and plastic.

3b. VARIETY II Heavy texture

Profile 136

1. 0 - 6" A 10YR 4/2 Dark brown loam with strong crumb structure and a mat of binding roots. Boundary clear. Reaction pH 6.9

2. 6 - 19" (B) 10YR 4/4 Dark yellowish-brown clay-loam with material from above passing down root channels and cracks. Cloddy structure. Restricted porosity and some clay coatings. Reaction calcareous pH 7.2 Boundary clear.
3. 19 - 30" Cg 7.5 YR 5/8 Brown clay with prismatic structure. Some roots but low in organic matter. Porosity only by fissures and cracks. Sticky plastic and tenaceous. Mottling. Impeded drainage particularly at depth.
4. 30"+ D 2.5Y 8/4 Pale yellow limestone.

3b. Discussion

There are soils in Series I with A.(B).C/D horizons but they are not so deep as those here described. The result is that 3b soils have a more distinct C horizon of drift material. The limestone may still exert significant influence on the profile but it can now be classed as a D horizon completely distinct from the parent material.

3c. A.A/(B).(B).C. Over 24" in total depth

These soils follow the progression and are different from 3b. They now have an A/(B) horizon quite unlike the A(humus) in having a lighter colour and less organic matter, and distinct from (B) in that it still contains appreciable humus. There is a (B) or (B) g horizon and a C horizon of weathered drift often with strong gleying.

3c. VARIETY 1 Light texture

Profile 9

1. 0 - 4" A 10YR 3/2 Very dark greyish-brown with a mass of roots. Crumb structure. Stoneless. Humus-rich. Friable non-sticky. Good open ubiquitous porosity. Free drainage Reaction pH 6.5. Boundary irregular and indistinct.

2. 4 - 10" A/(B) 10YR 4/2 Dark greyish-brown loam with a small crumb structure. Almost stone-free except for a few small coal fragments. Less humus than in 1. but still appreciable. Friable, non-sticky. Good open porosity. Drainage free. pH 7.3. Boundary clear.
3. 10 - 20" (B) 10YR 4/3.5 Dark yellowish-brown loam with horizon of rounded and angular boulders at 15". Humus almost gone. Friable and non-sticky. Porosity more restricted and towards base dampness and slight gleying. Reaction pH 6.0. Boundary clear.
4. 20 - 36" Cg 10YR 5/6 Yellowish brown clay-loam with prismatic structure. Many stones of various sizes. Sticky, compact, mottling in greys and blues moderate to severe at depth. Moisture held and very wet. Still some roots. Reaction pH 7.0.

3c Discussion

There is only one variety, the light textured in this Type. Where clay content increases the drainage deteriorates and gleying is more severe and nearer the surface. Such soils will be included in Series 4. It is conceivable that a heavy variety could exist but none was encountered. Drainage throughout this Series can range from free to impeded.

4. HASWELL SERIES. (Including severely gleyed soils of the Triassic drift).

This Series is a logical progression from Series 3 in increasing drift depth, increasing clay content, or increasingly impeded drainage with a strong G or (B)g horizon. The textural range within plough depth is from loam to clay. Topography is usually gently undulating

or depressional. The centre of the East Durham Plateau displays the widest development of the Series in which site drainage is frequently wet. Profile drainage is impeded. The parent material is the single Carboniferous drift with variable redistribution and differing Permian influence. The heavier and poorer drained soils of the Triassic drift area particularly around Sheraton-Hulam are included in this Series.

The Series comprises such variation in original drift, transferred and resorted material, and depth that many subdivisions could be made. Texture and depth Types and varieties would vary foot by foot along any transect. The transects Section One to Section Three are useful indicators of variability. Examples are given of three of the variations encountered.

4. Shallow example
Profile 20
1. 0 - 6" A 10YR 3/2 Dark greyish-brown clay loam. Frequent stones from large gravel to boulder size, mainly rounded sandstones up to 12" x 12". Sed crumb structure to granular with tendency to clod. Porosity varied in aggregates, very fine to porous. Inter-aggregate porosity good along root channels. Slightly compact, rolls to wire, sticky when saturated. High in organic matter. Roots for the full depth of horizon, living and free-growing. Drainage adequate with no mottling. Reaction calcareous pH 7.8 Boundary clear.
2. 6 - 25" (B)g 10YR 5/6 Light yellow-brown clay-loam. Many large sandstones rounded shapes and up to 7-8". Cloddy with porosity mainly down root channels and cracks. Compact and sticky. Occasional fibrous root at top of the horizon. Drainage impeded, with rust and grey mottling. Reaction calcareous pH 8.2 Boundary at limestone.

3. 25"+ Soft yellow Magnesian Limestone.

4. With ground-water gley at depth

Profile 11

1. 0 - 8" A 5Y 4.5/2 Light olive brown clay, almost stone-free except for a few coal, sandstone and limestone fragments. Coarse angular blocky to nutty structure. Very fine aggregate porosity with fine fissures between aggregates. Mellow compactness, no induration. Firm consistence when moist. Slight stickiness. High in humus. Frequent medium, small and fine roots, influenced by firmness of soil; woody, fleshy and fibrous; tangle of dead and living. Drainage imperfect, horizon moist. Reaction calcareous pH 7.9 Boundary sharp.

2. 8 - 31" G 2.5Y 4.5/4 Light olive brown mixture. Brown matrix with severe grey and brown mottling. Silty clay almost stone-free. Very coarse sub-angular blocky structure tending towards prismatic. Prism fissure porosity. Tenacious compactness, no induration, very plastic, slightly sticky. Low in humus. Few small and fine roots, shape affected by the clay; fibrous, weak, alive and dead. Drainage poor to very poor with much mottling. Reaction calcareous pH 8.0 Boundary indeterminate.

3. 31"+ Stiff, blue, sticky clay.

4. With (B)g and G horizons

Profile 144

I. 0 - 13" A 5Y 5/2 Light olive brown clay-loam nearly stoneless. Crumb to granular structure. Porous honeycomb. Interaggregate along cracks. Friable

to mellow compactness, no induration.

Consistence when moist loose to friable. Organic matter high. Roots frequent fine to small, free-growing. Drainage free. No mottling. pH 5.9 Boundary with 2. gradual and diffuse. Passing down root channels and welling in waves and dips.

2. 13 - 21" (B)g Brown and grey mixed and mottled. Clay, nearly stoneless. Subangular blocky (coarse) structure. Porosity fissured and root channels. Tenacious compactness. Grey clay very plastic; sandy brown areas only slightly plastic. Low in organic matter but some passes down root channels. Few roots. Drainage poor Reaction 6.4 pH Boundary clear to gradual.
3. 21"+ G Bright blue-grey and rusty mottled silty loam. Very stony with sandstone up to 4" structure large angular blocky. Little porosity. Tenacious difficult to dig. Very plastic consistency and sticky. No organic matter. Drainage very poor. This horizon was similar to 2 but gleying was more severe and a considerable amount of water was held in the mass.

The chief characteristics of the Haswell Series are then, a depth of more than 24" and severe gleying of the profile within 6 - 18 inches of the surface.

5. SHOTTON SERIES

This Series is developed in a restricted belt of mixed Carboniferous and Triassic drifts. Perhaps because of the agencies at work during re-deposition clay content is more uniformly high than in Series 4 and the soils are all very badly drained. The surface horizon is usually shallow and of clay-loam texture. There is strong gleying

near the surface. Topography is gently sloping and site drainage is periodically wet in patches. The soils puddle easily under heavy mechanised implements.

5. Profile 148

1. 0 - 12" A 10YR 3/2 Very dark greyish-brown loam. Few stones including red-stained sandstones up to 2" x 1". Massive to cloddy structure. Porosity along root channels. Very hard consistence, impossible to break by simple finger and thumb pressure. Once crushed falls into granular mass. Roots throughout. Very slight mottling at the base of the horizon. Reaction pH 6.4. Clear boundary.
2. 12 - 50" G 2.5Y 4/4 Reddish brown with severe blue mottling. Small Magnesian Limestone fragments. Massive prismatic structure. Silty clay. Severe blue, grey and rust mottling throughout, along cracks and weaknesses giving veined appearance. Where large sections fall away the whole face is covered with a blue silty film. Strong consistence, yielding very little to pressure. Very badly drained. Sticky. Slightly micaceous. Calcareous reaction pH 8.3.
3. 50 - 72" Gg 2.5Y 4/4 Reddish brown silty clay-loam. Occasional rounded, red-stained pieces of Magnesian Limestone. Slight grey-blue mottling. Strong consistence, compact, sticky. Little porosity. Calcareous reaction pH 8.6.

Stratigraphic variation is indicated in transects Section Four to Section Six.

6. HESLEDEN SERIES

This Series has two modes of origin. Some of the red Triassic drifts are inherently texturally lighter than those included in Series

4 and 5. This may be due to the influence of incorporated Magnesian Limestone although in 4 and 5 total carbonates can be very high. In other cases soil movement has led to the development of very deep loamy profiles over the drift (3.3). Surface horizons are therefore usually loams. The topography is gently to steeply undulating. The site drainage may be seasonally wet and the profile drainage may be imperfect. The redness of the soil, which shows in some lights even when the surface is rich in organic matter, is a useful distinguishing feature in this Series. There is obviously variable horizon development depending on colluviation. The soils can be divided into a shedding sites, b stable sites, c collecting sites.

6a.

Shedding Site

Profile 52

1. 0 - 6" A 10YR 4/3 Dark brown sandy loam with small coal fragments. Crumb structure. Good ubiquitous porosity. Mellow compactness. Non-sticky. Roots throughout the horizon. Drainage adequate, no mottling. Reaction pH 6.8 Boundary indistinct.
2. 6 - 20" (B)/C 5YR 5/4 Reddish brown medium clay-loam with stones up to 11" long. Strong blocky to massive structure. Slightly compact but small fragments of rock mainly Magnesian Limestone throughout. Breaks under pressure into crumbs. Sticky. Medium porosity. No mottling. Calcareous reaction pH 7.7

6b.

Stable site

Profile 8

1. 0 - 3" A 5YR 4/1 Dark grey clay-loam stone free. Crumb structure many roots. Friable. Boundary undulating. Calcareous reaction pH 7.2
2. 3 - 6" A/(B) 10YR 3/2 Very dark grey-brown loam to silty loam with crumb to cloddy structure. Porosity ubiquitous fine. Mellow compactness. Non-sticky. Roots and organic matter throughout. pH 6.2. Boundary clear.

6 a

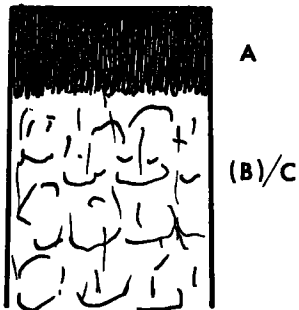


Fig 71

6 c

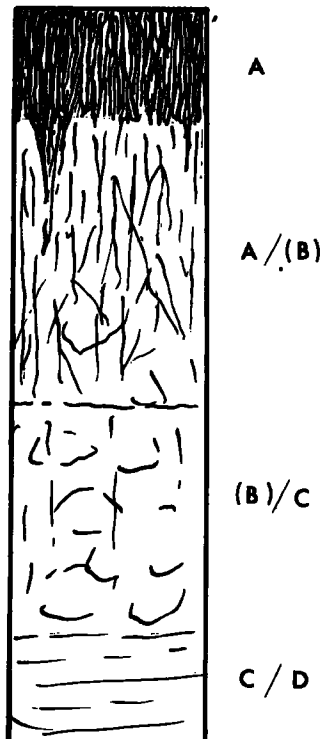


Fig 73

6 b

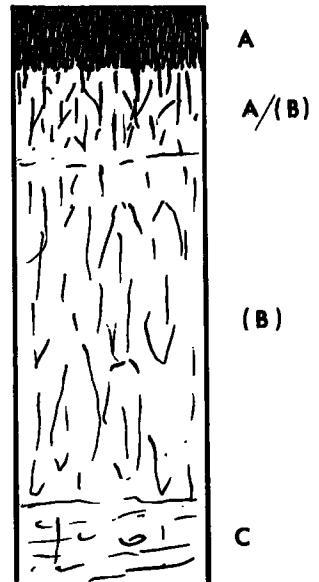


Fig 72

3. 6 - 32" (B) 10YR 5/3.5 Yellowish brown with red tinge and some grey and purple mottling(dull). Loamy clay fissured and prismatic. Magnesian Limestone fragments and rounded boulders frequent. More tenacious and sticky with depth. PH 6.6
4. 32" + C Mixture of Triassic drift and weather Magnesian Limestone.

6a/b. Transitional Profile. Shedding site but weathering maintains the profile.

Profile 101

1. 0 - 7" A 5YR 4/1 Dark grey with occasional brown mottles. Loam with rounded quartz grains and occasional mica flakes. Cloddy to nutty structure. Moulds to moderately stable mass but not sticky. Humus very rich. Fine fibrous roots very common. Boundary uneven and undulating. pH. 7.3.
2. 7 -15" A(B) 10YR 3/2 Dark grey-brown sandy clay loam. Massive structure breaking to granular. Friable. Occasional weathered sandstone. Roots rare. Humus from above fairly consistent. Calcareous pH 7.8
3. 15 - 26" (B)g Red and grey mottled and indurated horizon. Clay. Many small gravels and occasional sandstone fragment and weathered Magnesian Limestone. Incipient columnar structure but mainly massive. Flecks of coal red and purple sandstone. Horizontal gleying dominates the horizon. Calcareous reaction pH 8.5.
4. 26 - 39"(B)/C Similar to the above and merging through a transitional boundary. Distinct because considerably damper.

5. 39 - 48"+ C 5YR 5/4 Reddish brown stony gleyed material similar to other drift clays. Gravel frequent and increasing to 2" x 1" Sandstones, coal, white and yellow limestone. Digs less easily.

6c. Collecting Site

Profile 102

1. 0 - 12" A 5YR 4/1 Dark grey humus rich sandy loam. (Plough horizon) Small gravel up to 1 $\frac{1}{2}$ " long. Circular to crumb structure. Many fine roots. Last years root mat ploughed in to 7" forming compacted 'pan'. Boundary uneven. pH 5.7
2. 12 - 36" A/(B) 10YR 3 $\frac{1}{2}$ Dark grey-brown sandy loam. Stones frequent. Cloddy structure. Many fibrous roots but humus less than above. No gleying, drainage good. Water passing freely into the pit along a rotted tree root. Stones mainly Magnesian Limestone and sandstone. All rounded with some weathering down to a rotten unstable mass. pH 6.7 Boundary indistinct and transitional.
3. 36 - 48" (B)/C Similar horizon but more compact and more clay. Very small Magnesian Limestone fragments and red sandstone. Cloudy to nutty structure. Medium tree roots and occasional fibrous roots still penetrate. Calcareous reaction pH 8.3. Boundary sharp.
4. 48 - 56" C/D 5YR 5/4 Reddish brown indurated upper boulder clay, slight gleying masking the redness. Many small Magnesian Limestone fragments in matrix of sandy clay. Roots still penetrate Calcareous reaction pH 8.6

Discussion

It is clear from the above examples that the soils of this Series give good deep loamy profiles with the only disadvantage that free drainage often leads to deficiencies in calcium.

7. MAINSFORTH SERIES

These soils are found on three similar parent material groups all light in texture.,

- (a) Glacial sands and gravels, mixed and bedded.
- (b) Middle Sands of the drift sequence.
- (c) Blown Sands of the coast.

7a. Glacial Sands and Gravels

Profile 150

1. 0 - 10" A 10YR 3/2 Very dark grey-brown clay loam with stones of varied size. Grumb to granular structure. Ubiquitous fissured porosity. Mellow compactness, no induration. Slightly plastic. Friable. Not sticky. Organic matter high throughout the horizon. Drainage free. No mottling. pH 6.0 Boundary sharp.
2. 10 - 15" (B) 2.5Y 4/4 Reddish brown clay loam with many more stones up to boulder size in sandstone, granite, Magnesian Limestone and coal. Structure small cloddy angular cubic. Aggregate porosity very fine but very open along stone faces. Compact with moderate induration. Plastic, slightly sticky. Roots and humus along root channels. Drainage good. pH 6.6 Boundary diffuse.
3. 15 - 30"+ C 7.5 YR 5/8 Brown with much white and yellow limestone. Clay-loam. Same as 2 but limestone fragments dominate the horizon. Roots rare. Drainage good.

7 a i



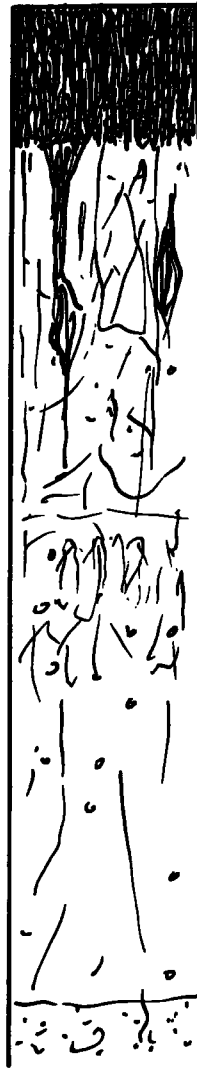
A

(B)

C

Fig 74

7a ii



A

A/(B)

(B)

C

Fig 75

7 b



A

C

Fig 76

7 c



A

C

Fig 77

7a

Profile 50

1. 0 - 7" A 10YR 3/3 Dark brown sand. Few water-rounded pebbles. Individual quartz grains visible in the soil mass. Single grain structure held together in something of a weak granular manner. Ubiquitous open porosity. Mellow. High in organic matter. Free-drainage. pH 5.8. Boundary sharp.
2. 7 - 30" A/(B) 10YR 4/2 Dark greyish-brown sand similar to above. Friable and mellow. Pebbles increasing with depth and organic matter decreasing with depth. pH 6.1. Boundary sharp.
3. 30 - 40" (B)/C 7.5YR 4/4 Brown stony and sandy horizon. Water worn fragments of sandstone, quartzite, dolerite, triassic pebbles and limestone. Peaty humus lenses. Root penetration throughout. pH 7.0
4. 40 - 56" C 7.5 YR 5/6 Strong brown coarse sand with occasional roots. pH 6.7.
5. 56 - 60"+ C 10YR 6/4 Light yellowish brown coarse sand. pH 8.3

7b. Middle SandsProfile 84

1. 0 - 7" A 10YR 3/3 Dark brown sandy loam. Humus rich, stone-free. Weak crumb structure held by roots. Drainage free. Open porosity. pH 5.6. Boundary sharp.
2. 7 - 36"+ C 5YR 5/4 Red brown coarse sand, slightly cemented together but separates easily.

7c. Blown SandProfile 96

1. 0 - 4" A 10YR 3/3 Sandy loam with weak crumb structure. Mat of roots and humus, drainage free to excessive. pH 5.6 Boundary sharp.
2. 4 - 12"+ C 10YR 6/4 Light yellowish brown sand. pH 5.7.

8

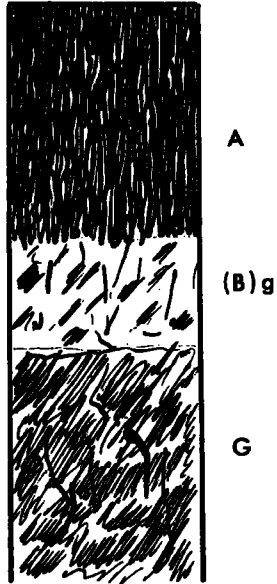


Fig 78

9

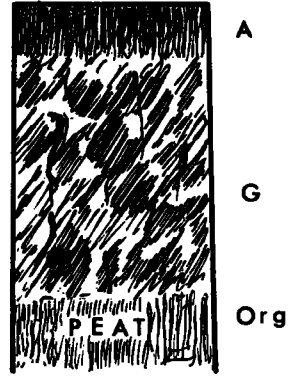


Fig 79

10

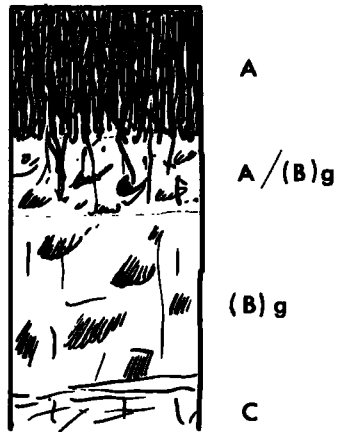


Fig 80

7. Discussion

The soils in 7a obviously show the widest variation. The glacial sands and gravels have varying proportions of clay within their mass but usually even in the extreme case given as the first example the stone content is sufficient to allow good drainage and early cultivation. The second example shows the effect of bedding in differently composed strata. 7b and 7c are very similar and represent immature soils not often cultivated.

8. CASSOP SERIES

These ground-water gleys with alluvium occur mainly in valley and depressional sites. The water surplus arises from neighbouring streams or where depressions are enclosed and ponds formed. They are subject to periodic flooding. They are differentiated from Series 9 because they are more localised and no peats are developed. There are ground-water gley horizons within Series 4 but these are usually combined with existing G horizons and have little additional extraordinary influence.

8. Profile 14

1. 0 - 14" A 5Y 5/3 Light olive brown clay-loam. nearly stoneless. Granular structure. Porosity very fine and restricted. Friable to mellow compaction. Consistence loose. Organic matter high. Roots frequent. Drainage free. Only slight rust mottling. pH 5.9. Boundary diffuse.
2. 14 - 21" (B)g Brown and grey mixed and mottled clay. Nearly stoneless. Coarse subangular blocky structure. Porosity by fissure. Tenacious compactness. Very plastic. Low in organic matter. Very few roots. Drainage poor as evidenced by moderate to severe mottling. Reaction pH 6.5. Boundary gradual.

3. 21 - 36"+ G Bright grey-blue and rust mottling. Silty clay. Stony. Large angular blocky structure. No porosity discernible. Tenacious and difficult to dig. The horizon was similar to 2 but absolutely dominated by gleying.

9. PRESTON SERIES

There are as many different horizontal developments as there are profiles in this Series. The two dominating features are banding of peats with silts of sand and the presence of ground water gleying. Variation is horizontal depending partly on topography and extends to great depth in lacustrine deposits as the first example illustrates. The most important distinguishing feature within the Series is how near the lacustrine deposits and thus gleying are to the surface. Depth of the lacustrine deposits is not the sole factor, however, because several perched water tables were encountered in a single profile. Also these soils are developed in depressional sites in the Carrland of Bradbury, Morde and Preston-le-Skerne. The depth of the ground-water gleying will therefore depend to some extent on elevation above the inadequate drainage system that unites in the River Skerne. The profile sites are still subject to frequent flooding, and river alluvium still plays an important part in replenishing the top horizons.

9. Profile 16

1. 0 - 5" A 5YR 4/1 Dark grey clay-loam. Free of stones. Good crumb to granular structure. Because of the mat of roots porosity is generally good. Red and grey mottling at the base of the horizon. pH 7.2. Boundary diffuse.
2. 5 - 18" G Mottled grey, brown and black clay loam with few small stones. Cloddy with some humus still passing down the occasional root channel. Plastic and sticky, quite compact. Mottling dominates the whole horizon. pH 7.3 Boundary clear and sharp.

3. 18 - 21" Black peat with some mineral sand.
4. 21 - 36" Band of stiff clay with silt. Light greys and reds.
5. 36 - 84" Coarse sand in fine sand matrix
6. 84 - 240" Purple-brown platy clay
7. 240 - 252" Gravels
8. 252 - 294" Sand and large gravel
9. 294 - 336" Stiff brown platy clay
10. 336 - 528" Softer brown clay with stones
11. 528 - 564" Damp sandy clay
12. 564 - 618" Brown soft clay with some small stones.

9. Profile 17.

1. 0 - 5" A 5YR 4/1 Dark grey clay-loam almost stone-free. Good crumb to granular structure. Humus rich. Ubiquitous porosity through dense mat of roots. No sign of mottling but permanently high water content.
2. 5- 12" G Mottled greys, yellows, browns. No stones. Clay-loam. Cloddy, granular and fissured. Humus along root channels and worm holes. Gleyed, sticky compact. pH 7.5 Boundary diffuse.
3. 12 - 24" S Mottled yellows, greys and blacks. Micaceous bands of peat and sand and silt. Some stones up to 1" x 1" x $\frac{1}{2}$ ". Cloddy, no roots. Humus-rich, because of peat bands. Extremely gleyed.
4. 24"+ Stiff platy red-brown silty clay. Impervious, dry. Grey bands of wood fragments within the mass.

These two examples illustrate the variety and yet the similarity of soils included within this Series.

10. RICKNALL SERIES

These soils comprise mixed tills of various origin on sites slightly elevated above the basin and valley sites of the previous Series. They usually rest directly on the lacustrine platy clay mentioned earlier. Surface horizons are usually strong and within the clay-loam range but quite considerable bands of sand are encountered, within the profile. Different horizontal development is illustrated in the two examples.

10. Profile 19

1. 0 - 5" A 5YR 4/1 Dark grey clay loam with few small stones. Granular to cloddy structure. Slightly plastic, compact, ubiquitous porosity because of the grass sod. High in organic matter. Slight mottling at the base of the horizon. Boundary diffuse. pH 6.8
2. 5 - 16" (B)g Dark grey brown with red mottling. Clay with sand lenses and stones of various sizes. Cloddy structure. Plastic, sticky, compact. A little peaty humus. Boundary clear pH 7.6
3. 16 - 108" G Mottled red, brown, grey clay with stones and boulders. Plastic and sticky. Peaty humus in cracks at the top of the horizon.
4. 108-240" Leafy platy red-brown lacustrine clay. Compact and impervious. Almost dry when exposed to the air dries to brick-like compactness.

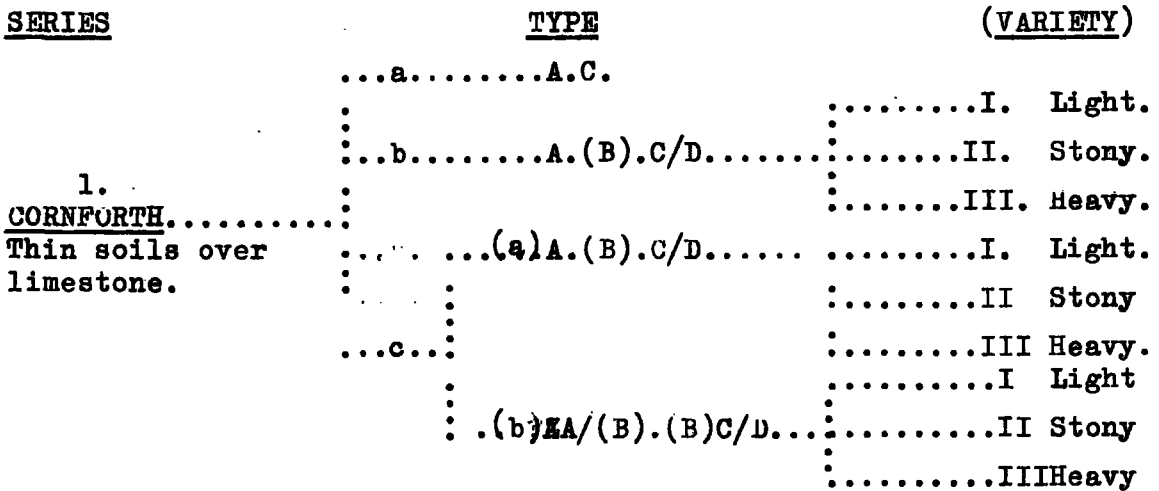
10. Profile 21

1. 0 - 7" A Dark grey loam with a few stones up to 2" x 2". Large granular structure with a tendency to clod. Porosity very varied but generally very fine because of the mat of very fine roots. Mellow compactness. Plastic but not sticky. Drainage adequate, no mottling. pH 6.6. Boundary sharp.

- 2. 7 - 11" A/(B)g 5YR 3/1 Lighter coloured loam to clay-loam with some sand. Similar to above apart from colour change and less organic matter. pH 6.1 Boundary sharp.
- 3. 11 -20" (B)g Red brown, yellow-brown, red and grey mottling with bright streaks of sandstone. Clay-loam to clay with cloddy structure. Compact and sticky. Occasional flecks of humus but horizon dominated by dull mottling.
- 4. 20"+ C Red-brown with grey mottling. Clay loam. Compact almost impermeable. Few stones. Sticky, cloddy. No drainage. pH 6.8

The following scheme illustrates the relationships between the soils described above.

FIG. 81 SOIL GROUPING



2.a. A.C/D
.....a/b.A.A./ (B).C/D.

MIDDLEHAM.....
.....b. A.(B).C/D
Thin soils over
limestonec.A.A/(B).(B).C/D.

3.a. A.(B)/C.....:.....I. Light
.....:.....II. Heavy

KELLOE.....:.....I. Light
Thin drift:.....II Heavy
soils.:.....I Light
.....c. A.A/(B).(B).C..:.....II Heavy

4.
HASWELL Undifferentiated.
Deep drift soils.

5.
SHOTTON Undifferentiated
Mixed drift
soils

6A..Shedding Site
.....b..Stable site
HESLEDEN.....:.....a/b Transitional
Light Triassic:.....c..Collecting site
drift soils.

7. a Glacial sands and gravel: ..I..Light
.....: ..II.Heavy
MAINSFORTH.....:.....b Middle Sands
Sand and gravelc Blown Sand
soils.

8.
CASSOP..... Undifferentiated
Alluvial and ground-water gleysols

9
PRESTON..... Undifferentiated
Lacustrine and peaty soils.

10. RICKNALL.....Undifferentiated - Drift (over lacustrine)soils.

Chapter 6.

THE HIGHER GROUPING OF THE SOILS

The Soil Series adopted were established in the belief that soil factors control soil processes which in turn control soil properties (7). This will explain some of the departures from conventional classification seen in the range within individual Series. A system must be based on the objects themselves. Different soil properties or even factors and processes could be emphasised to group the soils in a conventional manner; but the spatial distribution of the soils themselves is important in deciding what classification is adopted. There is a logical progression written into the Series classification above.

Classification at Parent Material Level is in this case largely academic. The following scheme illustrates this.

(Fig.82) <u>Parent Material Association</u>		<u>Series Included</u>
	.... I <u>Cornforth</u>	1 and 2.
	..... Limestone and drift	
...A...	.....
	....II <u>Haswell</u>	3,4,5,6 and 10.
	..... Drift	
GEOGRAPHICAL	.....
SOIL	.....
ASSOCIATION:	....III <u>Mainsforth</u>	7.
	..... Sand and gravel	
	....B...	
	.....IV <u>Preston</u>	8 and 9
	..... Peat, lacustrine and alluvium	

The dominant Series name is given to the appropriate Parent Material Association. It is clear that Associations I and II are linked in depth progression and that III and IV are linked in mode of origin. These two groups A and B are related in source of origin and thus the soils of the whole plateau fall neatly into a Geographical Soil Association (7).

It would perhaps be better to leave classification at this point, because to go further involves a long history of controversy and gives undue emphasis to a minor part of the problems of soil survey as

conceived by this thesis. It is difficult to fit the Series developed here into any system from Thaer, based on texture, humus and lime content, to Dokuchaev and Sibirtzevs' concept of zonality or indeed that of the later Russian School (33). At Series level the influence of Kubiena (6) must be acknowledged but drift soils do not fit a system with any degree of zonality. Where cultivated these soils might be classed as Brown Earths (see section two): where under deciduous trees they would be Brown Forest Soils and where under conifers they would be immature podsoils. Order and class in the American and French systems (24) are similarly difficult to accommodate. Vilenski (8) introduces the concept of domestication of soils although his three stages- slightly, moderately and extremely cultivated soils is not satisfactory. It is however from this agricultural point of view that the above Series were established. Agriculturally significant units or spatial distribution was considered more important than the controversial 'natural' or 'artificial' concepts of Kubiena (6) and Leeper (6). For this reason diagnostic horizons were taken into account and the Seventh Approximation (5) was useful. In such biased systematisation higher categories are of necessity difficult. For academic interest, but with the mentioned reservations, the European systems of Duchaufor (1956 34) and Kubiena (6 1958) involving (A)C., AC., A(B)C., and ABC soils are chosen as the least disturbing method of higher classification. (See also Joffe, (35) and Avery (35) and section two chapter 2.)

AC Soils

Semi terrestrial : Series 8 and 9 as humus gley soils and peats. Terrestrial: 1a and 2a as rendzina-like soils.

A(B)C Soils

Terrestrial: 1b,c,2b,c,3,4,5,6,7, and 10 as variable Brown Earths of high base status. (Eutrophic braunerde).

The soil classification system used for a soil survey is fundamental to the success of the survey and if it is to be a valuable system its nature must be determined by the nature of the survey (1). The idea

of a soil classification system which may be applied generally is valid only if the criteria required for different purposes are similar or correlate closely. Such general purpose systems may thus be of strictly limited value particularly when used over a wide range of environments. The two solutions to this problem are selecting better general key criteria or adopting a specialist classification for different purposes and both are of limited value.

Profile Characteristics

Chapter 7

Certain chemical characteristics of profile development were not described in previous discussion of horizon differentiation. They are investigated below with reference to the graphs in Appendix II.

|| ...pH.

Several interesting patterns of pH change down the profile emerge from a study of the pH graphs. pH correlates in absolute terms, with important implications for liming practice.

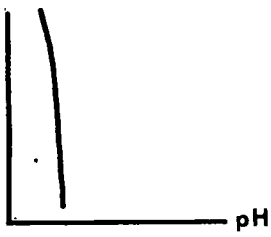
1. Soils of the Cornforth Series, Type a, have pH of over 7.0. This applies to Type b and in the lighter variety of type c. With the introduction of more mature profiles in Type c, (b)II and (b)III there is a probability of slight acidity, particularly in A/(B) horizons. (Profiles 13, 14 and 36.) Liming will be needed regularly on these heavier, more mature limestone soils, when under cultivation.
2. The Middleham Series with much brash limestone incorporated in the profile are always above pH 7.0.
3. The Kelloe Series repeats the pattern of the Cornforth Series. Types a, (A(B)/C) and b, (A(B)Cg) are slightly alkaline throughout whereas the more fully developed Type c, (A A/(B) (B) C) has slightly acid conditions in the A/(B) horizon. The (B) horizon shows an increase in pH to more than 7.0. It is interesting to note that where the top-soil is disturbed by ploughing the low section of the pH graph curve is pushed further down the profile. (See also Profiles 34 and 36).
4. In the Haswell Series the topsoil is often acid although at depth pH is always above 7.0. Liming is especially beneficial on these soils, both to counter acidity and to improve soil structure when ploughing up the sticky gleyed subsoil.
5. The mixed drifts of the Shotton Series also produce low pH in the topsoil (below pH 6.0). At depth very high pH (8.5-9.0) is the general rule. Regular liming is essential, for the same reasons as in Series 4.

6. Ploughed soil in the Hesleden Series Type a, (Shedding site) and b, (Stable site) are adequately supplied in weathered carbonates (Profiles 56 and 84, but the deeper profiles of Type c (Collecting site, c.f. Profile 57) have pH as low as 6.0 and need annual liming. This is despite the concentration of Magnesian Limestone in the topsoil. This and variations at depth will be described below.
7. The sandy and gravelly soils of the Mainsforth Series are, as one might expect, low in lime but periodic small-scale application maintains satisfactory status.
8. The ground-water gleys of the Cassop Series are acid (pH 6.0) in the surface soil, but where ploughed there may be a slight rise in pH at the junction with the gleyed subsoil. Even here however pH is usually less than pH 6.5 (Profile 47). Liming is essential even when, as is often the case, these soils are down to grass.
9. The Preston Series of peats and lacustrine and alluvial soils have slightly acid top-soils. They are usually devoted to grass which rapidly deteriorates to moor and marsh species when not limed.
10. The Ricknall Series comprises varied mixed drifts but slightly acid top-soils are invariable (pH 6.0 - 6.5).

The shape of the pH curve is important and more detailed inspection reveals interesting correlation. The distinguishing features can best be envisaged by reference to the diagrammatic abstracts adjacent, which are derived from pH graphs in Appendix II. In the lighter varieties or immature profiles of Series 1, Types b, (A(B)C/D) and c, (A A/(B)C/D), Series 2, and 3a (A(B)/C) the pH varies very little down the profile. (See Figs. 83 - 110). This is to some extent the function of light texture and illustrates the immaturity of the profiles (Figs. 83, 86, 89, 92 and 95).

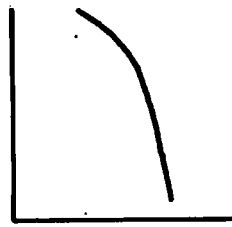
In the stony varieties of 1b, (A(B)C/D) and 1c, (A(B)C/D) and in 3b, (A(B)Cg) pH increases with depth. (Figs. 84, 87, 90 and 93).

Depth



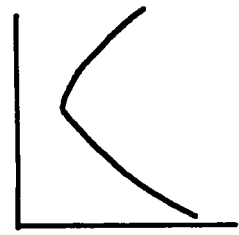
Series 1b I Profile 33

Fig 83



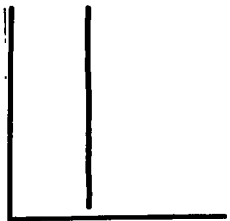
1b II 37

84



1b III 36

85



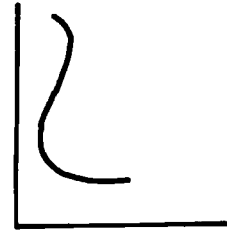
1c a I 4

86



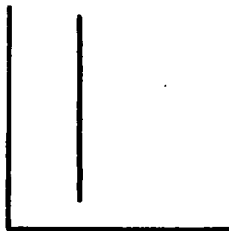
1c a II 5

87



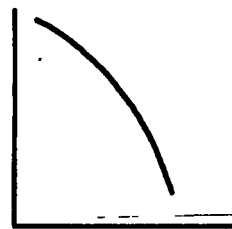
1c b III 34

88



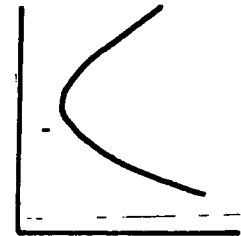
1c b I 28

89



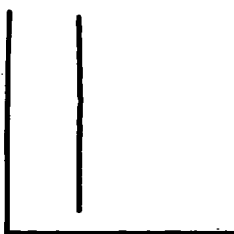
1c b II 13

90



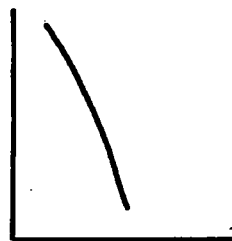
1c b III 35

91



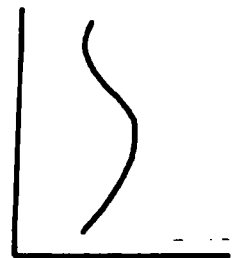
2c 29

92



3b 6

93



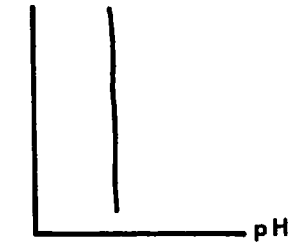
3c 9

94

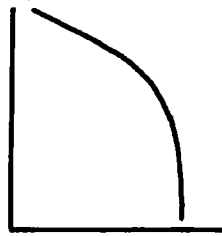
Y

pH CURVES.

Depth



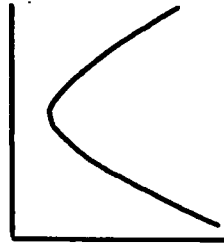
Series 3a Profile 7
Fig 95



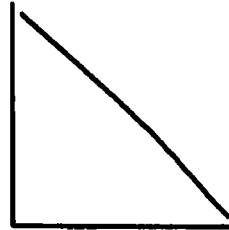
4&5 15&48
96



6a 56
97

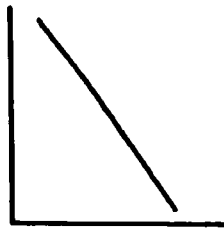


6b 8
98

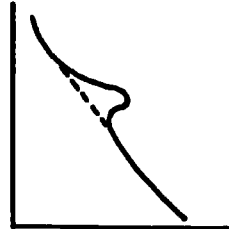


6c 57
99

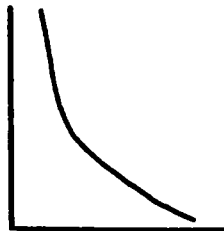
pH
CURVES.



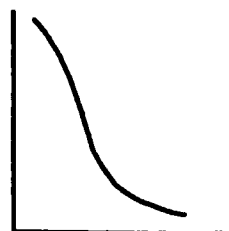
7 15
100



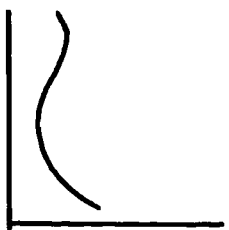
7 50
101



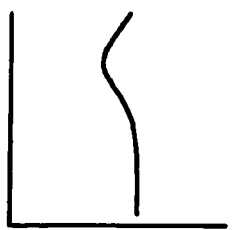
8 14
102



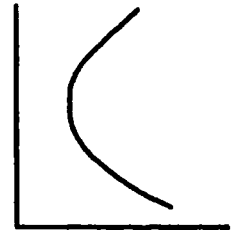
8 47
103



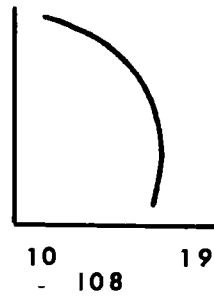
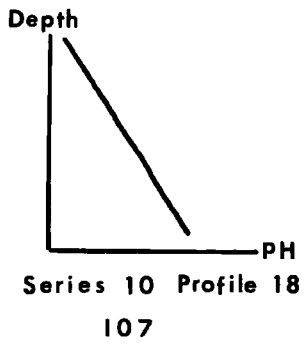
9 16
104



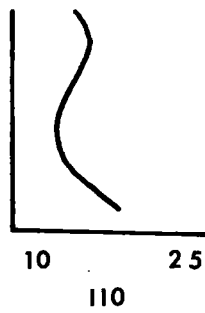
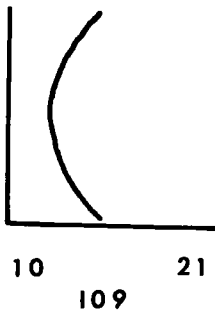
9 17
105



9 27
106



pH CURVES.



Maturity of profile or increasing clay content is expressed in lower pH in the A/(B) horizon, or (B) in 1b III. See diagrams illustrating 1b III, 1c III (i and ii) and 3c (Figs. 85, 88, 91 and 94). Cultivation results in the lowering of pH in the topsoil as seen in the first example of 1c. In deeper soils such as 3c the A/(B) has a low pH (6.4) and the (B) horizon shows a rise to over pH 7.0. Below this pH falls again to pH 6.5. (Fig.94). The mixed drifts of the Shotton Series produce low pH in the topsoil (below pH 6.0) but there is a rise on a convex curve to very high pH (8.5 - 9.0) (Fig.96). In the Hesleden Series site conditions are important. Shedding sites (6a) have pH above neutrality as weathering of the calcium-rich drift continually replenishes the surface soil. The curve (Fig.97) shows a convex increase in pH with depth, but there may be a slight negative fluctuation at the top of the weathered drift. Stable sites have more mature profiles and the A/(B) horizon has a pH of 6.5 (Fig.98) while in the (B) horizon there is a rise to pH slightly over 7.0. Collecting sites are lighter in texture and the top horizon is acid at for example pH 6.0 (Profile 99). There is a straight line increase to pH 8.5 in the C horizon but neutrality is not attained until considerable depth, in the (B)/C horizon.

The sandy and gravelly soils of the Mainsforth Series have low pH in the top-soil (pH 5.5 - 6.0). In the heavier variety there is a straight line rise to pH 8.5 at depth (Fig.100). In the deep glacial sands more mature profiles seem to develop (Fig.101), with low pH in A and A/(B) horizons and a rise to neutrality at 30 - 40" in the (B) horizon. Below this pH falls off in the C horizon but in Profile 50 (Fig.101) a band of limestone and gravel at 60" lifts alkalinity to pH 8.5.

The Cassop Series of ground-water gleys shows a ^{convex} concave increase in pH from 6.0 in the A horizon to pH 8.5 deep in the C horizon. (Figs.102 and 103). This is the only concave curve encountered. Where there is cultivation there may be, as already mentioned, a slight rise in pH at the top of the gley. The Preston Series of peats and alluvial soils developed over lacustrine deposits show the strongest signs of podsolisation in contorted S shaped pH graphs, but the influence of peat bands is a disturbing factor. There is a positive pH trend in the (B)

horizon and a strong negative disturbance above this. As in 1c ploughing pushes the negative pH zone lower down the profile. (of profile graph shapes Figs. 104, 105, 106).

The pH graph in the Ricknall Series varies considerably depending on the variety of materials encountered in the mixed drifts. (of Figs. 107, 108, 109 and 110).

Total Carbonates

Using graph shape down the profile total carbonates show marked differences from pH trends in some cases while ⁱⁿ others they are very similar.

In all 1b and in 1c, (b)I and (a)III there is a straight vertical line representing little change from a high carbonate status (20%). In 1c, (a)I and (b)II, carbonates rapidly increase in percentage in a concave shape although the pH line shows no change down the profile. This is because there are variable but increasing amounts of unweathered Magnesian Limestone in the profile at depth and is no reflection on profile maturity.

In Series 3, pH variations are again not met by variations in the carbonate graph. This is because carbonates are very low (less than 3%) and do not influence this series, the first of the non-limestone series, substantially in chemical processes. Physical effects are, however, important as explained when differentiating the soils into Series.

In Series 4 and 5 carbonates and pH follow the same increasing convex shape to 30 inches and then level off down the profile. This reflects the immaturity of horizon development. Calcium is reduced in the root supporting horizons but there is a pH of 8.5 - 9.0 in the parent material and total carbonates amount to 28% (Profile 48. Figs. 96 and 117).

In Series 6, the shedding site shows an interesting S shape in the carbonate graph. Carbonates are low in the top 20 inches which represent the shedding soil. Below this there is accumulation in the (B) not reflected in the pH graph. If the trend above (B) is projected

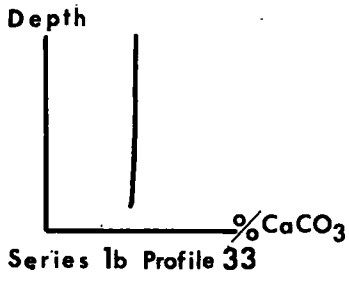
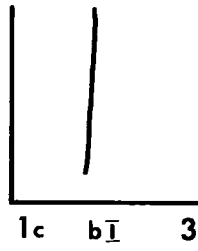
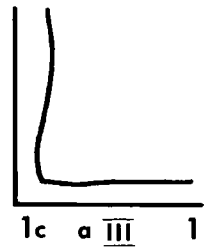


Fig III



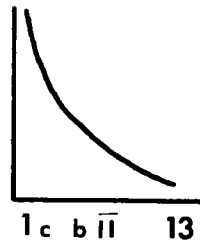
112



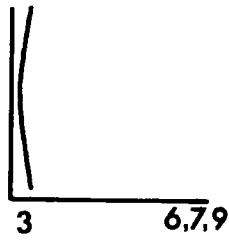
113



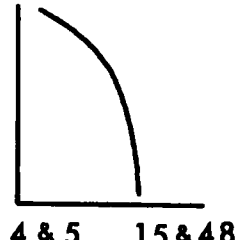
114



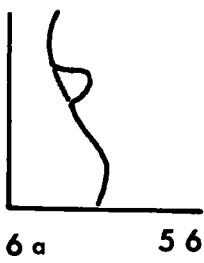
115



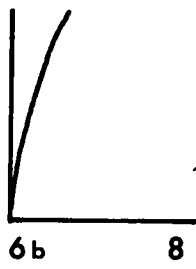
116



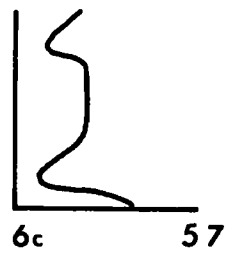
117



118



119



120

CaCO₃ CURVES.

(dotted line Fig.118) it meets the carbonate concentration below the (B) horizon. This is similar to the pH graph of profile 50 and substantiates the claim of carbonate accumulation. There is a levelling off, still within the weathered material, at 17% total carbonates.

The stable site (Fig.119) shows the effect of stability in the carbonate graph better than in the pH graph. All carbonates have been leached out of the A and (B) horizons and high concentration is not achieved till some depth into the parent material.

The carbonate graph for the collecting site (Fig.120) substantiates horizon designation where the straight lines: rise of the pH graph does not. The surface is endowed with carbonates to 7% (partly through replenishment), but these correspond with a PH of 5.6! As pH rises in A(B) carbonates are weathered out to a mere trace. This may account for some of the rise in pH. The deep (B) is reflected by accumulation of carbonates to 4-5% (and a continuing rise in pH^{to} 7.0). At 44" the influence of (B) accumulation disappears and carbonates amount to only 1-2%. Here they are highly weathered (seen in the profile face) and supply to maintain a rise in pH is not withdrawn. pH is over 8.0. The Upper drift below shows clear differences from the weathered C horizon above, in that carbonate content rises to 13%. This corresponds with the largely unweathered limestone of the top horizon. Change in pH is not dramatic. The lack of correspondence between pH and carbonates is quite remarkable.

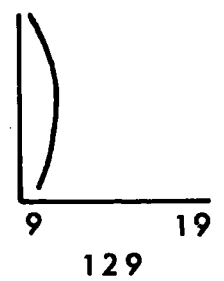
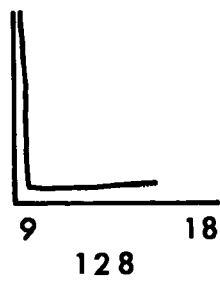
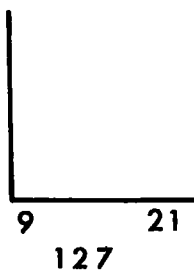
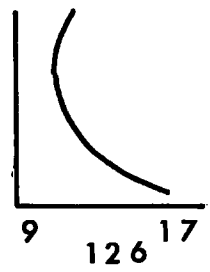
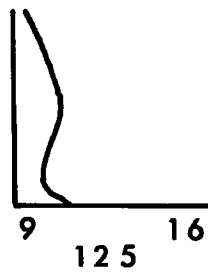
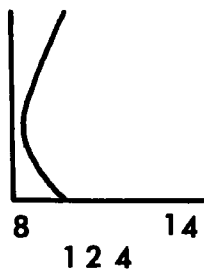
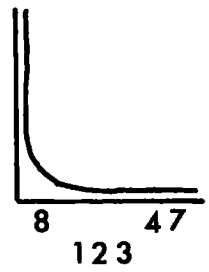
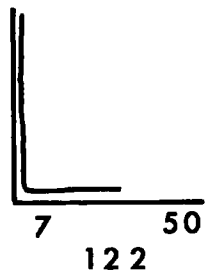
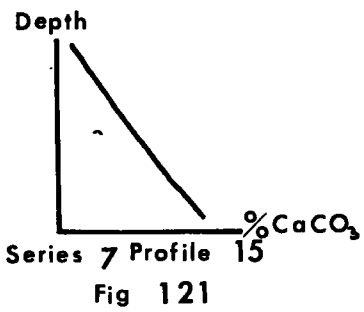
(Fig.130)

Profile 57

30 - 36"	pH 7.6	4.5% total carbonates.	(B)
36 - 48"	8.3	2.0	C
48 - 56"+	8.6	13.0	D

The carbonate graph for the heavier textured variety of Series 7 corresponds exactly with the straight lines increase in pH. Carbonates from 0 - 10% and pH from 5.6 - 8.5.

This correspondence does not apply in the lighter sands for example in profile 50, (Figs.101 and 122). Here the pH shows a slow concave rise between pH 6.0 to pH 7.0 disturbed by higher pH in the (B) horizon.



Ca CO₃ CURVES.

The carbonate graph shows only a trace down to 60" where a band of limestone and gravel reveals 18% carbonates. Weathering is still active here and pH rises sharply from 6.9 to 8.3. Carbonates in Series 8 are very variable from profile to profile. For example in Profile 47 where pH increases on a slightly concave curve from pH 6.0 to pH 8.2 (Fig.103) carbonates are only represented by a trace until a band of limestone gravel is encountered at depth (Fig.123). In profile 14, (Fig.124) however, there is a more substantial amount of lime in the surface soil at 5%. This declines to nothing just above the surface of the gley. The gley horizon has 2% carbonates. The pH graph (Fig.102) disregards these fluctuations and follows a slightly concave increase throughout as in the previous profile.

Soils of Series 9 show very erratic carbonate graphs which cannot be smoothed out by ignoring peats, or by projecting trends. Surface carbonates are found only in trace amounts (Figs.125 and 128). Below this fluctuations vary to maxima of 4 or 5% but certain bands may contain over 10% carbonates (Profile 128). Profile 17 (Fig.126) shows a different pattern with 5% carbonates at the surface disappearing to a trace at 10 - 20" and then rising to 7% at 30". It is impossible to determine which parts of such complicated graphs are due to pedogenetic processes and which to inherent properties.

In Series 10 carbonates are either absent as in Profiles 21 and 25, (Figs.127 and 131) or are consistently below 2% as far down the profile as is important to plants (Profiles 18 and 19) (Figs.128 and 229). In Fig.128 the sharp increase to 10% carbonates is due to a band of clay with limestone gravel and this occurs at 55" and has no obvious agricultural significance.

Organic Matter

The distribution of organic matter down the profile is obviously affected by cultivation, particularly in the top horizon (see graphs for Profile 37 and 12). There are important observations arising from the graphs, although correlation within the Series is difficult.

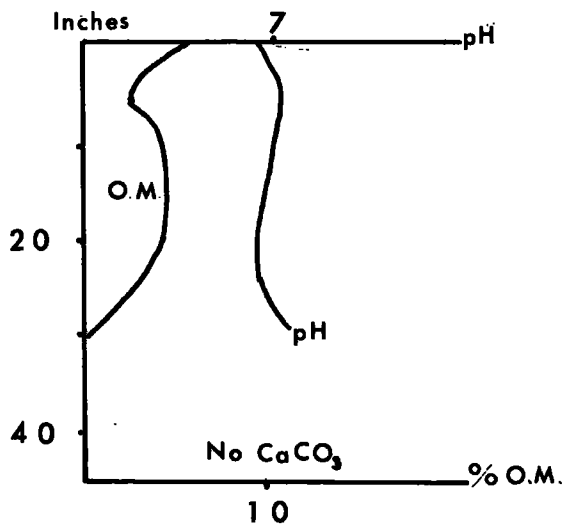


Fig 131 Profile 25

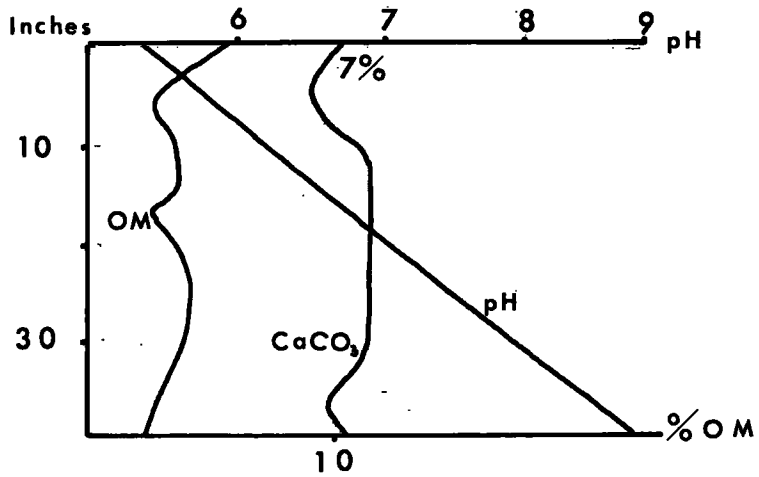


Fig 132 Profile 102

Most soils in Series 1, 2, 3, 4, 5 and 6b have only a slightly varying pattern of humus declining with depth from the surface (where humus is comparatively high). The only profile encountered in these Series with signs of humus depletion and accumulation was in Profile 36 (1b Type III). This isolated observation is dubious. The lighter texture variety of Series 3 Type c, (A A/(B)(B)C) (Profile 9) shows humus extending to a greater depth than in any of the limestone soils or than the clay soils of Series 4 and 5. The shedding site and collecting site of Series 6 Profiles 101 and 102 show S shaped curves (Fig.132). In 102 there is double accumulation of organic matter. (Profile 103) (shedding) and 104 (collecting) are different in that the graphs are smoother and do now show pronounced zones of accumulation, although organic matter is present in appreciable amounts to considerable depth. This is a function of the light texture of the soil and the feature is repeated in the Mainsforth Series. Here despite differing amounts of humus in the topsoil humus persists to at least 30" in both Profile 15 and 50. Profile 50 has been under grass for at least one hundred years.

Organic matter persists down the profile in the ground-water gleys of Series 8 and in Profile 14 there are signs of accumulation above the G horizon. This is doubtless because of conditions unfavourable for organic decomposition.

In Series 9 the influence of peat is marked. In Profile 17 the alluvial material contains organic matter to depth in the form of wood and leaf fragments deposited with the silts and clays. Profile 16 reveals one of the many marked peat horizons encountered.

Series 10 has different organic matter graphs which are very variable. One graph (Profile 25, Fig.131) is very interesting. The organic matter graph has a marked S shape, although the total quantity is low. The pH graph meanwhile shows a direct mirror image. pH increases as organic matter decreases, and decreases where organic matter increases (Fig.131) an understandable phenomenon.

The general conclusion obtained from comparison of the above collection of graphs is that pH, carbonates, organic matter and clay do not necessarily change at the same pace or degree down the profile. It may be that there is a sequence of movement in the combination of processes, and that certain processes must become more or less at equilibrium with each other before others become fully active. There are many instances to substantiate this but the example of Profile 102 is the most useful. Here both the carbonate graph and the organic matter graph show accumulation and loss of material, but in different parts of the profile (which was sampled at every two inches to 60"). Carbonates are low in the A/(B) horizon but accumulate throughout the thick (B) horizon. They are present to 60" but in smaller quantities. Organic matter meanwhile accumulates in the A horizon, in the top only of the (B) horizon and in the top of the (B)/C horizon. It is low in the A/(B) (as are carbonates) and in the middle of the (B) (not the case with carbonates). The pH however has a straight line rise from surface to depth. It is tempting to postulate a progression of movement down the profile in sequence of humus, carbonates, pH and clay but no fast conclusion can be drawn except that there is room for further study.

It will be noticed that in the different graphs there are often close similarities in particular aspects between soils of different Series. This is not surprising when considering the many and variable forces which work to level out conditions. What is surprising is that, although by no means complete, there is substantial agreement within Series. This has not always been the case in many soils grouped together as Series (36).

Cationic status

In absolute terms cationic exchange capacity is very low in many of the soils throughout the region, particularly in the heavier clay soils. It reached higher levels in shallower soils with good drainage and a high organic matter content. The potassium ion was particularly

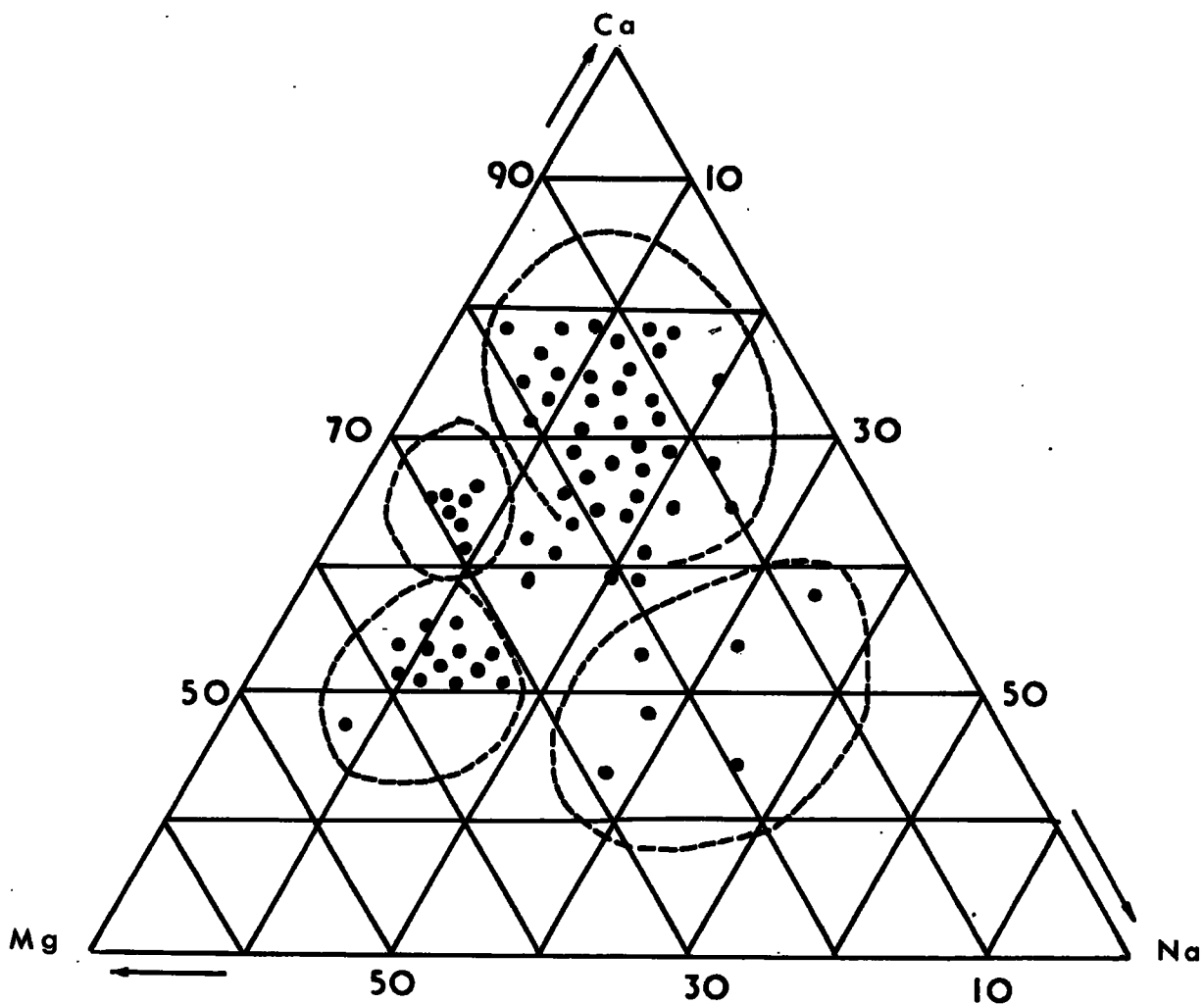


Fig 133 % meq/100gms soil Ca/Mg/Na in samples from all

Soil Series.

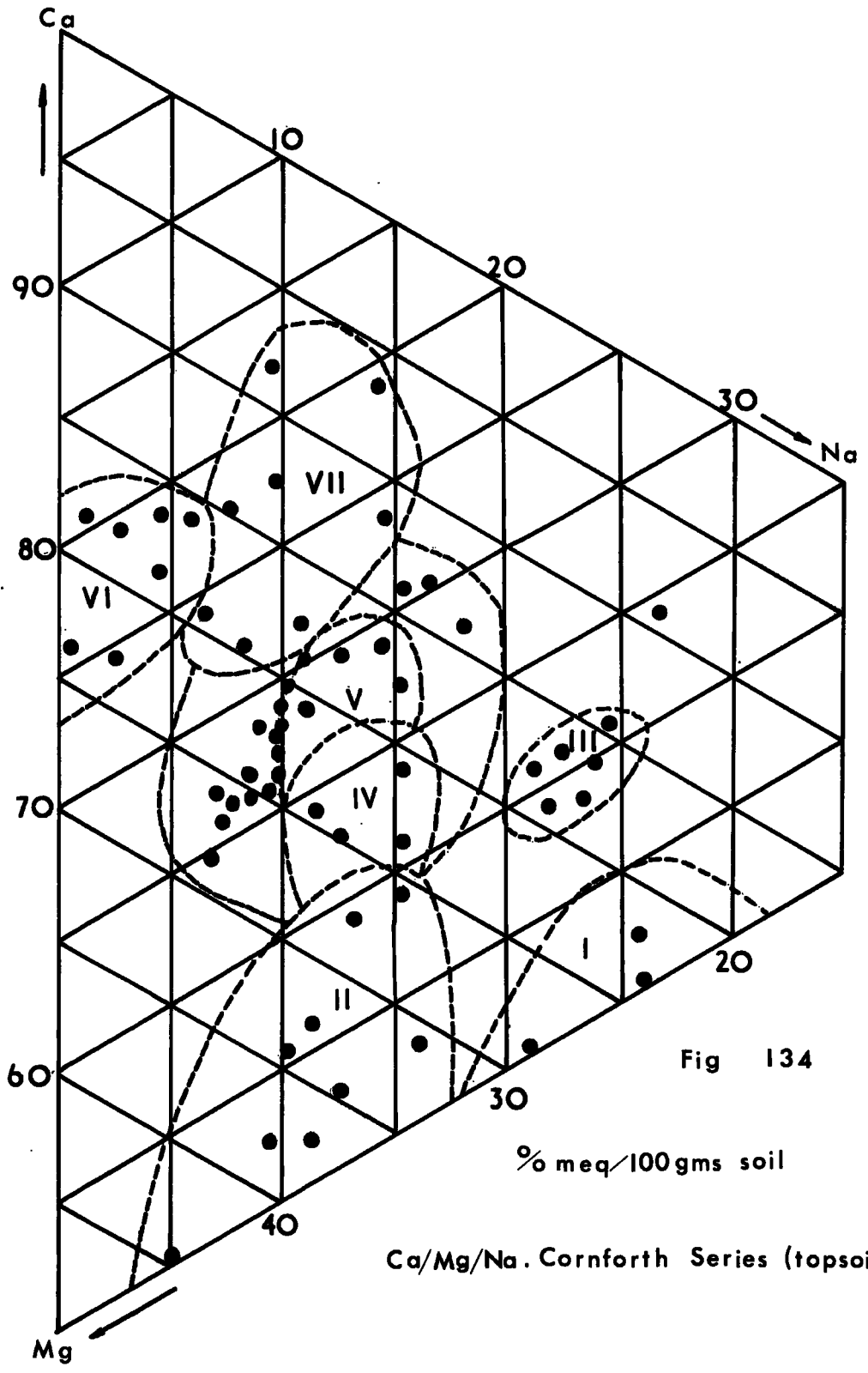
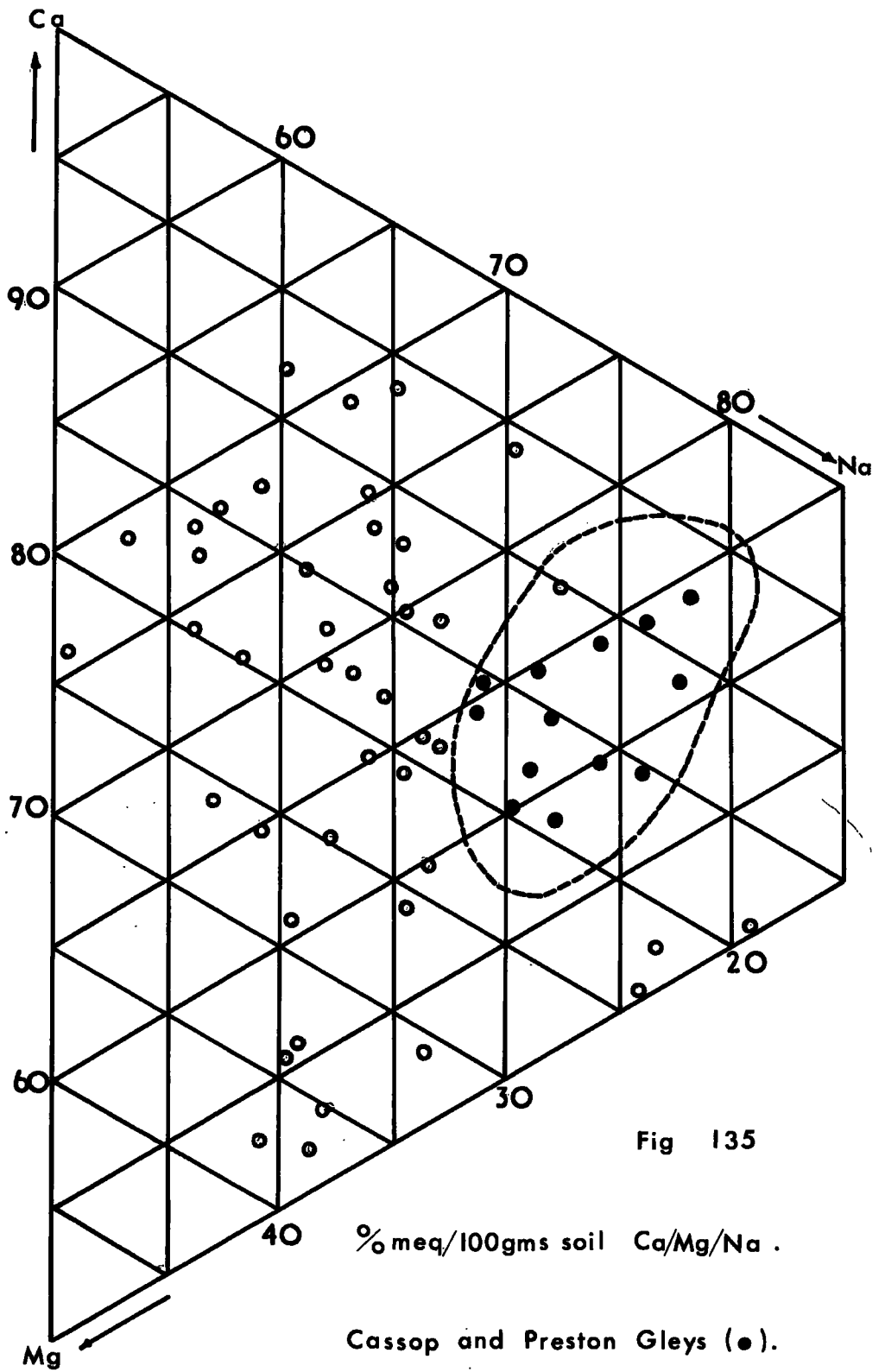


Fig 134

% meq/100gms soil

Ca/Mg/Na. Cornforth Series (topsoil).



low throughout. Several interesting patterns emerged mainly when considering cations in proportional relationship to each other rather than as absolute meq/100 gms. soil.

Plotted on triangular graphs Mg/Ca/Na relationships, in the topsoil only, seems to segregate into clear groups (Fig.133). On breaking down the composite parts it was found that only soils of the Cornforth Series in fact maintained this particular triangular relationship. The topsoils here seem to some extent correlated to type of limestone beneath and degree of incorporation of limestone within the soil profile (Fig.134). The following groupings correspond with Fig.134.

- I. Soils with incorporated brecciated and fragmented limestones developed above thin bedded limestone.
- II. Soils over bedded limestone with little or no incorporation of weathered limestone material.
- III. Soils directly above limestone but with gleying within two feet of the surface.
- IV. Soils above soft, friable and powdered limestone with variable incorporation into the solum.
- V. Similar to I, broken limestone with some weathered powdering, over bedded limestone.
- VI. Deeper soils incorporating fragmented limestone.
- VII. Deeper soils developed over Magnesian Limestone in the Pontefract area of the West Riding of Yorkshire.

The correlation of surface cationic relationships with limestone type is not sufficiently substantiated to arrive at satisfactory causes. It may be due to drainage influences or chemical effects of different limestone types or could be purely coincidental correspondence with different humus forms. Examination of similar relationships for other soils revealed little correlation except in the case of the Preston and Cassop Series of ground water gleys which are all grouped within

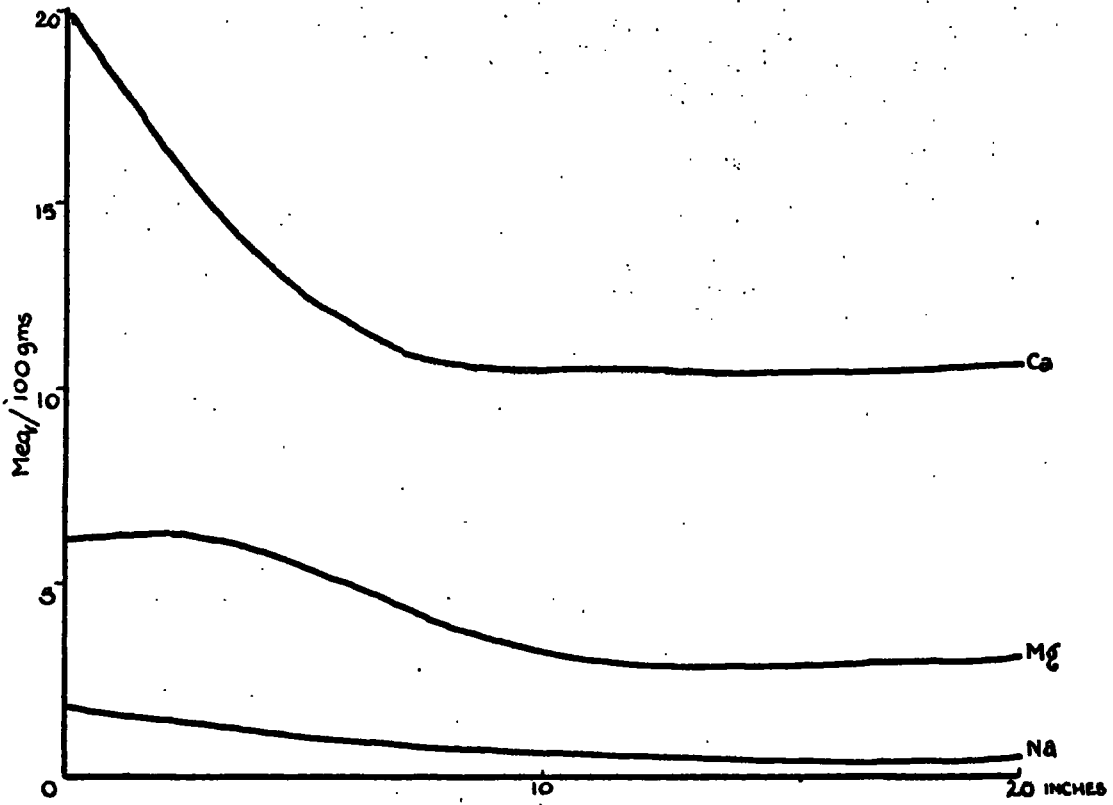
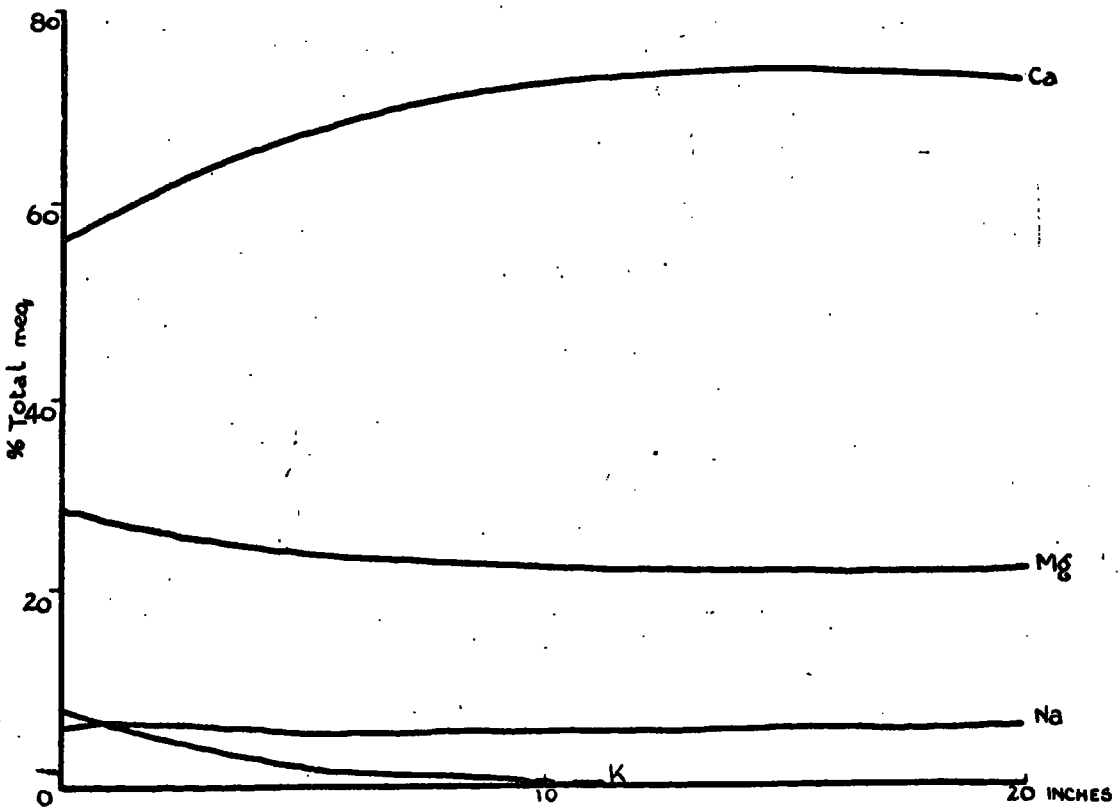


Fig. 136 PROFILE 28.



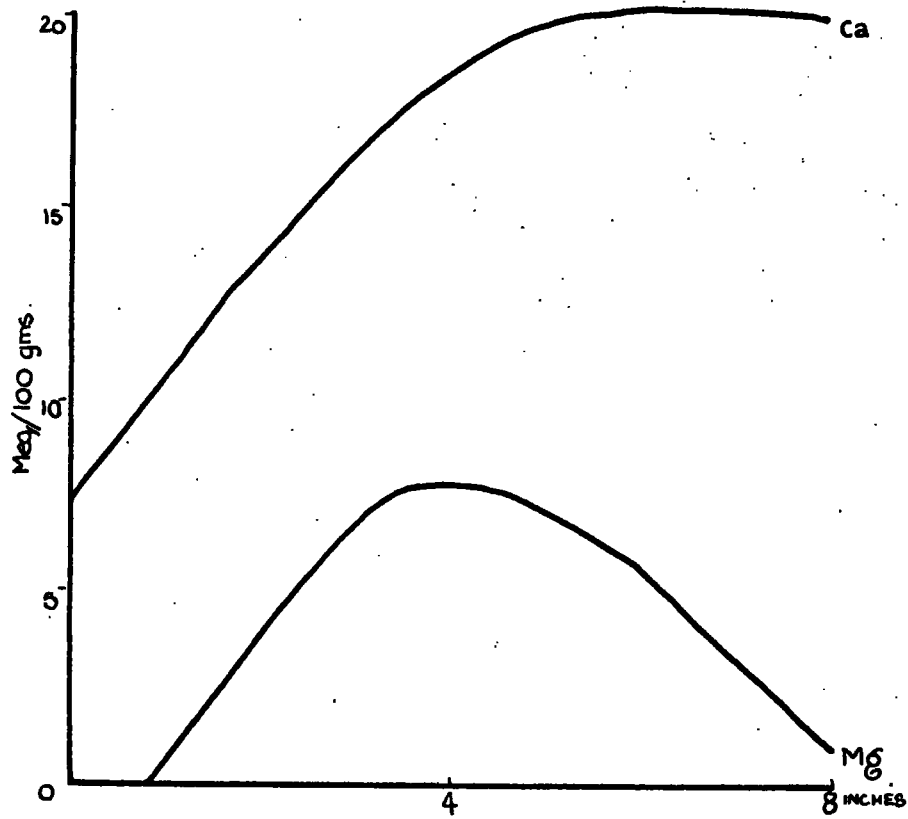
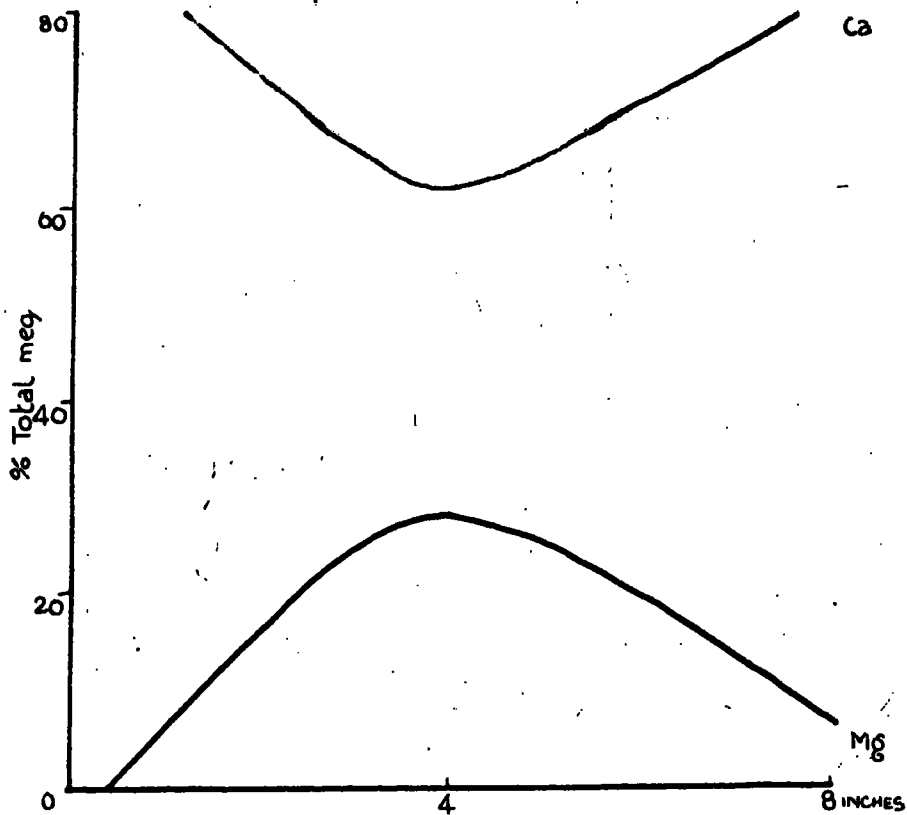


Fig. 137 PROFILE 37.



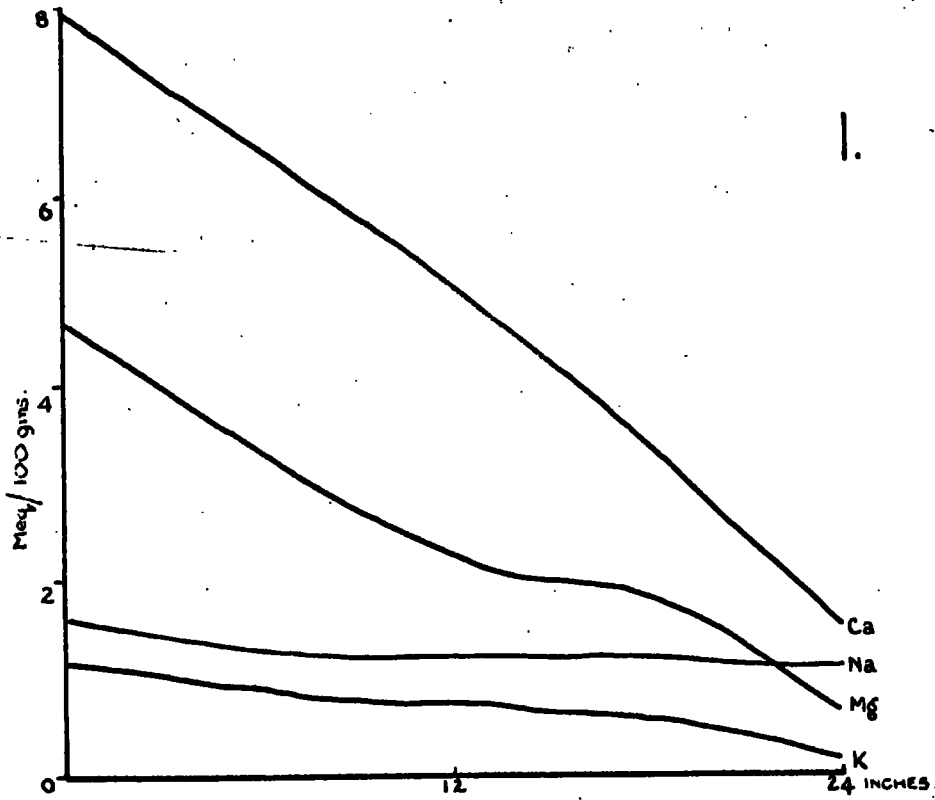
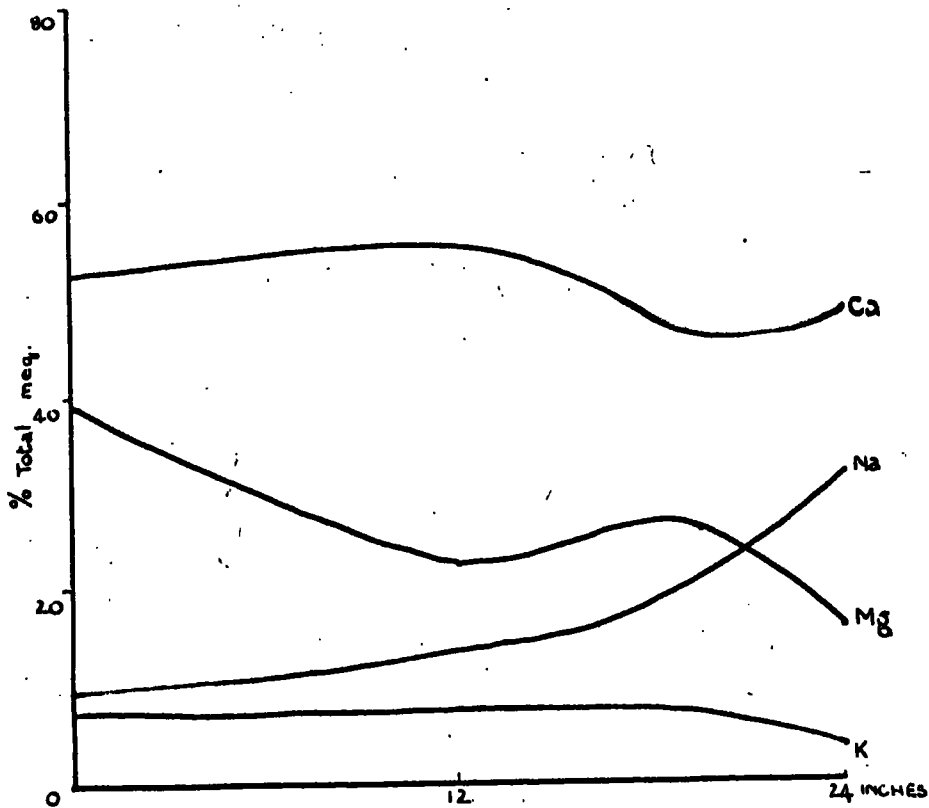


Fig. 138 PROFILE I



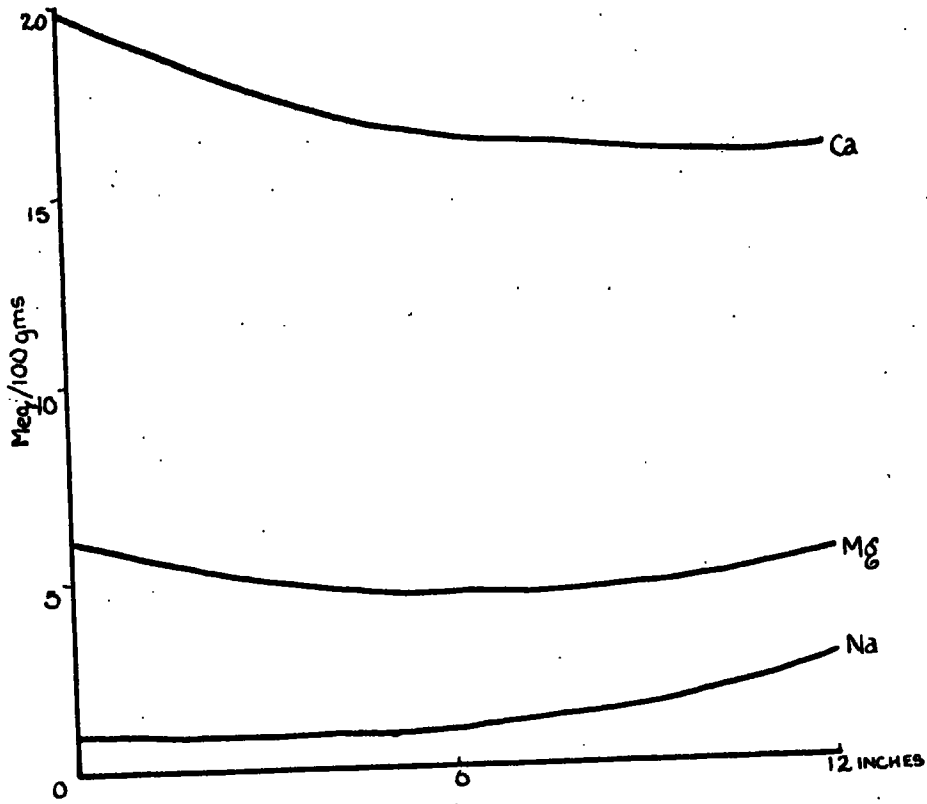
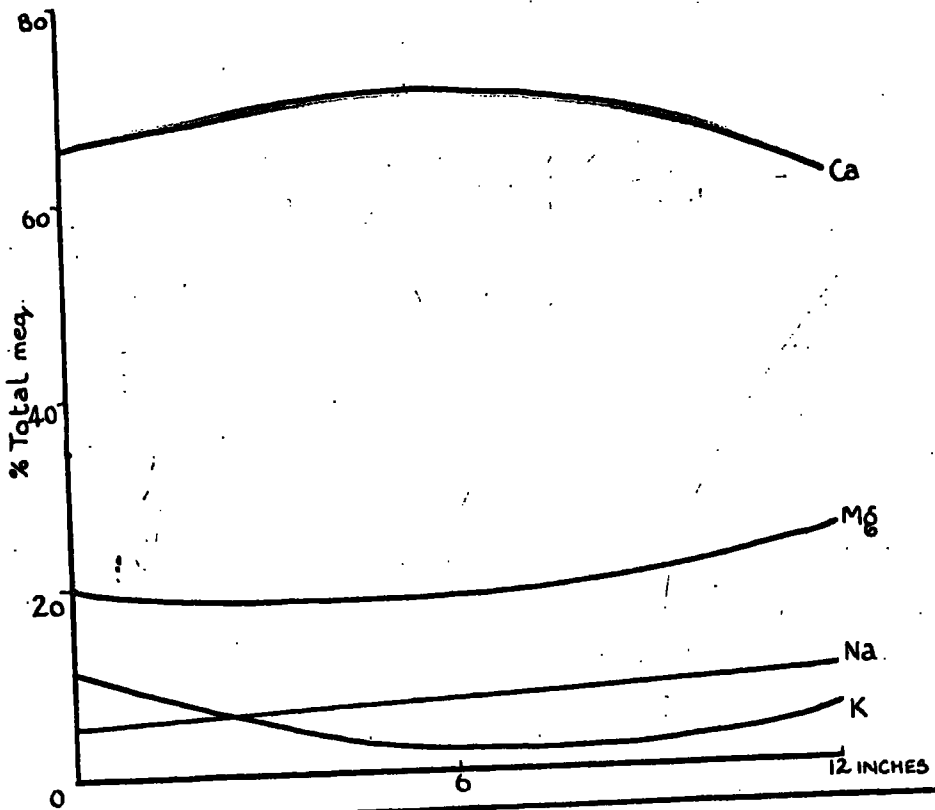


Fig. 139 PROFILE 34.



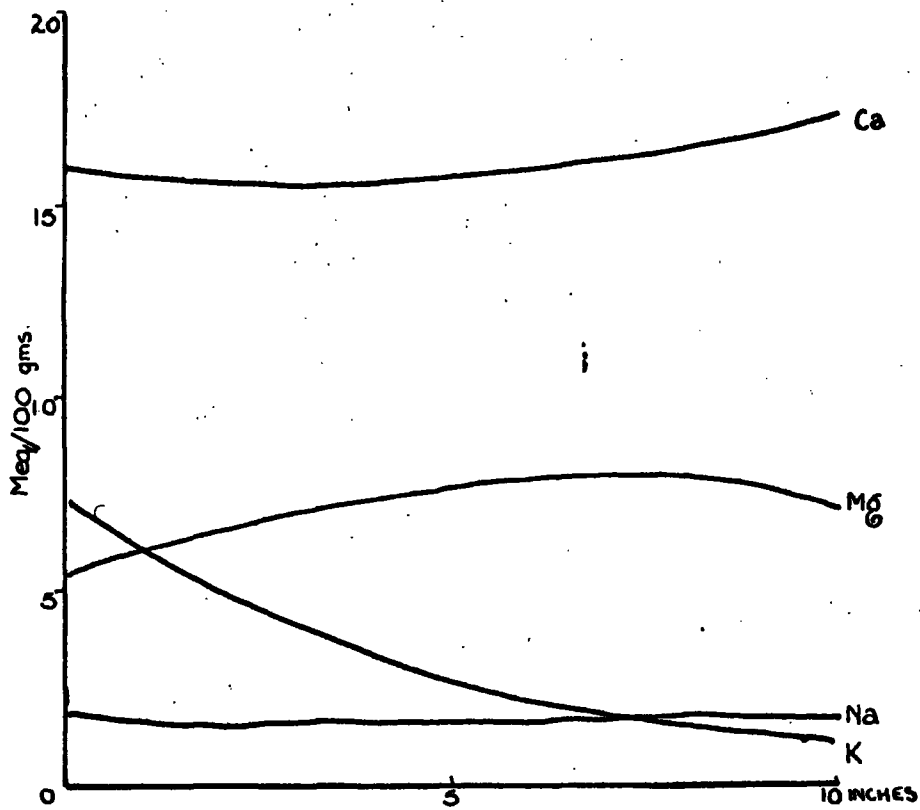
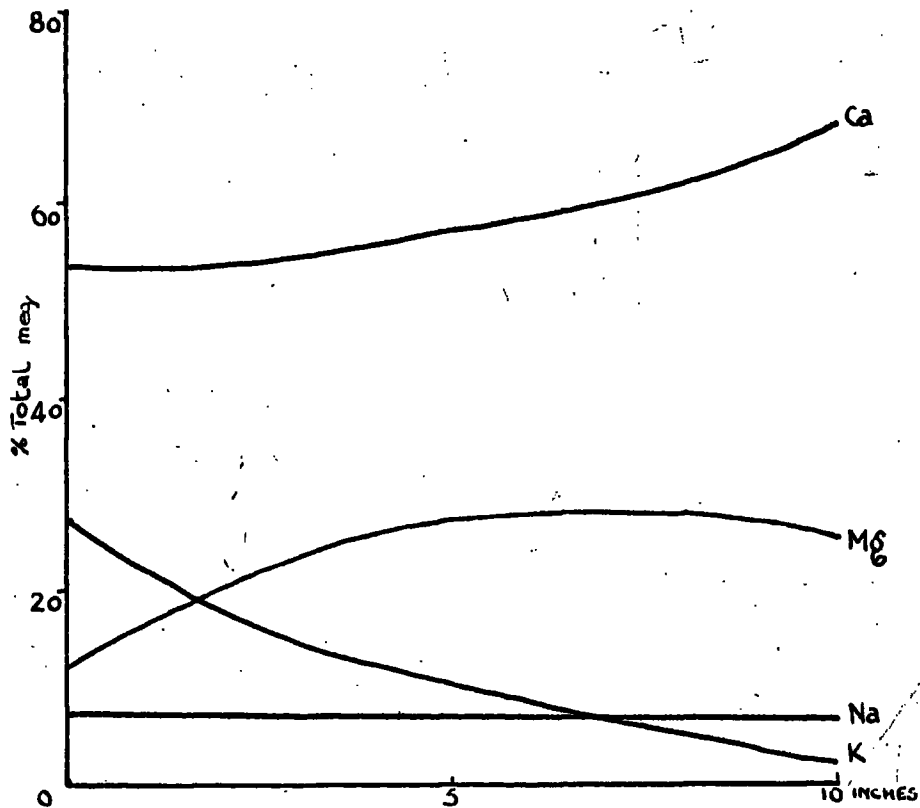


Fig. 140 PROFILE 33.



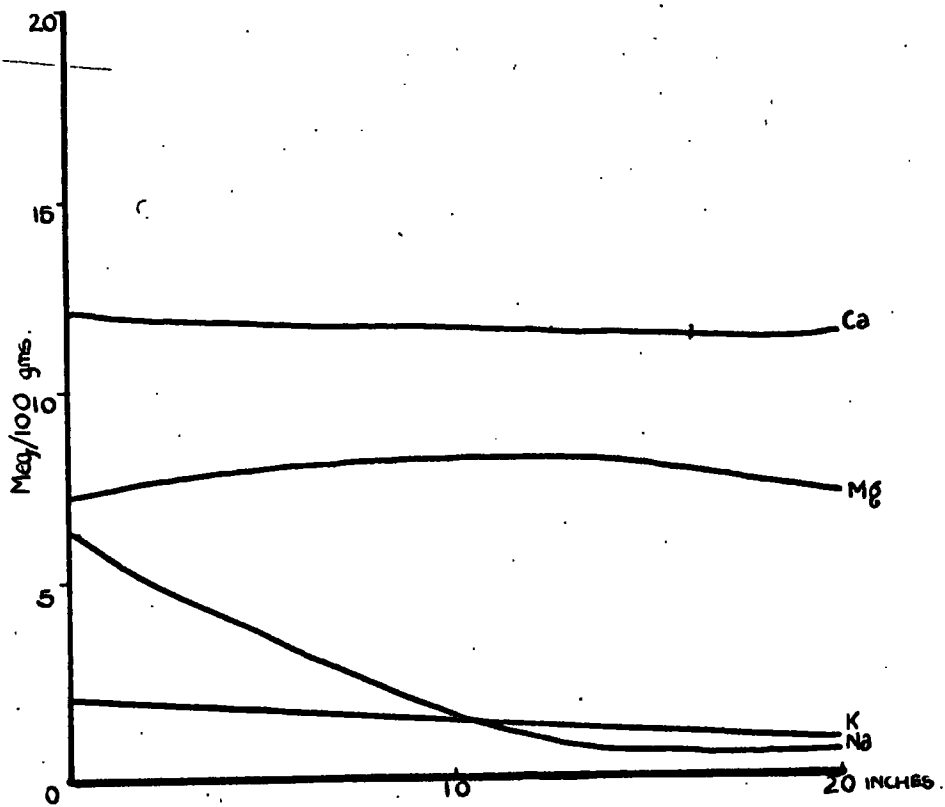
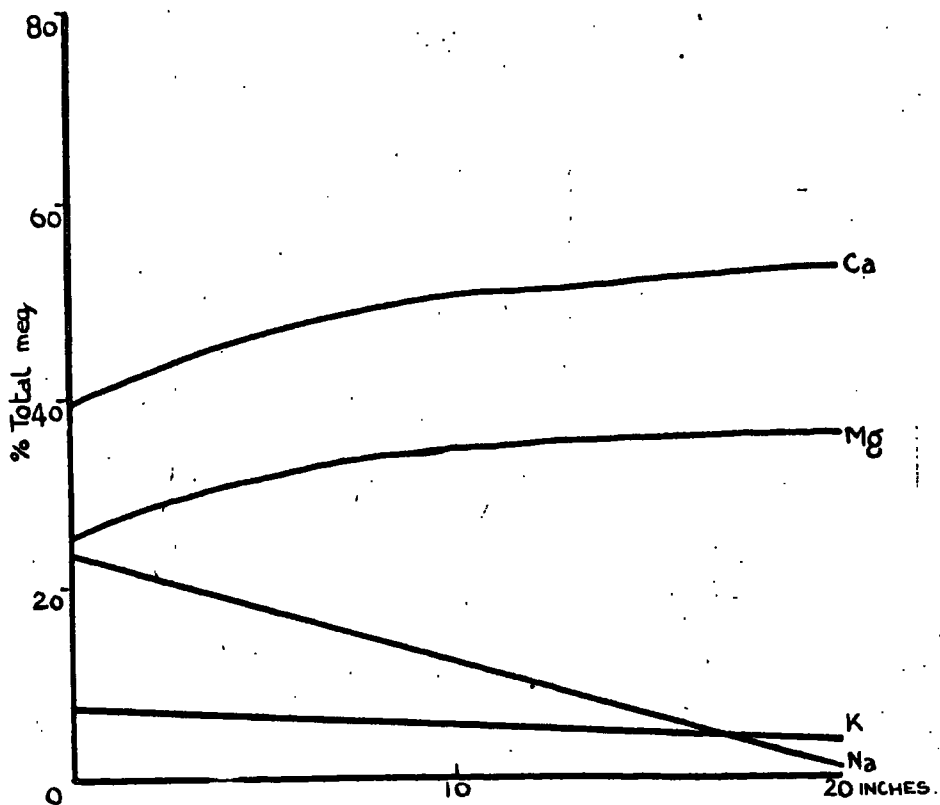


Fig. 141 PROFILE 41.



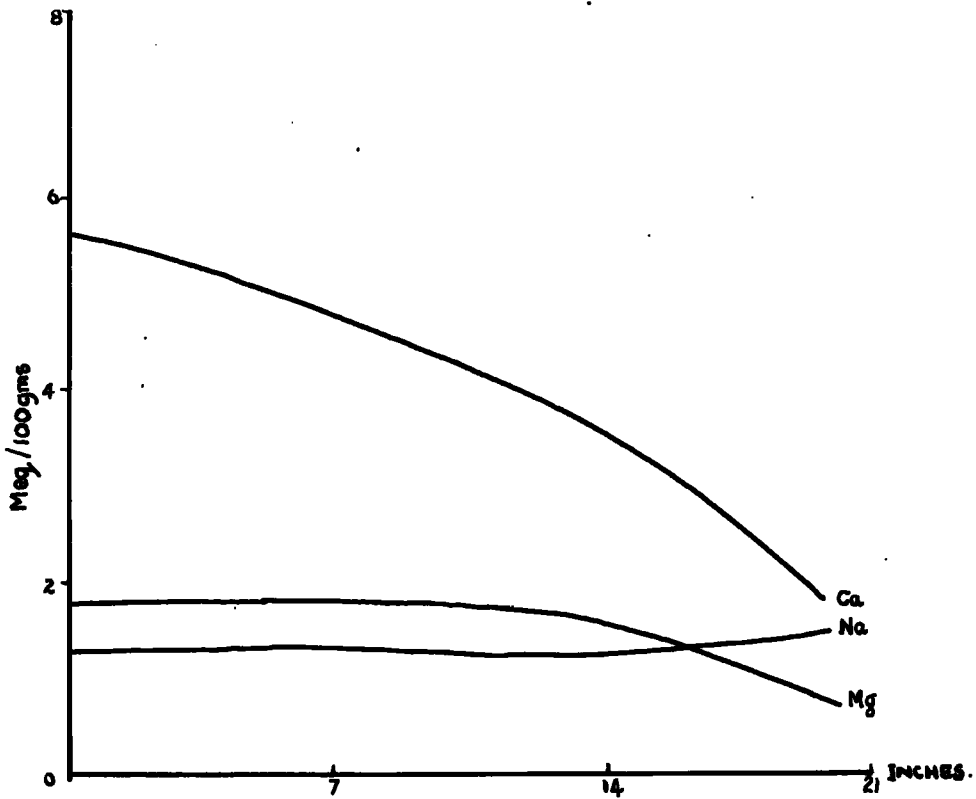
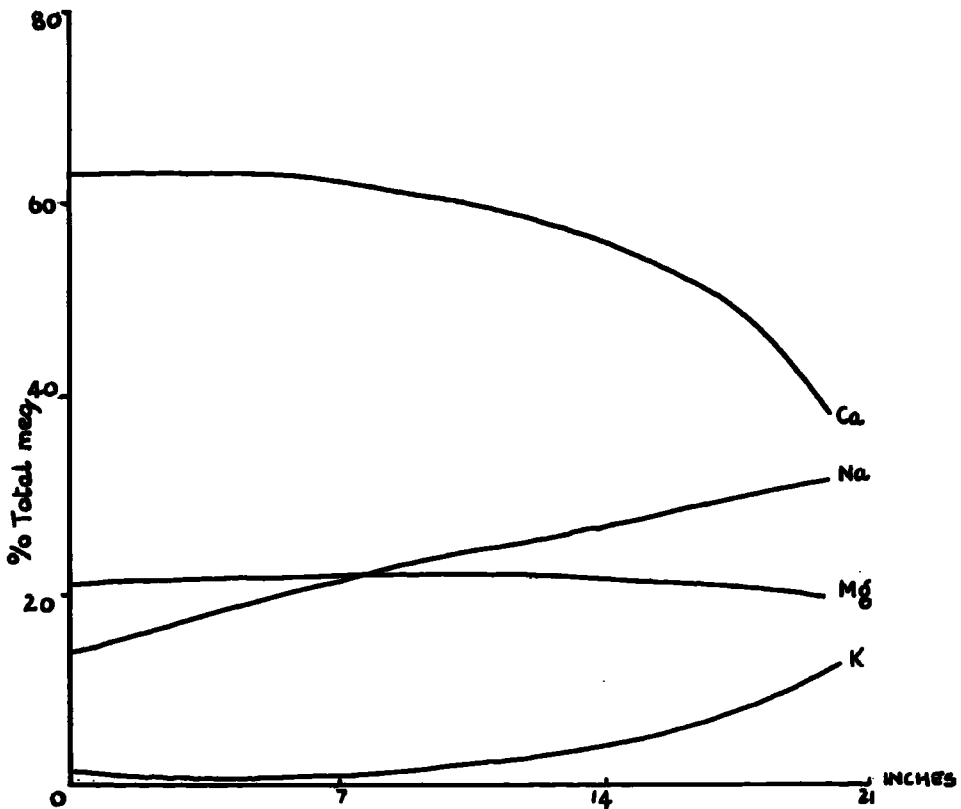


Fig 142 PROFILE 3.



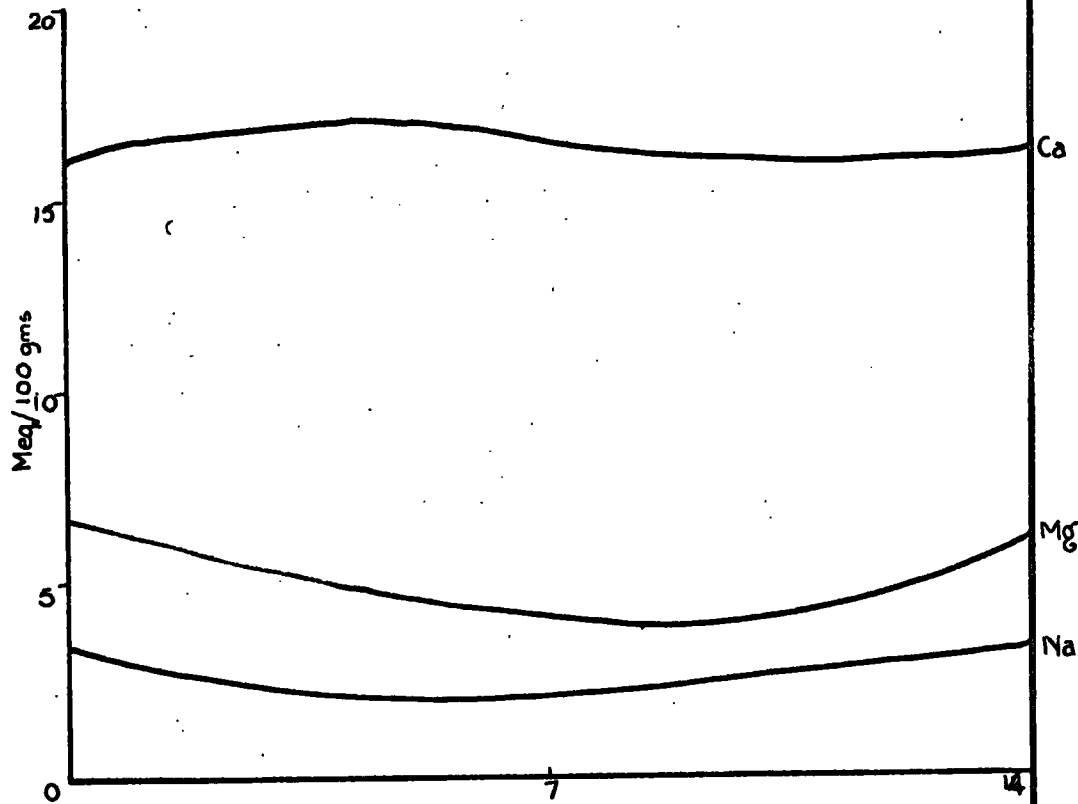
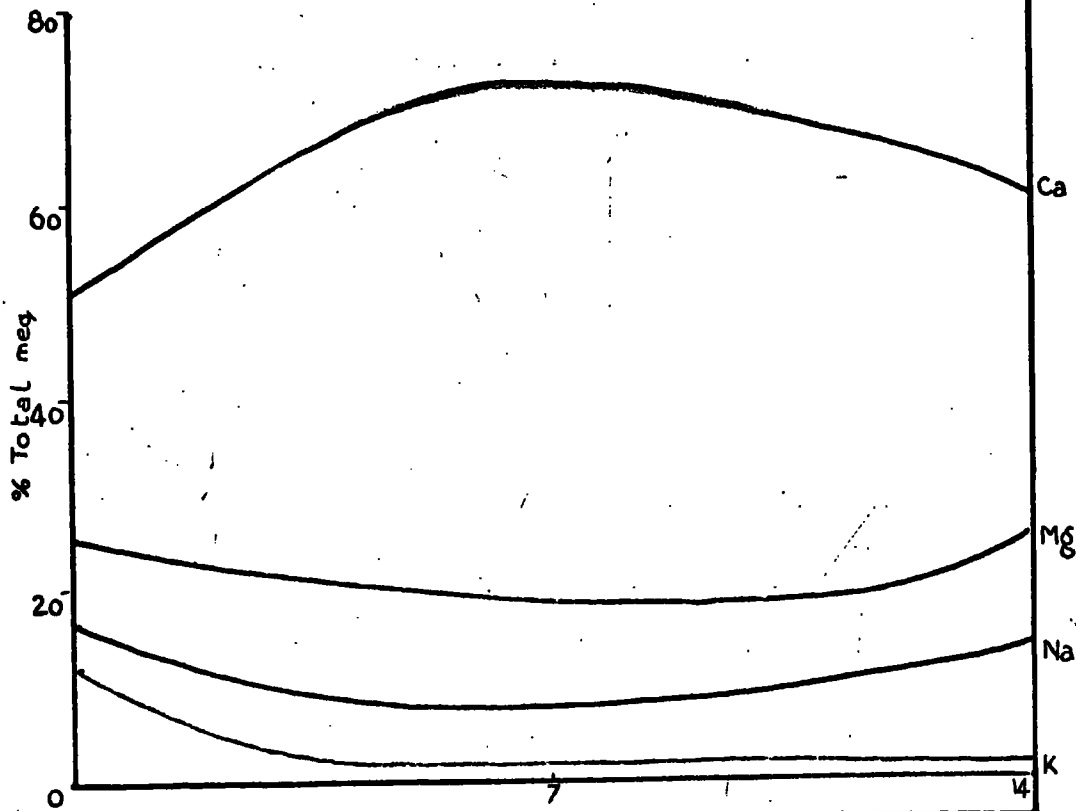


Fig 143 PROFILE 36



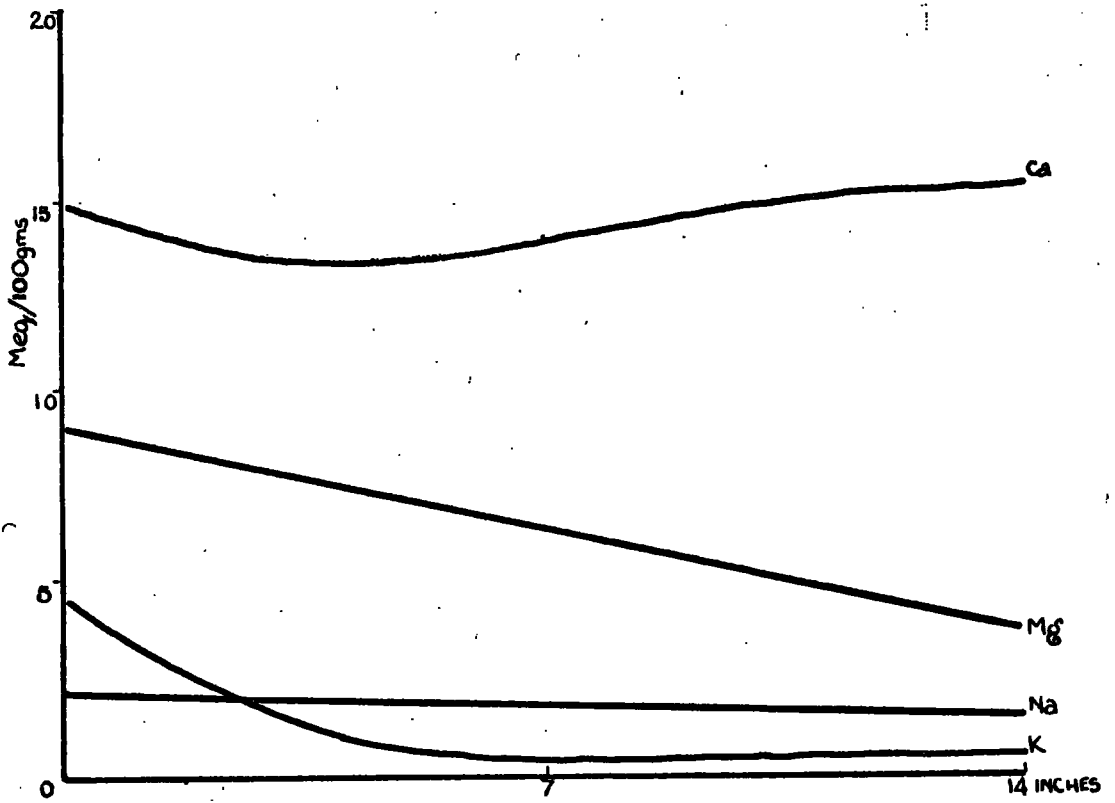
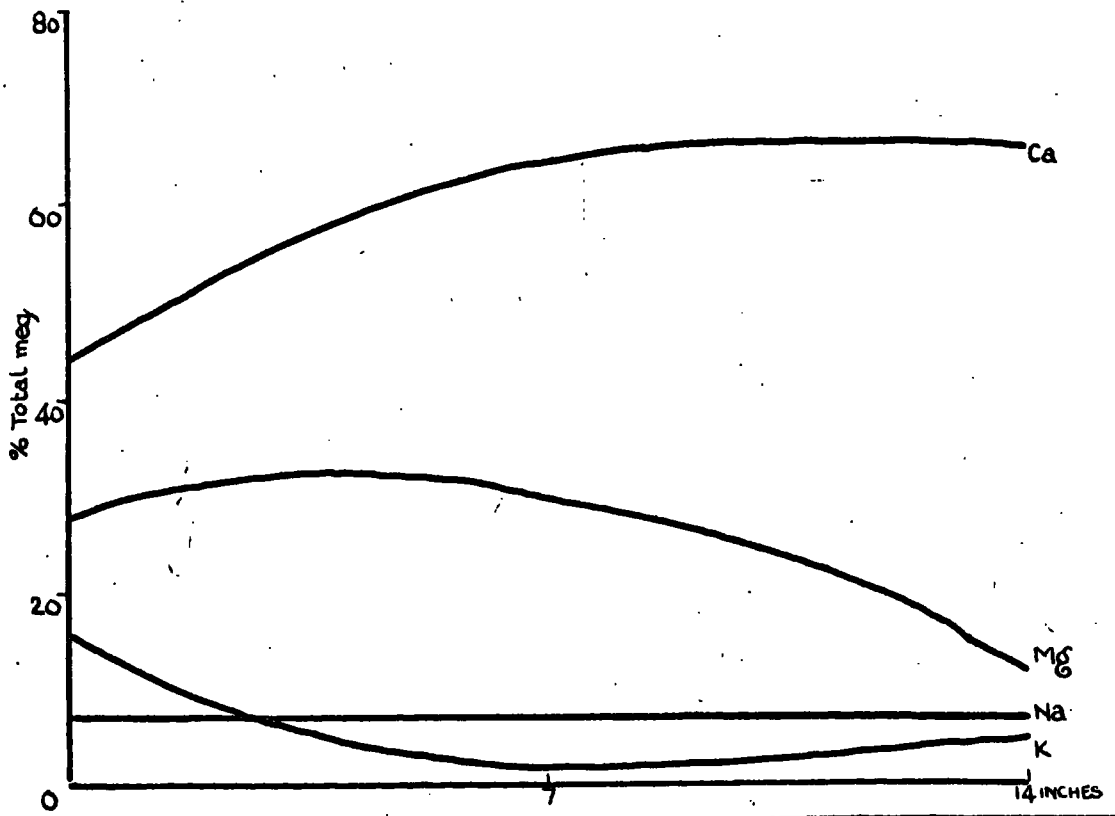


Fig 144 PROFILE 29



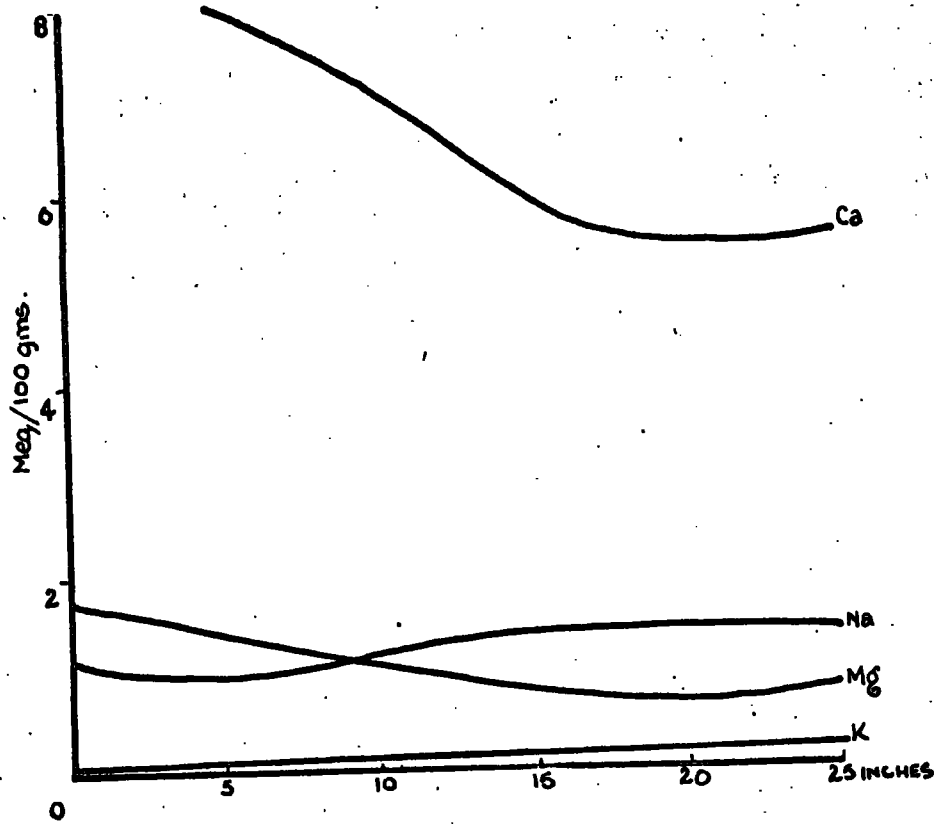
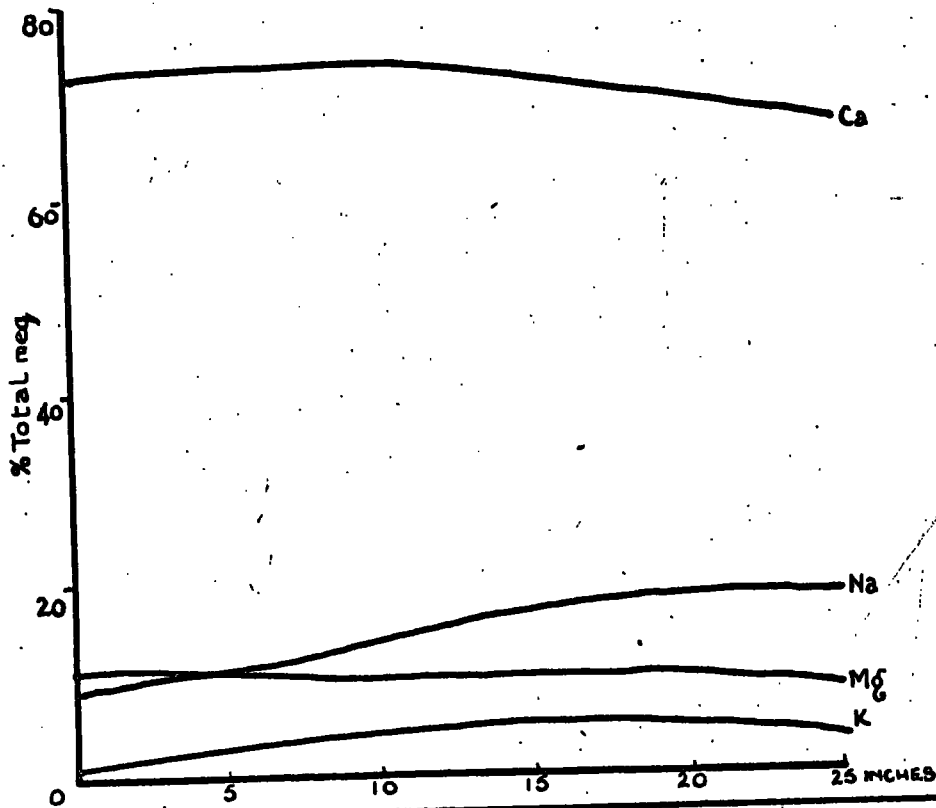


Fig 145 PROFILE 20



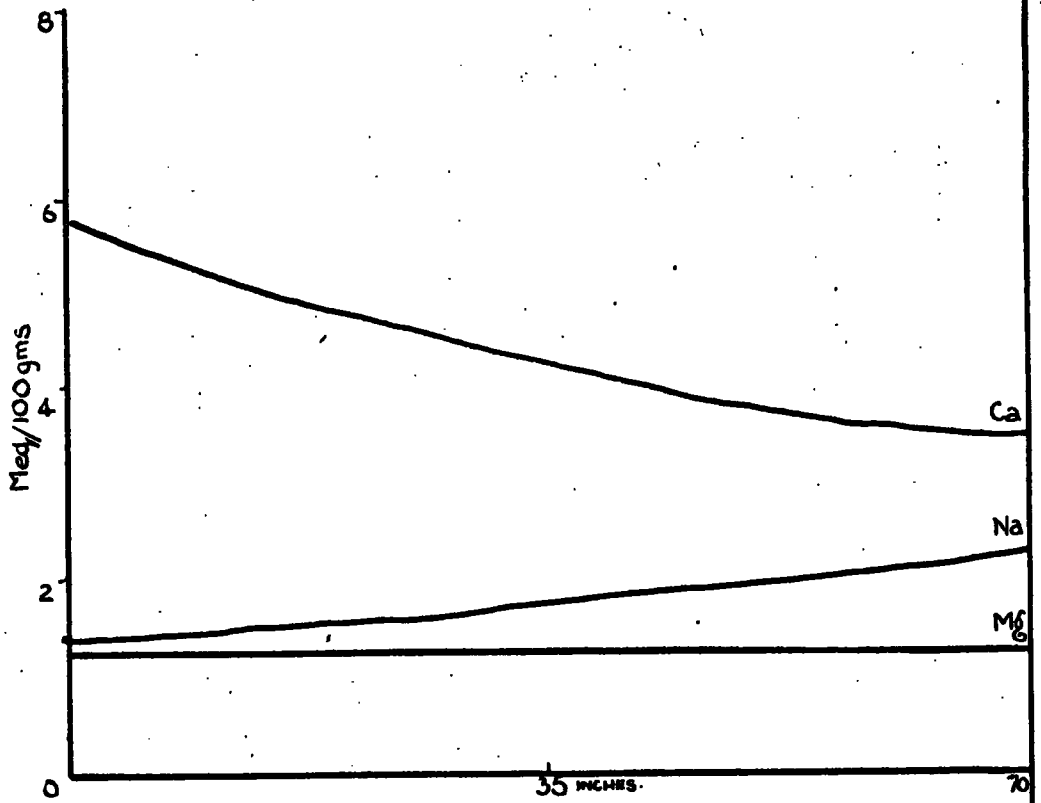
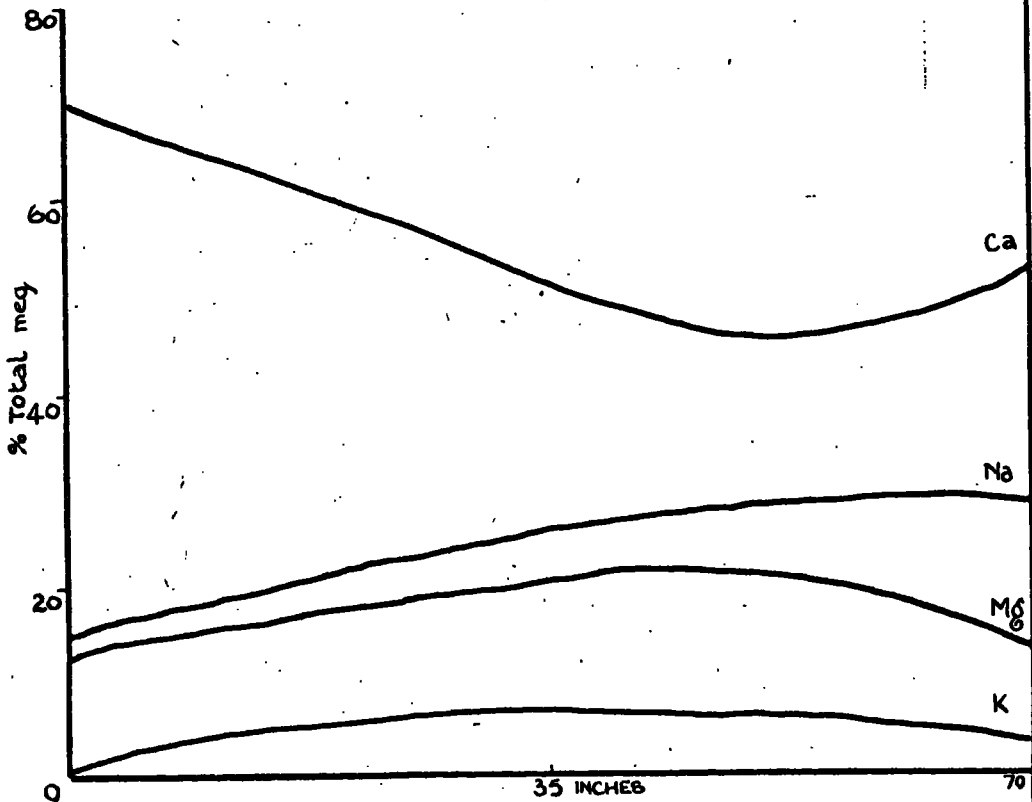


Fig 146 PROFILE 48.



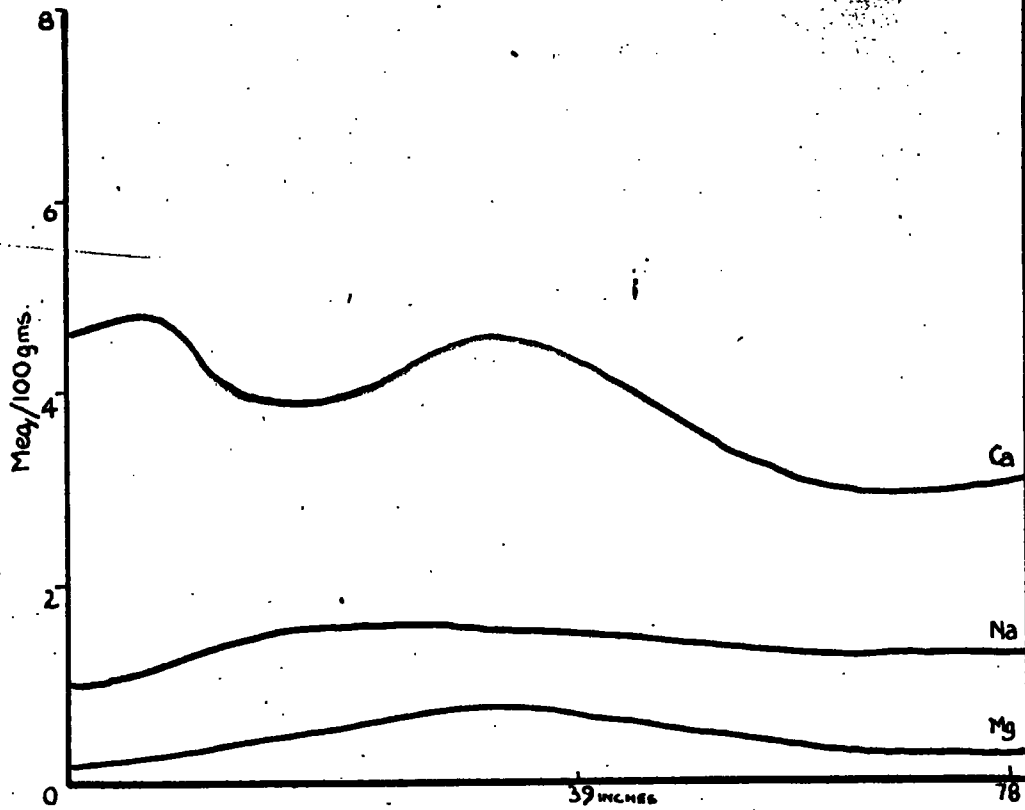
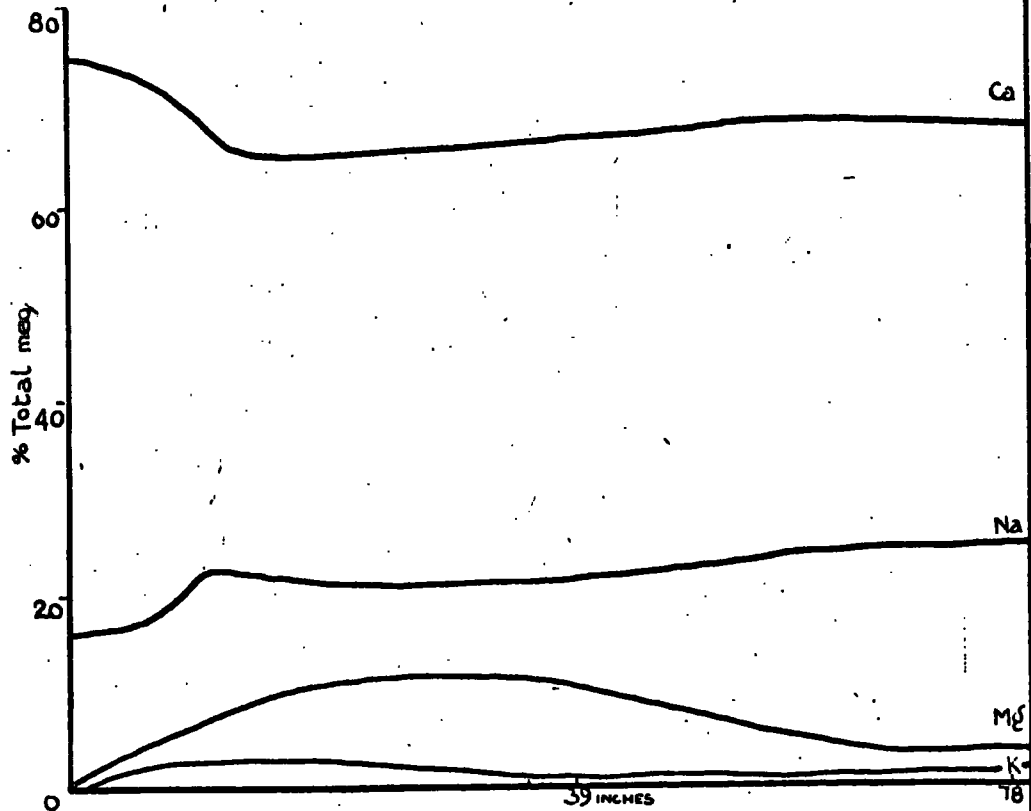


Fig 147 PROFILE 47



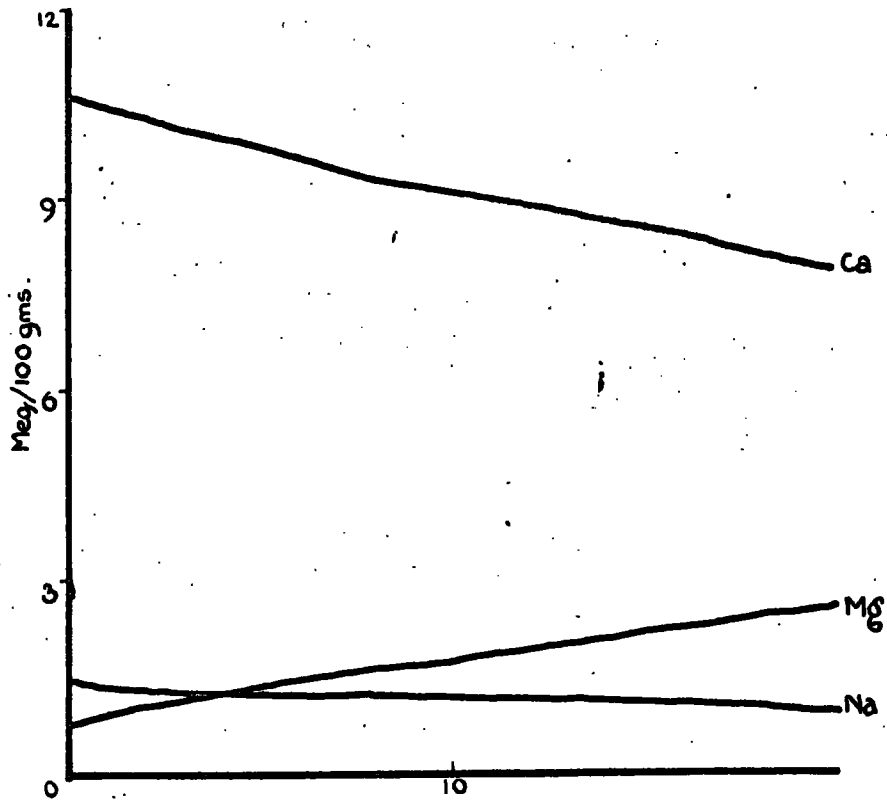
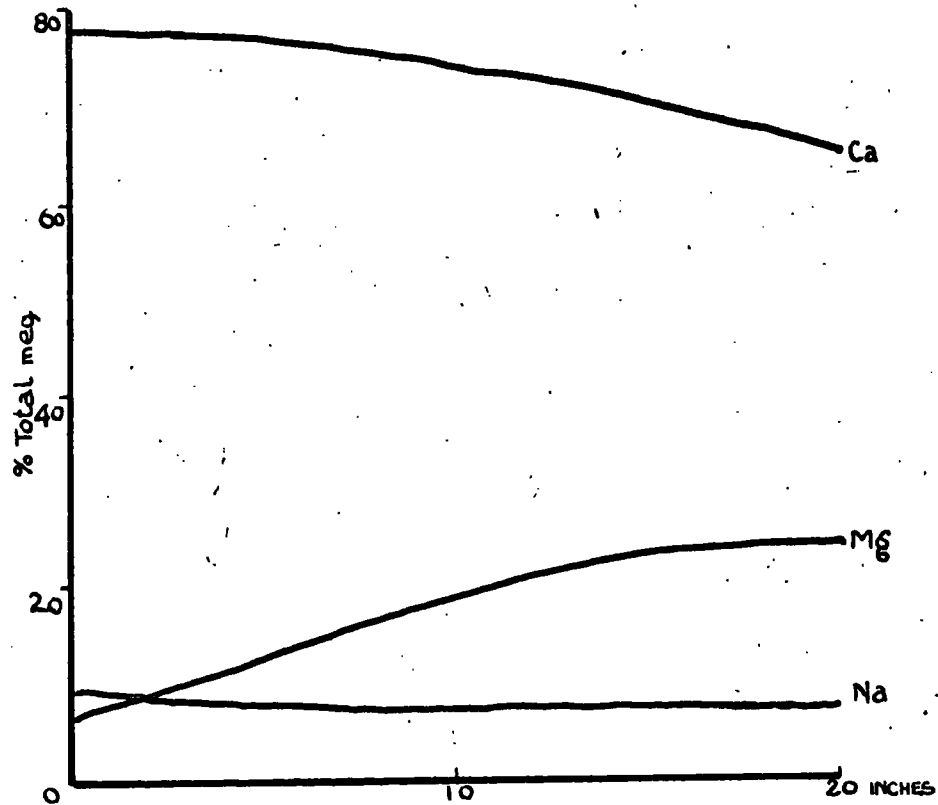


Fig. 148 PROFILE 52



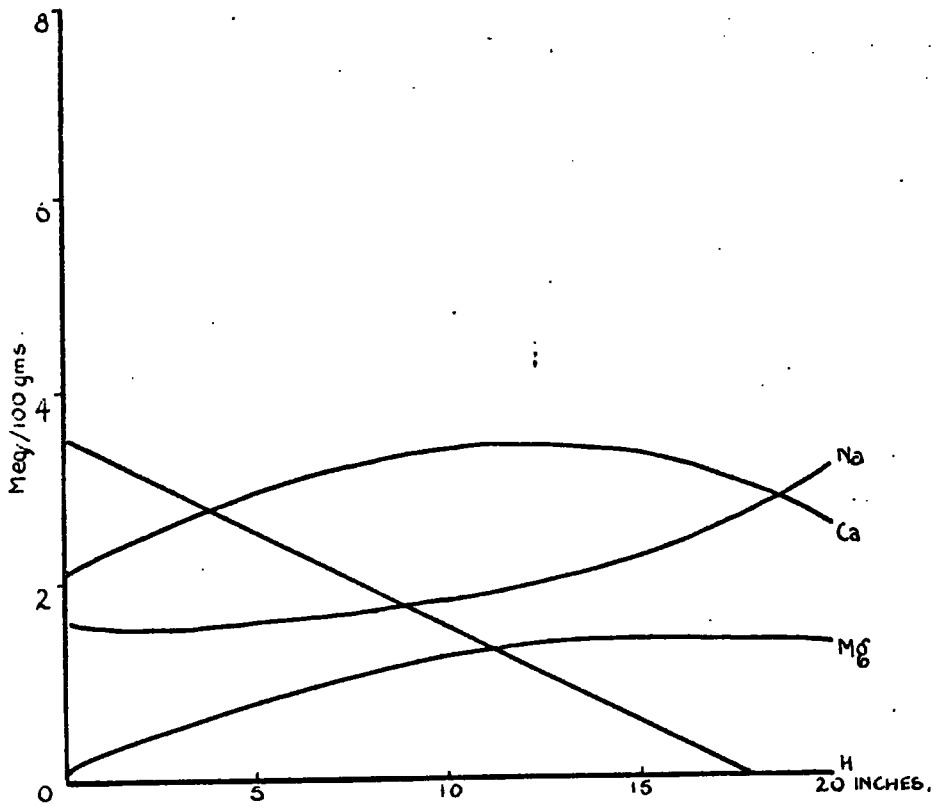


Fig 149 PROFILE 15

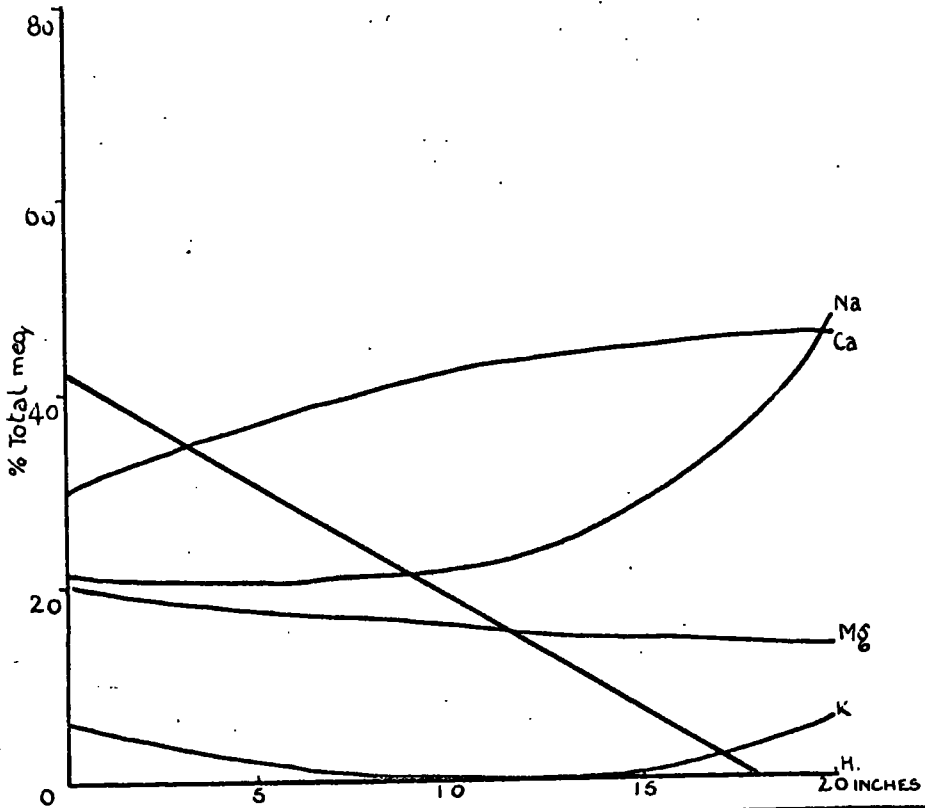
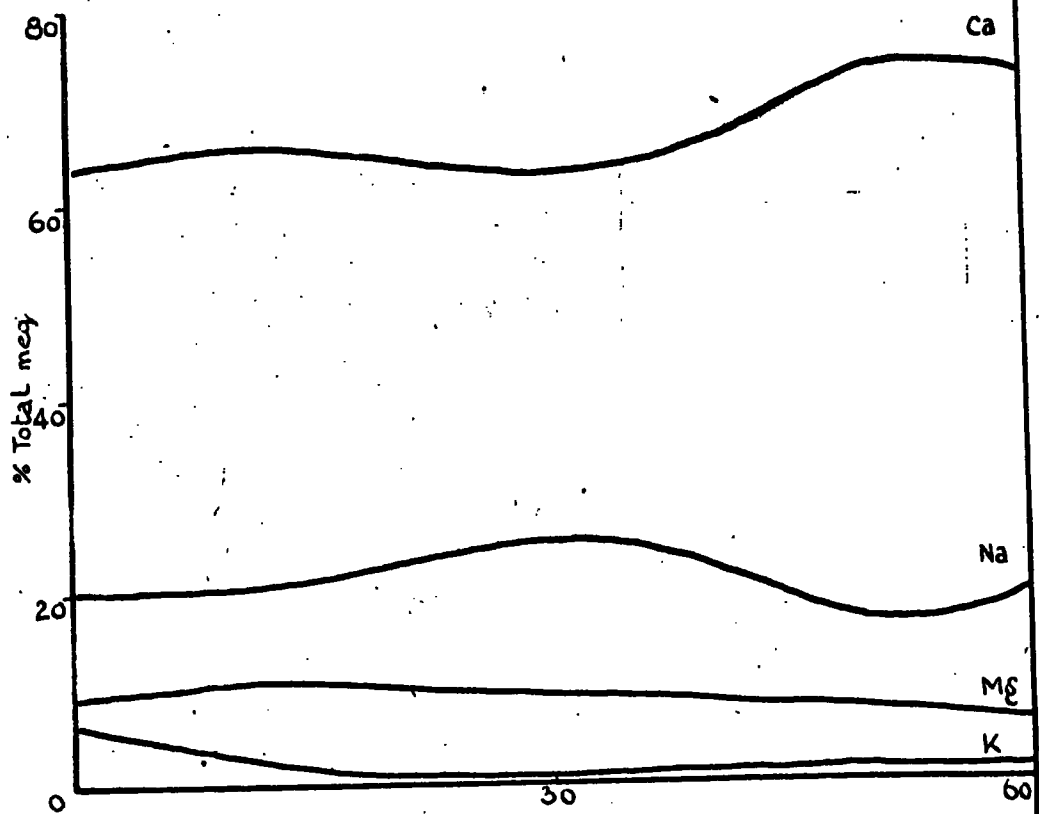




Fig 150 PROFILE 50



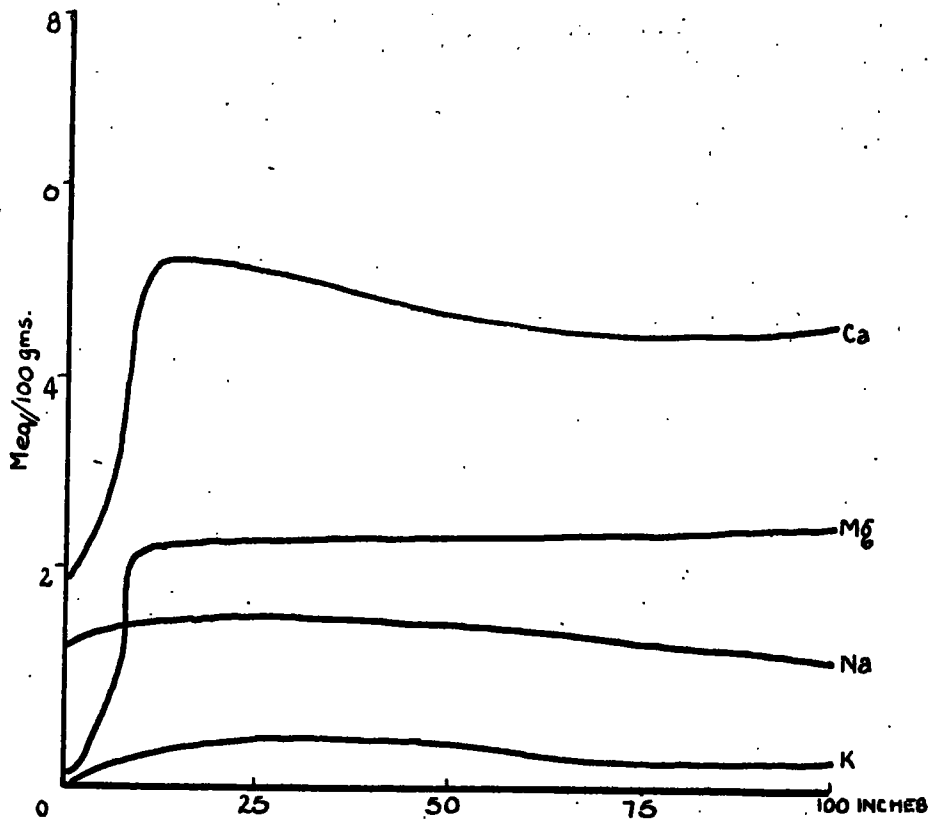
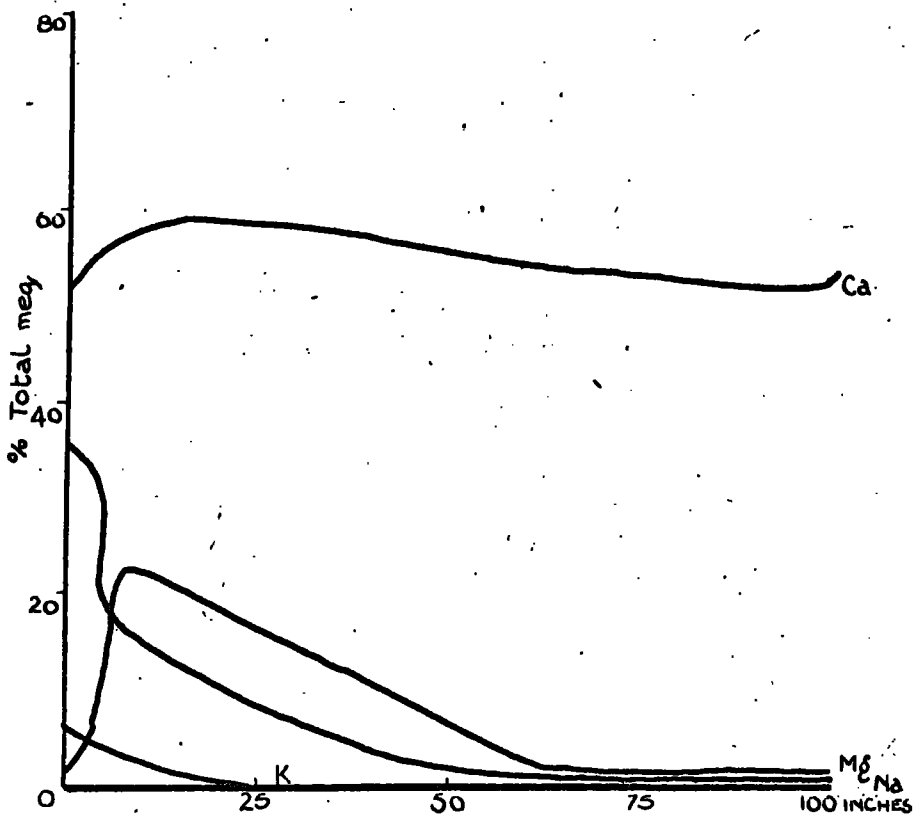


Fig 151 PROFILE 19



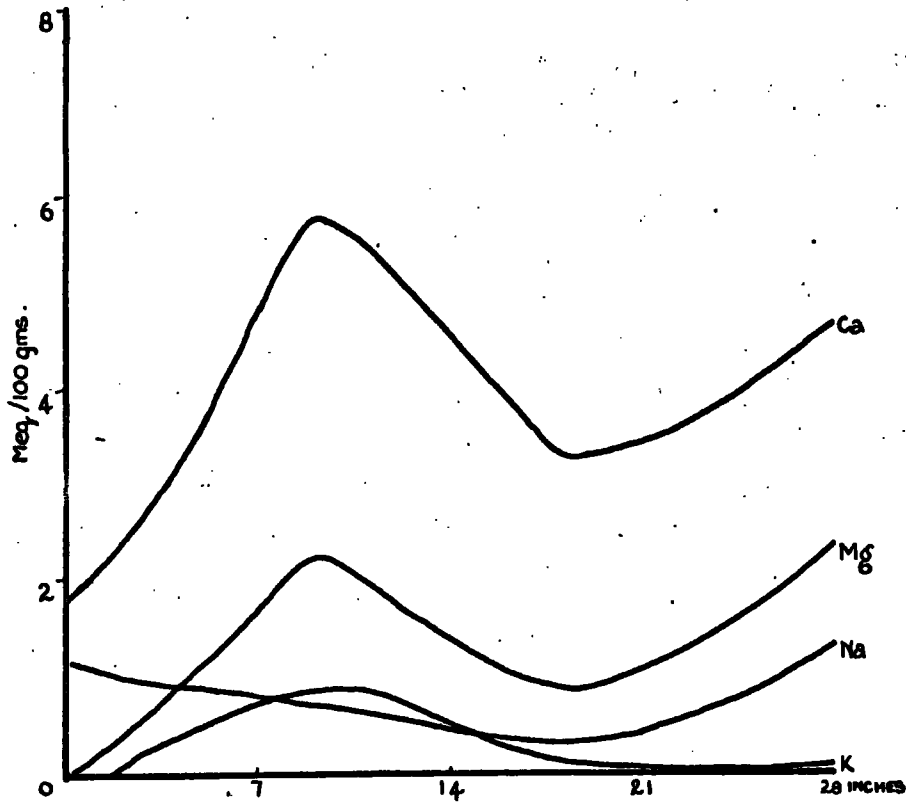
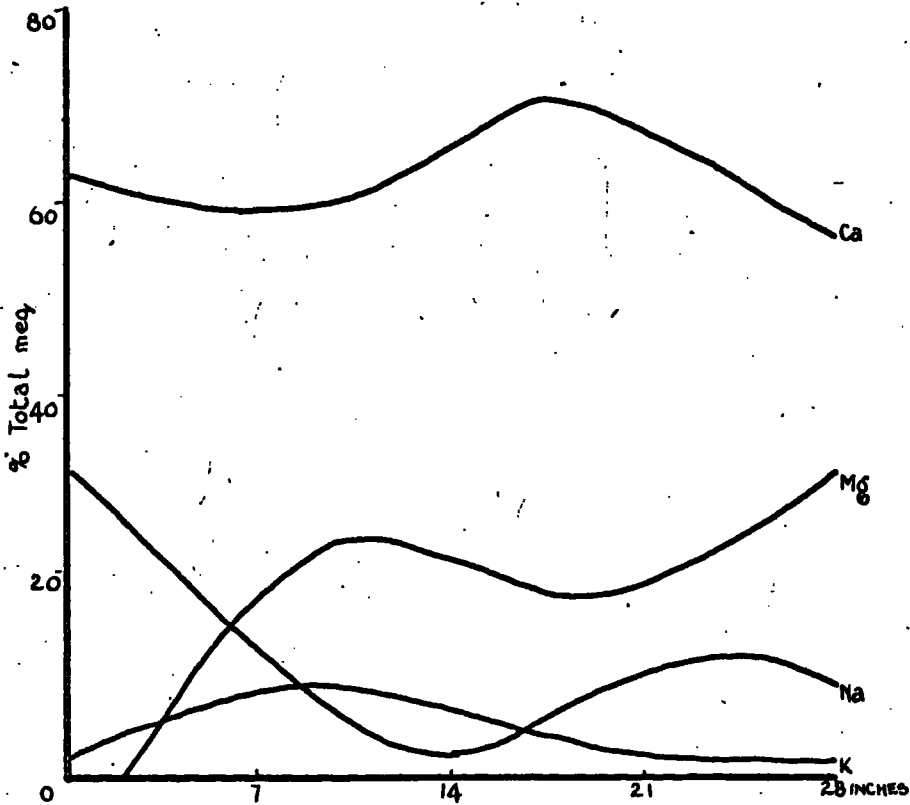


Fig 152 PROFILE 17



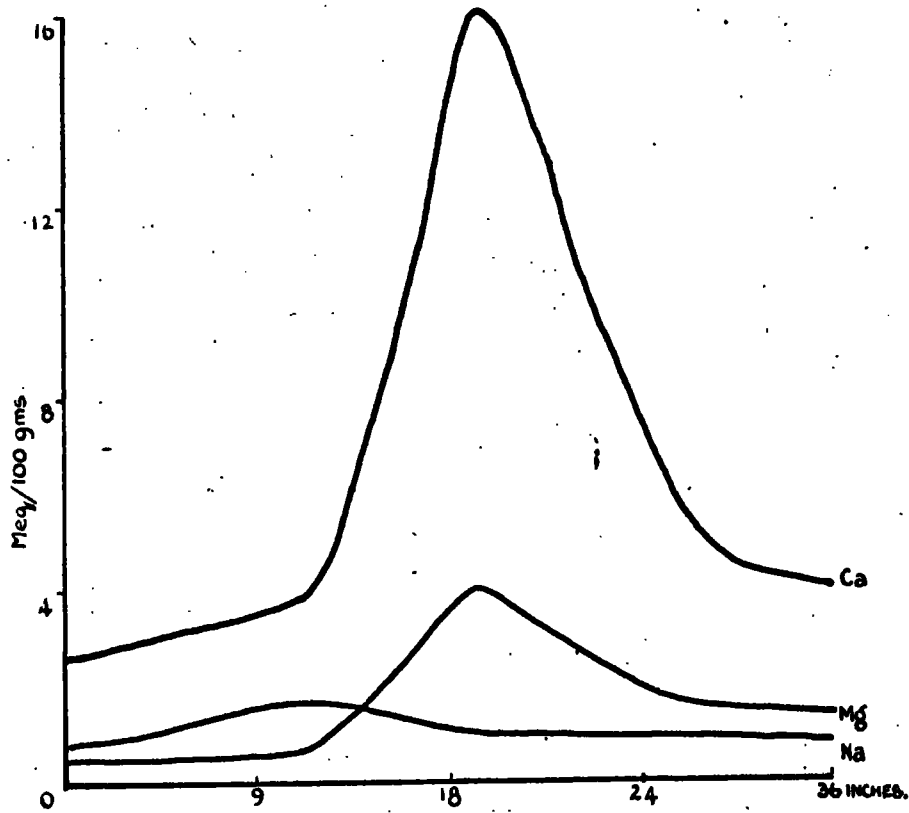
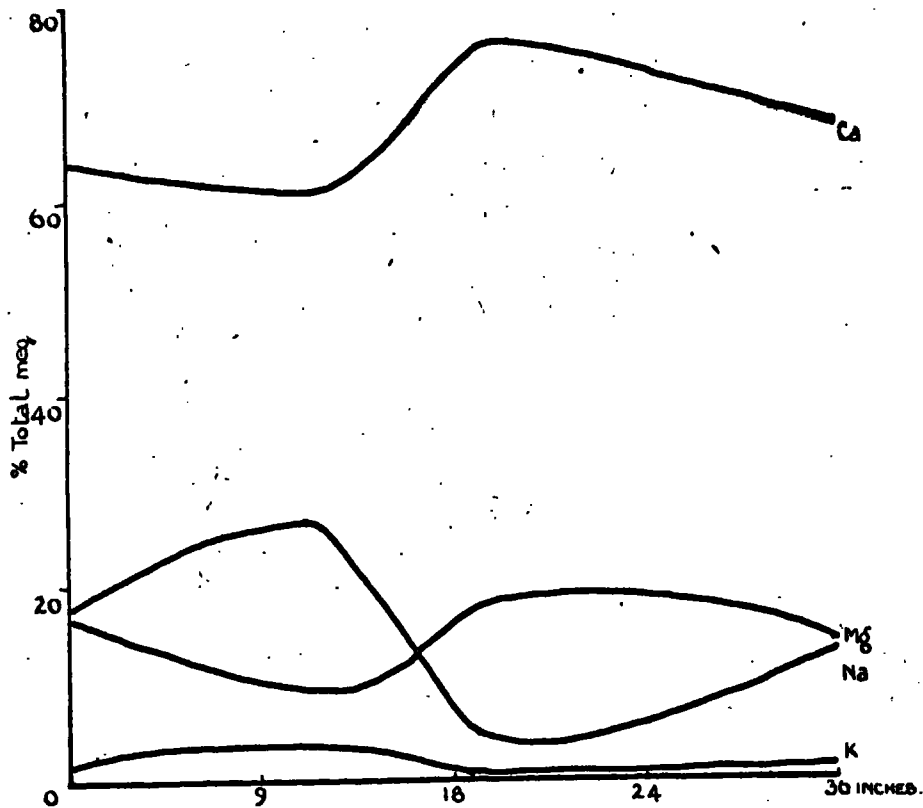


Fig 153 PROFILE 16



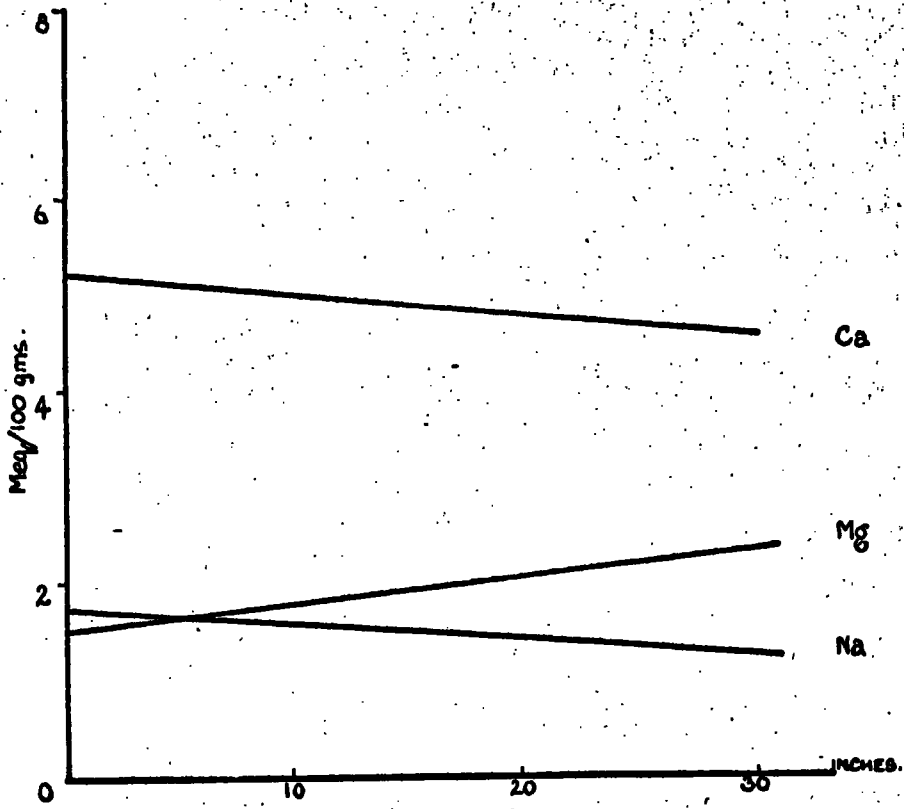
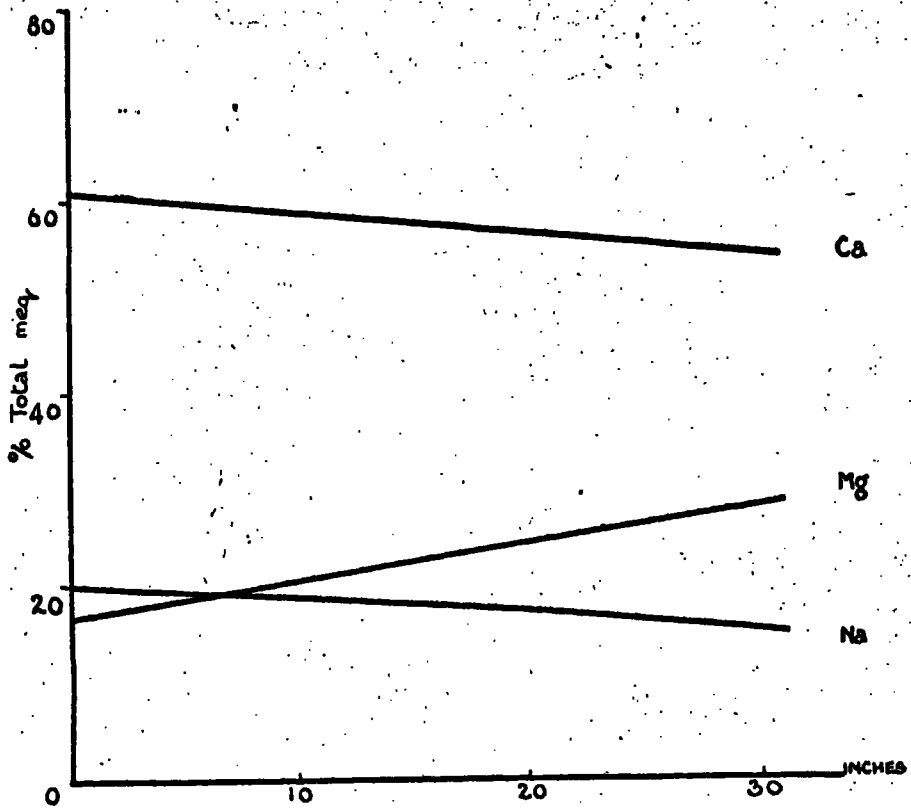


Fig 154 PROFILE II



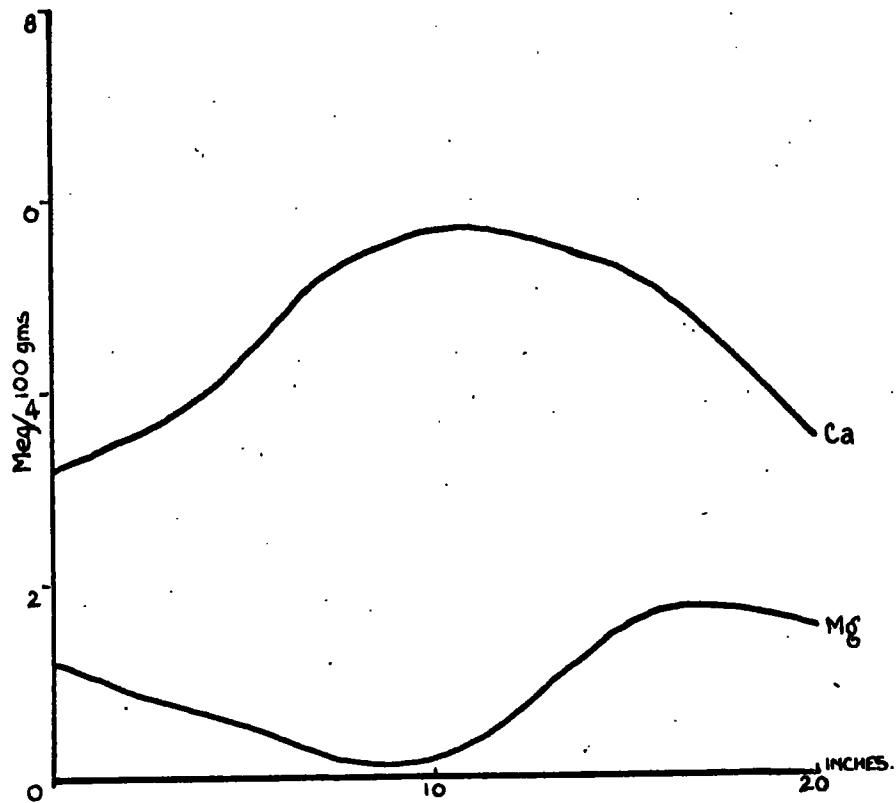
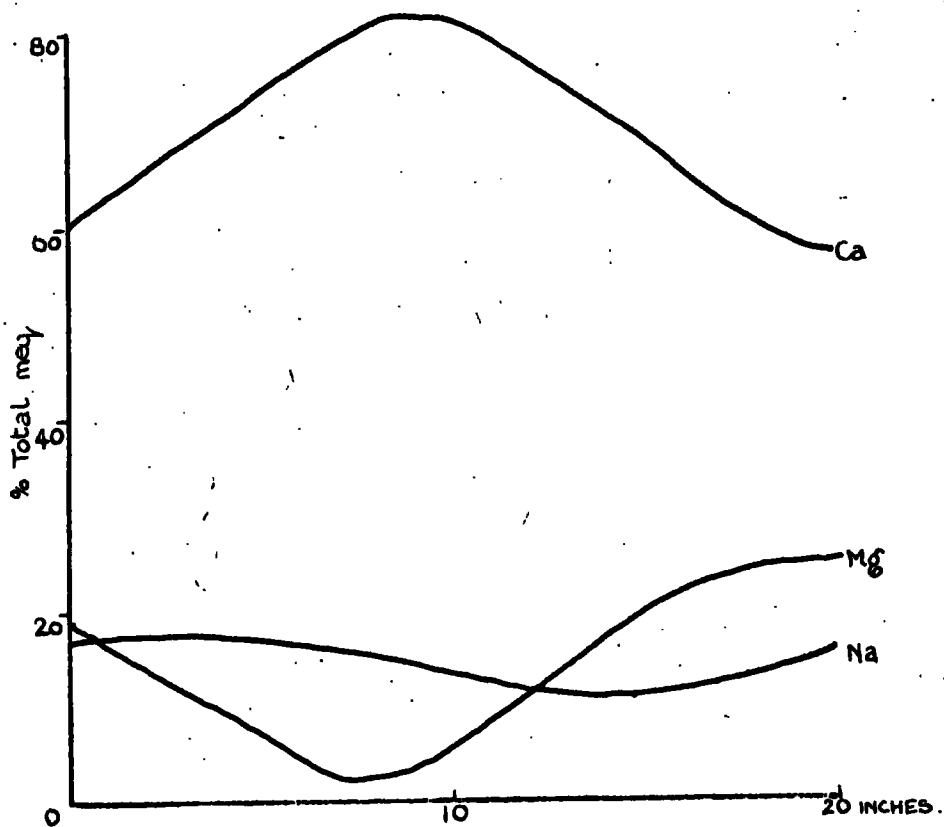


Fig 155 PROFILE 21.



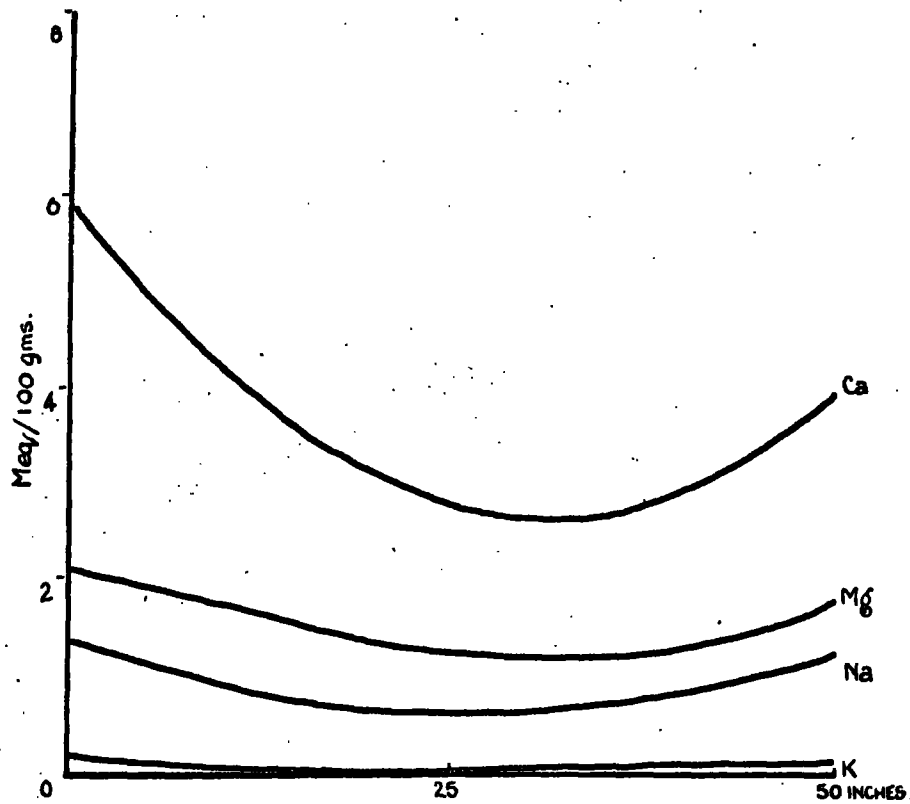
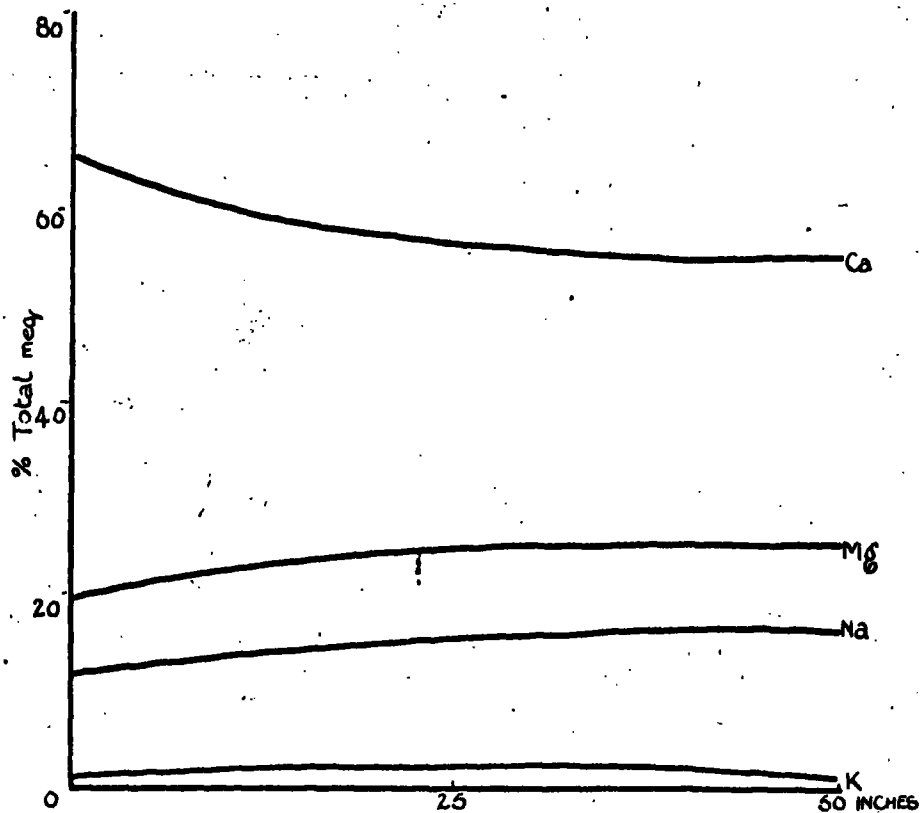


Fig 156 PROFILE 18



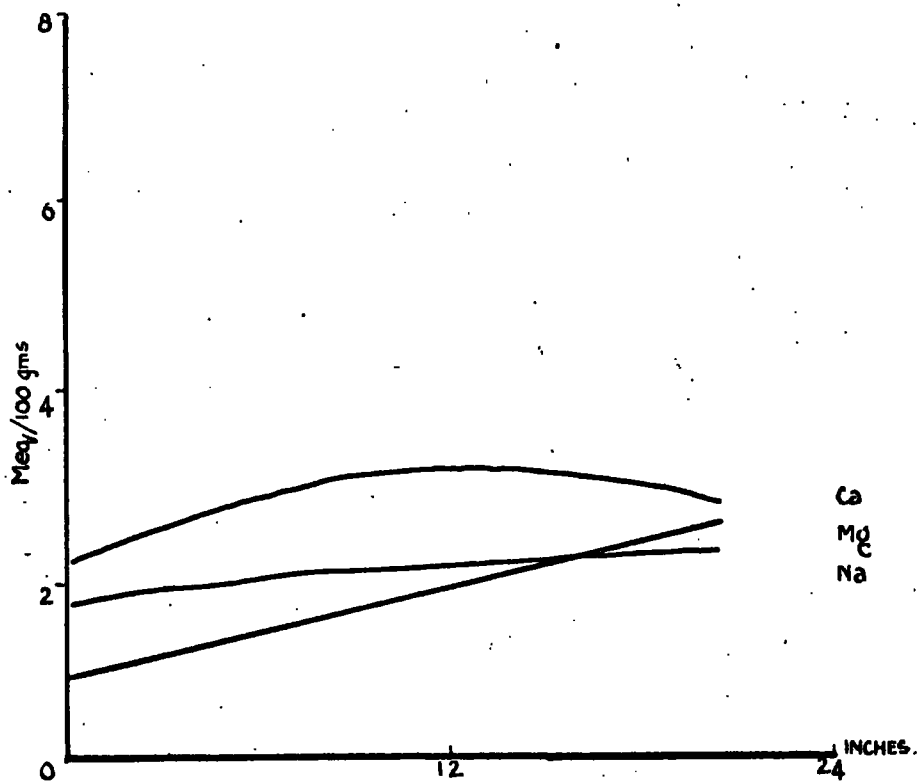
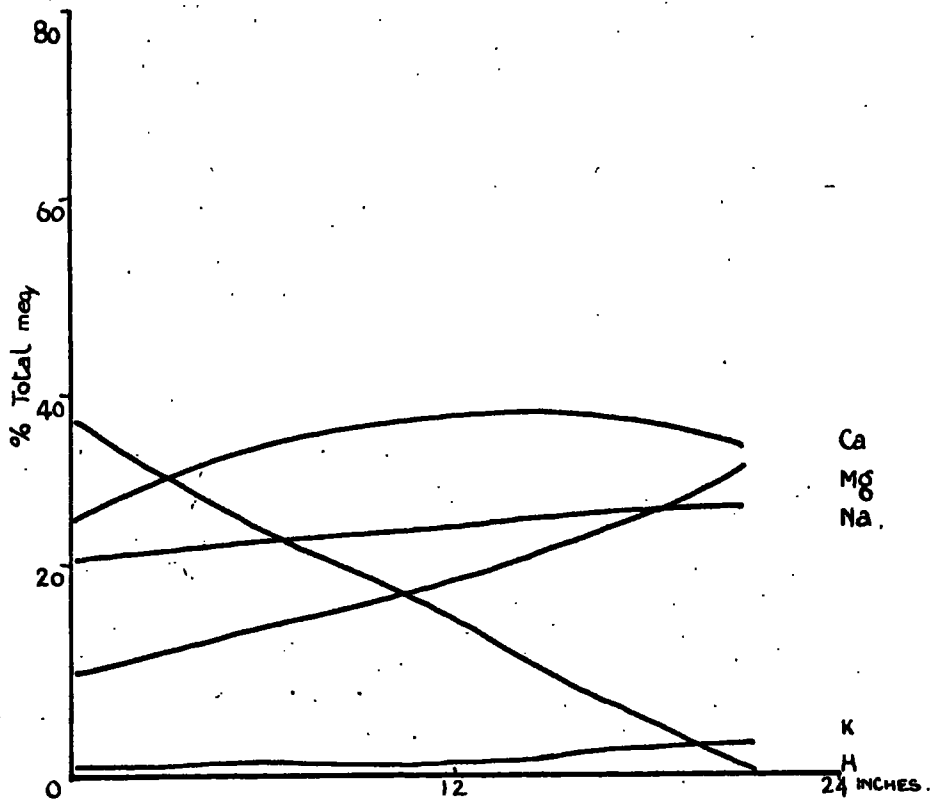


Fig 157. PROFILE 14



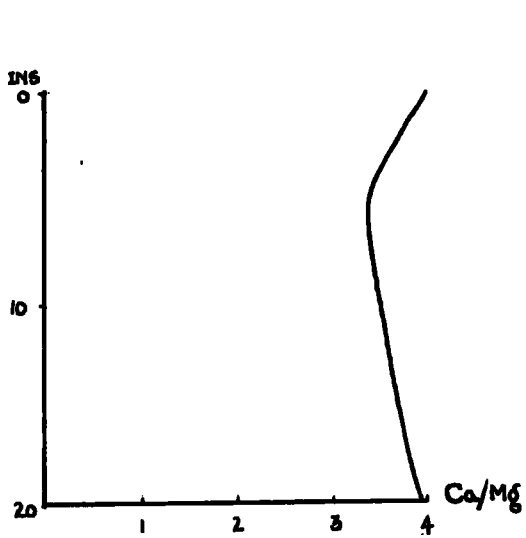


Fig 158 Profile 5

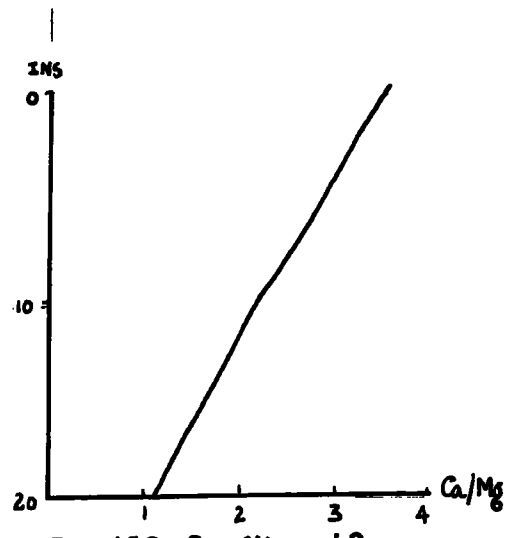


Fig 159 Profile 12

CATIONIC Ca/Mg CORNFORTH SERIES.

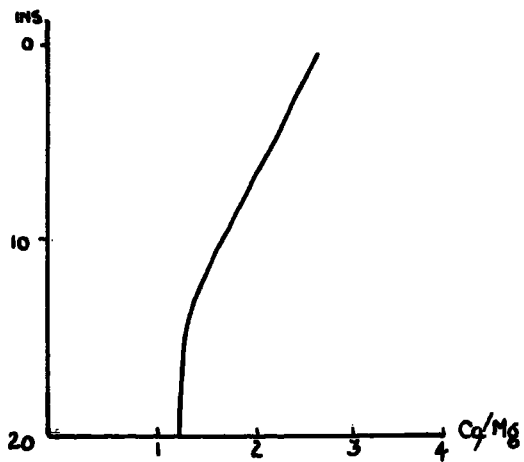


Fig 160 Profile 13

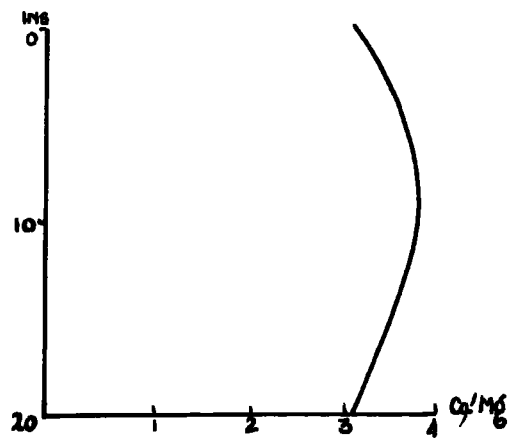


Fig 161 Profile 34

a sodium bias on the triangular graph (Fig.135). Other triangular graphs plotting Na/Mg/K, horizons below the surface soils and trends down the profile gave inconclusive patterns except that certain aspects of details already described were in some cases repeated. For example soils grouped as I and II in Fig.134 were constant in grouping and position on the graph throughout. The alluvial and gley soils remained grouped together when plotted as Ca/Mg/K but the position on the graph was far closer to the calcium apex as the sodium influence was ignored and replaced by a weak potassium aspect.

Trends down the profile were better examined on individual graphs. In the Cornforth Series the dominant cation is calcium in all cases and magnesium is second in importance. Sodium and potassium compete in absolute importance but often there is very little or no potassium recorded (Fig.136) and 137). Of more interest is the proportional balance of cations down the profile. With calcium in such a dominant position it might be expected that any changes in its graphed curve down the profile would be reflected in a mirror image by other ions. What is of interest is that while in absolute terms meq/100 gms - calcium and magnesium are similar in profile trend (Figs.136 - 143) sodium and potassium are not. This is also true in the proportional graphs. Magnesium and calcium reflect each other in a mirror fashion, (perhaps partly because of differential rates of leaching from native limestone sources) but sodium and potassium often do not make up a directional part of the balance of increasing or decreasing calcium. They fluctuate independently (Figs. 138-142). This adds weight to the relationship between calcium and magnesium and the concept of differential weathering rates in the limestone and the greater mobility of calcium than magnesium down the profile. The mirroring of calcium and magnesium is sometimes weak (Figs.136, 140-142) but often very strong (Figs.137-139, 143). Calcium depletion in the A/(B) horizon is matched by proportional accumulation of magnesium. The two never exchange dominance in this series but Ca:Mg is in some cases very close to 1. (Figs.158-161). The sodium ion behaves independently it would seem. In some cases it is higher than magnesium (Figs.138, 142) but only at depth in the (B) or C horizons. The trend of sodium is to increase

slightly in importance with depth. In absolute terms it is usually constant or very slightly decreasing down the profile. Potassium can be comparatively high in the surface soil and at depth but is often very low in the A/(B) horizon. It occasionally mirrors calcium as does magnesium (Figs.139,140,142,143). In this series potassium seems to show no response to difference in magnesium except that where magnesium is highest potassium is completely absent. In Fig. 142 where calcium falls to about 40 percent of the total meq., potassium rises markedly to 18 percent at depth.

In the whole Series the most interesting features are therefore dominance of calcium and magnesium, which often mirror each other proportionally down the profile; low absolute and proportional potassium with dependence on calcium proportions and magnesium absolute levels; independence of sodium, which gradually accumulates with depth.

In the Middleham Series Mg:Ca relationships are not clear. As this relationship breaks down a stronger relationship between magnesium and potassium is established and a mirror image perhaps based on magnesium potassium antagonism arises (Fig.144). In Fig.144 potassium also reflects changes in calcium but in most cases the Mg:K relationship is dominant. Sodium is as in Series 1, constant or slightly increasing with depth.

In the Kelloe and Haswell Series cationic relationships are very varied not only because of varying gley influences and differing lithography but also because of variable land use. Fig.145 is one illustration from which no conclusions can safely be drawn except to indicate the increasing importance of sodium as in the Preston and Cassop Series as the gley influence increases.

The Shotton Series shows similar variation and sodium is usually more important than magnesium throughout the profile. Despite this, sometimes magnesium mirrors calcium as in Series 1 (Fig.146). In other cases, and more to be expected, it is sodium that mirrors calcium down the profile (Fig.147). Potassium is in all cases very low.

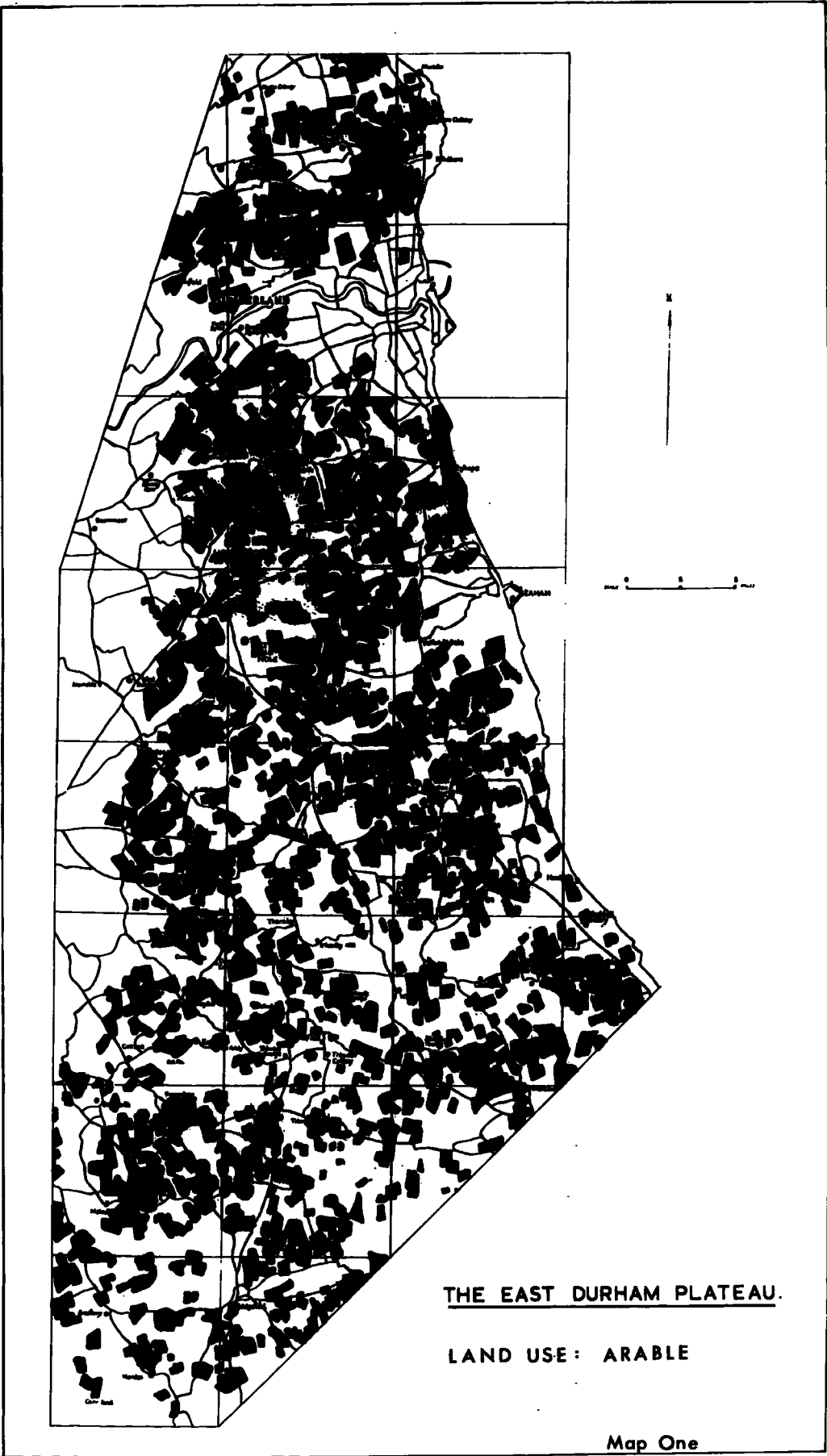
In the Hesleden Series calcium is the dominant cation and, although sodium is second in importance in the surface horizons (perhaps because of marine contamination in local sea frets), magnesium usually asserts its influence and increases proportionally with depth (Fig.148).

As might be expected in the Mainsforth Series of sands, gravels and varying clay influences there is great cationic complexity. Although Figs. 149 and 150 tempt interpretation, because of lack of repetition of patterns, little valid interpretation is possible. Of note is the low magnesium status, subordinate in all cases to sodium.

The Preston Series presents even more complexity because of peat influences and complicated lithography (Fig.151). In some cases specialised influences noted in other Series are present. For example calcium and magnesium are mirrored in Figs.152 and 154, but in Fig.153, even though not as important in lower horizons, it is sodium more than magnesium that mirrors dominant calcium. Potassium is in all cases low. Sodium is sometimes greater than magnesium in the surface soil but of less importance at depth (Fig.154 and cf.Fig.155). In other cases this is not so (Fig.156).

Soils in the Cassop Series show equal complexity but because of the combination of ground water gleying and considerable susceptibility to flooding, surface horizons for the first time show a high proportion of hydrogen ions (dominant in Fig.157). Other trends in Fig.157 are not repeated in different profiles of the Series.

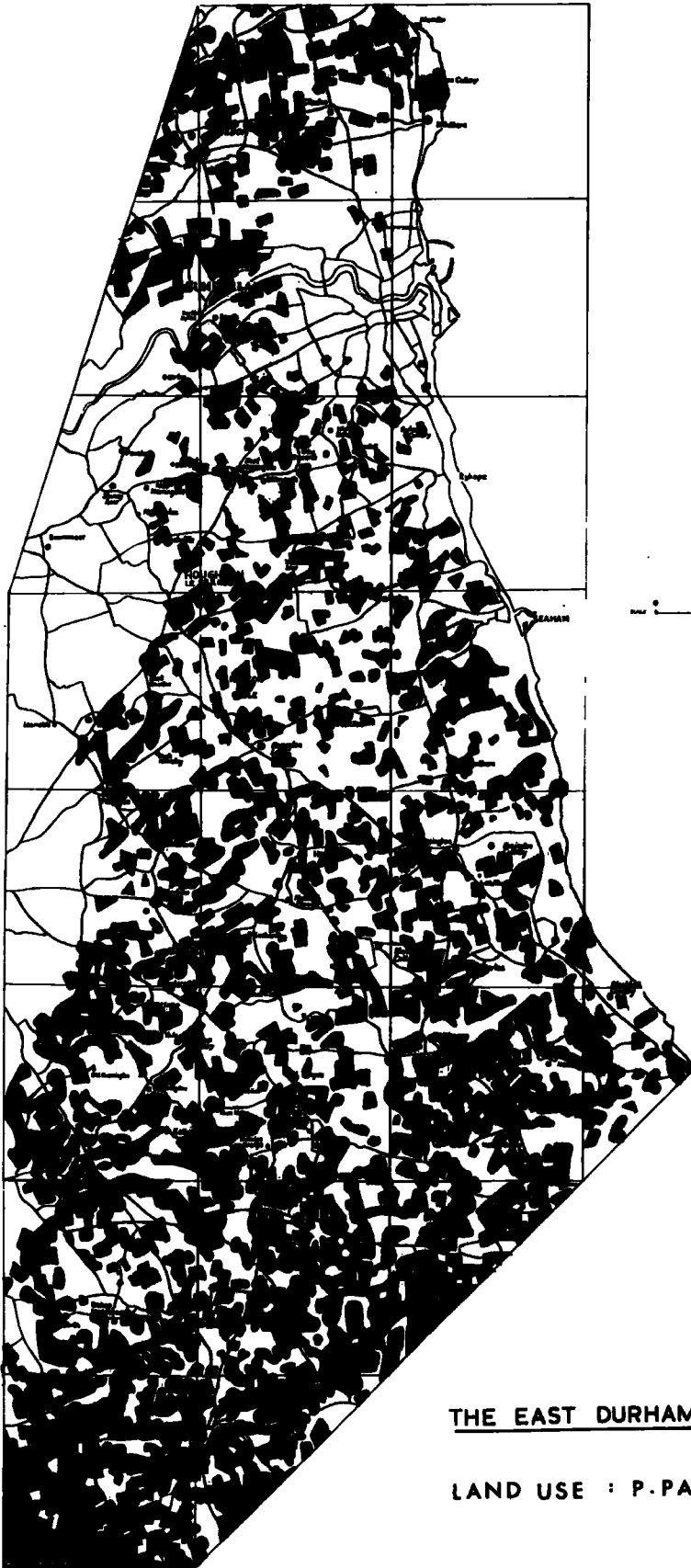
The influence of cationic relationships on productivity is difficult to establish but some development of the above summary is made later in the text.



THE EAST DURHAM PLATEAU.

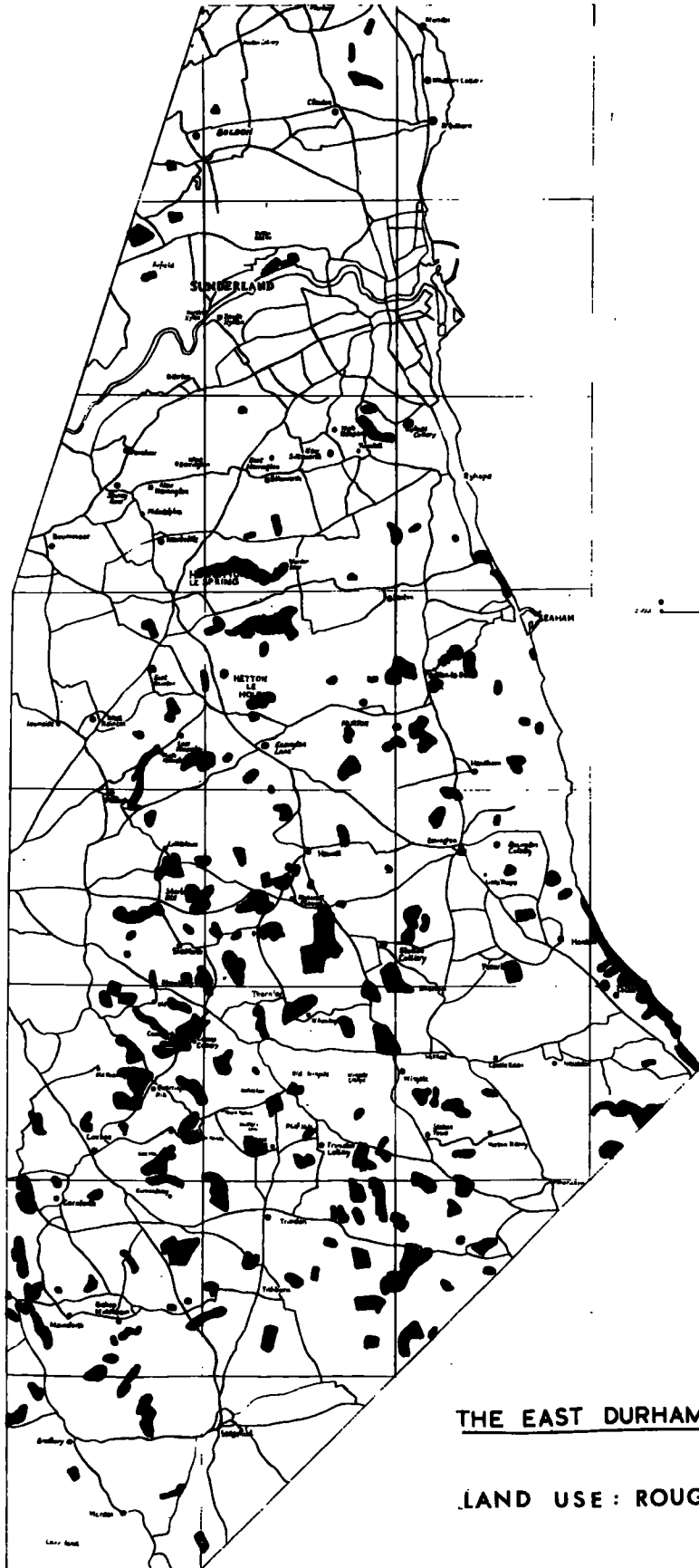
LAND USE: ARABLE

Map One



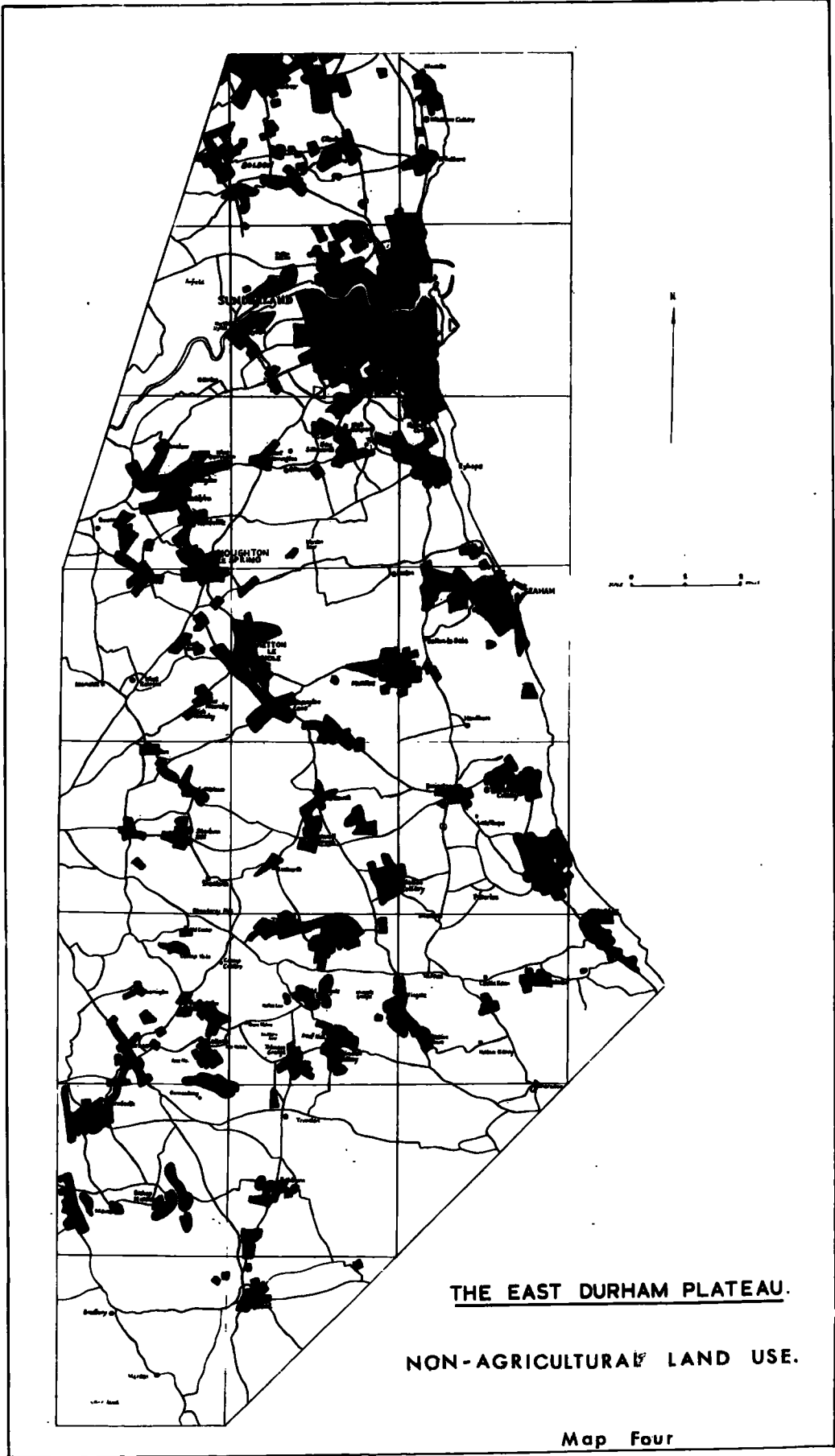
THE EAST DURHAM PLATEAU.

LAND USE : P. PASTURE.



THE EAST DURHAM PLATEAU.

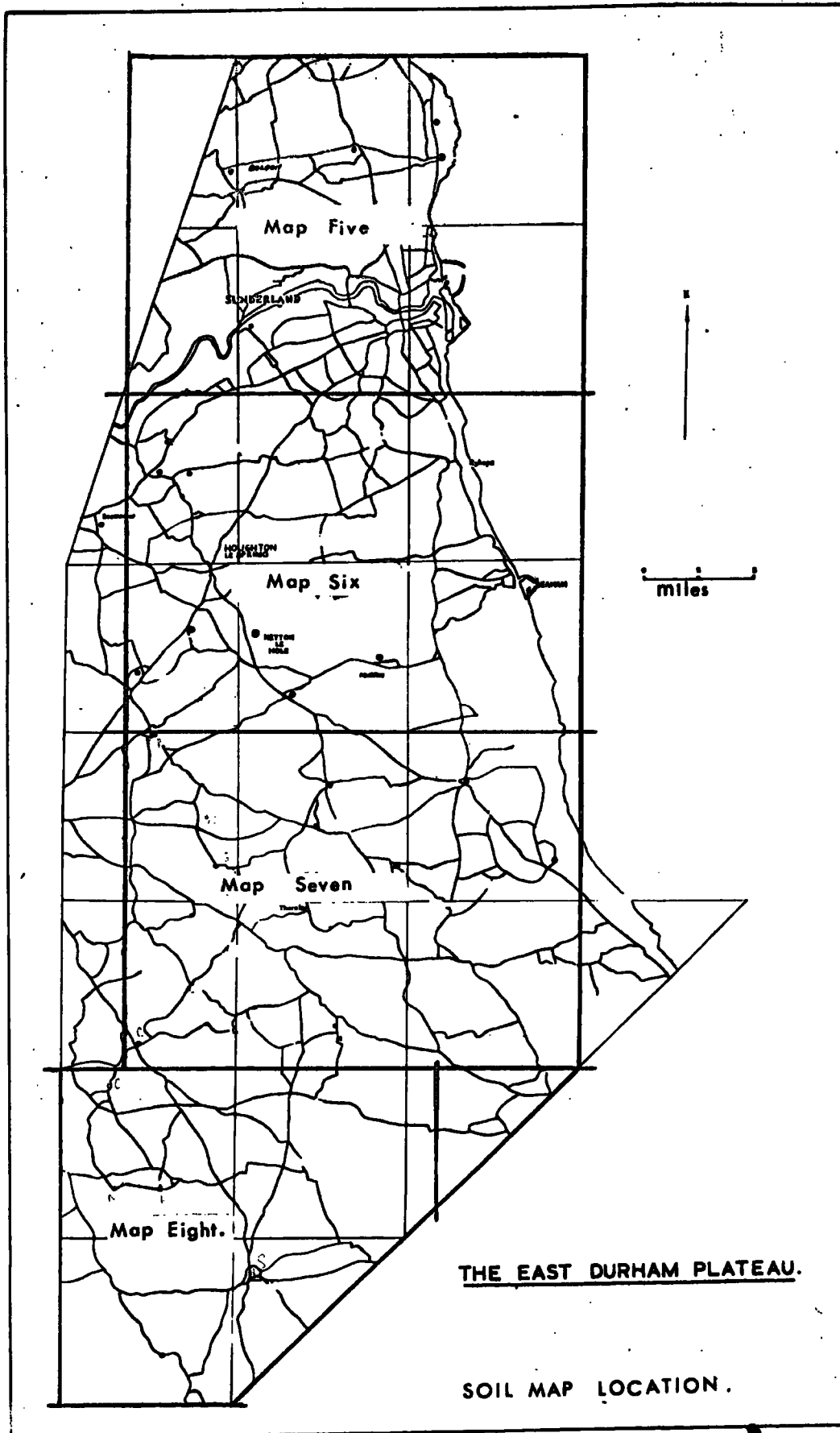
LAND USE : ROUGH LAND.



THE EAST DURHAM PLATEAU.

NON-AGRICULTURAL LAND USE.

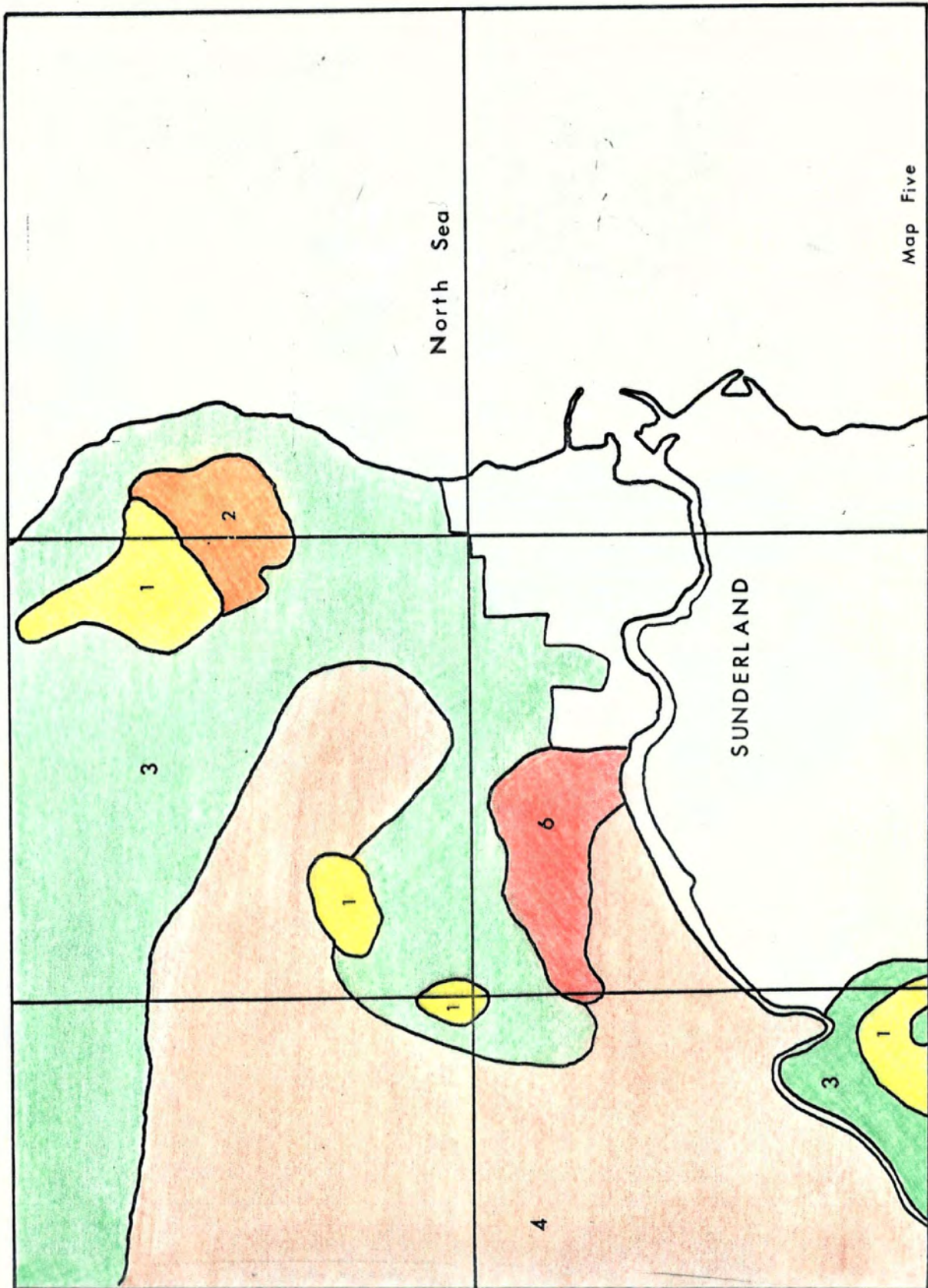
Map Four



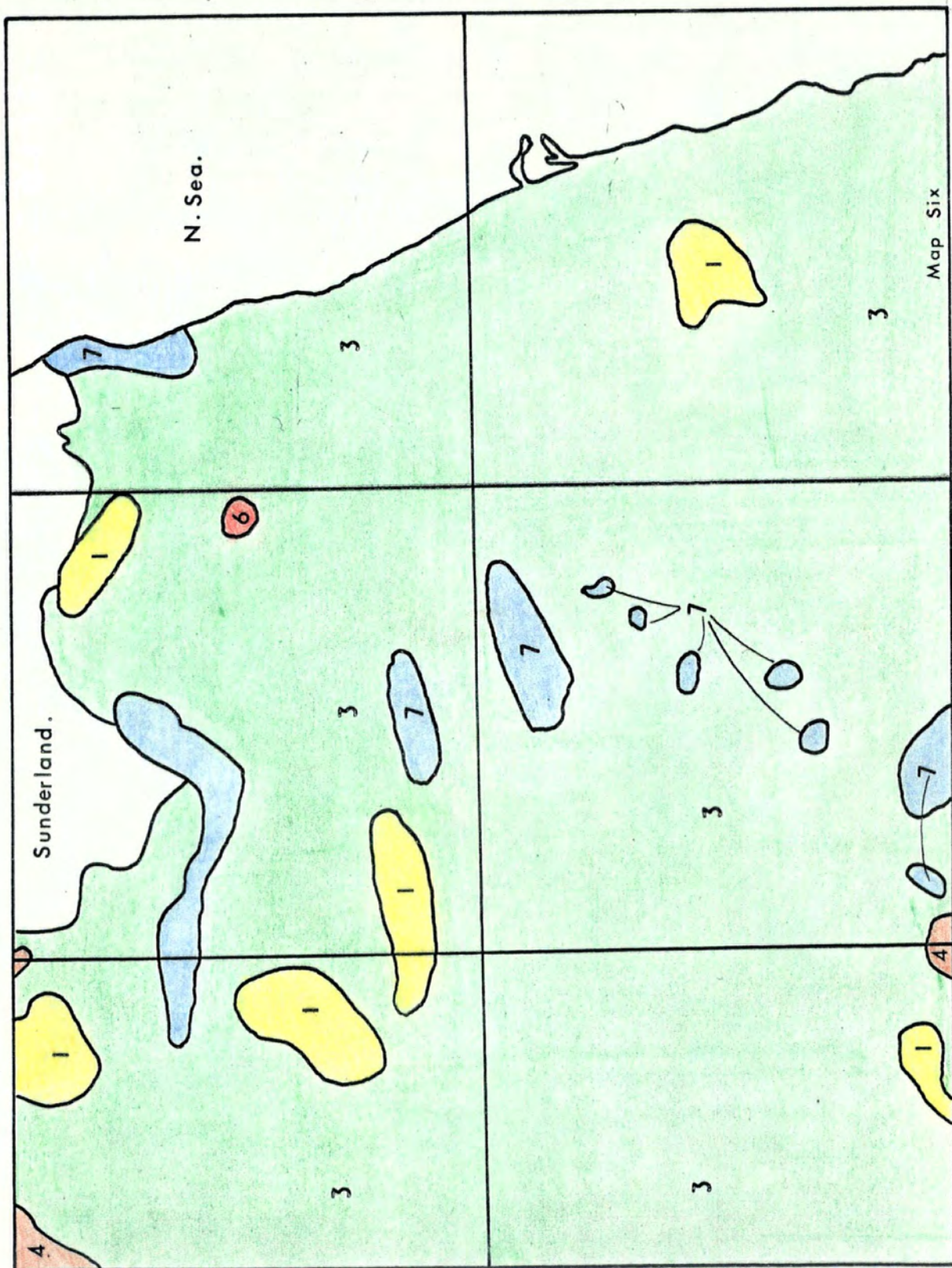
1	CORNFORTH SERIES
2	MIDDLEHAM SERIES
3	KELLOE SERIES
4	HASWELL SERIES
5	SHOTTON SERIES
6	HESLEDEN SERIES
7	MAINSFORTH SERIES
8	CASSOP SERIES
9	PRESTON SERIES
10	RICKNALL SERIES

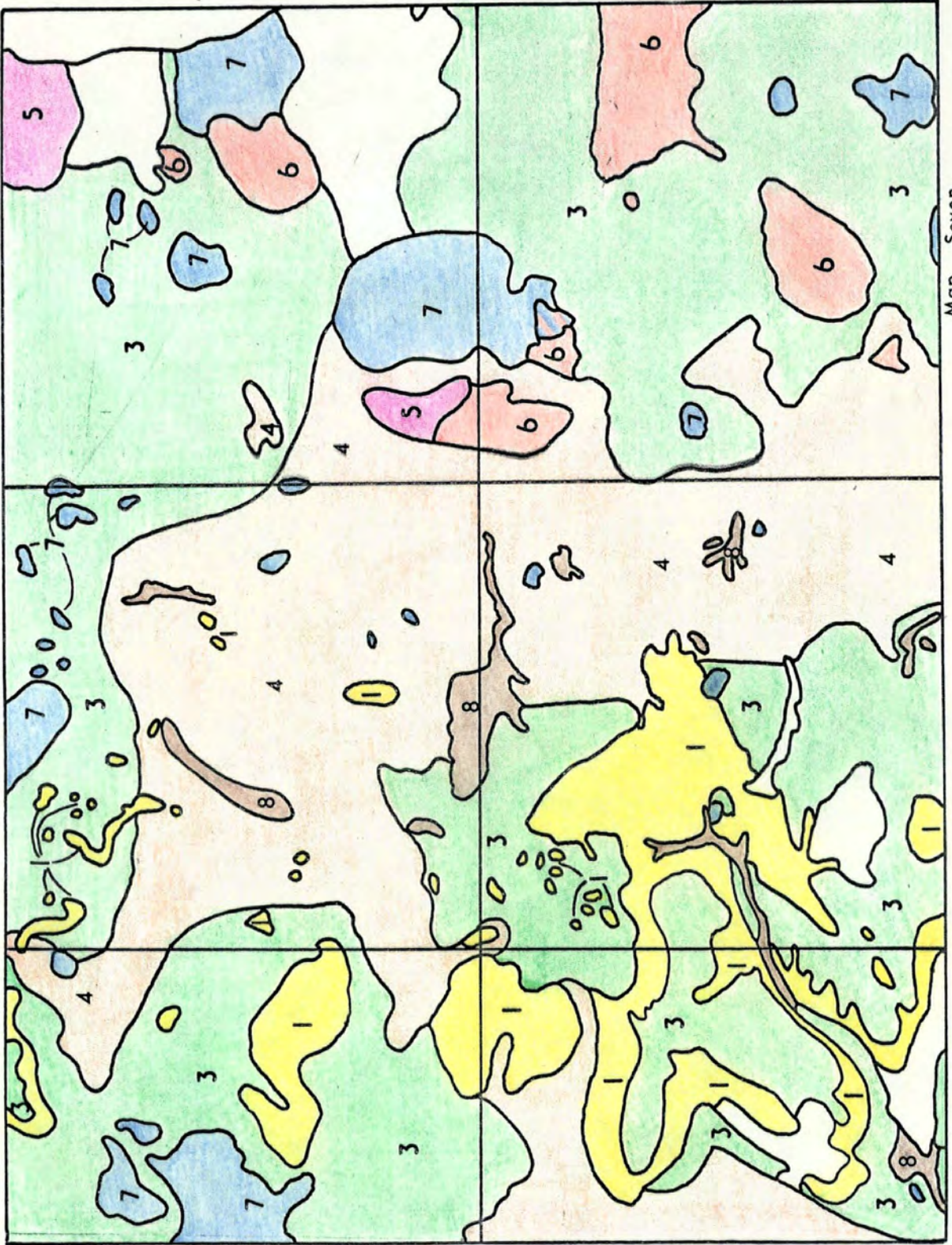
Scale: One mile : One inch

KEY TO SOIL MAPS FIVE - EIGHT

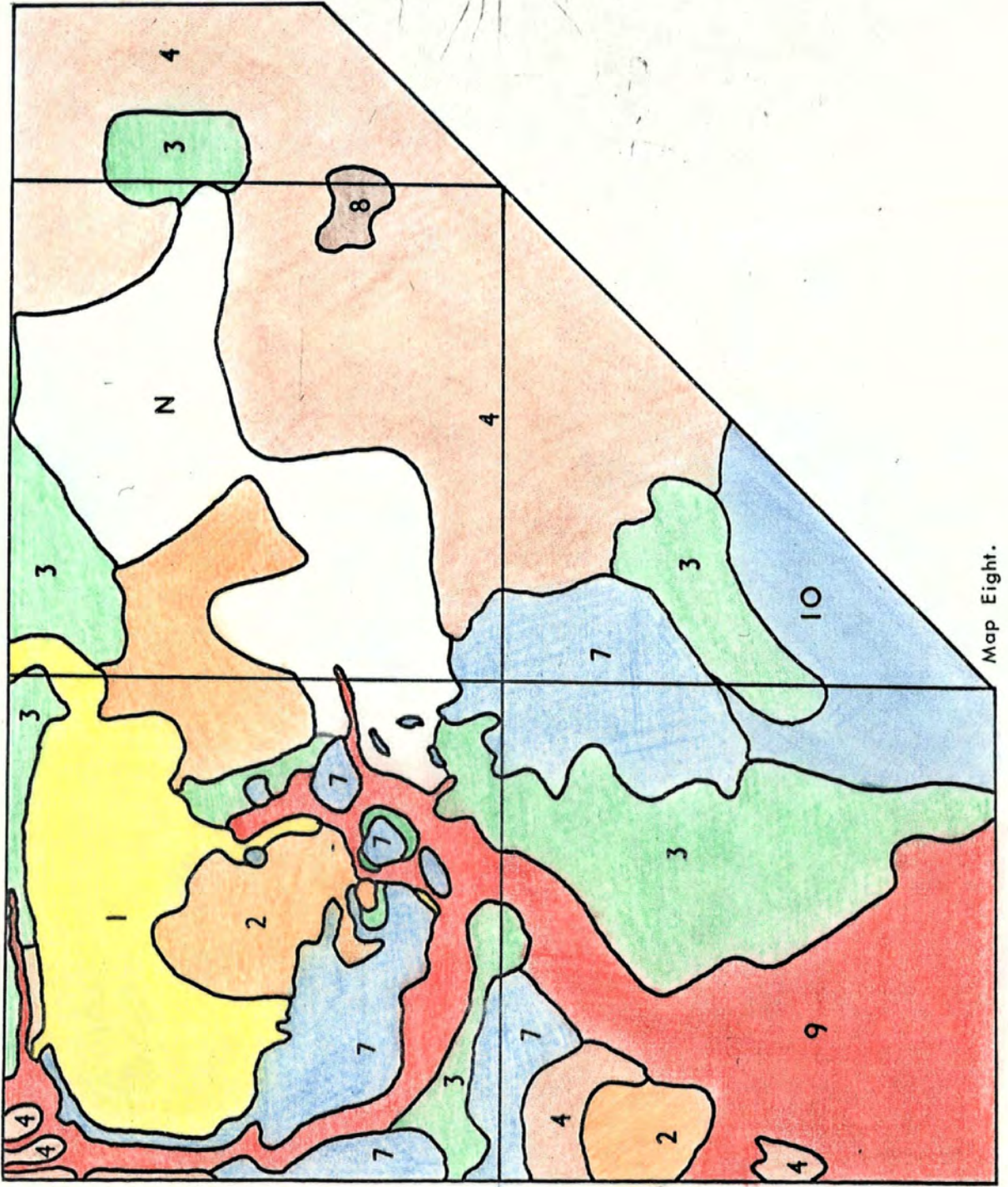


Map Five





Map Seven



Map Eight.

SECTION FOURAGRICULTURAL HISTORYChapter 1Before 1912

Some of the earliest history of farming practice in parts of this region has been traced by Simpson (15). Modern farming practice can perhaps be seen as early as the late eighteenth century when modern crops and rotations were established. The pace of farming was of course slow, because of the comparative lack of mechanisation and reliance on manual labour. Leases included compulsory rotations such as wheat, oats and fallow repeated for up to twenty years when wheat could be undersown with rough grass seed. Grass was down for up to ten years and it required a full year's labour to pare and burn old turf and plough back to the arable rotation. Severe penalties could be incurred by infringement of rotation as stated in lease. The system doubtless retarded the introduction of new crops but it maintained stability in an overpopulated countryside by maintaining the balance between arable and pasture land. Other lease conditions included the spreading of moderately large amounts of lime at regular intervals usually in association with the fallow year. Crops less common than wheat and oats included barley, usually only in the season following the plough-up of grass (doubtless wireworms were as common then as now following long periods of grass), and very rarely peas. Clover appeared in leases at Layton in 1772 when it formed part of a four course rotation - wheat, oats, clover and fallow. As late as 1777 restrictions on potatoe planting, except for home consumption and turnips, mustard, rape, clover, ryegrass or any other grass seed were strictly imposed and could only be modified with the landlord's consent. Simpson established that arable land accounted for only one third of the acreage of several farms which corresponds with present patterns particularly over less well-drained soils in the central portion of the region.

The large acreage of grass would be utilised in a mixed manner if Wingate Grange (modern farm study number 24) was typical. Here there were 9 horses, 6 milk cattle, 12 bullocks, 1 Galloway, 2 calves, 67 ewes, 2 rams, 59 lambs and seven pigs. The tally was taken in May 1783 but

by November the lamb total was greatly reduced which suggests that there was some degree of system and perhaps interdependence in the region.

Despite moderate indication of sophistication in agricultural practice eastern Durham was not nor is it today remarkable for its arable yields or its management practice. Arthur Young compared east Durham with the south-west of the county and the Tees basin. In these areas yields were in the order of 25 bushel/s wheat, 35 bushells barley, and 40 bushel/s oats. At roughly the same period yields at Wingate were 13 bushel/s wheat, 20 bushel/s barley, 24 bushel/s oats, in each case only slightly more than half the yields of the neighbouring areas.

By the time Bailey (37) reported in 1810 something of a revolution had occurred in the farming system. His description of the 'old rotation' is similar to that already mentioned with fallow, wheat and oats as the major components, with peas or beans playing an important part on some farms. Clover and turnips were however established when he wrote. He listed the following rotations as typical :-

(Fig.162)

<u>Dry soils</u>	<u>Strong loams</u>	<u>Ochrey clay</u>	<u>Moor soils:</u>
Turnips	Fallow	Fallow	Fallow
Wheat or barley	Wheat	Wheat	Oats
Clover (1 or 2 yrs)	Clover (1 or 2)	Clover and seeds	Clover and seeds (2 yrs)
Oats (or wheat if not already used)	Beans or oats	Oats	Oats

The new crops were there and doubtless making their effects felt, particularly on stock carrying capacity, but fallow land must still have been extensive and Young's advice unheeded. Fallow land can still be seen today, and, considering the poor quality of ploughing which is quite widespread, doubtless fallowing eventually becomes essential.

The East Durham Plateau was still the subject of scorn as Bailey described the area from Seaham to Trimdon as producing 'miserable crops of corn and a herbage that scarcely any kind of stock will eat unless compelled by hunger'. A modern commentator would probably modify such

comment only slightly. There were however some notable improvements beyond the central core of poorer soils and poorer farming. At Sedgefield one farm replaced carrots with Ruta бага for young rams as did a farm at Hutton Henry. At Haverton Hill continuous drilling of cereals for eleven years was employed to clear a farm of wild oats and yields were raised to 30-40 bushels to the acre.

Perhaps more important was the development of improved cattle. At Sedgefield local Shorthorns were crossed with Dutch bulls to produce large beasts and near Darlington similar developments led to the appearance of the famous Durham Ox. The Galloway was replaced. Leicester crosses were the sheep dominant on better soils while local breeds persisted on strong land.

(Fig.163)

Crop returns 1801 (Due to Simpson)

Parish	Acreage	Wheat	Barley	Oats	Rye	Potatoes	Peas	Beans
Castle Eden	1630	89	4	44		2	2	2
Yield (bu)		15	25	20				
Easington	12400	1270	48	1325	1	43	66	16
Yields (bu)		13/14	20	20			13	13
Monk Hesleden	6060	551	32	512		17	15	58
	Turnips and rape							
Castle Eden	10 acres							
Easington	157							
Monk Hesleden	60							

These figures indicate the predominance of wheat and oats and the very small yields.

In the middle of the nineteenth century there was lack of progress on the central area with poorer soils. Fallowing was still ubiquitous, farmers were unwilling to introduce innovations and there was an overall ethos of poverty. Land required drainage, manures were little used and few root crops were grown. The coastal margin was deserving of more praise. Excellent potatoes, turnips and other vegetables were noted.

The growing number and size of colliery villages gave increasing impetus to farm improvement. New markets for food and fodder for pit ponies arose and colliery owners to some extent began to improve the land they acquired. Bell (38) made the important observation that much-needed drainage of poorer land was initiated with an extra charge of five percent above normal rents. There were, however, persisting husbandry controls in leases. For example, permanent pasture could not be ploughed out on many farms. The result was that there was a great turn-over of small tenants. Consequently new building and general farm improvements was at a slow pace.

This was the period of peak agricultural production throughout England but if Bell's report is accurate at least the central block of the East Durham Plateau did not share the full effects of national growth. The more coastal areas did not increase arable acreage considerably however. Castle Eden had 45 percent under crops in 1866 compared with 12 percent in 1777 while at Monk Hesleden the increase was from 20 percent to fifty nine percent.

(Fig.164) Crops as a percentage of total farm land 1881

Parish	Wheat	Barley	Oats	Potatoes	Legumes	Roots	Fallow	T.Grass	P. Grass
Castle Eden	7	2	9	3	1	9	2	11	55
M.Hesleden	14	3	14	1	2	7	8	9	41

These two parishes are typical of the picture assessed by Simpson (15). They show that wheat and oats are still dominating the arable use although there was by now a marked increase in root crops and some degree of sophistication as the range of crops widened. Fallow land was however still extensive.

From 1870 onwards, in common with the major part of Britain, the arable acreage fell considerably especially on poorer soils. Permanent grassland was more extensive even in those areas already dominated by grazing. With wheat at a very low price, 1894-1895 was the worst year and was followed by a very slow recovery. In 1901 arable land had shrunk from the 1877 total of 45 percent in Castle Eden to 30 percent,

and in Monk Hesleden from 59 to 41 percent. Of the arable land wheat had lost some importance to roots and potatoes. Temporary grassland was extensive and much of this must have eventually reverted to permanent grass under the pressure of existing conditions. The following figures indicate more precisely the above statements.

(Fig.165) Crops as % of total farmland 1901

Parish	Wheat	Barley	Oats	Potatoes	Legumes	Roots	Fallow	T.Grass	P.Grass
C.Eden	-	6%	7	2.5	1	6	1	7	70
M.Hesleden	2	5	10	2	1	6	2	13	59

These figures are taken from the 1901 census and represent the percentage of individual crops of the total parish farmland. It is interesting that barley is beginning to be more important but fallow land is still a significant though reduced percentage of the total. Parish statistics are of course unreliable and undue emphasis is not placed on them for that reason but those indicated are complementary to remarks of contemporary observers.

The reasons for the decline in wheat and the increase in roots and to some extent oats was of course the low price of wheat in competition with American grain. Animal fodder was the only real alternative. It was also during this period that potatoes came to have a significant share of the arable acreage, particularly near to towns and villages. Legumes naturally declined as grass acreage expanded. Increased hay and roots were in future to be the main stay of winter fodder to balance the oats.

v That livestock increased in all classes is reflected well in the following table.

(Fig.166). Stock per 100 acres of total farmland

Parish	Dairy cattle		Beef cattle		Sheep	
	1870	1901	1870	1901	1870	1901
Castle Eden	6.0	8.7	6.0	11.2	37.6	48.2
Monk Hesleden	3.1	4.1 v	5.3	6.4	36.4	65.5

The increase of sheep in Monk Hesleden is particularly noteworthy. Stock carrying was at greater density over the total farmland but taken with the increased acreage of grass actual density per grazed acre fell.

The change in farm unit size is difficult to trace but in several parishes there were more than fifty percent of the farms under 50 acres in 1870. This position was changing by 1901 and today the farm of less than 50 acres is a rarity.

The beginnings of farm amalgamation are observable in the following table.

(Fig.167)

Amalgamation of holdings

Parish	Number of Holdings.		Average size of holdings in acres	
	1870	1901	1870	1901
Castle Eden	31	20	47	72
Monk Hesleden	57	60	94	98

The average size of farm increased in both cases even in Monk Hesleden where there was an increase in the total number of holdings.

By 1912 there were in some parishes slight increases in the acreage under crops over the 1901 figures but in some cases, where statistics are available permanent grassland continued to expand.

(Fig.168)

1912 Crop acreages

Parish	Acreage	Arable acres	% arable	% change since 1901	Since 1870
Sheraton	2044	723	35	+4	-15
Sedgefield	5003	1835	35		
Trindon	2089	745	36		
Embleton	2858	690	24		
Shotton	2780	1139	41		
Wingate	3488	1138	33		
Bradbury	1853	391	21		
Mordon	1509	367	24		
M.Hesleden	1971	845	43	+2	-16
Foxton	1494	667	45		
Castle Eden	1436	420	29	-1	-16
Fishburn	1983	854	43		

1912 Crop acreages. (contd..)

Parish	Acreage	Arable acres.	%arable	%change since 1901	since 1870
Butterwick	1437	428	30		
Hutton Henry	1808	917	51		
Bishop Middleham	1723	830	48		

Important differences in land use are distinguishable in this period between the Tees basin, and to some extent the coastal areas of the East Durham Plateau and the central higher land to the north and west. Cereal cultivation was more extensive in the former areas while permanent grassland still assumed greater proportions to the north and inland. This is a continuation of historic distributions already outlined. Furthermore on the heavier soils of the plateau oats continued to dominate the cereal contribution to arable land use and a great proportion of this must have been for animal fodder on the home farm, although some doubtless found its way into the local collieries for pit ponies.

(Fig.169) 1912 Crop acreages for parishes as percentages

Parish	Wheat.	Barley.	Oats.	Pots.	Legumes.	Roots.	Mallo.	T. Grass.	P Grass.
Sheraton	2	25	7	1.5	0.3	5	-	14	65
Sedgefield	3	6	8	3.5	0.3	5.5	0.9	9	65
Trimdon	3	5	8	1.6	1	5	0.5	13	64
Embleton	2	3	5	0.8	1.1	3.5	2	7	76
Shotton	2	6	9	4	0.1	7	0.6	12	59
Wingate	3	4	8	2	-	4.5	0.7	11	67
Bradbury	3	3	6	1	-	3	0.7	6	79
Mordon	3	4	6	0.7	-	3	3	5	76
M.Hesleden	3	7	8	3.5	0.2	6	3	10	57
Foxton	4	5	6	1.3	0.1	4	2	9	55
C. Eden	2	4.5	6	3.5	0.3	4.5	1	8	71
Fishburn	4	7	9	3.1	-	5.3	2	12	57
Butterwick	3	6.5	7	2.6	0.2	4	1.6	5	71
H.Henry	5	7	11	4.6	0.2	8	1.8	12	50

By this period it is clear that barley had established slight dominance over wheat, although this was not so further to the south. Potatoes and roots had established themselves in the rotation everywhere and legumes had declined to an insignificant role. Fallow land was much decreased in acreage and this can perhaps be attributed to the greater feasibility of cleaning the land under potatoes and roots. Of the arable acreage of course oats were still supreme. Temporary grass was high but the most striking feature was the large percentage of land under permanent grass, particularly in the two carrland parishes of Bradbury and Mordon where the effects of drainage were not yet fully operative.

The position of livestock is difficult to analyse with any degree of accuracy. Simpson (15) in a study of 35 parishes finds that absolute number of stock decreased, in an area largely to the south of one under present consideration. Individual parishes obviously would behave differently and the fortunes of individual farms within a parish would perhaps significantly modify census data and thus adversely affect accurate correlation. For example in the two parishes so far followed showed different trends in 1912. In Castle Eden dairy cattle were slightly reduced in numbers per total available land since 1870 while beef cattle increased and sheep population more than doubled. In Monk Hesleden however, density of dairy cattle increased, beef cattle were less numerous and sheep remained stable. Overall density assessment in terms of grazing acres per grazing unit show that grazing density in Castle Eden was in fact stable and in Monk Hesleden grazing density declined. Animals per 100 acres of farmland for various parishes are listed below.

Table (Fig.170)

Animals per 100 acres of farmland
Stock 1912

1912	Dairy	Beef	Sheep
Sheraton	3.0	7.9	82.9
Sedgefield	7.0	4.3	39.2
Trimdon	6.6	2.6	23.7
Embleton	3.4	4.6	55.1
Shotton	4.2	2.3	41.7
Monk Hesleden	6.4	1.8	34.1

(Fig.170) contd..

Parish	Animals per 100 acres of farmland		
	Dairy	Beef	Sheep
1912			
Wingate	3.3	5.4	32.7
Bradbury	5.5	5.6	68.8
Mordon	5.8	4.0	49.8
Foxton	4.3	4.5	69.6
Castle Eden	5.2	10.2	77.8
Fishburn	4.2	2.5	36.6
Butterwick	3.1	3.3	30.3
Hutton Henry	5.3	6.6	27.6
Bishop Middleham	3.7	4.6 v	20.8

Although the absolute totals of the above table are perhaps inaccurate the table itself has a subsidiary function in enabling the establishment of traditional patterns of distribution. The overall pattern of emphasis of southern and eastern areas on arable and milk and the centre of the region on beef and unused grassland is historic and fairly stable despite economic conditions. The more favourable areas perhaps respond to economics more strongly and fall back on beef in 'hard times'. The areas with poorer soils do not react so strongly as they have not so far to fall back. The surprising number of sheep at Castle Eden during the 1912 census is difficult to explain. One might hazard a facetious guess that it happened to be market day but certainly this high density of sheep is not a permanent characteristic of that parish. Elsewhere, in the region and certainly as an average of Simpson's findings sheep declined roughly in correspondence with the national trend at this time. Surely it cannot be that all the missing sheep were in Castle Eden. The size of farm holdings bears some correlation with type of farming. For example parishes with farms of over 300 acres occurred mainly in the low density beef grazing parishes, for example there were three in Sheraton, 3 in Embleton, 2 in Wingate and one in Foxton.

During this period the opening of new large collieries on the coast, at Blackhall in 1894, at Hordon in 1900 and in Easington in 1900

doubtless give some impetus to agricultural activity but the degree of impetus is difficult to assess. Wheat prices were still low and with a new prospect on land use value much agricultural land was lost to the mines themselves and to the accompanying growth of residential areas. It was during this period that so much of the twinning/villages took place.

The growth of industrial population has been analysed in the following manner (15).

(Fig.171) Population analysis

Industrial parish	1901	1911	1921	1931	1939
Easington	1731	2711	9186	11986	11846
Shotton	1917	12561	15647	19529	21264
Monk Hesleden	1302	2093	5781	7298	8518

Simpson states that the population in rural parishes maintained its nineteenth century level but this is not consistent with the combined increase of rural and industrial villages' population, for example Easington.

(Fig.172) Population Easington

1901	1911	1921	1931	1939
40526	60040	75642	88027	81598

One can hardly conceive of a large increase in the agricultural population during this period and the only conclusion is that the boundary of industrially occupied populace did not correspond with the administrative boundary of Easington Colliery. Certainly from this period onwards analysis of parish statistics is very difficult as losses of agricultural land were enormous and with increasing population in new areas administrative boundaries were inevitably to change considerably. Only rough guides or vague indications can be drawn from correlation between past and future parish statistics.

1912 - 1945Chapter 2

The period from 1912 is complicated by the effect of war time contingencies. On a national scale Agriculture was governed by District Committees; anable acreage was first encouraged to increase by the Food Production Department and then compulsory ploughing out of permanent grassland was enforced. Guaranteed prices for grain and labour were established. The establishment of dairy collection services and the high prices following the war were reflected in the region by a somewhat more balanced agriculture. After 1921 however wheat prices tumbled when government support was withdrawn. Beef prices until then correspondingly high also fell. Farming was again in a serious position. Profit margins were very small or did not exist at all. In any case there was little capital available for investment or improvement. Management quality was bound to reflect this in such things as low fertilizer application levels and inadequate rotation. This was the national picture but in the East Durham Plateau changes were not so drastic. The traditional fall back to reliance on stock and permanent grassland was not so marked here because there was very little improvement to whittle away. There was not a great distance to fall.

While Simpson finds a significant decline in the arable acreage in the whole of the area he studies, in that part that encroached on the East Durham Plateau this is not generally the picture as data for 1930 indicates.

(Fig.173) Arable acreage 1930

Parish	Acreage	Arable acres.	percent.	percent change since		
				1912	1901	1870
Sheraton	2041	658	32	-3	+1	-17
Sedgefield	5178	1760	34	-1		
Trimdon	1919	664	34	-2		
Embleton	2858	647	24	-		
Shotton	3363	1594	47	+6		
Wingate	3199	871	27	-6		
Bradbury	1851	485	26	+5		

(Fig.173) contd...

Parish	Acreage	Arable acres.	percent.	percent change since		
				1912	1901	1870
Mordon	1492	391	26	+2		
M. Hesleden	1755	1024	58	+15	+17	-1
Foxton	1528	546	36	-8		
Castle Eden	1413	481	34	+5	+4	-11
Fishburn	1995	864	43	-		
Butterwick	1483	351	24	-6		
Hutton Henry	1782	929	52	+1		
Bishop Middleton	1600	764	48	-		

Realising that the changes since 1870 are by no means accurate it is still possible to say that a rapid increase in permanent grassland did not occur in this region. Small changes up or down are to some extent balanced in neighbouring parishes. What is of great interest is that Monk Hesleden had all but regained its 1870 position perhaps due to the increase in population and an pitponies at Easington, Hordon and Blackhall. The slight increase in arable acreage in Bradbury and Mordon, the two parishes above-all traditionally pastoral and dominated by poor quality permanent pasture, is of interest. This could be attributed to the improvement of drainage conditions at last coming to fruition as the level of the Skerne was lowered and drainage slices cut through the peat carrs. This is a dangerous assumption however. Single cause changes are never valid. Better to accept the position as it is and accept that at least this one traditionally grazing area did not fall back to permanent pasture during the depressed times of the 1920-38 period. This perhaps enforces the thesis that such regions had reached the absolute maximum of 'specialisation' in permanent pasture and could not fall back without becoming a 'mono-culture'. There is one example of such a state of affairs today as described in Farm Study (30). Here the farmer has gradually rejected dairy produce, then all cultivation and now maintains a very low standard permanent pasture. It is doubtful if such an enterprise can continue for any length of time. The distribution of the various crops in different parishes in 1930 was as follows :-

(Fig.174) Crops as a percentage of total farmland 1930

Parish	Wheat.	Barley.	Oats.	Pots.	Legume.	Roots.	Fallow.	TG.	P.G.
Sheraton	4	3	5	3	0.3	5	0.5	10	68
Sedgefield	4	3	9	2.6	0.04	4	1.2	10	66
Trimdon	3	3	7.5	2.5	0.3	4	0.5	13.5	65.5
Embleton	3	1.5	6	0.7	-	2.3	1.8	8	76
Shotton	4	6	14	3.8	0.6	5	0.5	13	53
Wingate	2.4	1.3	9	1.3	0	4	0.5	9	73
Bradbury	3	2	6	1.4	-	3	0.8	10	74
Mordon	4	2.7	6	1.5	-	2.7	2	7	74
Monk.Hesleden	8	2	16.5	7	-	7	1.6	17	42
Foxton	5	2	10	1.2	-	3.3	0.3	13	64
Castle Eden	5	1.5	8	3	0.2	4	0.5	11	66
Fishburn	4	5	12	3.5	0.1	4	1.6	13	57
Butterwick	2.5	4.0	4	1.6	0.4	2.5	2.5	6	76
Hutton H.	5	4	12	4.7	-	6.4	1.3	18	48
Bishop M.	4	8	12	3.6	-	6.3	0.2	14	52

Small changes in individual parishes, as already mentioned have doubtful significance but it is possible to gain an overall impression of what has happened during this period of recession. At first sight it appears that nothing really significant has happened, but as closer inspection reveals it is clear that any gains that the barley acreage had made since 1901 were reversed in 1930. Wheat increased its acreage slightly at the expense of barley but oats were more substantially increased. Potato acreage varied slightly from parish to parish but the overall pattern is one of stability. Legumes continued to decline in importance and were indeed less extensive now than fallow land which had remained fairly stable throughout the period. Rather surprising is the slight decline in roots. This may suggest that in fact stocking capacity was reduced. Changes in temporary and permanent grass balance each other with remarkable consistency. Where temporary grassland increased permanent grassland was reduced and conversely. This indicates that there was in fact little change in grassland use. This supports

the previous argument that farms could not in fact fall back any further on permanent grass to save capital expenditure and a future contention that stock numbers did not increase during these difficult times. The central areas of the East Durham Plateau were then at this time virtually marginal in terms of agriculture.

There were notable exceptions to the above observations. As has already been mentioned there was a drastic reduction of permanent grassland in Monk Hesleden. This was balanced by increased oats and potatoes and a significant increase of temporary grassland. There was however a decline in barley production which corresponds with the rest of the region. The above changes were due to the large increase in Colliery activity and population on the coast. A similar reason can be postulated for the increase in oats at Shotton, in association with the colliery, and a similar increase at Foxton together with more wheat can be associated with the same colliery. At Castle Eden oats and wheat acreage expanded also, in association with mining at Wingate. In all the above mentioned parishes temporary grassland increased at the expense of permanent pasture. The case of Fishburn is interesting. Here the soils are better than those to the north in the heart of the plateau, but the parish is away from the coast and really dense population. Here a very stable pattern of crop distribution was maintained throughout the period 1901 - 1930 despite adverse conditions elsewhere. It was not a case of not being able to fall back on permanent pasture because here only 57 percent of the land was used in this manner. Stock density was higher here, and there was generally a premium on agriculture. Competition with industry for occupation of the land was less, the landscape was and still is tidier and more rural, and land use was well adjusted to the land through long term inherent fertility. It can be put perhaps crudely by saying this was less of a marginal area than the plateau proper.

Changes in total grassland can be expressed in the following manner.

(Fig.175)

Changes in percent of agricultural land under grass (temporary and permanent)

Parish	1901	1912	1930
Sheraton	81	79	78
Sedgefield		74	76
Trimdon		73	79
Wingate		78	82
Bradbury		85	84
Mordon		81	81
Monk Hesleden	72	68	59
Shotton		71	66
Embleton		83	84
Foxton		64	77
Castle Eden	77	79	77
Fishburn		69	70
Butterwick		76	82
Hutton Henry		62	66
Bishop Middleham		63	66

Where oats were increasing in acreage and grassland was remaining stable as the above table indicates (with exceptions already discussed). It is now clear why roots diminished between 1901 and 1930. It is clear that stock density could hardly increase, although it must be remembered that during this period imported concentrates were forming an increasing part of animal diet, particularly in the case of dairy cattle.

An important result of the depressed years was the amalgamation of many of the smaller farms particularly those below 50 acres. In many cases also land was hired to larger farms with more reserve capital, for grazing. Mechanisation did not proceed at any pace during this period, quite understandably and in fact horse numbers increased in many farms as a measure of recovery from the large quantities taken during the continental war of 1914- 1918.

The 1933 land use map (maps one to four) can be analysed to show the following distribution. South of Sunderland there is a belt of land from the coast to the scarp in which arable land, including rotational grass, is comparatively plentiful. Permanent pasture is a secondary constituent of the landscape and rough pasture is almost completely absent. Built up areas and industrial sites take up as much of the land as rough pasture in the rest of the region, however. To the south and west, bounded by the escarpment and in the east by the Sunderland and Hartlepool Branch Railway, the arable acreage decreases in favour of permanent pasture and rough grazing. In the extreme south west in the carrland permanent pasture is dominant. East of the above mentioned railway and south of Cold Hesleden there is a narrow coastal belt which extends in to the Tees basin to the south in which arable and permanent grazing land is almost equally balanced, and rough grazing land is absent. The western edge of this belt is, however, indistinct and merges into the zone of permanent and rough grazing, for example around Sheraton, and Embleton. South of Sedgefield as far as Stockton and Darlington roughly one third of the agricultural land is arable and two thirds permanent pasture.

Farming today is not identical with this comparatively primitive pre-war condition but the zonation distinguished before the war is still present and this will find explanation to some degree as a result of the present study.

After the period already described farming conditions deteriorated rather than improved. Eye-witnesses still remember how difficult it was to seed anything whether grain, potatoes or beef. Many farms sank into dereliction. Most farms cut their labour supply and undercultivated the land. More small farmers left the land while others at all scales of enterprise retired prematurely to cut their losses. This left room for some farm labourers to occupy farms they would normally never have considered within their means. The result was a cumulation of low standards of living, undercapitalisation and inexpert farming practices. But the new farmers were tough and hard-working. They had to be. They were not particularly concerned with the condition of their newly rented Manor House or Hall but more with milking their cows and then

delivering their own milk. This is of course a generalisation but expresses the ethos of those who struggled through these very lean years. As the older farmer left, the traditional rural pattern crumbled. Customs and institutions disappeared. As transport improved the local mill and the local smithy were closed. Rows of tied cottages associated with village farms were emptied as the farmers cut the cost of labour and tried to do most of the work themselves. Villages such as Old Wingate and Old Cassop soon came to be nothing more than a couple of farmsteads.

Changes enough, and more to follow during the next war and yet the zones described maintained to varying degrees distinct differences. Just as different soils in the region respond to different amounts of rainfall in different ways (to be described later) so the farming in different zones of the region did not respond uniformly to economic conditions. This much can be determined from simple land use study.

The precise system of arable farming and stock turnover is difficult to establish because of the large-scale changes in the people doing the farming. Memories are short in this region compared with many other parts of the country. There seemed however to be something of a pattern of raising calves from the higher land in west Durham or stores from Ireland and lambs from the hills and Scotland. Calves were raised to the three^{year} stage when they were ready for the butcher and stores were fattened on a short term basis. Lambs were finished off on a very short term basis on the better grazing land but on poorer pastures there could be little advantage over the places where the lambs had been raised.

Amongst cattle breeds Shorthorns were popular, with Ayreshires and, to a lesser extent, Friesians, Jerseys and Guernseys for milk. The man in the milk was the man who survived the crisis perhaps best of all in farms with a strong specialist emphasis. Hard work was required but milk was saleable even if the price was low. The Milk Marketing Board set up in 1934 fixed milk prices and made markets more secure. The introduction of subsidised milk in schools and for pregnant women helped considerably to increase the volume of milk consumed and the introduction of Grade A and 'T' bonus systems proved valuable incentives.

Half-breds were the most common sheep, producing lambs fat for May to June. When they were sold replacements were brought in from the north. Pigs were reared for pork and the Large White was common here as in the rest of the country.

Also in 1934 the Potato Marketing Scheme was introduced. This was aimed at preventing the saturation of the national market, which periodically happened because of fluctuations in yield and acreage down to the crop. The major intention of the scheme was to control the yearly acreage and to place the disposal of the crop in the hands of only authorised merchants. The general effect of these measures seems to have been to increase the acreage of potatoes in the East Durham Plateau although the major part of the region is far from good potato land.

War-time controls of course brought many changes and many difficulties to the region although the more permanent result was to improve conditions. Waste land was not to be tolerated and with controlled cropping and prices, and assured markets there was a movement to grain production in common with the rest of the land. Wheat, barley and oats with rotational grasses came to dominate the scene as permanent pasture was ploughed out, Beans almost disappeared as a field crop and roots were greatly reduced. This last point is of great importance, because it reflects the disappearance of much of the stock from the region. The difficulty was that farmers selling so much of their stock were in fact selling a great part of their investment in the land that had been built up over the years. In addition to this the credit from the large scale selling was heavily taxed and many farms were to be considerably decapitalised. This may be one of the reasons why there was slow mechanisation throughout the period, despite the removal of much of the remaining labour force through conscription. Permanent labour was not subject to conscription but the casual force normally relied on in heavy times was greatly depleted. Tractors did of course replace the labourer to some extent but in this region it is significant that horses continued to work on many farms well after the conclusion of the war. This is indicative of the state of general

mechanisation, which is only in the early 1960's undergoing a break through as combines and driers and hydraulic equipment prove their merits. The place of the casual labourer and to some extent the permanent force was taken by the Womens' Land Army and P.O.Ws. The position is described in detail in neighbouring areas by H.C.Pawson (39)

Old pastures were ploughed out and cleaned with roots and oats and then continually sown down to wheat and barley. Farmers report very good yields initially but by the end of the war, as might be expected, trouble was widespread, particularly with 'Take-all'. This was particularly severe in this region because of the necessity to sow winter wheat, which allowed little time for the soil to be cleared of disease before the next crop was germinating.

One of the more important features of the war time contingencies was the introduction of large scale application of inorganic fertilisers. Yields were greatly improved, but perhaps because of initial inexperience, early prejudices arose and several farmers are only in very recent years accepting the use of nitrogen. One can imagine the results of early imbalanced fertiliser application and the effect it had on the margin conscious farmer of East Durham.

Chapter 31945 - 1960

Since the Second World War subsidy and planning have determined much of the farming pattern in this region as in the whole country. Together with the permanent guarantees of prices in grain, milk and livestock products, established subject to annual review under the 1947 Agricultural Act, radical changes in security of tenure have allowed many farmers to undertake long needed improvements to the land. The N.C.B. having taken over the land occupied by former colliery owners have taken their part particularly in providing improved buildings and farm houses. Encouraged by grants improvements have been made in drainage, water supply, approved buildings, sewage, tracks, fencing, hedge removal, and land clearance. The difference is marked but there is still an atmosphere of incompleteness, because there has been little integration or planning. To drain one field is not sufficient. The neighbouring fields up-slope and down-slope must be taken into consideration and it is in this respect that the region is most seriously handicapped. An overall plan of regional drainage taking into account mining subsidence has yet to be achieved. The present condition is a combination of partially working nineteenth century drainage usually leading water into areas of periodic and permanent accumulation because of subsidence, or newer efficient drainage not integrated with lower lying land. This in many cases is actively stripping the top-soil from cultivated land or again increasing the problem of accumulation in areas with subsidence hollows or impeded main courses. The grant system has however made the farming life more tolerable throughout the region. Rough grazing is ploughed out and fertilisers are applied more liberally. Generally there is more capital available to invest in such things but noteworthy cases will be mentioned where, in the central part of the region particularly, there is a serious problem of undercapitalisation still in force.

The following table shows that the improvements listed and the war-time controls have left a permanent influence on farm system in favour of grain crops. Milk and stock must of course remain of great

importance in this area but even here intensive feeding methods have allowed more land that would otherwise have been down to grass to be incorporated into an arable system. Mechanisation has furthered this process. More power and better equipment has allowed better and more selective cultivation of the soil. This has allowed the cultivation of barley for example where it would once have been almost impossible. Many farms could not afford combine harvesters or grain driers until after 1950 and it is since then that barley has increased considerably. There is also the corresponding national increase in barley production to take into account in seeking causes of change but there can be little doubt that particularly on heavier land such changes would have been impossible without the tractor. There was only one caterpillar tread tractor in the whole of the region during the 1964 survey however which perhaps indicates the low level of margin and capital investment which would if higher allow the use of this highly desirable, if more limited form of traction. Larger farms of course began their major investment in machinery during the war but the smaller farms have been long finding it possible to purchase combines and driers.

(Fig.176) 1960 arable land as percentage of total farm land.

Parish	Acres	Arable	%arable	% change since			
				1930	1912	1901	1870
Sheraton	2055	1050	51	+19	+16	+15	+3
Trimdon	2012	993	49	+15	+13		
Sedgefield	4395	2846	65	+31	+30		
Embleton	2448	1385	56	+32	+32		
Shotton	2022	1528	75	+28	+34		
Wingate	3414	2216	65	+38	+32		
Bradbury	1853	823	44	+18	+23		
Mordon	1044	712	68	+42	+44		
Monk H.	1623	1323	82	+24	+39	+41	+40
Foxton	1632	1266	77	+41	+33		
C.Eden	1004	837	83	+49	+54	+53	+28

(Fig.176) contd...

Parish	Acres	Arable	% arable	% change since			
				1930	1912	1901	1870
Fishburn	1650	1179	72	+29	-		
Hutton H.	1829	1244	68	+16	+17		
Butterwick	1923	1364	71	+47	+41		
Bishop M.	1625	1118	69	+21	-		

This present day pattern is here reflecting permanent influences from the past and also the growth of more recent factors. For example although more concerned with arable practice than ever in the past, the traditionally pastoral Sheraton has a comparatively low acreage under cultivation and has made less marked gains over the years than other parishes. Bradbury is still low lying and ill-drained and has only 44 percent of the land under crops, but Mordon a similar parish has responded better to drainage and now ranks as an arable area. The most marked devotion to arable practice is in the densely populated parishes of Shotton, Foxton, Monk Hesleden and Castle Eden. The traditionally stable Fishburn has shown an increase of twenty nine percent in arable acreage since 1930. If such a figure is taken as representative of national changes due to war time controls and post-war subsidy, although it must be admitted that there has been some increase in industrial activity there since the war, several interesting features can be surmised from the figures. Parishes with poorer soils such as Sheraton, Trimdon, Hutton Henry and Bishop Middleham have increased their arable acreage above the rate of increase of the 'average'. A third group, those parishes with high population density and with the highest proportion of land already under crops have not increased at the same rate as the average, perhaps because their arable acreage was in any case very high. This is the reverse of the principle evolved during depression years when certain areas could not devote more land to grass because they were already so pastoral in character. This is obviously not a full explanation, but it uses all the facts available and is helpful in giving indications of pattern and influence that are followed up in the map interpretation.

More precise cropping/^{is} indicated below :-

(Fig.177) Crops 1960 as percentage of agricultural land

Parish	Wheat	Barley	Oats	Pots.	Legume	Roots	Fallow.TG.	PG.	Mt.Veg.	
Sheraton	8	6	12	4	-	5	-	13	49	-
Trimdon	7	6	12	3	-	3	0.5	17	51	-
Sedgefield	6	10	15	4	-	4	0.7	23	35	-
Embleton	6	10	12	1	0.3	2	0.5	22	41	-
Shotton	12	6	16	4	1.1	3.5	0.4	32	25	-
Wingate	6	11	10	3	-	2	0.2	29	35	-
Bradbury	3	10	9	2	-	2	0.7	15	56	-
Mordon	6	14	15	3	-	4	-	26	32	-
Monk H.	14	12	12	8	-	5	-	28	18	1.6
Foxton	9	22	12	3	-	4	0.6	25	22	-
C.Eden	6	3.5	10	20	-	8	-	30	17	7
Fishburn	7	14	11	4	-	2	2	30	28	-
Butterwick	11	14	22	3	0.2	3	0.6	16	29	0
Hutton H.	7	7	16	5	-	5	-	27	32	-
Bishop M.	10	15	9	8	-	2	-	21	31	2

These are the latest comprehensive parish statistics used in this work and they illustrate important changes but they are by no means representative of the present day, as analysis of the farm studies will illustrate. Perhaps the most significant change is the move from oats to barley production, although as the figures illustrate in several parishes in 1960 oats were still the major group. Oats had increased their share of the land in some cases but by far the bigger share of ploughed up pasture has gone to barley. The position with regard to wheat is not as clear. In some parishes wheat is still more important than barley, particularly in those parishes associated with large collieries although there can hardly be any relation between the two. In other parishes however the trend to barley in expense of wheat as well as oats is clearly indicated and by 1964 it was marked. Barley has at last ^{been} discovered as a fodder group on the East Durham Plateau, for only

little and very rarely is any sold as malting barley, and its potential as offering highest return per acre of any crop is being taken advantage of.

Potatoes have increased since 1930 in total acreage but only slightly, and when considering the amount of land brought out of pasture into the arable rotation the increased contribution of potatoes is negligible. This is not good potato land. The one exception is Castle Eden, the parish straddling the mixture of morainic drift material, where in 1960 the total of 20 percent of the total acreage was surprisingly occupied by potatoes. This is not the case in 1964. Legumes continued to decline down even from their 1930 position when they were already ⁱⁿ significant. The root acreage has remained quite stable despite various complex factors. Throughout the land for example first kale and then silage has tended to displace roots. Also improved concentrate rationing and greater amounts of hay due to better fertiliser practice have reduced the requirement of roots. In the East Durham Plateau however tradition dies hard and the heavier labour involved in root cultivation is not objected to. At least roots still hold their place in the rotation. Very little kale is grown and few farmers now make silage although several have experimented with it. Fallow land has shrunk to a very small proportion and at least on the individual farm must be insignificant and perhaps represents the problem field that cannot be cleaned in any other way or, as often happens when a crop fails and is ploughed out, the field is entered in the June Returns as fallow.

The proportion of temporary grass has of course increased greatly but only in a few cases, again the areas associated with high population density, does the temporary grass exceed the permanent pasture. Also the permanent pasture has in most cases been improved to some extent, if only by being ploughed out during the war. Some farmers are also coming to understand the benefits of improving their pasture if only by sporadic dressings with mixed surplus fertiliser or the occasional dung.

Also of interest in the 1960 returns is the mention of market garden type vegetables. These are again associated with the denser populations, in the case of Monk Hesleden and Castle Eden, and with specialisation on lighter soils in the case of Bishop Middleham.

Stock carrying capacity has increased since 1930 despite the overall decline in grassland. Up to 1960 dairy cattle increased, in particular, by over 50 percent. Beef cattle increased by 10 percent (Simpson 35 parishes) and young beasts by a far greater amount. Sheep also increased in numbers, this is due partly to a greater average drop in a season. In some cases for example Bradbury, increases were so great that they represent increased capital investment and a greater capability of developing traditional practices. The great increase in young beasts is indicative of more local rearing on a multiple suckle basis with improved supplementary feeds. The increase in milk cows would also contribute to the greater numbers of calves. The increase in dairying after 1930 is perhaps the most remarkable feature of stock changes in the region. The improved markets, guaranteed prices and quality incentives all contributed to this, although, as will be demonstrated later, the position is radically and rapidly changing. Many farms are going out of milk. This is illustrated by the statistics to some extent. Most parishes show substantial increases in total stock density but Trimdon in 1960 shows the reverse. This was to some extent a transitional year in that parish, because since then four out of seven dairy farms have gone out of milk. Not all of them have replaced the dairy herd with beef cattle and those who did have naturally taken no short time to build up stock numbers.

There was also a change in the use of grass during the period under consideration. In most cases there was a decline in cut hay as opposed to other uses of grass since 1939. Simpson produces the following table.

(Fig.178)

Use of grass as percentage of total grass

Parish	1930			1960		
	Cut	grazed	rough	Cut	grazed	rough
Sheraton	30	70	-	26	59	15
Sedgefield	41	53	5	40	55	6
Trimdon	52	46	2	42	52	6
Bradbury	33	67	-	30	43	27
Bishop M.	44	53	3	26	71	3
Fishburn	52	41	7	45	54	1
Butterwick	47	43	10	43	52	5
Monk H.	35	54	11	41	48	11
Wingate	37	47	16	29	57	14

As Simpson points out there are some unaccountable increases in grazing land in Sheraton and Bradbury. He also points out that the places which maintained or increased previous levels of hay cutting were those associated with high population and consequently dairying. The general decline in hay cut can be attributed to different causes. Increased grass per acre, under the influence of inorganic fertilisers, on selected specialised leys would undoubtedly be one reason, with the cutting of more than a single crop in a season in response to nitrogen. The other main influence would be the greater awareness of selected seed mixtures for controlled grazing. During the farm survey several farms were encountered where not only were grasses grazed several times in a season but where special early bite mixtures were sown which were cropped for hay after grazing and produced yields equivalent to or greater than older and more traditional mixtures.

The total area of land available for farming continued to decline after 1930 as mining waste spread, as quarrying activity increased, as housing redevelopment around old settlement areas expanded, and as larger housing estates and places such as Peterlee came into existence.

Simpson suggests that farm sizes generally decrease during this period due to similar influences but it is difficult to be dogmatic about

this because the total number of farms decreased considerably during this period. What is certain is there must have been considerable amalgamation of holdings and a decrease in the number of the farms below 100 acres, although this last fact is masked in Simpson's work by the small holdings instituted during the 1930-1940 period at Hutton Henry and Hart.

Total labour force has declined in many parishes although some show slight increases. This is difficult to interpret because some farm enterprises have been linked into chains which employ mobile labour. The general impression received from most farmers, particularly near industrial centres, is that labour is difficult to obtain or at least to hold. This is partly due to the distance of travelling to work and partly because during depressed times farm cottages were either neglected or pulled down and there are now no side-benefits to compensate for the lack of comparability between industrial and agricultural wages.

There has been a change in the structure of the labour force employed on farms in the direction one might expect and for simple reasons. The number of females employed has declined most severely (C.F.Pawson 39). This is particularly noticeable in dairy occupation as mechanisation has progressed. Furthermore the older element in male labour has increased proportionally at the expense of the farm lad and the middle aged group. Most young workers transfer to industry as soon as they can. The turn over in labour under the age of 21 is therefore very high and expertise is not continued in the industry. This leads to increasing difficulties in that when the old man who has been on the farm for thirty years under the same employer retires there is no-one with sufficient skill to replace him. Mechanisation of course relieves the problem to some extent but even here there are skills necessary which take a good apprenticeship to acquire. Unskilled casual labour can usually cope with heavy harvest periods because mechanisation has speeded up the system so much, but many farms are now run by the family and one experienced hind. It is difficult to conceive of mechanical improvements that could replace the hind when he comes to

retirement.

(Fig.179)

Changes in labour structure (Simpson) on 41 parishes

	Permanent workers		Temporary workers	
	Men	Women	Men	Women
1930	1151	211	150	152
1960	964	47	106	33
percent reduction over the same period	16.2	87.7	29.3	78.3

It is clear that as the time required for most farm operations doubles as the acreage doubles the large farm will suffer most from a labour shortage although it can be argued that this is incentive in itself to speedier and more comprehensive mechanisation and chemical farming. A final consideration at this point is the effect of labour on cropping policy. With modern equipment, the rotavator, the combine and the drier, barley requires far less hours per acre in terms of labour than any other crop. In comparison with wheat for example it requires less organic manure application, less spring treatment in the form of top dressing, harrowing and rolling and far less time at harvest and in storage. There is an incentive to spring barley production inherent in a labour shortage regardless of other factors. To set against this is the consideration that a balance between spring and winter crops allows a wider spread of labour requirements throughout the year. Nevertheless, as will be indicated in the following section, the pressures of change in terms of economics and labour seem to be militant in favour of a greatly increased barley acreage. This makes perhaps the greatest change of patterns that have been traditional in East Durham for more than a century.

SECTION FIVESOILS AS APPLIED UNITSChapter 1The Sector

For the purposes of correlation between farm practice and soils a general unsynthesised picture was obtained from farmers throughout the region during the period of soil survey. This involved field by field observations of 172 farms within the broadest strip across the East Durham Plateau. Here there is a wide development of the major Soil Series encountered in the region. Boundaries were as near as possible those of three six inch O.S. sheets and were in the west 4320; east 4450; north 5400 and in the south 5350. The total area was about twenty four square miles. Time involved on each farm varied from a few hours to several days.

Farm analysis was attempted in two ways. To complete the picture established in Section 3, which is again based largely on the same sector an overall analysis was made. This analysis was based on data obtained during the survey and not parish statistics. It revealed several important changes since 1960. A more complex survey was undertaken using soils and other physical factors in combination as practical survey units.

Farm size

Farm distribution according to size of holdings was established for the whole sector. It revealed an almost symmetrical distribution curve (Fig.180). The optimal range was found to be those farms within 150 - 200 acres. It may be that a region requires a spread of farms of all sizes to fulfil an integrated function but as the graph shows there is some weight on farms below 150 acres, which is not desirable. Several farmers stressed that with the capital they had invested in machinery and especially

% of total farms.

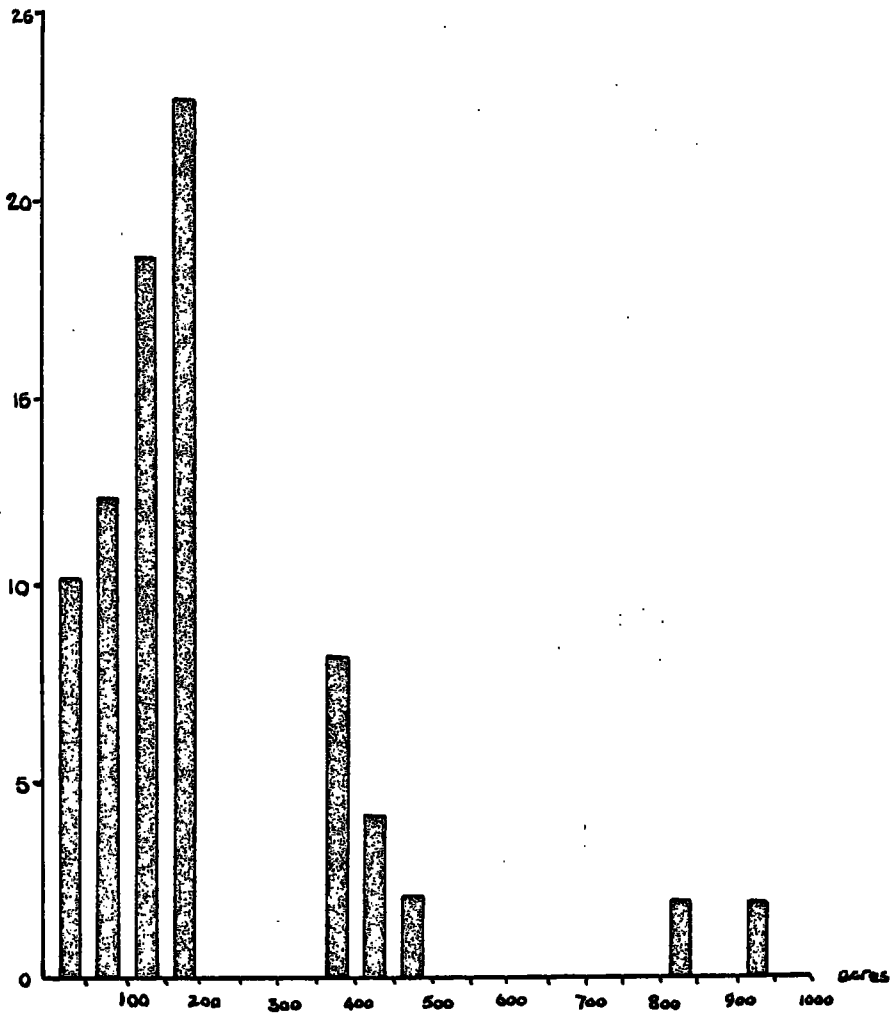


Fig 180 SECTOR DISTRIBUTION OF HOLDINGS
BY SIZE.

% of 172 farms

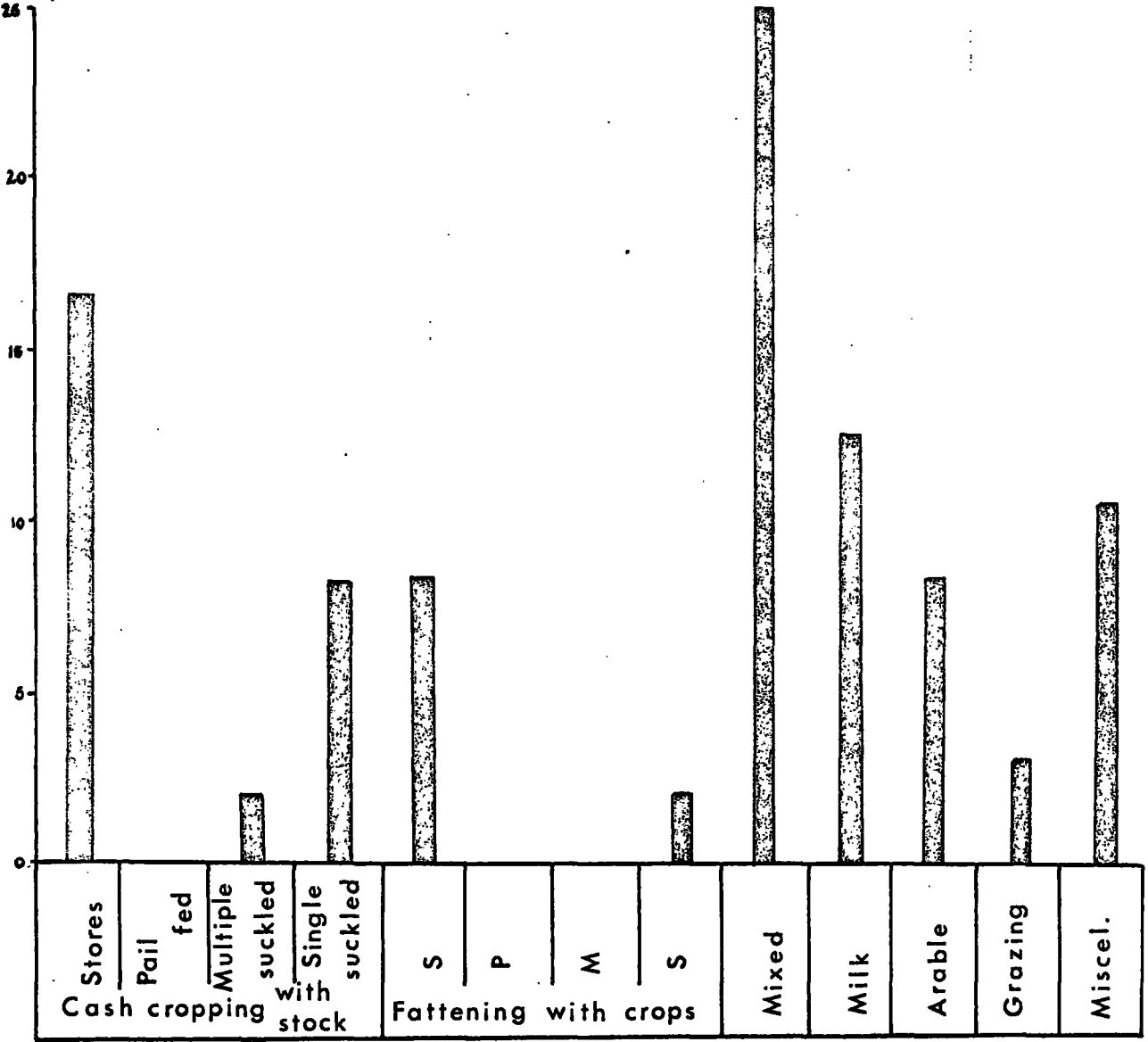


Fig. 181 DISTRIBUTION OF HOLDINGS BY AGRICULTURAL SYSTEM.

under mixed farming systems they could often use an extra 50 - 100 acres of land when acreage was below 150. Several farms have within the last ten years become derelict and the land included in amalgamated units. How long 0 - 50 acre units can survive is doubtful because the strain is already on 50 - 100 acre farms.

Farm systems

Using a slight modification of the system of farm classification adopted by the Department of Agricultural Economics, Newcastle University (see Appendix III) farms were divided according to agricultural system (Fig.181). This rather arbitrary system revealed the dominance and desirability of mixed farming as a single type. Next in importance is cash cropping with stock, and especially stores fattening. Stores are also dominant in the fattening with cropping type but as the graph shows this type is not as important as might be expected in a reputedly stock fattening region. Milk production is third in importance and over twelve percent of farms have a dairy as a dominant source of off-farm sales. Miscellaneous farms include dealers in cattle and sheep and others engaged in specialised production for example of pigs. Single system arable or grazing farms are very rare and as described in the farm studies not at all satisfactory units unless highly capitalised.

% of all farms.

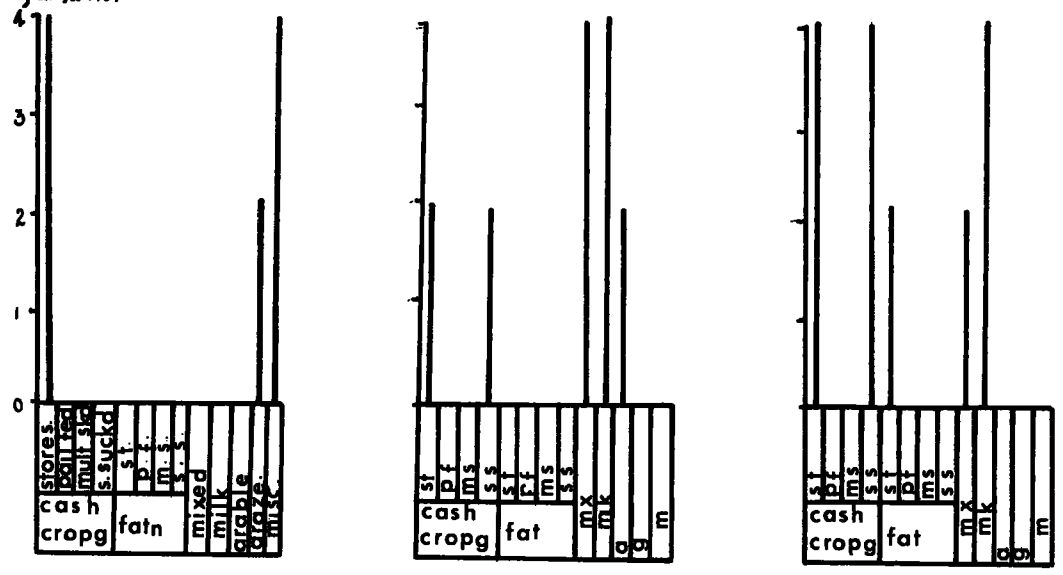
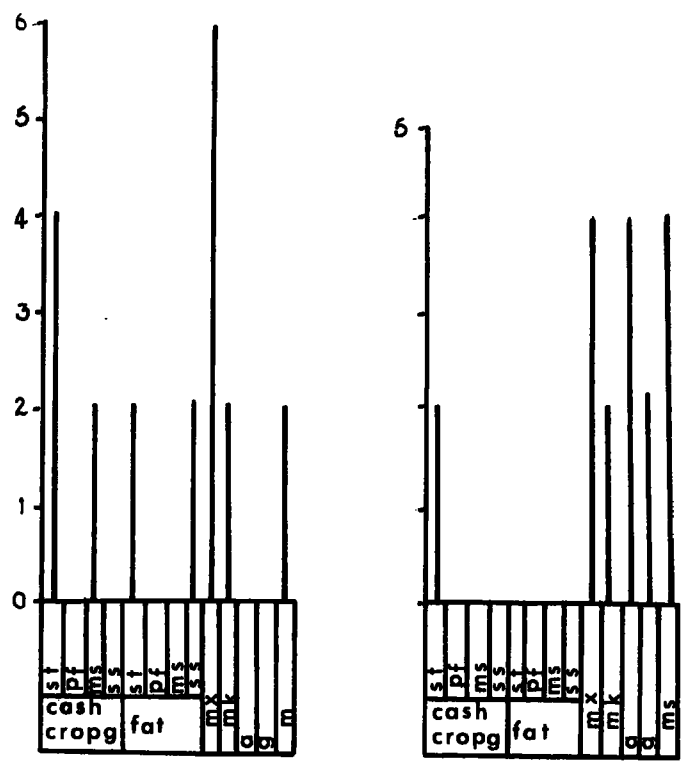


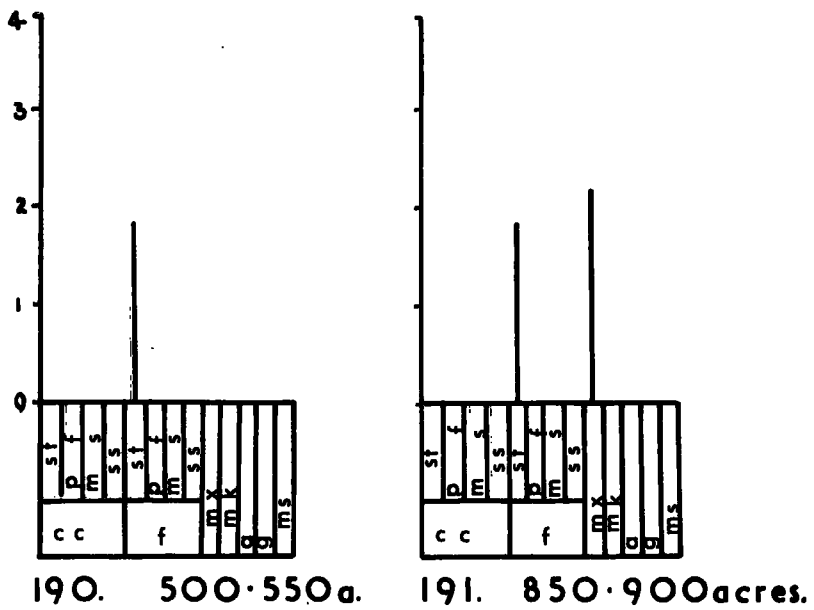
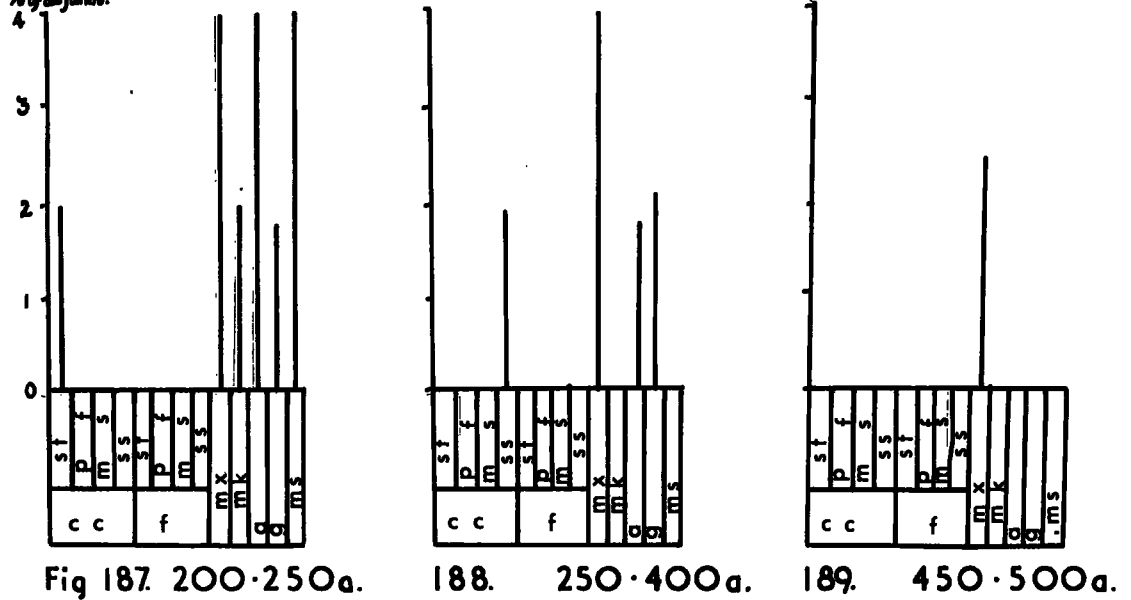
Fig 182 0-50 acres 183 50-100 a. 184 100-150 a.



185 150-200 a. 186 200-250 a.

Sector Distribution of Holding Size-Groups by Farm System.

% of all farms.



Distribution of Holding Size-Groups by Farm System.

Farm system distribution according to holding size

Combining the above information analysis can be made of farmholdings by agricultural systems within different size ranges (Figs.182-191).

In the 0 - 50 acre range cash-cropping with stores is equal to miscellaneous farms. At this range single system grazing represents four percent of all farms. The importance of miscellaneous types is significant. A high turnover of stock by a dealer using his land mainly for temporary grazing can be a prosperous undertaking. Cropping with store fattening is more difficult to understand and yet the farms in this class were all owner occupied and appeared to be thriving with adequate and new machinery much in evidence.

In the 50 - 100 acres range mixed farms and milk farms/^{are} of equal major importance although cash cropping with stock, and single system arable farms are represented. At 100 - 150 acres there is even more emphasis on cash - cropping with stock and mixed farms assume minor importance. Milk is of course still represented. In the optimal range of 150 - 200 acres mixed farming dominates and there is a balanced spread between other systems. Single system arable or grazing farms are not represented. Above 200 acres and below 500 acres mixed farms always assume significant proportions. Above this size there are too few farms and too many special considerations to allow analysis.

The farms are divided amongst owner occupiers and tenant farmers in very close proportion. There are 41.8% owner occupiers with 58.13% tenant farmers.

farmers.

Important differences in cropping practice since 1960 emerge from Fig. 194 (cf Fig. 177). It is clear that there has been a dramatic rise in barley acreage, as its fodder potential is realised. Potatoes, roots and fallow have remained stable but oats have continued to decline. Many farmers insist that they are growing less wheat every year but the statistics show almost absolute stability. The increase in barley has been rather in association with a revised fodder programme in the oats and grass sectors of the farm system. This change has reached different stages in different parts of the region. Permanent and rough grass has declined by more than a third and now assumes third place in acreage behind leys-seeds-hay and barley. Wheat is elevated in importance above oats but this is entirely due to the decline of the latter. The introduction of new uses of barley seems to have done more than World War II for the cultivation of land in this region although it must be remembered that ploughed up grassland is not necessarily reflected by more off-farm grain sales. The barley is used on-farm as fodder. Changes in cropping practice can be of more importance to land classification than more stable characteristics (40).

More detailed survey will follow under zonal analysis. The more important observations arising from the sector analysis are the desirability of farms in the 150 - 200 acre range (of 41), the desirability of a mixed system and the increase in barley fodder which has important implications for soil fertility. These factors must be borne in mind when analysing agricultural potential and planning land use. It is important to examine

(Fig.193) contd...

ACRES	CROPPING		FATTENING		MIXED		ARABLE		MILK		MISCELLANEOUS	
	O.O	Ten	O.O	Ten	Own	Ten	Own	Ten	Own	Ten	Own	Ten
350-400		8			5	3						
400-450						5						
450-500				4								
500-1000	4			4								
TOTAL	20	44	8	16	24	16	8	4	12	12	0	8

172 Farms AGRICULTURAL SYSTEMS, FARM SIZE GROUPS, AND OWNERSHIP/TENANCY

(Fig.194)

SECTOR CROPPING ANALYSIS.

Crop	Percentage of Total Acreage
Ley, Seeds, hay	28.85
Barley	22.75
Permanent Grass	22.45
Wheat Winter	7.30
Spring	8.56
Total	7.86
Oats	7.26
Potatoes	3.54
Roots	2.74
Silage	0.74
Kale	0.22

(Fig.194) contd...

Crop	Percentage of Total Acreage
Cabbage	0.03
Fallow	0.26
Woodland	0.23
Unclassified	2.96

SECTOR CROPPING ANALYSIS

Chapter

2. The Soil Zones

Defined. It is the purpose of this survey to show that there are units which can be used for planning purposes which are more reliable than the parish (42p.110 and 40 p.65,69: of. 43). It is often the case that farmers make false June returns, either deliberately to obtain more deficiency payment, or more often because ^{of} genuine difficulty in adding up acreages. When field boundaries change it is not easy to declare crops according to a pattern that no longer exists. It is also difficult when a single field is divided amongst several crops. The units chosen for study were closely related to soil distribution with several reservations, and the information was exacted from farmers field by field (of.40.p. 71).

It is obvious that Soil Series will be intermixed within a given area and the Series is not always the best unit or even a possible unit for analysis. (44 also 45 and 46 p. 41). Also factors such as rainfall, topography and proximity to large concentrations of settlement are important considerations (40p. 66). The resultant three-fold picture (Fig.195) was

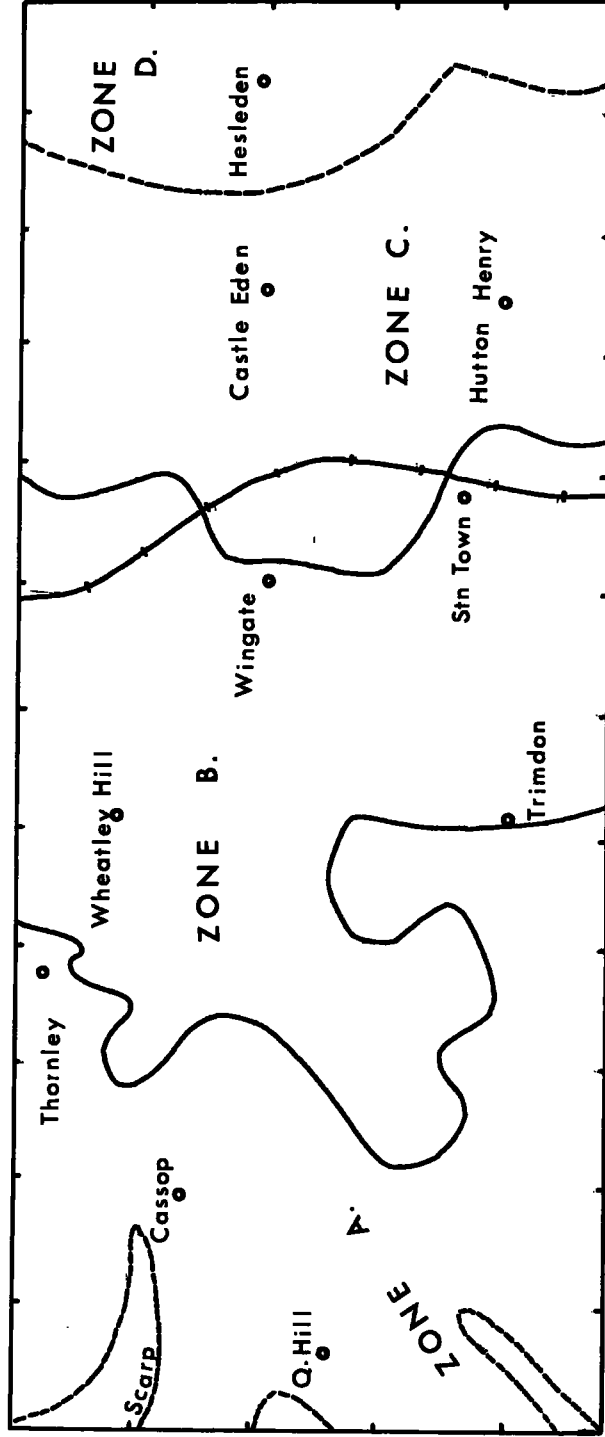


Fig 195 ZONAL DIFFERENTIATION WITHIN SECTOR.

obtained by combinations of the above considerations. Soil grouping (47) or association (44 p. 92) is the basis of division as this represents the most permanent unit of analysis (44 p. 97).

Zone A consists mainly of soils in the Cornforth and Kelloe Series. They are mixed but related, and the conditions likely to occur will be familiar after consulting Section Three. Topography is usually rolling to difficult, in association with the escarpment. Rainfall is the highest in the region, which to some extent compensates for shallowness of soil profile. There are not large concentrations of settlement, although Thornley, Cassop Colliery and Quarrington Hill exert some influence.

Zone B is influenced by the bad drainage of the poorer Haswell Series soils. There is an area of thin Conforth Series soils within this zone but soil is equally poor here, but for different reasons (see Limitation map). Rainfall is less than in Zone A (25 - 30"). Topography is mainly gently undulating although there are some steep valley sections. There is a string of colliery villages including Wheatley Hill, Wingate, Station Town, and Trimdon Colliery. These have in the past been beneficial influences in providing markets but today they present many difficulties such as claims for building land and tipping space, trespass damage, and dogs.

Zone C includes a wide spread of soils in the Kelloe Series, some lighter soils in the Mainsforth and Hesleden Series and heavier representative of the Shotton Series. Topography is rolling and hummocky and climate is generally less severe than in Zones A and B. Farmers are aware of a marked divide in land potential roughly corresponding with the railway that passes through Shotton Colliery and Station Town. There is close

approximation between this line and the boundary between Haswell Series and Kelloe Series soils. There is no large settlement within the zone, although the influence of the above mentioned villages slightly to the west and the Hartlepoons to the south east is important.

A further zone D, could be postulated to the east but this is not considered in detail largely because it is so closely within the sphere of West Hartlepool and has been described by Simpson (25), and also because it includes an area of soils not described within the present system. Furthermore there are numerous multiple holdings which can be ordered as follows :

2 holdings

Littlethorpe 160 acres.	Littlethorpe
Leechmire 200 acres	Hutton Hwnry.
White Hurworth 500 acres	Near Trimdon
W. Murton Blue House 171 acres	" "
Lambs Close 31 acres	Hutton Henry
Heads Hope 100 acres	" "
Sheraton Hill 365 acres	Sheraton
High Heslden 271 acres	Hesleden
Hulam 564 acres	Sheraton
Sheraton Hill 336 acres	

3 holdings

Benridge 74 acres	
Parklands 35 acres	Near Shotton
Oakerside 25 acres	

7 holdings

Dene Leazes 300 acres	Castle Eden
Hart Moor 170 acres	Hart
Wellfield 200 acres	Wingate
Park House 199 acres	Trimdon
Red Hurworth 171 acres	
Murton Hall 283 acres	
Murton Blue House 130 acres	

These separate holdings sometimes intrude into zone C and although mainly in zone D they extend completely outside the sector in several cases. They are often maintained as different units with co-operative use of machinery and sometimes mobile labour. In Zones A and B several farms have combined but they are usually worked as single units. D-type influences are often strong in zone C and will be considered as need arises.

In the region as a whole the main landowners are :-

1. N.C.B.
2. Church Commissioners
3. Bishop Wilkinson Estate Trustees
4. Castle Eden Estate Trustees
5. Durham County Council (Hutton Henry)
6. Lord Londonderry (Wynyard)

Since 1950 land has come onto the market only irregularly although both the N.C.B. and the Church Commissioners have offered and sold land to

tenants. Some farms have been purchased by means of hard work and a mortgage while others have been the result of compensation for removal from other farms which have been used for building purposes or quarrying (see Farm Studies 3,6,7,9,11,37). There are particularly difficult areas near Sunderland and Marsden where building demands and trespass have induced selling-out. Nevertheless there are farmers who are working land without any buildings, from council houses, who are waiting for farms to become available at the right price. It is often the owner of multiple holdings, however, who can outbid all offerers on such rare occasions when land is available (cf.48).

Farm size distribution by zone (c.f. Figs.196 - 198)

In zone A the major concentration is clearly within the 200 - 250 acres range. In this zone the 150 - 200 acre range probably represents the less efficient unit because there is much waste land due to steep slopes, limestone outcrop and subsidence cracks. Larger units are necessary than the average optimal unit for the whole sector, to match investment in machinery (Fig.180). In the 200 - 250 acres range every farm in the sample has adopted a different agricultural system whereas those within 150 - 200 acres are dominated by fattening and cropping.

Zone B shows concentration in the 250 - 200 range. The unit size is less than in A and there is less land wastage. The smaller 100 - 250 acre units could support greater acreage on existing mechanisation, but the 0 - 50 acre units are depressed and must have a very limited life. The juxtaposition of depressed farms alongside land-hungry farms could be put to good use in combination and land redistribution, but these are all

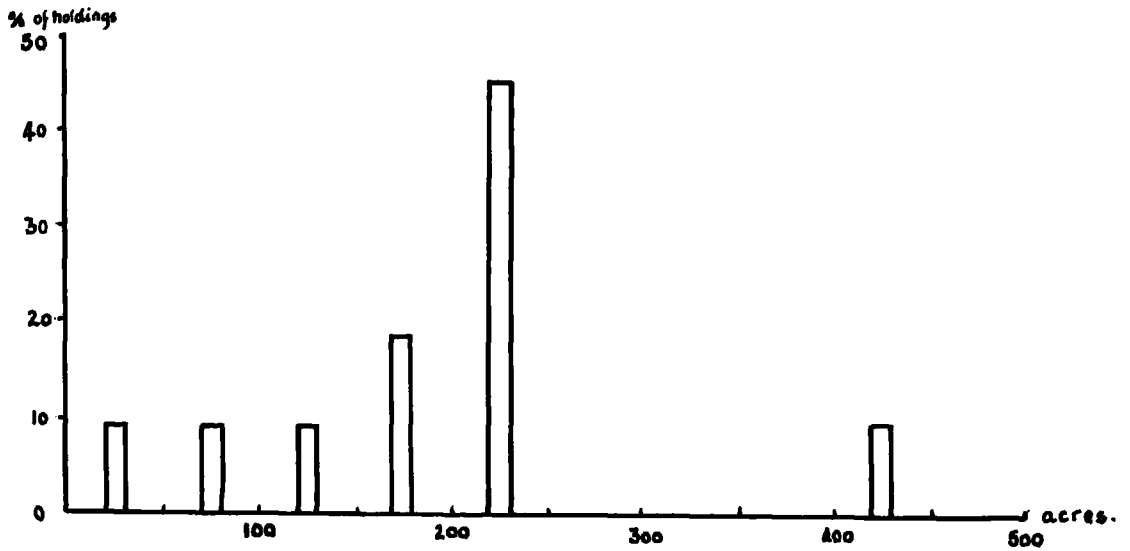


Fig. 196 ZONE A

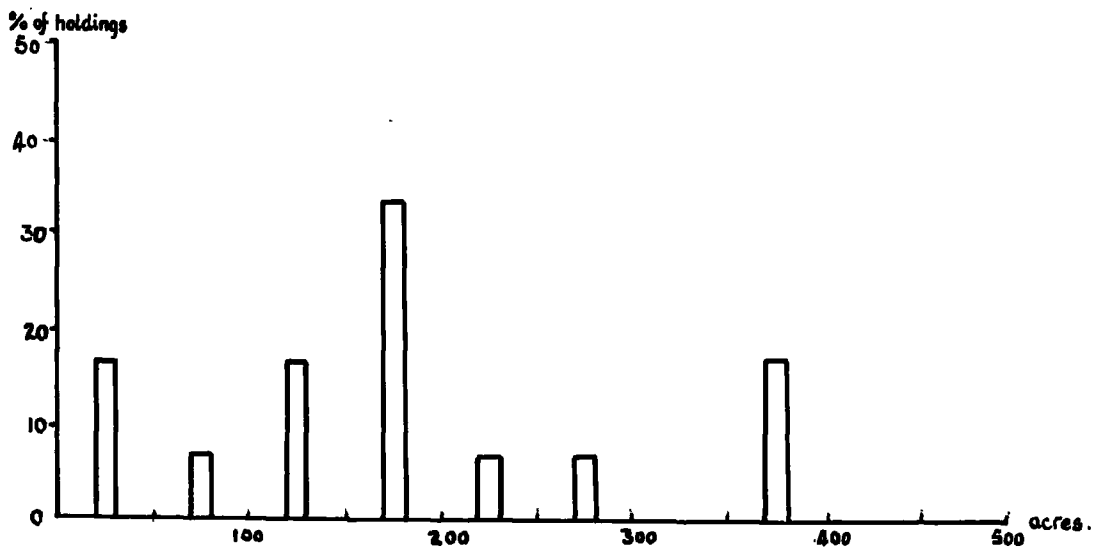


Fig. 197 ZONE B

ZONAL DISTRIBUTION OF HOLDINGS BY SIZE.

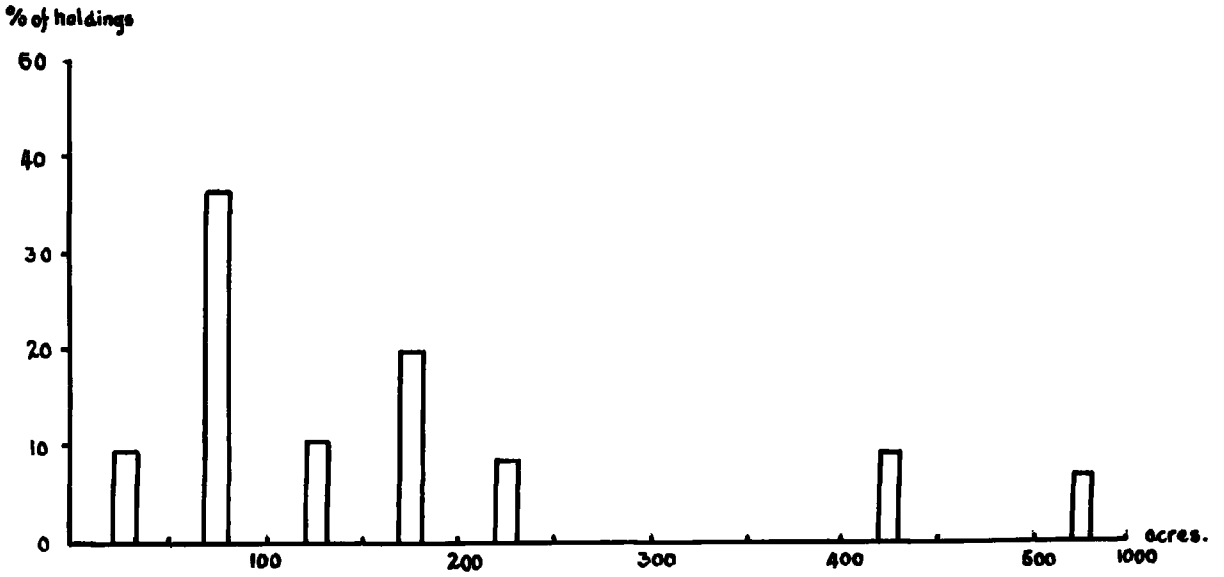


Fig 198 ZONE C

ZONAL DISTRIBUTION OF HOLDINGS BY SIZE.

tenanted farms and it is doubtful whether a wise amalgamation policy will ensue. The common experience is that small farms on becoming derelict are absorbed into a single large unit with a neighbouring farm, rather than planned division to the benefit of several holdings. There is no correlation between system of farming and size of unit in this zone. In all size ranges cash-cropping with stock is most important.

Zone C has a peak concentration at 50 - 100 acre unit size, with a secondary peak at 150 - 200 acres. There is generally a wider spread in zones A and B in size range, but smaller units appear to be thriving better in zone C in the lighter textured soils. The dominance of small farms would be further enhanced if smallholdings at Hutton Henry were included in Fig.198. Between 50 - 100 acres and between 150 - 200 acres milk and mixed systems are the more important with arable farming spread evenly throughout all ranges. It is very difficult at this stage of interpretation to lay hard rules, but it appears that there are two size groups optimal in each range which will vary according to zonal characteristics. The first group includes the very small farms which can be worked without extra labour by the farmer himself. As long as the farm is within one man's capabilities cash otherwise expended on labour can be invested in machinery. The second group, in zone C between 150 - 200 acres, represents units sufficiently large to prevent serious underemployment of labour and machinery. Farms between these two ranges find underemployment a great burden on efficiency (cf. 49p.48). Above the larger size range, farms are of decreasing efficiency in selling; they produce lower yields to the acre, but are of increasing efficiency in buying; it is easier to buy

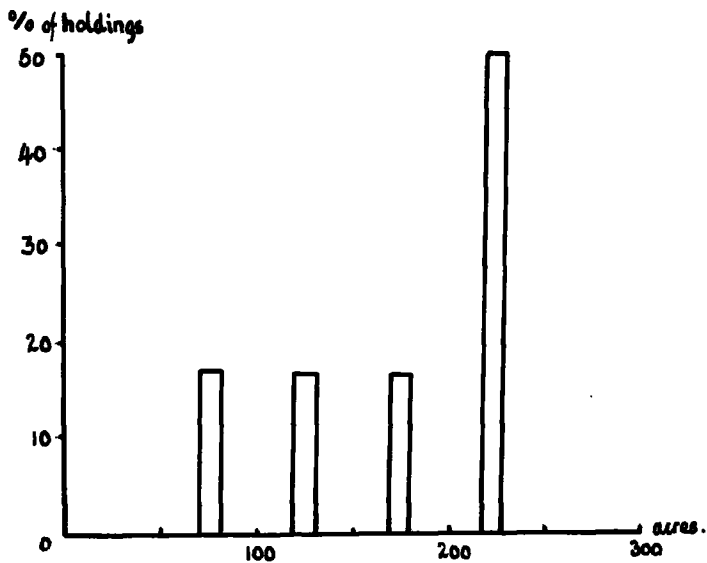


Fig 199 ZONE A CORNFORTH SERIES.

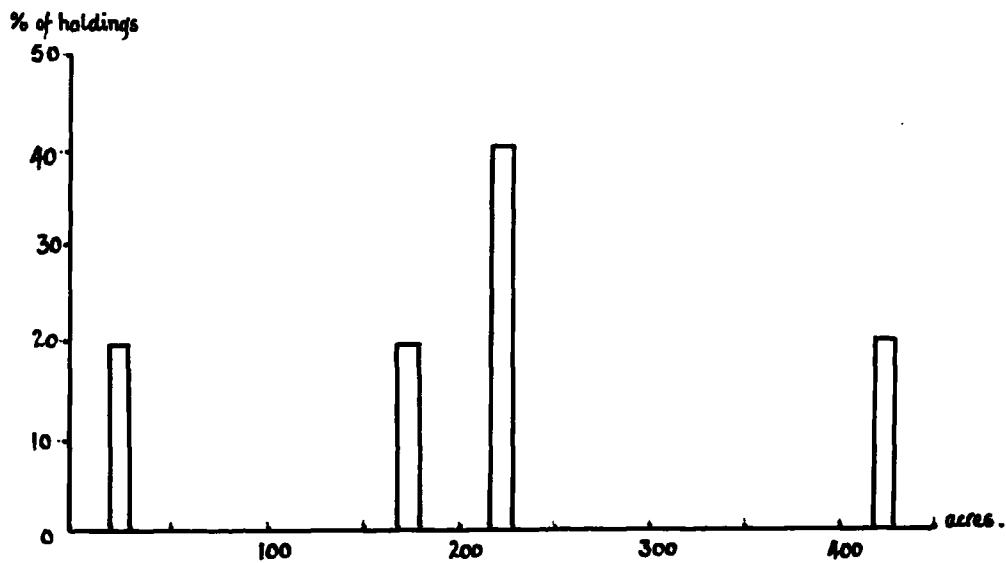


Fig 200 ZONE A KELLOE SERIES.

DISTRIBUTION OF HOLDINGS BY SIZE.

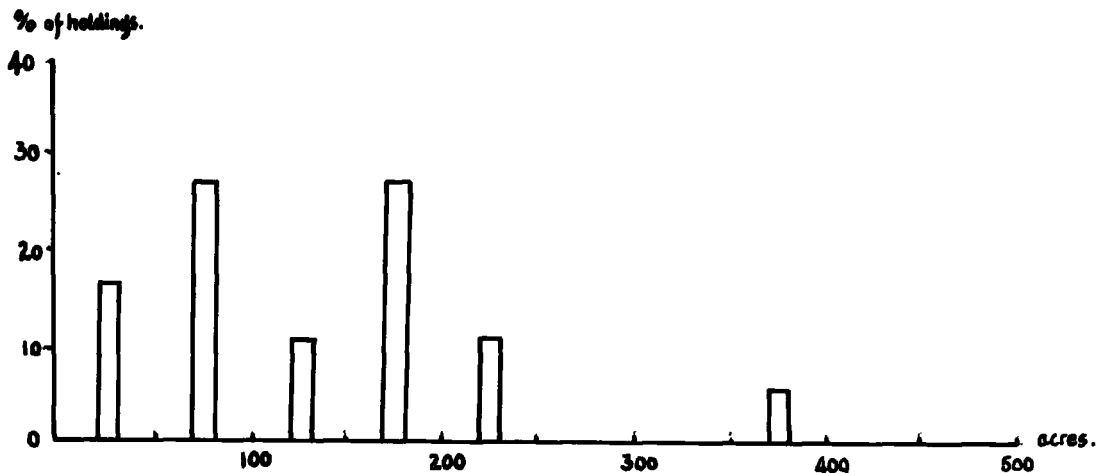


Fig. 201 OWNER OCCUPIERS.

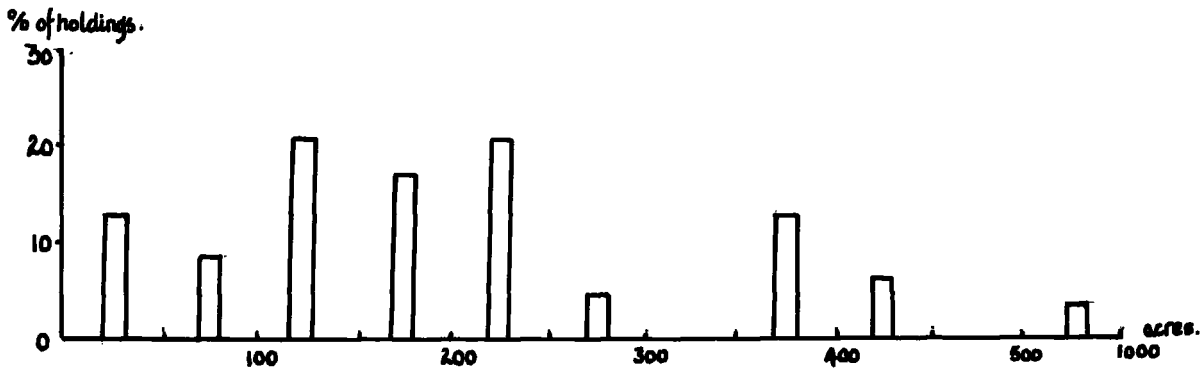


Fig. 202 TENANT FARMERS.

SECTOR DISTRIBUTION OF HOLDINGS BY SIZE.

machinery, fodder, fertilisers and replacement stock because of greater overall capitalisation. There is often a greater profit margin therefore in the larger units (41), but obviously at the present state of investment in agriculture in this region such units cannot be referred to as optimal because so few farmers could afford the initial capital.

Size distribution on different soils within the single zone, A, was analysed. The thinner soils (Figs.199) are those in the Cornforth Series. The thicker soils (Fig.200) are in the Kelloe Series. In both cases 200 - 250 acres units characteristic of the zone as a whole are dominant. There is a narrower range of acreage on the thin soils, but differences are not significant.

It is possible to compare size distribution with tenancy conditions. In the whole sector (Fig.201) there are two maxima in owner occupiers

1. 50 - 100 acres representing farms in the east (zone C)
2. 150-200 acres representing farms in the west (zone A).

Tenanted farms (Fig.202) are similarly grouped into two maxima:

1. 100 - 150 acres representing farms in Zone B of less than optimal range.
2. 200 - 250 acres representing undercapitalised farms of Zone A or those on poorer soils in the same zone.

There is a secondary peak at 150 - 200 acres which represents better sized farms of zone B (see Fig.197). The zonal influence is thus strong in all cases. There is no pattern of agricultural system in correlation with size range.

Zonality of ownership and tenancy

The most surprising differentiation between the three zones was in the respect of owner or tenant occupation. This was the first source of differentiation encountered which supported the boundaries on Fig. 195.

In zone B, on the poorer soils it was found that all farms were tenant occupied. All owner occupied farms occurred in Zones A and C, 26 percent in A and 73 percent in C, remarkably similar to the proportions of Kelloe Series developed in each case. It is tempting to assert that there is correlation with soils but other factors must first be considered. In zone A 83 percent of owner occupied farms have been purchased within the last 40 years and 56 percent within the last ten years. This enforces the argument in favour of soils influence. Farmers on these better soils can, by virtue of greater profit margins, buy their farms sooner than those in zone B. The history of land sale is complicated but there is certainly no regional differentiation in willingness of the landlord to sell. N.C.B. and Church Commissioners have periodically shown willingness to sell property throughout the region. Also, in zone A farms are equally divided between owner occupiers and tenants. The owners are remarkable for their sensible policy and progressive thinking (cf. 50 p. 54). They usually have substantial areas of Kelloe Series soils on their land. The tenant farmers suffer either from poor soil and topography or in several cases blatant bad management leading to undercapitalisation (c.f. Farm Studies 2 and 27). One farm is particularly difficult to explain (Farm Study 14). Management is good but the farmer is content to rent his land. Even here however the same farmer has recently purchased a farm (Farm Study 9) for his son. Profit margins would therefore seem

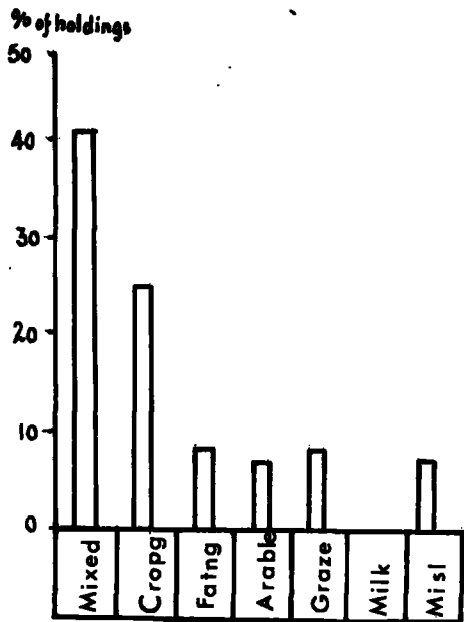


Fig. 203 ZONE A

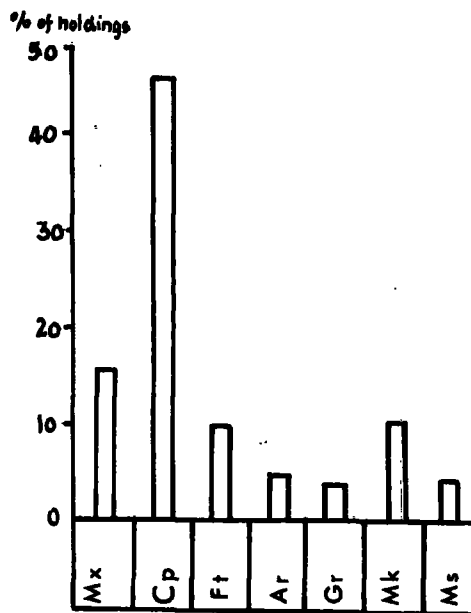


Fig. 204 ZONE B

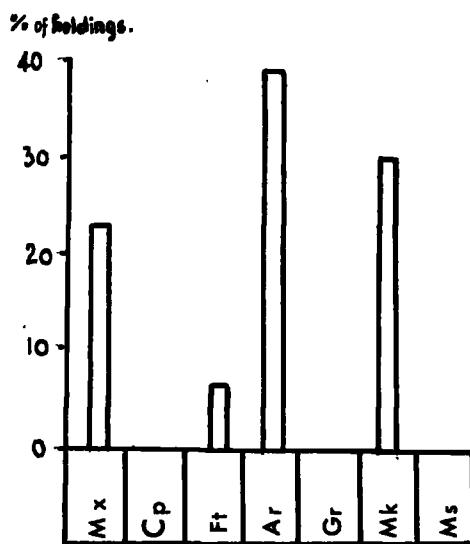


Fig. 205 ZONE C

ZONAL DISTRIBUTION OF HOLDINGS BY AGRICULTURAL SYSTEM.

satisfactory.

In the east in zone C, 92 percent of the owner occupied farms, some of them recently purchased, are under 200 acres in size and therefore within reasonable purchasing power to tenants. In the west all owner occupied farms are under 250 acres in size and similarly within reasonable purchasing power. A substantial proportion of owner occupied farms in both zone A and zone C are mixed farms but this fact cannot be taken alone to justify the mixed system.

The Zonality of agricultural system

In zone A mixed farms dominate (Fig.203). Variety of system is understandable on these mixed and variable soils. Cash cropping with stock is of significant importance utilising the poorer topographic areas and thinner soils.

In zone B stock assumes more importance and cash cropping with stock dominated (Fig.204). Two influences contribute to the restriction of product variety. The land requires more cultivation and because of comparatively poor grass yields more land must be devoted to the individual beast for fodder.

In zone C (Fig.205) arable and mixed farms are both important. The arable dominance is partly due to the introduction of several new farm enterprises, which are still in the cleaning stage and not fully established. Milk assumes greater importance here because of proximity to the colliery village markets and under the influence of West Hartlepool. There is a very narrow range of system in this zone compared with A and B. To the east (D) and north stock plays a more important role.

(Figs) 206,207,208.

ZONAL CROPPING PATTERNS

Crop	<u>Percentage of total acreage</u>		
	Zone A	Zone B	Zone C
Ley, seeds, hay	26.68	21.29	36.48
Permanent grass	32.84	24.72	12.00
Total grass	59.52	46.01	48.48
Barley	23.34	27.01	17.85
Wheat Total	4.28	9.29	13.56
Oats	7.90	6.43	12.19
Potatoes	1.27	3.33	4.78
Roots	2.68	2.94	3.12
Silage	0	1.08	0
Kale	0.51	0.11	0.29
Cabbage	0.07	0	0
Fallow	0	0.53	0
Woodland	0.47	2.80	0
	Zone A	Zone B	Zone C
Fig.No	206	207	208

Zonal Cropping analysis

Using figures 206, 207 and 208 it is possible to see certain zonal trends and significant differences from 1960 returns. These trends are incorporated in the construction of the agricultural potential map and are thus important constituents of any useful planning process (45p. 4 and (42) p.109).

Wheat

Zone A is not good wheat land as soils are thin and comparatively dry (51 p. 22) There is severe exposure which has to a large extent led to restriction to winter varieties. Zone B supports a larger acreage and yields are higher (see land potential map). The mixed drifts of zone C support the highest percentage of this traditional crop.

Oats.

Oats are comparatively high in zone A although they have suffered from the expansion of barley. At present however oats still compensate to some extent for the low acreage of wheat both in preserving the fillage balance and as a source of off-farm^{sales}/(as fodder). Oats are still significant in zone B although here they have to a large extent been replaced by barley and wheat in combination. In zone C oats are almost equal to wheat which is still very important in acreage.

Barley

In zone A barley has become supreme and completely outweighs wheat and oats. It is not a simple case of one crop displacing another. The cereals have different uses. Different farming systems and inherent soil advantages are important factors in the changing balance of crops (see comment in Coppock(40 p. 71)). In zone B barley percentage is greater than in any other zone. Here the grassland is comparatively poor and barley is especially attractive as a fodder crop. The dominance of barley over other grain crops is not however as severe as in zone A because wheat is still a useful crop on those heavy soils. A barley/other cereals ratio for zone A would be 2:0 whereas in

Zone B it is only 1:7. In zone C barley does not even balance wheat-plus-oats. The barley/other cereals ratio is 0:6, Thus if a two-fold historic trend is envisaged (see Section Four) with wheat displacing oats and then barley displacing wheat and oats, the different zones have reached different stages (see also (40)). In zone A barley is supreme. In B barley is of increasing importance but part of the earlier phase of wheat expansion is still discernible. Soil is important as wheat does well and barley is ^{not} ideally placed on heavy wet land. In C the earlier stage is still marked and wheat is very important. Oats suffered less displacement by wheat in zone C however than elsewhere. In zone D oats the traditional crop of the north-east still assume major importance and often dominate wheat and barley.

Grass

There is a higher percentage of total grasses in zone A largely because of the big acreage of rough pasture on steep slopes and thin soils. Zones B and C have similar percentages of total grass but zone C is particularly low in permanent grass. The ley is widely used here. This pattern changes to the north east of the sector where industry and topography interfere, and to the south-east where heavier lacustrine clays support a larger acreage of permanent grass.

Swedes

In all zones there has been little change in root acreage since 1960, but zone A is distinguished by its particularly small acreage, due to the

thinness of soil and the wide practice of using barley as the major winter fodder.

Potatoes

Potatoes occupy a very low acreage in the west but increase slightly through the heavier drifts to the highest acreage on the mixed drifts of zone C and particularly on the sandy loams of the coast - zone D. This region does not generally have good yielding potato land.

Cabbage, Kale, Silage, Fallow and Woodland.

These are all almost negligible although each is represented most in zone B (Fig.207)

Fig.209)

AGRICULTURAL SYSTEM INFLUENCE ON ZONAL CROP DISTRIBUTION

ZONE.	MEAN.	WHEAT.	OATS.	BARLEY.	ROOTS.	GRASS.	POTATOES.	CABBAGE KALE AND WOOL
A	Mixed	3.8 %	7.9	30.0	2.7	52.4	1.1	0.8
	Zonal	4.2	7.9	23.3	2.7	59.5	12.	0.6
B	Mixed	6.8	7.4	28.2	3.4	41.2	3.2	8.3
	Zonal	9.2	6.4	27.0	2.9	45.0	3.3	3.0
C	Mixed	9.7	12.4	11.5	0.6	48.6	6.9	6.4
	Zonal	13.5	12.1	17.8	3.1	48.4	4.8	0.3
TOTAL	Mixed	6.7	10.9	23.2	2.3	47.0	3.6	3.2
	Sector	7.8	7.3	22.8	2.7	51.1	3.5	0.5
C	Cash Crop	13.7	9.0	24.5	3.1	46.0	4.9	
	Zonal	13.5	12.1	17.8	3.1	48.4	4.8	
B	Cash Crop	5.3	8.2	26.3	4.4	52.9	2.0	
	Zonal	9.2	6.4	27.0	3.0	46.0	3.3	
TOTAL	Cash Crop	9.5	8.6	25.4	3.5	49.4	3.5	
	Sector	7.8	7.3	22.8	2.7	51.1	3.5	
B	Milk Zonal			32.8		63.8	3.3	
				27.0		48.0	3.3	

(Fig.209) contd...

ZONE	MEAN	WHEAT	OATS	BARLEY	ROOTS	GRASS	POTATOES	GABBAGE KALE & WOOD
C	Milk			19.0		42.1	12.2	
	Zonal			17.8		48.4	4.8	
TOTAL	Milk			23.5		50.0	9.1	
	Sector			22.8		51.1	3.5	

So far it has been possible to consider the general crop development through different zones in general terms without reference to statistical significance. When subjected to statistical analysis using wheat, barley and oats as indices (also see Fig.209) it was found that, 1, the zones A,B and C are distinguishable in the majority of cases within the range of probably significance, or with less than five percent probability of chance occurrence of the given crop distribution (52). Barley was the best indicator. All farms with arable land grow some barley, and in each case the zones were significantly '(probably)' distinguishable. Oats were less useful in distinguishing between zones A and B (more than five percent but less than seven percent possibility of a chance occurrence).

2. Within individual zones, farm system (using the major systems, mixed farming, cash cropping, with stock and dairying - see Table 209) had less influence on crop distribution than might have been expected. The use of barley as an index was again useful. In mixed farms all three zones were again distinguishable within the range of probable significance. There was some positive deviation from the zonal mean but this was greater in Zone B than in zone C and slightly greater in zone A than in zone B.

With wheat and oats deviation was not as clear but probably-significant differences were maintained. Cash cropping with stock proved less distinguishable with a barley index, although wheat distribution maintained probably-significant differences. With milk farms only zones B and C could be compared and here differentiation broke down. In both zones B and C divergence from the zonal average was considerable in wheat and oats. Although barley shows visual correspondence there is no statistical significance in the difference between zonal-less-dairying distribution and dairying distribution itself. This is partly due to an insufficient sample of dairy farms in zone B.

The correspondence described above is of course quite remarkable. The boundary lines between zones are at best, approximations within a transitional zone. This applies especially between zones A and B. Here, several farms include parts of both zones. Each farm is grouped according to the zone supplying the larger acreage. This is often not a very satisfactory procedure because a farm unit may in fact preserve distinct and separated functions of both zones depending on 'soil' conditions. This incorrect information is incorporated in the zonal analysis. Analysis of variance using Snedder's variance ratio test (52) provided good results throughout the sector, but where the region narrows and the transitional errors assume more importance such good results would probably not be possible.

The subdivision into three major zones is considered at this stage self-evidently justifiable but several questions were posed to check validity.

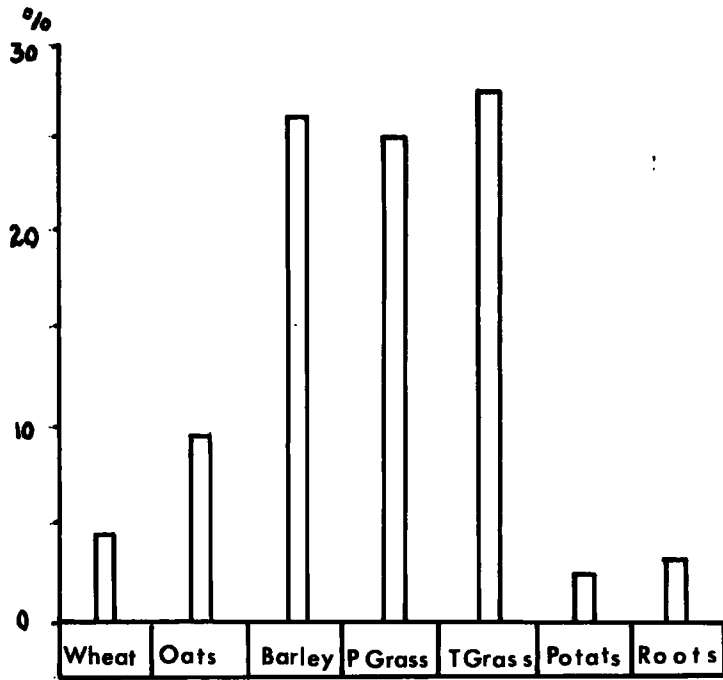


Fig 210 CORNFORTH SOILS.

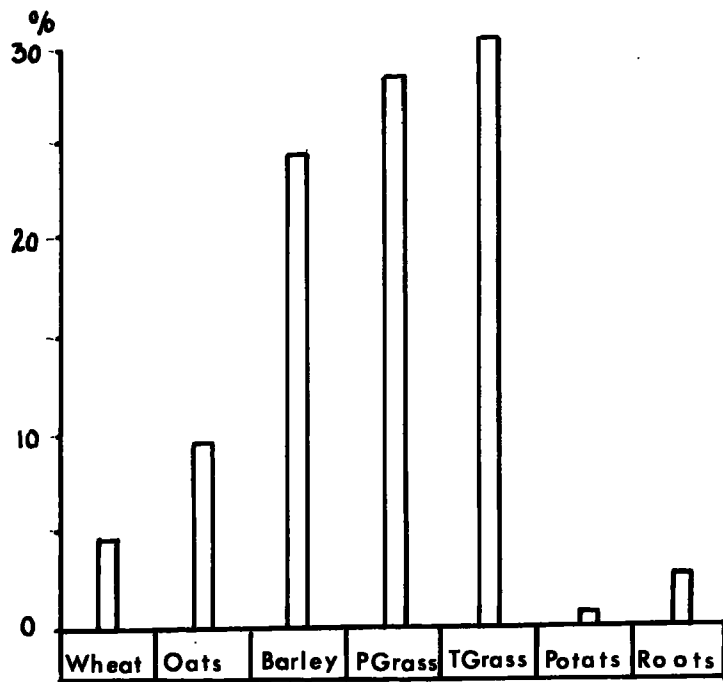
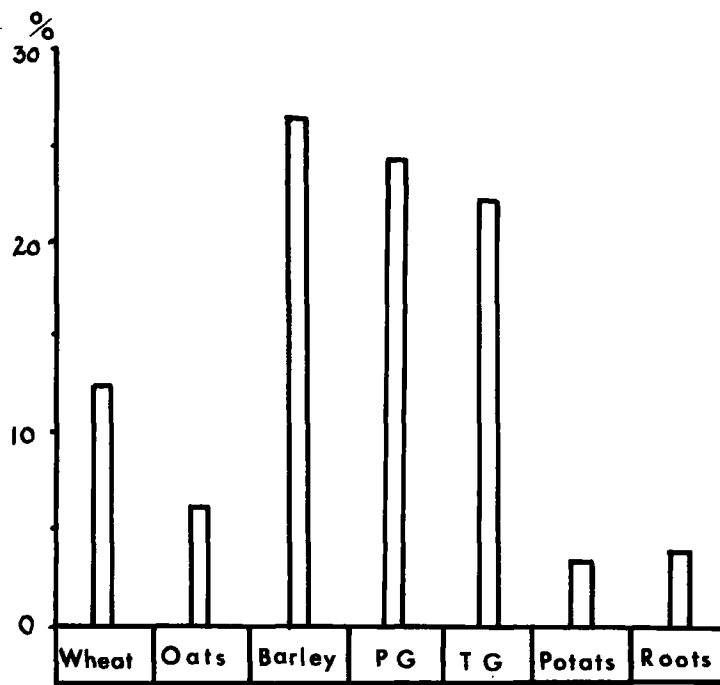


Fig 211 KELLOE SOILS.

CROPPING.ZONE A.



**Fig 212 CROPPING IN TRANSITION
FROM ZONE A TO ZONE B.**

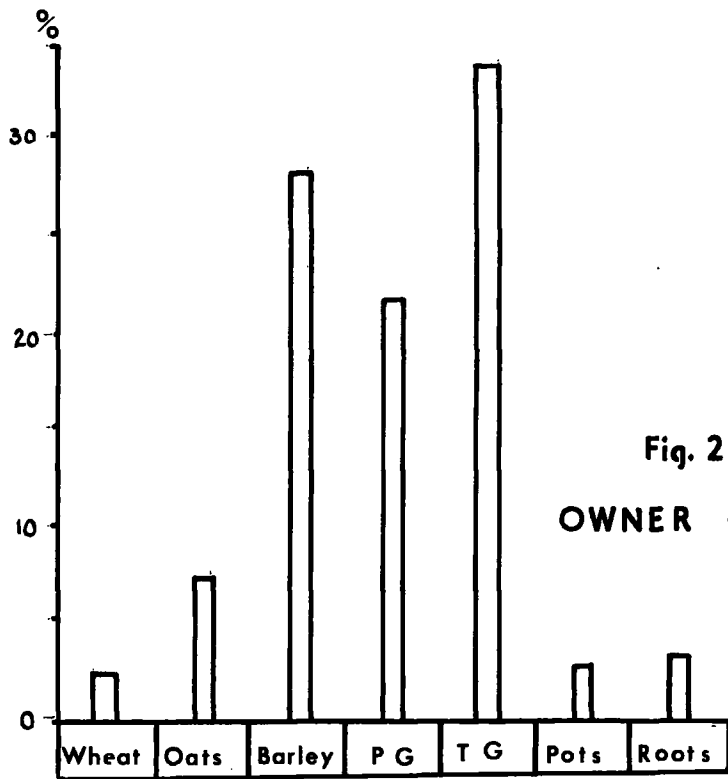


Fig. 213
OWNER OCCUPIED.

CROPPING ZONE A.

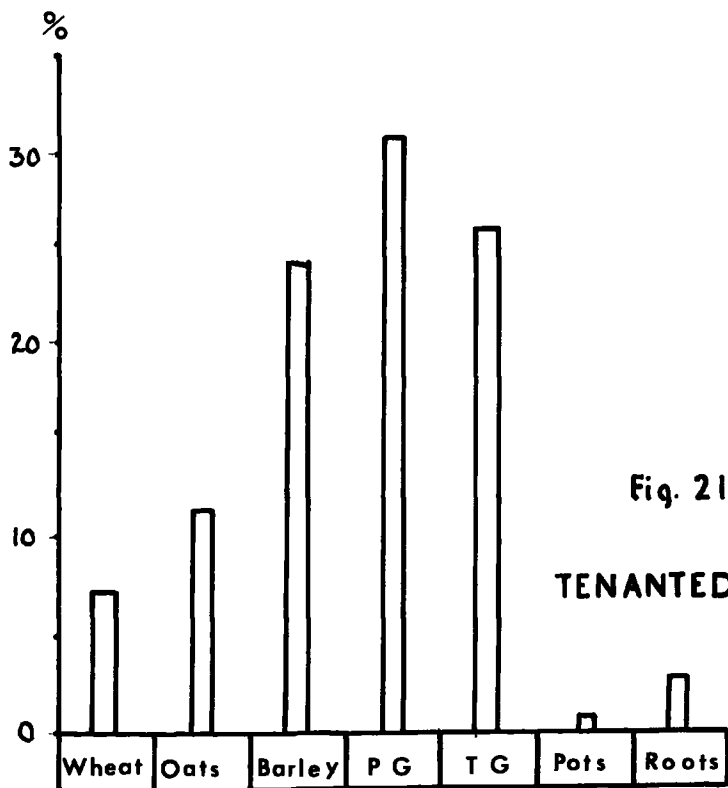


Fig. 214
TENANTED FARMS.

1. Do farms on different soils within the same zone differ in farming system? Comparing Figs. 210 and 211 it is clear that there are no significant differences between farms with thin soils and those with thicker soils. Although the samples were chosen for major development of one particular Soil Series most farms in zone A have a mixture of Cornforth Series and Kelloe Series soils. It is thus the mixture of those two soils that give the distinctiveness to the zone. This was further checked by analysing several farms with large areas inside or transitional to zone B where Haswell Series soils dominate. Marked differences become clear. There is more wheat, less oats, more roots and far less grass, particularly temporary grass, than in zone A proper. This reflects the dominance of crops already described as associated with zone B.

2. Do owner occupiers grow different proportions of the various crops from tenant farmers in zone A (Figs. 213 and 214)? In general they are more in accord with national trends than tenants and they grow less wheat and more barley. Roots are virtually the same in both cases as all farms tend to have the same stock requirement. Total grass is similarly balanced between the two but owner occupiers have less permanent grass and more leys than the tenants. It will be remembered that non-owners were described earlier either as farming on poorer land in this zone or as exhibiting low management qualities. The same explanation applies in the case of grass. The temporary lay in preference to permanent pasture requires more effort, expense and ~~planning~~ ^a and some degree of good management. Similarly owner occupiers plant more potatoes than tenants. They admit that in this area they do not expect to ~~make~~ any profit, but the crop is ^a useful one for cleaning

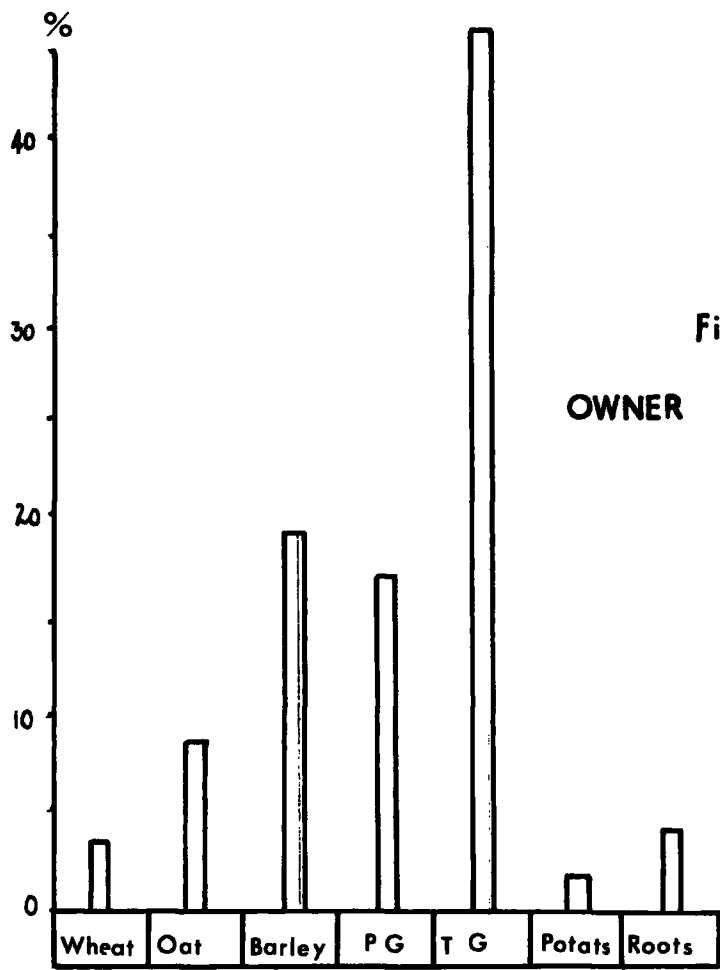
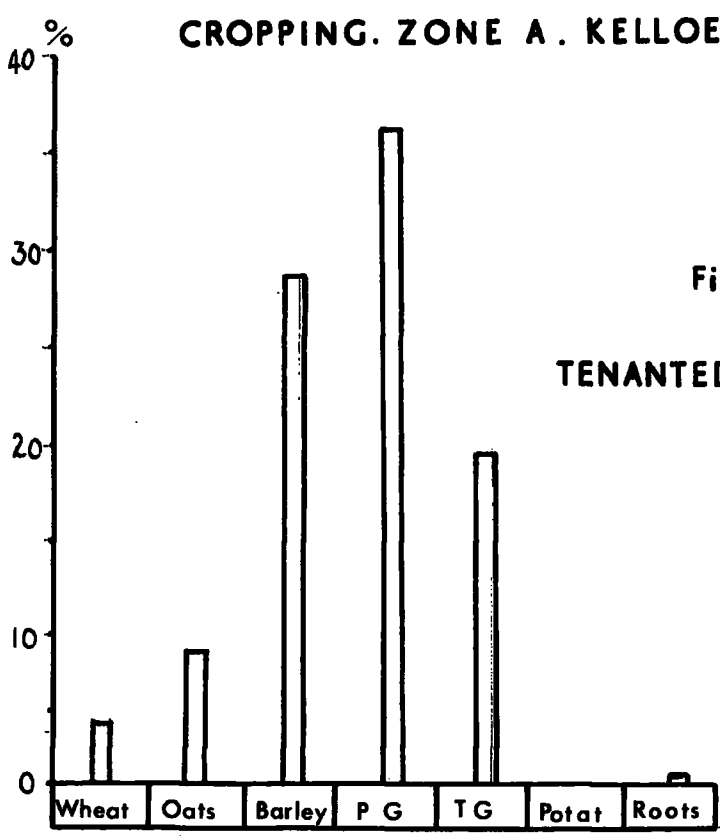
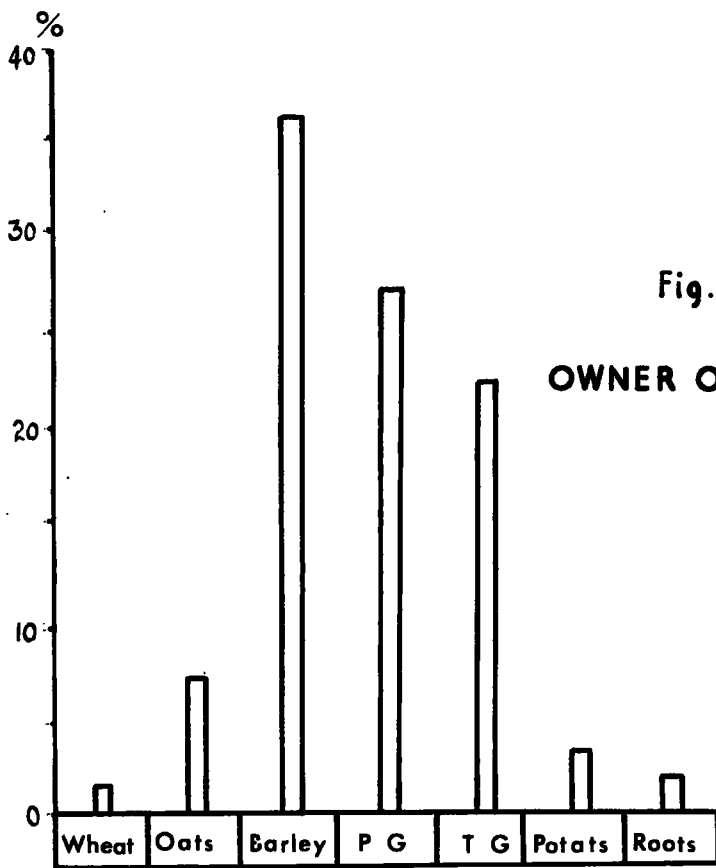


Fig. 215
OWNER OCCUPIED.

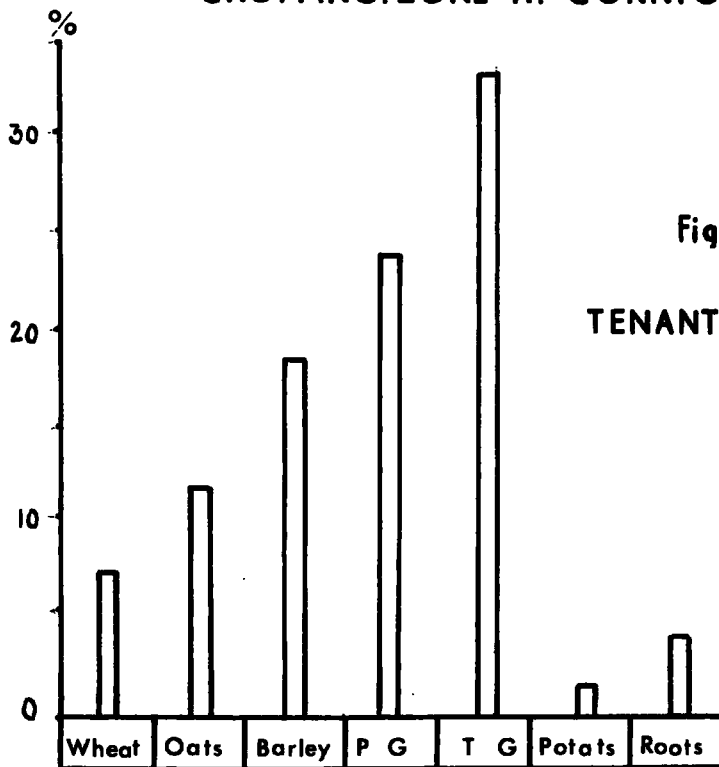


CROPPING. ZONE A. KELLOE SOILS.

Fig. 216
TENANTED FARMS.



CROPPING.ZONE A. CORNFORTH SOILS.



the land, and again fits into an intelligent approach to soil fertility.

The differences encountered in answering this question do not in any way invalidate the established zonal differentiations. Tenant practice is not greatly dissimilar from the average zone A practice and is quite distinct from zone B. Again there is divergence from the mean zonal distributions but not significant divergence. When zone B is compared to the united population of zone A owner occupiers practice may represent something of a more progressive outlook and only serves to accentuate the differences between zones A and B. Given an infusion of capital into the region it is reasonable to assume that the trend would be with the owner occupier in increasing differentiation from zone B.

The question can be broken down one stage further to see whether owner occupiers and tenant farmers differ in cropping practice on different soils within the same region. Using graphs 217 and 215 it is possible to see that owner occupiers with substantial areas of Cornforth Series soils grow less oats and wheat than those on the deeper Kelloe Series Soils. Barley is more important on the thinner Cornforth Series soils. The thinner soils also grow slightly less roots which could again be related to soil depth. More difficult to understand is the apparently greater percentage of potatoes on the thinner soils. This could be due to the excessive concentration of magnesium ions in the Kelloe Series cationic balance which together with very low inherent potassium status inhibits good tuber bulking. The leached thinner soils show a more propitious cationic balance. There is more grass, especially permanent grass, on Cornforth Series soils a result of topography, soil depth and subsidence.

The Kelloe Series owner occupier has more temporary grass to compensate for the lower barley acreage.

It is difficult to compare tenant farmers on the two soils as the figures show no statistical variance.

Again, comparing the four graphs it is clear that zonal differentiation is not invalidated. Difference between owner occupiers and tenants on the same soils are greater than the difference between farms on different soils within the zone. As in Figs. 213 and 214 owner occupiers seem to show accentuated zonal characteristics on thinner soils while both owners and tenants on deeper soils are still quite distinct from the pattern in zone B. The distinctive features of zone A can therefore be summarised as response to an intimate mixture of two Soil Series with the influence of owner occupation important but itself due in part to soil consideration and in part to management quality.



Chapter 3.SECTOR ANALYSIS RELATED TO SOIL ZONES

Farm analysis to this point has been confined to detailed local study on a farm unit basis within zones, related in a sector, which itself was regarded as a representative part of a region. This policy of surveying from the small to the large was deliberate. There are valid reasons for investigation processes that work from the general to the detailed but in the case of agricultural productivity the small unit is of initial importance. To keep the effort required within reasonable bounds it is the reconnaissance level that should suffer and be kept to the minimum. Many important classification systems fail to be of use within the range of requirements imposed by emphasis on productivity for this very reason (of papers in Tec Rep 9 and the particularly thorough paper by Hilton 42). They are too generalised and often based on unsound data. Information available is often limited (40 p. 65.) but it is important to search for the right information in the right place, which is more often than not in the field. While pointing out the limitation of the Land Utilisation Survey (53) p.61 (40)p. 65 (42) p.p.107-108) the plea is often submitted that farm analysis and land analysis is not and never can be precise (54(, (44). p. 97. While this is true to a certain point, that point can be pushed considerably further towards the aim of precision than has been the case in the past. This aspect will be considered more fully with reference to land classification systematics and fertiliser practice.

Having made these qualifications it is now admitted that certain aspects of farm analysis are better considered on a more general basis although still founded ^{on} information revealed in detailed study. Such

aspects as crop rotation, crop variety, stock breed and labour requirements are more conveniently studied on a regional basis, in this case within the confines of the sector. Reference will be made to significant zonal characteristics or to more precise soil characteristics, but the regional ethos is dominant.

Crop Rotation

Most farmers have abandoned a rigid planned system of rotation. Regular rotation began to decline when lease restrictions were lifted and the decline was made more complete as inorganic fertilisers and weed controls became available. Of the factors that control which crops shall be sown the most important are prevailing prices, the state of the farmer's fluctuating financial condition, the season and special needs. One example will illustrate the situation. A mixed farm of over two hundred acres had found difficulty in cultivating the land in autumn because of the lateness of the harvest. The farmer did not plant any winter wheat. Noticing that the same was true for most of the neighbouring farms he bought in large quantities of wheat seed and sowed during a short mild spell in February to the extent of ninety acres. Some farmers plant just what they think they will require while they take a ploughed-up ley round the farm in nearly five-yearly cycles. Others simply put roots on the dirtiest land or grow barley after barley on the same land until they are forced to change. The loose systems that remain are simply variations of the same theme and are often more apparent in the mind of the farmer than in his practice. They can be best grouped from the following programme.

1.	2.	3.
1. Seeds 1 - 4 years	1. Seeds 1 - 4 years	1. Seeds 1 - 4 years
2. Corn	2. Corn 2 years	2. Corn 2 years
3. Roots	3. Roots	3. Roots
4. Corn 2 years		4. Corn
4.	5	6
1. Seeds 1 - 4 years	1. Seeds 1 - 4 years	1. Seeds
2. Corn 2 years	2. Corn 3 - 4 years	2. Corn 4 years
3. Roots	3. Roots	
4. Corn 2 years.		
7.	8	9
1. Seeds 1 - 4 years	1. Corn 3 - 4 years	1. Corn 2 years
2. Roots	2. Roots	2. Seeds or roots
3. Corn 2 years		3. Corn

The above rotations will vary according to system of agriculture but the above can be grouped into three types and related to soils

I	II	III
1. 1 - 4 years seeds (to ley) ¹	3 - 4 years corn	1. 1 - 4 year seeds
2. 1 - 4 years corn	2. Roots or seeds	2. Roots or potatoes
3. 0 - 1 year roots		3. 2 years corn
4. 0 - 2 years corn		

Group I includes parts of zones A and B and corn is seen to be at a premium.

Group II is restricted mainly to the thinner soils of zone A where barley is supreme, or to the more traditional areas of zone D where oats are supreme.

In group III roots and potatoes assume more importance and lighter soils are often found in association. In Group I potatoes may follow the ley occasionally as a cleaning crop with the hope of an economic yield. The last corn of cycles I and III are usually undersown with seeds

The primary aim of this thesis is not to present a final report on agricultural conditions in East Durham and there is no recommendation section. It is by now clear however that recommendation could be made by simple correlation and some degree of inference. For rotation the following would seem relevant to the situation, if any value is still inherent in systematic cultivation.

On thin soils of zone A, as in group II above, barley can be sown up to four successive times followed by seeds. Roots should be omitted unless absolutely essential as they do not do well except in wet years.

More productive soils frequently occur on moderately deep boulder clay soils than on shallow or very deep clays (55). This applies to the Kelloe Series soils in the region which have slightly different depth limits from those cited in the previous paper. Areas of soil developed on boulder clay also show the capability to adapt to wide changes in the economic situation (40 p. 71). It would seem desirable to put the Kelloe Series soils to as varied a use as possible within the framework

of mixed farming. To some extent this is already the case and the following suggested rotation would be reasonable.

1. Short ley. These soils provide good permanent pasture, considerably better than in Series 4. It would therefore be to advantage to improve permanent pasture as much as possible and to use temporary grass mainly for hay under a short-term high quality basis.
2. 1 - 4 years corn. Wheat can safely be grown twice to be followed by barley. Some of the soils in this Series are strong even if comparatively well-drained and wheat will not follow barley well if it has already appeared in the rotation.
3. Roots or potatoes, although potatoes do not do very well.
4. Two years corn finishing with undersown barley. On the heavier clays of the Haswell Series and Shotton Series the following is suggested.
 1. 3-4 years ley. These soils produce very poor permanent pasture although little consistent attempt at improvement is evident. Longer leys would therefore seem essential to supplement grazing.
 2. 1 - 4 years corn. Barley or wheat may be used at first but wheat may suffer after grass from wireworm. This is especially true in the second year after ploughing out. A regularly cultivated and well dressed root crop would take the second year to be followed by wheat using the residual fertiliser value.
 3. Roots or potatoes depending on 2.
 4. Corn using the residual root fertiliser value.

The Mainsforth and Hesleden Series with lighter textured soils in other Series can include roots and potatoes to more advantage than elsewhere.

1. 1 - 4 years seeds (to ley) or a longer pasture. Ploughed in with heavy manuring as the soils are texturally light.
2. 1 - 2 years potatoes or roots using above manure in the first instance and in the second year heavy inorganic compound fertilisers.
3. 2 years corn as wheat, using residual inorganic value of 2 and only top-dressed, or barley undersown and using high nitrogen compounds and no top-dressing.

It will be seen that the above suggestions place some emphasis on wheat which is a crop of declining importance, and does not give cash returns comparable with barley. But it deserves emphasis from the fertility point of view in that it responds well to the post-seeds or post-potato situation if there is time to cultivate and sow after the potato harvest. To compensate for this use of wheat a widening of the cereal phase of the cycle to accommodate more successive barley crops is highly practicable. It is important to remember that in a long cereal phase wheat should not make a late return. Losses from 'take-all' because of injudicious returns to wheat have led to the abandonment of wheat altogether on some farms in zone B.

Crop Varieties

Wheat Capelle-Desprez, a general purpose winter wheat is the most common encountered. It is noted for heavy yielding and a stiff short straw. It does well in a variety of conditions and is not out of context in this region. It is of moderate milling and

milling and bread-making quality. Newer varieties encountered include Champlin. Opal is the only spring wheat grown.

Barley In the west the most common barley is Varda or Pallas with Freja an early maturing feeding variety. Proctor is of course grown as a heavy yielding, stiff, short-strawed general purpose barley. It is noted for its small grain and high malting quality but is not a very early variety. It is therefore somewhat misplaced on the East Durham Plateau. In the east and south-east Rika is the main variety with its heavy yields and stiff straw. It is recommended as a feeding barley on more fertile soils with liberal manuring. Its main disadvantage is its susceptibility to 'smut'.

Oats. Blenda is the most common variety as a cereal throughout, with comparative earliness and heavy yielding potential under a wide range of conditions. The grain has a high kernal content. A second spring oat is Condor, a very heavy yielding variety with a short straw and a large grain. Other varieties encountered include Pallox and Aster.

Potatoes. Mackintosh is by far the favourite variety but in first earlies Home Guard is used, particularly on less well-drained soils. It yields uniform small to medium tubers which at maturity are suitable for crisping (Tudor Crisps at Peterlee). It sprouts early and is fairly resistant to dry rot.

Maincrop potatoes include Majestic, a general purpose variety with low yields in this region. Tubers are subject to cracking but

keeping quality is satisfactory. Ulster Supreme is also grown although it is rather late in maturing and needs very early planting to avoid tuber damage when full maturity is not achieved. It is resistant to severe "mosaic". Other potatoes include Peaks and Dunbar standard. Redskins are not popular especially since the recent widespread redskin disease.

Kale Narrow stem kale, both green and purple is common as it is hardy and flowers early. Rape is grown but only in the south-west where conditions^{are} less severe than on the higher land.

Swedes The dark purple group of swedes with the hard root is the most common and winters well. Soft turnips are grown but only rarely.

A quality guide to the main varieties encountered may be of use (56).

(Fig.219)

<u>Crop Quality</u>	<u>Wheat</u>	<u>Barley</u>			<u>Oats</u>	
	Capelle-Desprez.	Rika	Proctor	Freja	Condor	Blenda
Standing power	7	7½	7	5½	5	5
Shortness of straw	7	7½	8	8½	8	5½
Resistance to shedding	7				Yield of straw	
to sprouting	7				8	6
to yellow rust	5					
to loose smut	2	3	8	4		
to mildew	7	5	4½	4	3	3½
Earliness of ripening	8	7½	5½	8½	5½	5½

(Fig.219) contd...

Crop Quality	Wheat Cappelle-Desprez	Rika	Barley Proctor	Freja	Condor	Oats Blend
Suitability for Feb. sowing	7					
Quality	Quality		Quality			
Milling	5	2	8	4	6	7
Bread	5			Kernal Size	7½	7
Biscuits	4					

POTATOES

	<u>Home Guard</u>	<u>Majestic</u>	<u>Ulster Supreme</u>
Early bulking	5		
Yield		6	8
Tubers. Size	4	8	9
Uniformity	8	6	7
Defect freedom	8	4	7
Number per plant	9	9	6
Field character			
Resistance to dry rot	7	6	5
to drought	3	-	-
common scab	6	4	3
leaf roll	6	5	6
severe mosaic	3	6	9
leaf blight	5	4	6

Seed supply and corn disposal

Local merchants supply most of the seed used but some farmers order special seeds direct from national producers or through a local Seed-House agent. Grass seeds are usually imported from some distance and potatoes come from southern and central Scotland. Cereal seeds can be divided into four groups.

1. Pedigree seeds produced over long periods and sold by specialist seed houses at high prices (57) These are sown on small acreages each year and by very few farmers. Part of the harvest is saved for the following year.
2. Field approved seed sold by most merchants under the Field Approved Scheme instituted in 1947. Such seed occupies a far larger acreage on the majority of farms.
3. Commercial seed from quality fore-runners and reaching acceptable standard of germination and variety of stability. This seed is supplied by local merchants.
4. Own seed derived from followers of any of the above or from cereal grown on the farm for many years. In this group there is not a little **cross-trade** in the region between individual farmers.

Farmers like to travel to ^awide range of markets, machinery exhibitions, and county shows. Here they come into contact with and often buy non-regional produce. They also make it a practice to buy from merchants from a wide area to 'keep competition alive', although they usually have one regular standby agent. The most popular dealers in order of preference are :-

Teeside Farmers (Darlington)
 Foster and Armstrong (#. Hartlepool)
 Maddox (Stockton)
 English (Houghton-le-Spring)
 Northern Farmers Trading Association
 M. Foster and sons (W. Hartlepool)
 W. Wilson (W. Hartlepool)
 Ferens (Bishop Auckland).

Repeated orders are given to West Cumberland Farmers, Parker of Blackhill, Consett, Buyers of York, Morgans of Shincliffe and a local cattle dealer H. Bell of Cassop. Pedigree seed is obtained from Nickerson, Webbs, Bibby's, Parker, and Elson. Potatoes are usually Scottish but regular orders are made as far south as Timperley in Cheshire.

Corn is usually sold to the merchant who supplies the seed, except in the case of pedigree seed. Merchants may give slightly higher prices to farmers taking their seed. Most of the corn is destined for Rank's of Gateshead, Spiller's of Newcastle or C.W.S. at Dunston. Prices fluctuate from year to year and throughout the season. Most farmers who can spare the room, store grain for the rising prices after September. Potatoes are usually disposed of within a few miles of the growing site.

Date of Sowing

This is a most important consideration as generally the earlier the germination the higher the yields. In this region early sowing is rarely possible and it has been stated that the plateau is at least a fortnight later than the Tees lowland and the Vale of York (15). Harvesting dates were

compared in 1964 and it was found that harvesting began in Lincolnshire at least 17 days earlier than the first harvest on the East Durham Plateau. The whole of the Vale of York was slightly transitional in this respect but the major transition was in a very restricted area rising from the Tees basin. A late cereal harvest also affects the potato harvest. Furthermore if the potato harvest is late autumn cultivation is drastically affected and late February sowing of winter wheat is not uncommon. In 1962 and 1963 the autumn cultivation was seriously delayed but in 1964 both harvest and cultivation were comparatively early.

The picture is complicated because of a lack of permanent records on most farms, but several factors are discernible.

1. Type of season.

In a wet year such as 1963 the harvest is generally later. In the west on the escarpment edge and on the heavier land of zone B harvest can continue on through late September well into October. Where there is a high proportion of limestone soil in the west, on eight farms the harvest was in by the end of September. This was true also on smaller dairy farms in the central area of zone B and on better soils towards the east. In the south-east harvest started in August and was completed by mid-September. One farm in the central part of zone B, on thin soils above limestone, near Wingate Quarries also started harvesting in August.

There is thus something of a pattern in a wet season. Harvests are late in the west particularly on strong soils; heavy soils further east have less rainfall but poor drainage to some extent levels out conditions and time of harvest. Similarly, light soils in central locations

although they have more rainfall than further east they have equally early harvests because of better drainage conditions.

In a dry year conditions and patterns are quite different. Harvesting is generally earlier, especially on the thinner soils of the west, and even more so on lighter soils in the centre and in the east. In the west some soils may be subjected to severe scorching or at an earlier stage germination may be delayed by lack of moisture. Over-cultivation for swedes resulted in such conditions at Hutton Henry in 1964. Germination was patchy and successive dry periods scorched the seedlings. A second sowing had to be made on a more compacted seed-bed in late June. Thus harvest can be late even in dry years but this is the exception. On heavier soils in zone B a dry year brings heavier yields and a harvest up to a fortnight earlier than in wet conditions.

The generally accepted pattern of light textured soils warming earlier and allowing earlier sowing, and therefore higher yields, needs some modification with respect to soils in this region. With a dry spring Kelloe Series soils allow early sowing. Several farms on these better drained clay soils started sowing in March 1964, a dry spring. Thinner soils had to wait for a wetter spell in mid-April before germination was successful. The heavier soils of the Haswell Series were not sufficiently dry for an early spring sowing and the wet period in mid-April further delayed cultivation. More easterly farms on Hesleden, Kelloe, and Mainsforth and to some extent on Shotton Series soils were able to share the advantage of the western Kelloe soils and sowing was in March. Crops on the heavier Haswell soils despite their late sowing were in advance of

the thin Cornforth Series soils of the west by the beginning of May. This brings out complicating factors other than wetness of the whole season. The general affirmation that thin or light textured soils prefer a wet year and the heavier soils prefer a dry year is true but the wetness of spring itself is of great importance. The thin soils prefer a moderately wet spring for germination. Heavier soils prefer a dry spring to allow earlier cultivation and intermediate soils (Kelloe Series) prefer a dry spring and a moderately wet year. A dry late summer is beneficial to harvest and yields on both heavy and light soils. Any heavy soil with some form of field drainage is always in better condition by harvest time. The eastern and southern areas are always earlier in sowing whether they have light or heavy textured soils.

Other complications arise from the state of the previous season and the intervening winter. In 1960 very little winter wheat was sown in the whole region because of a late cereal harvest and a difficult and very late potato harvest.

It is clear then that there is an important interplay between rainfall ischyets and different soil Series, moving away from the escarpment, and that seasonal and soil conditions are more important than management levels in earliness of sowing. There are however management considerations worth noting.

Despite the heaviness of the land only one crawler tractor was encountered. This is of course largely a matter of distribution of capital investment and the general lack of available capital. Reid's assessment that farmers on heavy soils 'incur heavier power and machinery

costs than on lighter soils' where there are 'fewer tractors per hundred acres and consequently a smaller burden of fixed costs' (5) is not wholly true in this area. That the land can be 'three day land' denoting the short period during which the soil can be cultivated easily is perfectly true. Such land often needs more cultivation than lighter soils to establish satisfactory seed-beds. To that extent cultivation is more costly. Moreover because of general lateness due to the northerly latitude, some farmers are tempted onto the land before it is ready for cultivation. Horse ploughing was once possible at an earlier stage without some of the damage done by heavy tractor machinery. Such damage was seen at a most serious level on one particular farm (Study 20). Here soils were comparatively thin, but the farmer had missed the dry spring of 1964. Sowing was commenced immediately after the wet spell of mid-April. The lines of the tractor wheels were clearly visible everywhere when the crop germinated. The farmer sowed crosswise as soon as he saw his mistake, but it was still too wet. The result was a patchwork of barley in widely separated squares. A further example is that of a dairy farmer on heavy land near Station Town who always waits until his land is absolutely ready for the plough and then works intensively and quickly. He complains that his neighbours go onto the land too soon. His crops are never early, and yields are by no means high, but particularly in the case of barley they are always higher than those of his neighbours.

Fertiliser practice

Fertiliser practice throughout the region is almost as varied as the number of farms surveyed, but general 'philosophies' of practice can be

grouped in the following manner.

- I. Those who use very little or even no fertiliser at all. A small group of farmers whose yields are as might be expected very low.
- II Those who year by year follow the advice of fertiliser distributor representatives and have little interest in their own crop returns and responses. Again yields tend to be lower than regional average.
- III Those who have evolved their own pattern ^{in response} to experience of results on their land. There are four main groups.
 1. Those using compounds and top-dressing with nitro-chalk
Farm yard manure goes on roots and grass gets the balance.
 2. Those using compounds and top-dressing with nitro-chalk.
Compounds, nitro-chalk or slag on the grass. This represents a wide group of farmers and compounds are used in accordance with nationally accepted crop suitability. An example might be :-
Barley 16.9.9 @ $2\frac{1}{2}$ -4 cwt. perhaps top with nitro-chalk
Wheat 6.15.15 @ 6 cwt. with nitro-chalk top-dressing.
Grazing 16.9.9 @ $2\frac{1}{2}$ cwt. with F.Y.M. 3rd year top with nitro-chalk
Hay 13.13.20 @ $2\frac{1}{2}$ -5cwt. perhaps with sulphate of ammonia
Potatoes 10.10.18 @ 8-20 cwt. perhaps with F.Y.M.
Swedes 6.15.15 @ 4-8 cwt. perhaps with F.Y.M. or basic slag
Oats 10.10.18 @ 3 cwt.
Cabbage 13.13.20 @ 4 cwt.
Muck is ploughed in at the end of the ley and permanent grass may get slag in the autumn.

Such a policy is dominant in this region and has serious limitations, partly because it is still geared to the relevant compound for the appropriate crop. Yields are very variable.

3. Those using high N on all crops.

(a) As a top-dressing only in the form of a high N compound or as nitro-chalk. This represents recent changes in policy and is based on the stored reserves established by heavy slag and superphosphate dressings in the past. The change has in some cases pushed the yield of barley up by 5 cwt.

(b) As a drilled high N compound with a late top-dressing Basic slag and superphosphates may still be used. Yields are variable but never high.

4. Those using potato fertilisers on all crops (10.10.18).

There are several farms in this group which have largely without knowing it responded to the inherent potassium deficiency of the region. Crops are only top-dressed when absolutely necessary as farmers are reluctant to use nitrogen. Basic slag and superphosphate may also be important. Yields are higher than those on unfertilised land but obviously with low nitrogen application they are not very good.

5. Those who use high P and K. (10.20.20) on all crops.

Again there is a reluctance to use nitrogen. Although yields are usually higher than in 4 nitrogen would seem desirable. It is interesting that several farms who have changed their policy from 1 and 2 to 5 have found yields increased by up to 10 cwt.

It is also interesting at this point to comment that when nitrogen top-dressing is undertaken response to ammonium sulphate seems better than to nitro-chalk. This is not backed by sound evidence and is the result of the opinion of ten farmers.

IV. Those farmers who use straight fertilisers to counter inherent deficiencies rather than using compounds which they find less effective and more expensive.

Typical of this small group of farms is the following system. Basic slag, superphosphate and muriate of potash are all used on grass while crops are top-dressed with a high N compound or nitro-chalk. Yields do not particularly flatter this system perhaps because there are other limiting factors such as poor drainage and lime requirement to be taken into account. Yields are however considerably higher than those when compounds were used and lower fertiliser costs are a distinct advantage. Potatoes show consistently better yields at 7 - 8 tons on a farm using this system compared with 5 - 6 tons in a neighbouring farm using compounds.

V. Those farms aiming to balance fertility through the grass section of the land.

1. The above example is of this order. Attempts are made to counter known deficiencies through the grass while crops receive only top-dressing.

2. A less refined system involves dressing the grazing and hay grasses heavily with up to 4cwt per acre with compound and slag followed by up to 3¹/₂ cwt high N top-dressing. Crops receive compounds in the normal manner. Many farms in III.2 are included in this system but the emphasis is shifted in the direction of grass as opposed to crop-compound relationships.

3. Further emphasis on grass is expressed by the practice of spreading all the muck and in one case sewage on the grass, this takes manure round the farm in three to five years, while keeping unincorporated manure away from high nitrogen inorganics.

It must be admitted however that most important farms plough in F.Y.M. at the end of a ley and some plough it in for roots or potatoes after stubble. It is difficult to say which is the better practice although on individual farms above average crops do come more often after a well-manured long ley or permanent pasture while other combinations are frequently disappointing.

4. One farm spreads slurry from a pig enterprise on all the leys at 2000 gallons per acre. The grass is grazed and manured by sheep and then planted to barley for pig-fodder. It receives only top-dressings, of ammonium sulphate or nitro-chalk. The enterprise is only just underway but results could be exciting.

VI. Permanent grass is generally ill-used and often very poor in quality (Bailey 37)(see Agric. His Sect.). It is rarely systematically treated. Often it gets the surplus F.Y.M. or spoiled compounds. In one case 2 cwt. potassium compound and 2 cwt of sulphate of ammonia were used with outstanding success but this is a rare exception to normal standards of treatment.

No pattern of yields in response to fertiliser application was possible. A study of available nutrients from pit samples and from N.A.A.S. reports for fields throughout the region show that although P and K are sometimes at acceptable levels there is always a possibility of rapid depletion and in most cases these nutrients were at a very low level of availability. Cationic exchange data obtained during the survey reveal low potassium status throughout the region although this should not be assumed to be equivalent to the available magnesium (58). Similarly at low levels Mg/Ca does not correlate with yields (59 and 60) but here especially in the Cornforth, Kelloe Middleham and to some extent Haswell Series both magnesium and calcium status are high and more important. Mg/K ratios are vital to an understanding of the fertility problems of this region (see also 61). Field soils are difficult to exhaust of magnesium if they initially contain a high status (62). This was to some extent substantiated by the cationic graphs of soils in the above series. Percentage Mg plotted against percentage Ca showed an exact mirror image. Where calcium was leached out and the graph had negative curve magnesium increased proportionally (although not totally) thus expressing a higher degree of stability within the profile. Add to this amounts of magnesium received annually from rainfall in this coastal location (63 and 64), and soil losses to crops are likely to be substantially countered. Further additions by limestone dust from local quarrying make it certain that magnesium reserves in the soil will not be depleted by crop losses or in heavier soils by leaching. At the other side of the ratio potassium can safely be assumed to occur only in very low availability (similarly with phosphates) because of the

frequent occurrence of low availability records in the history of fields representing the whole region. Magnesium status is comparatively high and potassium low. These two ions are antagonistic and the ratio is so great that K deficiency will certainly be aggravated. When tackling the problem magnesium status will be important.

Farmers reflect conditions in their fertiliser programmes although they are not fully aware of this. Some use potato manure with its emphasis on potassium, for all crops. Even on potatoes however, soil containing adequate K reserves will give higher yields than from soils poorer in K dressed heavily with K fertiliser (66). The potato manure does not work in the year it is applied but its continual use is justified as it helps to build up a reserve (67). The same is true of phosphates applied as superphosphate in liberal dressings. Broadcast in the first year it is of little use, nor when ploughed in (68). When sufficient reserve is built up to give uniform spread and adequate availability just below the seed there will be a response similar to the 'starter' P (69) which gives strong germination so essential to this late region.

Secondly as indicated farmers tackle fertility through their grass. Most grass is harvested by cattle and determining fertiliser requirements is difficult (67 p. 71). Few attempts to measure fertiliser needs, and particularly potassium needs have been made (67 p. 77). Most advice is based on guesswork but certain observations can be inferred from regional soil characteristics which are of relevance and importance. When nitrogen is applied to grass, and particularly leys, more potassium is lost in successive cuts than is normally applied (70). This further increases the deficiencies already described. Grass itself does not necessarily respond to K (67 p.p. 71, 75, 79). (67 p.p. 72, 75, 75) and in this sector it rarely gets any potassium fertiliser. Its response to K can be so far less than arable crops on soils poor in potassium, that grass returns do not justify the use of fertiliser. This is partly due to the ability of grass to take reserve

K from non-exchangeable forms perhaps from the fine clay fraction in a soil (71 and 72). Although the response of the grass is poor K should be used to keep a surplus balance for the succeeding crop (73) which may not respond to fertiliser K (67 p. 79). To do this all nitrogen applied must have a corresponding amount of K_2O in the following proportion - $N/K_2O = 2/1$ (67 p. 75 and (74). In alternate husbandry systems therefore and particularly as here where K is inherently of low status potassium should be used intensively on long leys and permanent pasture prior to ploughing out. Potassium must be given similar consideration on short leys under preparation for wheat. A one year clover ley is, with reference to fertility, to be preferred to other leys. The clover leaves a residual nitrogen benefit for the wheat, which reduces expense on nitro-chalk, but of more direct importance to this region clover takes less K from the soil than does for example the popular early and late bite rye-grass leys (75). Widdowson has shown that where inherent K is low a normal nitrogen top-dressing to ryegrass can be responsible for the complete removal of available potassium. Even more than in the case of long leys and permanent pastures, K inorganic fertiliser should be applied on ryegrass in a proportion approximating to the amount of nitrogen used. Otherwise the autumn sown wheat which responds greatly to reserve (76) will have depressed yields.

It is therefore clear that all grassland in this region can play an important part in maintaining a potassium reserve in face of many antagonistic factors, if it is dressed substantially with K fertiliser. If the grassland itself were to become more economically used by the greater application of nitrogen this emphasis on potassium balance would be increased. Farmers fear to use nitrogen because they have seen it do damage, most likely through induced K deficiency, but the present use, only when absolutely essential, is highly inefficient.

It also rests on a philosophy of waiting for a balance to show signs of disturbance and then the creation of another disturbance by correcting the first. It would seem reasonable to infer that use of nitrogen is not efficient because it is not sufficient. More liberal

application of nitrogen on grassland with correspondingly liberal yet balanced application of potassium would produce greater overall fertiliser efficiency and more profitable returns on the diminishing returns scale. This assumes that the reserve capacity of the soil is capable of utilising higher input. Cationic exchange capacity is not high in most of the soils but this is not necessarily the last word on reserve capacity as already indicated. The actual response to residual potato manure suggests however that reserve capacity is sufficient to accommodate the increased application suggested. The question of fertility involves the efficiency of fertiliser conversion (50). Many farmers regard their fertiliser cost as a regular charge like rent (77). Cooke observes that many farmers spend time and effort in bargaining for fertilisers instead of studying available technical advice. Study of past cropping results and correlation with known soil characteristics as indicated above would decrease fertiliser bills and increase profit and production, especially if straight inorganic fertilisers were used.

Liming must fit in with the above fertiliser pattern. There is need for periodic application of lime on all but the shallower drift soils in the region. At one time heavy dressings of local magnesian limestone were applied, but in more recent years farmers have begun to use more distant sources and Carboniferous Limestone. The superiority of Magnesian Limestone in composition and efficiency per unit weight have been demonstrated by Jones (78). It might seem that refusal to use it locally is mere prejudice or perhaps unfortunate experience of burning due to too heavy application. It may be however that the farmers are right. The soils are already rich in magnesium which, as has already been stated, is difficult to remove (79). Magnesium is antagonistic to potassium which is already very low. To supplement the magnesian status can only aggravate the Mg/K imbalance. This imbalance is the only ready reason for the problem of poor potato yield on the otherwise satisfactory Kelloe Series soils. When required a calcium limestone such as the Carboniferous is therefore preferable.

The solutions offered in this section are clearly to a high degree

specific. Information available is limited and specificity may be brought into question, but there is a strong case for precision. Boyd called to question what is the basis of modern fertiliser practice in the country, the work of Crowther and Yates. Their recommendations for manuring were based on averages of a very large number of experiments and no differentiation was made between substantially different crop environmental conditions (81). Such average recommendations have applied until quite recently (82) and even now experiments for different 'kinds' (Boyd) of soil conditions are not satisfactory. The soil surveyor cannot supply all the solutions but it is clear that he can present much needed information with a certain degree of valuable interpretation. This could be presented in map form and would correspond to a large degree with the soil map. Soil Type and Variety will assume greater importance and there would in the sector under consideration be some reflection of rainfall conditions and zonal considerations moving from west to east.

Livestock

Most farms have some cattle and most farms that are not too near towns or popular leisure areas have some sheep. Some farmers do not like sheep, and for no other reason do not keep them even on thin limestone soils which are acknowledged to be good sheep land.

Dairy cattle

There has been an accelerated movement away from milk farming especially since 1950. This conforms with the national pattern where between 1958 and 1962 40,000 milk producers stopped production (54 p. 58). There are several reasons which are important nationally and locally. The greatest movement into milk was during the period 1923-29 when the dairy provided some degree of security and regular income while overall capital was too low to support large beef herds and while cereals were commanding very low prices. The monthly milk cheque is still valued but farmers who were working very hard in 1929 can now afford to live better without the increasing inconveniences of milk farming. They do not want to be restricted by the twice daily routine of milking, which is

particularly burdensome now that female labour has left the land and male dairymen are so difficult to find. Financial returns from milk have also become less attractive recently in comparison with subsidy buffered arable and beef stock farming. Furthermore increasing regulations involving costly improvement and periodic inspection have always been irksome. Under a T.T. subsidy incentive they were perhaps tolerable. Since the replacement of that incentive by emphasis on total solids content of milk, many farms cannot hope to qualify for high price milk. In Trimdon since 1960 seven out of nine farms have gone out of milk. Some have left stock farming altogether but the majority have turned to beef and sheep. In the last five years over ten percent of the present sample of 172 farms have displaced the milk contribution on their holdings.

The remaining dairy farms form major groups within several acreage ranges: i.e. 50-100, 100-150 and 150-200. There is only one dairy farm of over 200 acres which houses the esteemed 130 strong Hesleden pedigree Friesian herd. Of the others, 33 percent are in the 50-100 acre group, 17 percent at 100-150 and 50 percent at 150-200 acres. In zonal terms onethird of all dairy farms were in zone B and two thirds in zone C, but the pattern is modified when considering dairy herds on farms with more varied agricultural systems.

Dairy farms represent only 12.5 percent of all farms sampled, but there were commercial dairy herds on 34.9 percent of total holdings. Considering dairy herds as opposed to farms they are spread more evenly through the zones. A has 31 percent, B has 31 percent, and C 37 percent. Total numbers of in-milk beasts are again weighted towards zone C at 54 percent. A has 26 percent and zone B only 20 percent.

Dairy herds are divided between mixed and milk farms in a ratio of about 2:1 (69:31%). In zone A they are all on mixed farms; in zone B 60 percent are on mixed and 39 percent on milk farms; in zone C herds are equally divided between mixed farms and dairy farms.

Total dairy beasts are distributed with close proximity to the distribution of herds. Mixed farms have 67 percent and milk farms 32 percent. It is clear then that mixed farms here make a larger contribution to milk production than dairy farms. The acres: milk cow ration on mixed farms was 6.8 and on dairy farms 4.4 but this carries no implication of differing efficiency and all the above data represent only one moment in a constantly changing cycle.

The pattern in zone D, according to Simpson (15) is quite different. Over two thirds of farms smaller than 100 acres and 75 percent of farms under 150 acres have dairy herds.

Dairy Breeds.

Friesians are now by far the most popular breed with high yields and much improved butterfat content. Bull calves and steers are very useful in the beef trade. Ayrshires are second in popularity and more so in the west than the east, but they are usually found in mixed herds and some farmers are in the process of changing from Ayrshire to Friesian. The Ayrshire has good butterfat record but is not as useful for beef.

Shorthorns are still used but they are ^{of} rapidly declining importance. Channel Island cattle are not/all common but are more frequently found outside the sector to the east and south.

Herd Policy.

Policy will of course vary according to total acreage, available grass and size of herd. Some rear their own heifer replacements and sell off cows at three lactations. Others rear some replacements and buy supplements as needed. Others buy all replacements having sold off all calves immediately to the ready beef trade. This is particularly true when Angus bull or A.I. is used to give easy first calving. Those rearing their own replacements may sell off their bull-calves immediately while others keep half or more to qualify for the rearing subsidy. This is particularly so where topography and soil quality necessitate a high proportion of grazing land.

All dairy cows are in this sector wintered indoors and fed up from oats to concentrates or more recently from barley to concentrates or silage. Dairy farms are usually careful in their grass management and most of them strip or paddock graze at least early on in the season. By June there is usually sufficient free range grass available. In milk cows receive concentrates throughout the summer. By autumn kale may be stripped but an increasing practice is to cut and chop.

At least 30 percent of farmers still keep their own bulls. In larger herds there may be more than one bull but in herds of less than 10 in-milk cows A.I. is the general rule. Breeding policy is usually slightly more sophisticated for Friesians where Angus bull is used for heifers and A.I. or larger bulls for cows.

Mixed farms manage their dairy herds in a similar manner but followers are most likely to be retained on farm to supply a beef enterprise. Grazing is usually not so tightly controlled as on dairy farms.

About 10 percent of dairy farms still deliver milk on a collect/exchange basis running one or two rounds. Delivery is still profitable especially as it guarantees a regular income. On one farm that ceased milk production recently a delivery round is still maintained. The bulk of distribution nevertheless is undertaken by large concerns such as Associated Dairies, C.W.S. or the M.M.B. and through local grocery stores and travelling shops.

Beef cattle

Over 35 percent of the total sample had beef cattle as a major enterprise. Of these the Cash Cropping with stock: Fattening with cash cropping, ratio was 2.5:1. The transitional nature of the period must be remembered, especially since the sample was taken in a year of great disturbance in the beef market. Stock was abnormally low on the many farms that had sold on rising prices but were unable to buy sufficient to replace for the same reason. The transitional phase has been permanently encouraged since 1955 by rising calf subsidies, increased average fatstock prices and the introduction of period/price

standards. There has also been encouragement of production of beef from dairy herds (already by far the main contributor) by reducing liveweight differences in the Grade I fatstock subsidy. The abolition of the T.T. subsidy and the influx of foreign buyers have more recently made a great impact. The movement is towards beef, but the major problem is capital, because of slower returns on a high initial investment. Some dairy farms are in the process of converting to beef and are at present in the mixed farming class. Others are further on in the transition and are grouped as cash cropping with stock fattening but are not yet stabilised. One farm was going out of cattle altogether. Another farm fluctuates in cycles between the mixed and the milk classification.

Fattening with cash cropping and cash cropping with fattening farms occupy a wider range of acreage than dairy farms and are also seen on larger units. As individual divisions pail-fed, multiple - suckled, single suckled and stores-dominated systems are not of major importance except between 0 - 50 acres where stores dominate. In combination however they dominate all groups except at 200 - 250 acres. They are mainly concentrated within the 0 - 200 acre range but on the very largest farms marginal grassland allows fattening and sheep to assume major importance, particularly in the east. In the west marginal grassland is not always good cattle land.

Breeds

Friesians and Friesian X Angus or Hereford form the major beef stock. Pure Friesian calves are much improved but with an Angus bull they deliver more easily and mature rapidly to good beef quality. A Hereford bull is popular, especially on dairy farms as it gives a larger calf which matures even more quickly. The Hereford and Hereford X n or Angus is second in popularity as a good, large, quick maturing beast. They are crossed with Herefords and Angus. Pure Angus are as common as Shorthorns. Ayrshires are still used for beef, coming from dairy herds, despite their poorer beef quality. One farm near Blackhall keep slow maturing Highland Cattle. Store calves from local markets include the above breeds and a large proportion of mixed Irish stock.

Herd Systems

Of the four aspects of cattle production all may occur on a single farm in varying proportions. Stores are the most common, pail-fed and multiple suckled dairy surplus follow in importance and single suckled calves are comparatively rare.

Single suckling involves a cow raising its own or a replacement calf. Such calves reach slaughter conditions more quickly than under any other method. Calving is in mid and late winter to take advantage of grass as it comes, after suckling for up to nine weeks. They are finished off on concentrates and sold at 15 months at high spring prices. A continuous supply can be maintained on a large farm but the demand on grass and the slow turnover make them less attractive to the smaller farmers unless he can establish a good reputation and maintain contracts with butchers (Farm Study 22).

Multiple suckling requires the purchase of surplus dairy calves to put to cow at up to four at a time. Two calves per cow are most common. Fattening is slower and is based on cheap autumn and winter dairy calves reared over a period of two years. Some farmers prefer a quicker turnover, finish off earlier and accept lower prices. Selling is where possible restricted to the high price months between February and June.

Pail-feeding is adopted where there are not sufficient in-milk cows and involves early weaning from dried milk. The calves may take grass in the first year but still need concentrates. This is an expensive system and is adopted on small farms or where grass is limited. The period required for preparing for the butcher is at least two years.

Stores arrive from surplus dairy followers at 12-24 months from local markets and from elsewhere in England and Ireland. They are fattened up for quick sale. Irish stores must be kept for thirteen weeks after importation but other stores turn over twice or three times in a year. Turnover is rapid and profits per head are small, but initial investment is considerable and losses are not easily overcome.

Marketing

Beef farmers like to travel, and buy cattle from all over the north of England but Darlington is the major source of dairy cows, fat cattle, English and Irish stores, calves and other stock. Hexham is popular and Alnwick, Fencehouses and Hawes are used. Fatstock is sold locally, and Castle Eden and Haswell are the favourite markets with Sedgfield and Stockton also used. Here the farmer has his local reputation and knows the butchers and dealers he trades with. Poorer beasts and old cows are sent away and Gateshead usually takes them. There is an active trade throughout the region on a private basis under the auspices and energy of a dealer in Cassop who does not like paying auctioneers fees. Farmers buy from him and sometimes sell back fat to him. He prefers to buy locally but supplements his trade from Scotland and Ireland. In the west and centre of the region few farmers use F.M.C. Darlington, but F.M.C. West Hartlepool serves the south and east well.

Apart from usual troubles such as mastitis in dairy cows more serious stock diseases include an instance of staggers (on magnesian limestone rich thin soils), New Forest disease on several farms, recurring Johne's disease which claims at least one cow a year on one unit, and bull-dog calving.

Sheep

The system varies throughout the region. In the west a permanent breeding stock is kept, put tup to lamb in March and the lambs sold fat before the end of August. Some may be kept back if the prices fall or to finish off roots and grass fodder. A modification involves the purchase of new old or young ewes each year. The older ewes are tugged once or twice and then sold fat. In the carrland area old ewes are used in the same way but the system extends as far east as Hutton Henry and as far west as Cassop Colliery on the plateau proper. The majority of lambs are sold fat but a further modification involves selling as stores.

Some breeders also winter hill sheep from 1st November to 1st April and return them fattened up on turnips. Hogs and stores may be wintered on hay and turnips in a similar manner. Others merely rent out grazing land for hill and Scottish sheep. A final system encountered was the tugging of half-breds from October to May for selling fat with lambs at foot.

Occasionally farmers clip their own sheep but more often they rely on contract work. Wool is sold through the W.M.B. The fat lambs are sold at Castle Eden and Haswell.

Flocks vary in size but ewes rarely exceed 100 in the west and centre. To the east flocks of up to 2,000 strong occur.

Breeds.

The two most common ewes are the Mule (Greyface from Blackface X Border Leicester) and the Scottish half-bred (Cheviot X Border Leicester). Other breeds include the Masham (Swaledale X n), pure Swaledales and Border Leicesters. The ewes are tugged with a Suffolk ram to produce a large drop of maturing lambs. Fertility is in the hill breeds and maturing quality in the lowland tup.

There are no unusual or regional diseases in the flocks. The occasional swayback or more persistent foot-rot are all that has normally to be contended.

Pigs

Pigs are of declining importance on most farms in the region. Near housing estates they can be useful instead of sheep but they are more often of very minor importance. They are useful for the conversion of manure and can provide good urine, but they are subject to greatly fluctuating market prices and are prone to disease and losses. Some farmers are clinging to 1-4 sows but have the intention of going out of trade. In the south-east the majority of herds are 1-3 in size but in the centre and west where they still exist they are taken more seriously and numbers, though fluctuating, are between 5 on a 45 acre farm to 230 at 200 acres. Acreage is not normally related to the numbers of pigs on a unit except at the extremes. One 128 acre unit has 163 stores.

There are almost as many systems of pig keeping as farms keeping pigs but with respect to purpose there are two main groups.

1. Breeding up to sell as weaners for pork or bacon. There is fluctuation within the system and farmers may intend to rear to bacon but have to sell as pork because of financial difficulties.
2. Buying in as stores to fatten or buying in as weaners to sell as pork rarely as bacon. As an end product pork is the main aim with weaners but with stores pork and bacon are equally divided.

Housing conditions for the pigs vary between very poor and moderate. Some are kept in old draughty sties and manure is trampled in a rough yard, the urine going to waste. Others are reared in open pens including larger areas for grubbing but they are more restricted for finishing off. Some receive infra-red heat in old enclosed pens while perhaps the best system seen was the restricted housing of many pigs in a solid but old building. Here the quantity of pigs was enough to create adequate heating. No bedding was provided and manure was swilled into an outdoor tank for spraying onto grass.

Feed varies from scratchings and swill to a balanced mixed diet. Barley is playing an increasing part to supplement expensive pre-mixed ration, or incorporated within farm-mixed rations.

The main breed encountered is Large White at a ratio of roughly 2:1 over Large White X Landrace. There are occasional pure Landrace and Essex.

The pig unit must doubtless be dispensed with on those farms not taking pigs seriously. To be successful pigs must be a major enterprise with a substantial part of arable land devoted to them, and sufficient numbers to maintain regular contracts and balance out price fluctuations to an acceptable mean. With the development of cooperative packing and selling in other parts of the country similar provisions would seem a requirement of survival here. Buildings and planned integration on a regional or county basis would involve substantial capital outlay which is rarely available even on those farms most seriously interested

in pigs. To put the pig in non-agricultural specialised factory unit would seem a retrograde step because this efficient animal can contribute much to the soils of the region which are not outstanding in terms of inherent fertility.

Poultry

Most farms keep some hens, but like pigs they are often not a serious enterprise or at best they are left to the farmer's wife. Some farmers will indicate they have only a few hens for private use. Sometimes this is true and very few or even no hens are kept on the farm. Near housing estates hens are stolen in large numbers near Christmas which discourages production. In other cases farmers have attempted deep litter or battery production but have been forced back to the few fowls scratching in the yard. The biggest complaint is against the Egg Marketing Board which is criticised for constantly giving low prices for eggs on the pretext of small size or dirtiness. For this reason farmers are not willing to disclose actual numbers, but frequently up to 200 birds are kept illegally for door sales while the old hens go to local butchers or fishmongers.

Organised systems vary. Under free range 1 - 700 hens are kept with the most common numbers around 50. In larger units the birds are brought in to deep litter to lay. Deep litter units vary from 1 - 200 birds with 100 most common. Battery units vary from a few birds to 4,000 with 400 the most common. There are equally variable numbers in pens.

Hybrids are the most common as they are the heaviest layers but in the farm yard the Rhode Island Reds and Leghorns are still common.

Turkeys are reared only on a small scale but they are proving increasingly profitable and units of 100 birds are reared from June to Christmas. Geese are even less common and only the occasional goose is seen.

Labour

In the whole sector there is almost a straight line rise in mean labour requirements against acreage groups (Fig.220). There is a hint of

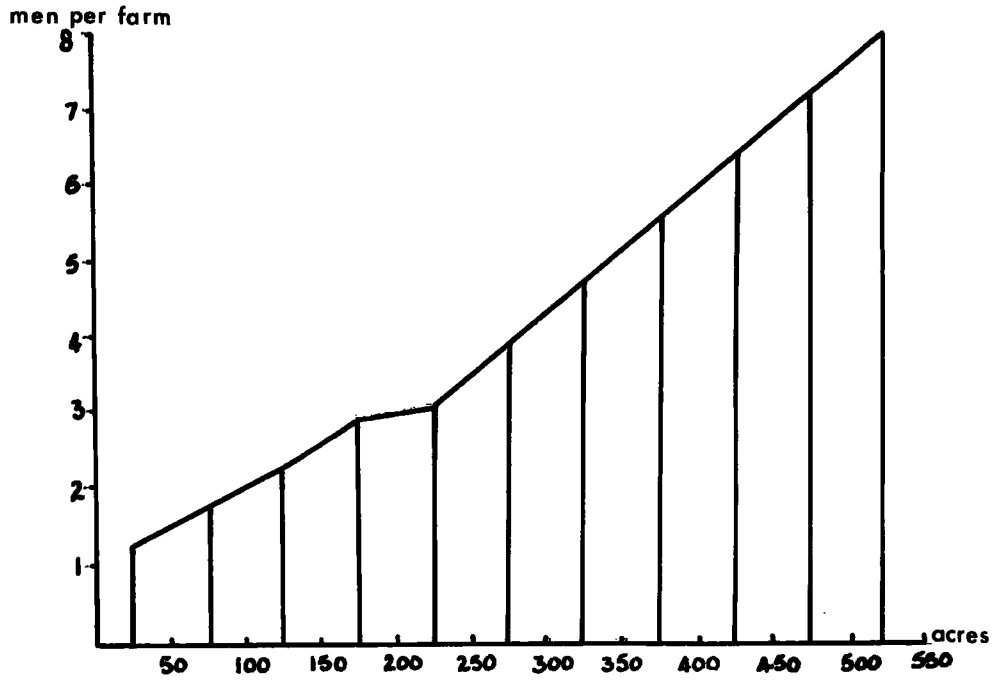


Fig. 220 AVERAGE LABOUR FORCE IN SECTOR.

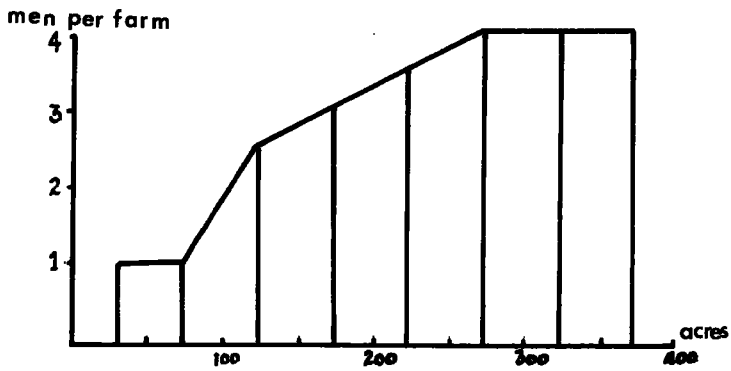


Fig. 221 AVERAGE LABOUR FORCE IN CASH CROPPING GROUP.

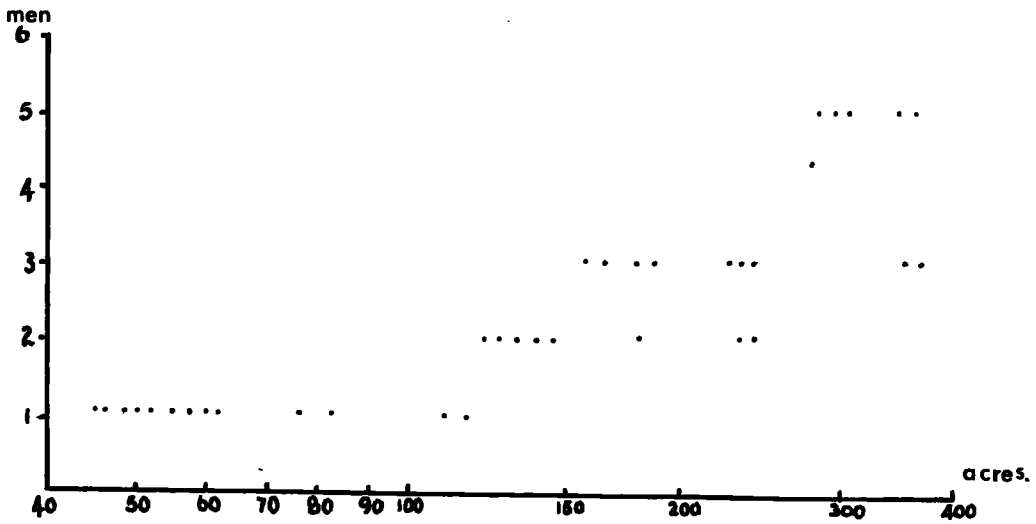


Fig. 222 LABOUR FORCE IN CASH CROPPING GROUP.

a break between 150 and 200 acres where labour requirements would seem to increase, but this is largely due to the influence of dairy farms concentrated within that size group. The frequency polygons for cash cropping with fattening and for mixed farms do not show this break of line. A general index of labour requirements can be determined in the following ways.

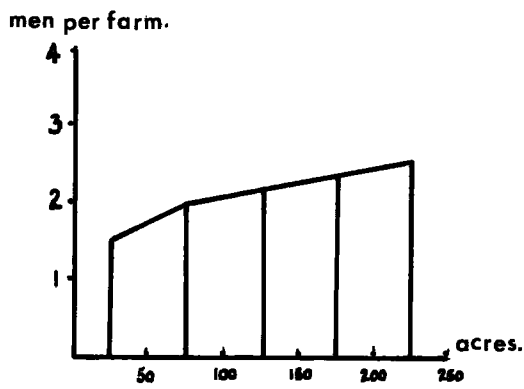
1. Mean requirements.

0 - 50 acres	1.2 men
50-100 acres	1.85 men
100-150 acres	2.25 men
150-200 acres	3.00 men
200-250 acres	3.14 men
250-300 acres	5.00 men
300-350 acres	5.00 men
500-1000 acres	8.00 men

2. A more realistic determination is the range distribution.

0 - 50 acres	1-2 men
50-100 acres	1-3 men
100-150 acres	1-3 men
150-200 acres	2-6 men
200-250 acres	1-4 men
250-300 acres	4 men
300-400 acres	3-7 men
500-1000 acres	8 men

The results so far established are not fully meaningful without some consideration of system influences and the zonal contribution to requirements. In Fig.221 mean labour requirements for the cash cropping system are seen to rise steadily from 100-300 acres from 1-3 men. Then they level off at an average of 4 men. The range distribution taken from the scatter diagram (Fig.222) is as follows.



**Fig 223 AVERAGE LABOUR FORCE IN
ARABLE GROUP.**

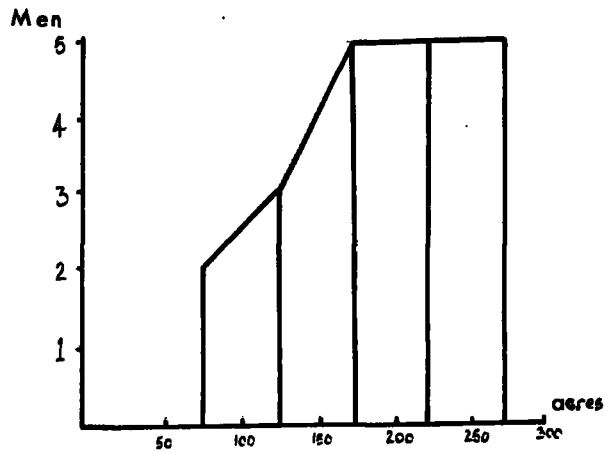


Fig. 224 AVERAGE LABOUR FORCE IN DAIRY GROUP.

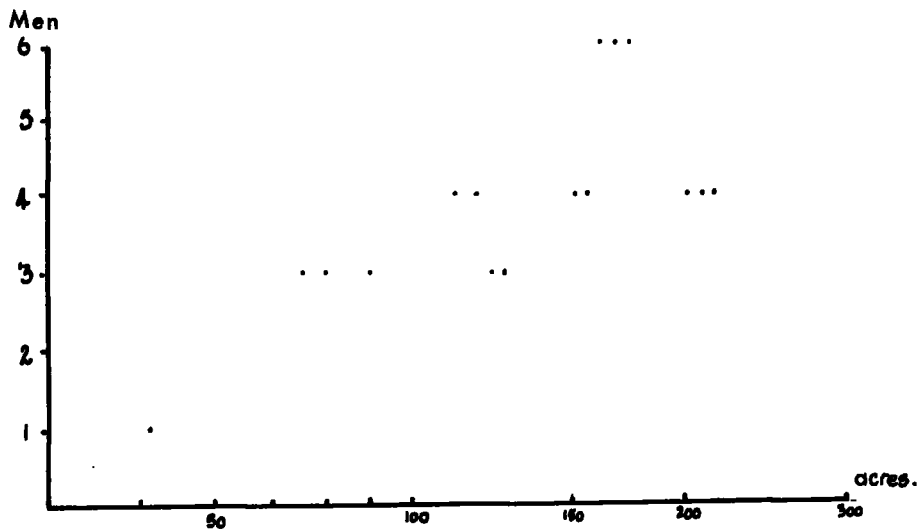


Fig. 225 LABOUR FORCE IN DAIRY GROUP.

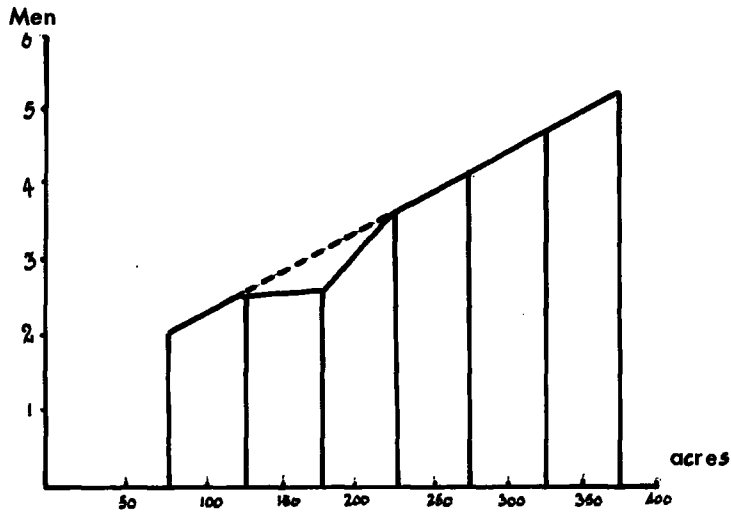


Fig. 226 AVERAGE LABOUR FORCE IN MIXED FARMING GROUP.

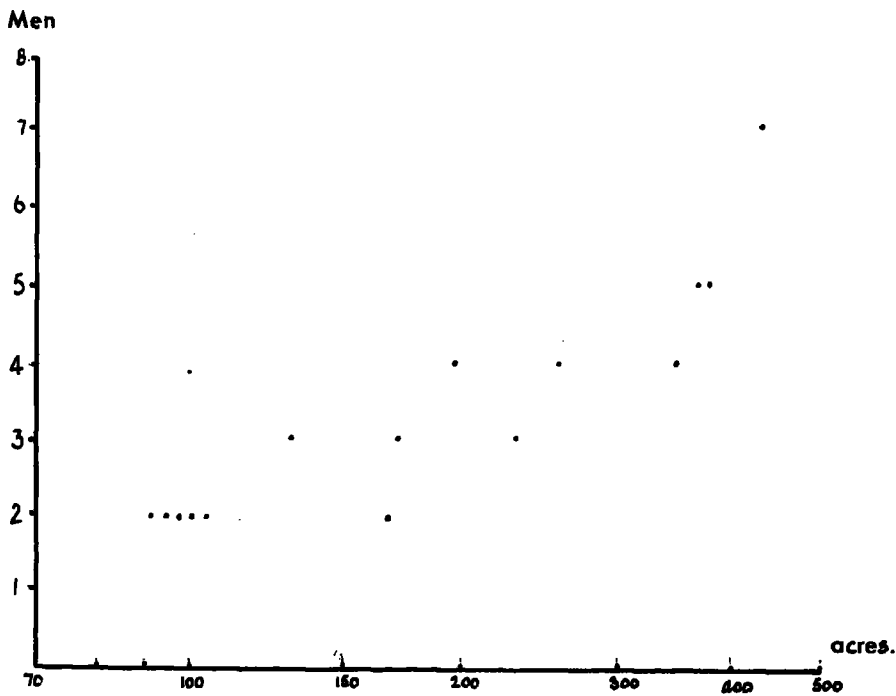


Fig. 227 LABOUR FORCE IN MIXED FARMING GROUP.

1 man	45 - 116 acres	0 - 50 acres	1 man
2 men	120 - 235 acres	50 - 100 acres	1 man
3 men	150 - 370 acres	100 - 150 acres	1-2 men
5 men	290 - 350 acres	150 - 200 acres	2-3 men
		200 - 300 acres	2-5 men
		300 - 400 acres	3-5 men

In comparison arable farms (Fig.223) need more labour at the lower end of the acreage grouping. On larger acreages where mechanisation is more important less labour is required than on cash cropping farms.

Milk farms show the need for more labour than under other systems above the 50 acre mark but at 200 acres the sharp rise levels out (Fig. 224). The range of distribution is seen clearly in Fig.225 which shows less wide scatter than under other systems.

1 man between 0 - 50 acres	0 - 50 acres	1 man
3 men between 80-120 acres	50 - 100 acres	1-3 men
4 men between 150-200 acres	100 - 150 acres	3-4 men
	150 - 200 acres	4-6 men

One farm at 160 acres employs 6 men but there are two milk rounds taking up part of the time of some of these.

Mixed farms (Fig.226) show an even rise from 50-400 acres with a slight down break at 150-200 acres. This break does not show statistical probability but it occurs at a point where as already mentioned farmers claim that they could work such an acreage with the labour and machinery needed for farms of 50 acres or more less land. The range distribution can be expressed as follows.

2 men from 95 - 165 acres	0 - 50 acres	1 man
3 men from 130 - 230 acres	50 - 100 acres	2 men
4 men from 200 - 350 acres	100 - 150 acres	2-3 men
5 men from 300 - 365 acres	150 - 200 acres	2-3 men
7 men at 465 acres	200 - 300 acres	3-4 men
	300 - 400 acres	4-5 men
	400 - 500 acres	5-7 men

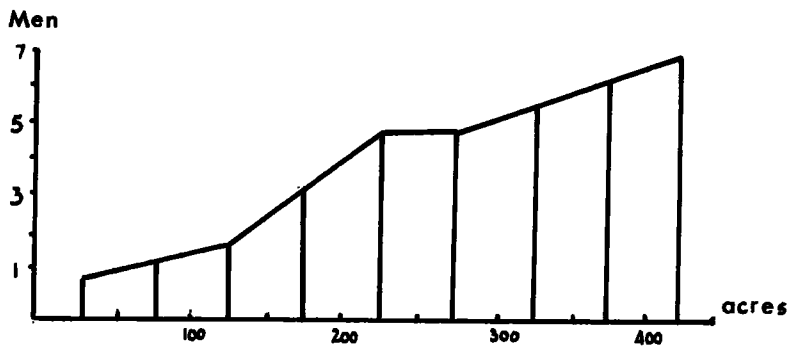


Fig. 228 TENANT OCCUPIED FARMS.

AVERAGE LABOUR FORCE.

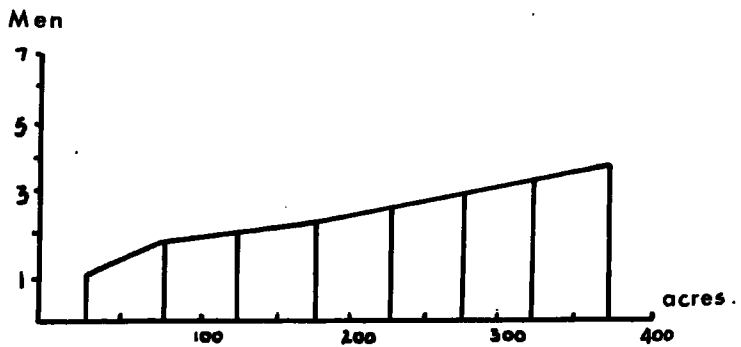


Fig. 229 OWNER OCCUPIED FARMS.

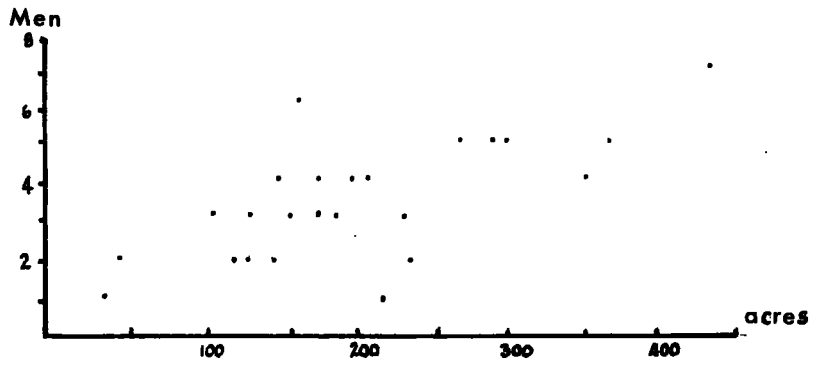


Fig 226_a TENANT OCCUPIED FARMS.

LABOUR FORCE SAMPLES

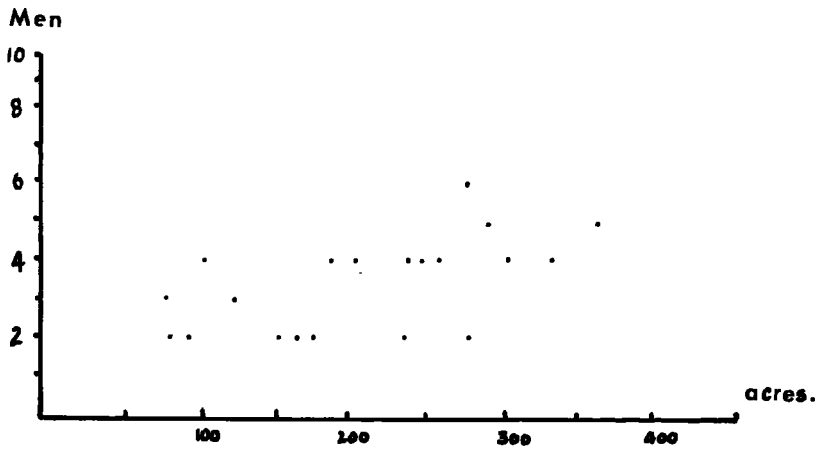


Fig 227_a OWNER OCCUPIED FARMS.

It is clear that the agricultural system decides how many men are required within different acreage groups. Milk farms always require more labour than mixed, arable or cash cropping farms. As might be expected mixed farms can always have more man-power than cash-cropping units in corresponding acreage ranges, particularly up to 150 acres. Beyond this mixed farms have a narrower range of labour requirements while cash cropping farms have very variable requirements depending on refinement of system. As the agricultural system is itself largely governed by zonal influences, it is impossible to say whether one zone requires more labour than another in individual systems. Range of efficiency is more important i.e. how many men are required as a maximum and a minimum within given acreage ranges. Older less well mechanised farms in some cases seem to rely on a larger labour force, but this is certainly not always the case. Some undermechanised farms 'get by' with less work. The range of profit can therefore be taken as very wide.

Comparison of owner occupiers and tenant farmers with respect to labour requirements reveals close similarity at least up to 150 acres (Figs. 226 a - 229). Above this level there are some indications that tenant farmers need more hands than owner occupiers.

Labour analysis is always difficult. As an ideal, man-hour input for different sections of each farm should be established for a yearly period. This is impossible at least in the East Durham Plateau, without a series of work study surveys. The pattern is now not as complicated as it once might have been when farm boys were more common and the surveyor had to decide what percentage of a man a boy represented. In 1964 only 17.77% farms surveyed had one farm boy and only one farm had two boys. About nine percent of the farms were worked by family labour with no outside help. These were usually owner-occupied farms. The sons of the family usually have to wait for the complete incapacity or death of the father before they can assume full responsibility for the management and this tends to restrict the speed of progress and innovation. Female labour except

for the farmer's wife is now very rare. Daughters do not now go onto the farm, nor does the farmer employ female labour. This is especially noticeable since the mechanisation of milking. The vast majority of casuals for potato-picking are however female, with a variable force of school-children. Turnip hoeing is however mainly a man's job and takes in off-shift miners.

Machinery

Interpretation of machinery requirements is very difficult. Understanding the present situation is complicated by the transitional nature of the period. Most farmers are in the process of buying new machines and there is much obsolete equipment which will be used only very rarely and should not necessarily be incorporated within analytical data.

The date of the horse and horse-drawn equipment is now over, During the past ten years the last of the farm horses has disappeared although the final change has in this region been more recent than in many areas. Several farms have used horses within the last five years and the one remaining working horse was sold in late Spring 1964.

All farms have tractors. Up to 100 acres one tractor is often sufficient. Above 100-150 acres two tractors are usually enough for most farms up to 250 acres. For some jobs it is desirable to have a third tractor, for example silage making and potato lifting, but the third tractor is seldom a new one. Because of low exchange prices an old tractor may remain on a farm and be used only very occasionally for specialised work. This is clear enough when considering the high proportion of old paraffin tractors remaining. As already indicated there was only one crawler tractor encountered and most units are now diesel powered. There is little difference between tractors needed on farms of different agricultural system, except that milk farms usually use less than mixed or cropping farms of comparable acreage. The average number of tractors on farms in the region is two. Acreage requirements are broken down in Figs. 236 and 237.

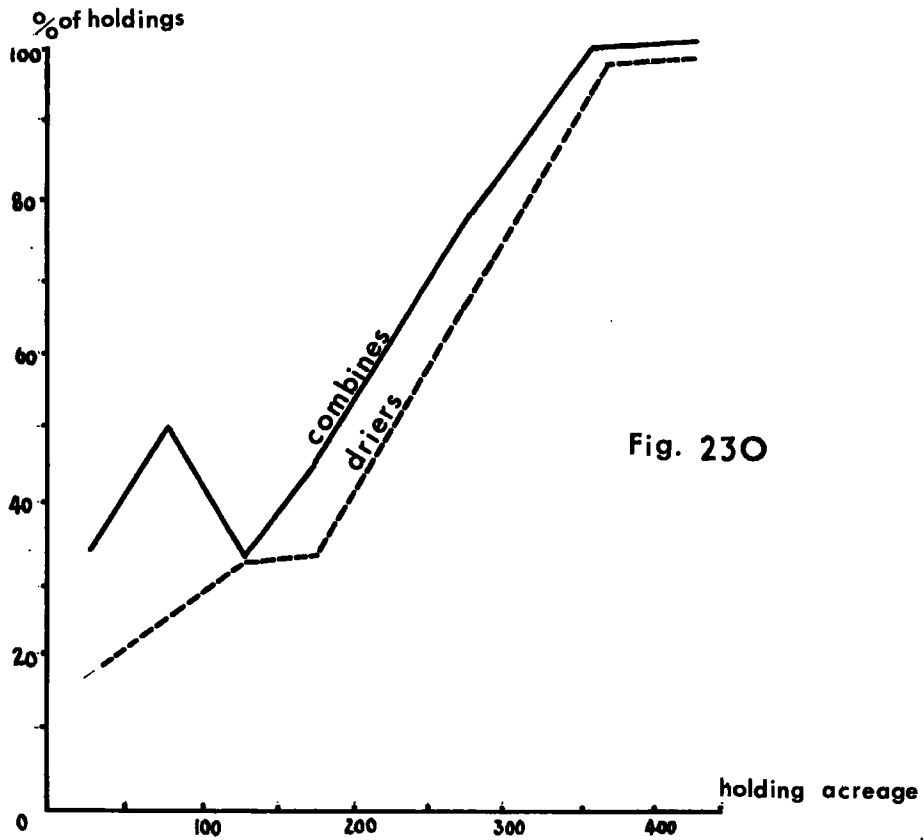


Fig. 230

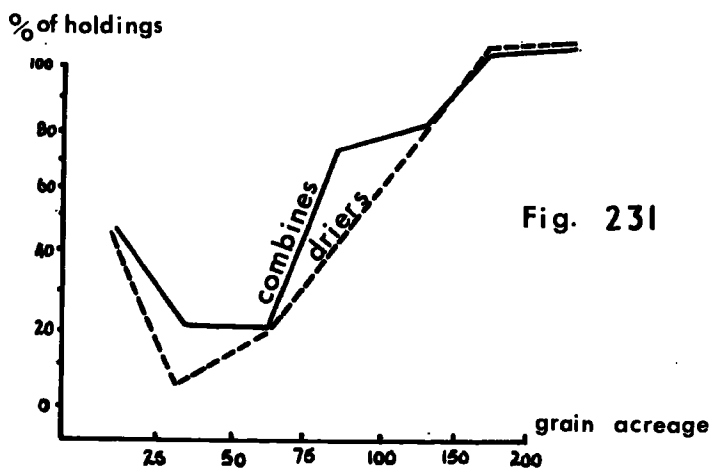


Fig. 231

FARMS OWNING COMBINES AND DRIERS

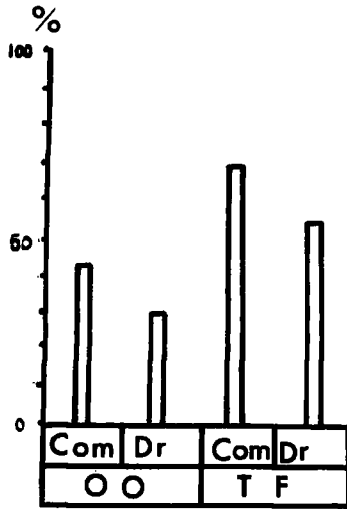


Fig. 232 OWNER AND TENANT OCCUPIERS.

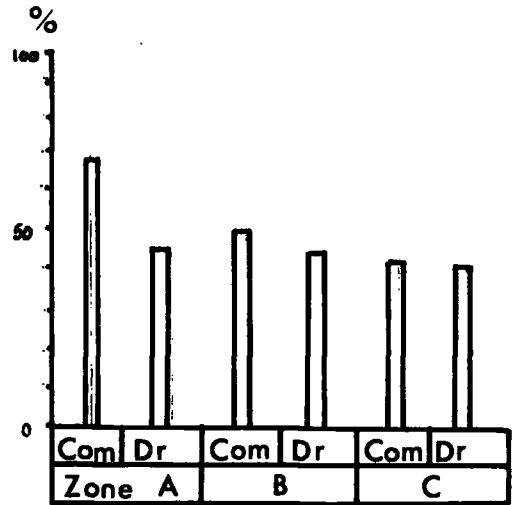


Fig. 233 ZONAL INFLUENCE.

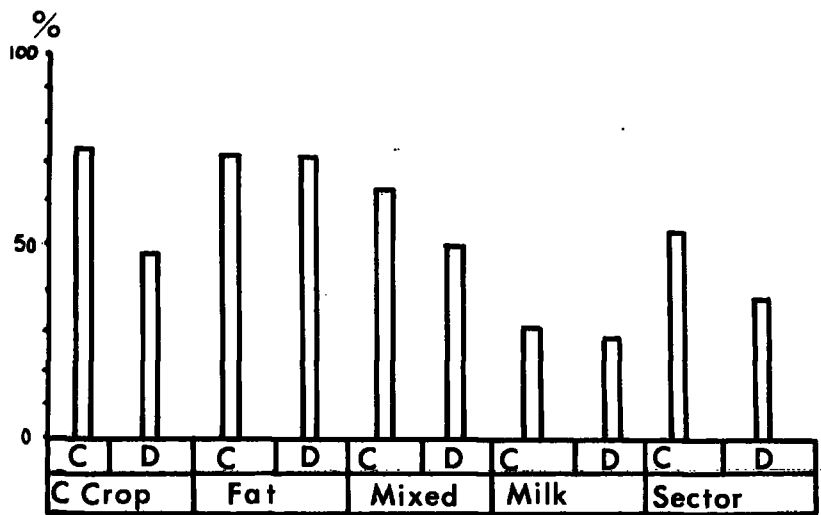


Fig. 234 AGRICULTURAL SYSTEM INFLUENCE.

FARMS OWNING COMBINE HARVESTERS AND GRAIN DRIERS.

Combine harvesters and grain driers form a better index of degree of mechanisation. In this respect there have been radical changes since 1950. At that time there were very few combines and driers to be seen. Now 59 percent of farms have combines and 43 percent have drying equipment. Most of the equipment is under four years old. Combines and driers are used on farms of under 50 acres even when they are not entirely arable holdings (Fig.230). In one case a combine was used on 19 acres of barley. Half the farms between 50-100 acres own combines but rather less than one third have yet purchased driers. There is a drop in the numbers owning combines between 100-200 acres which is caused by the concentration of dairy farms within this range. This is in marked contrast to the labour requirements within the same acreage range (Fig.220). Above 200 acres two thirds of the farms have combines and over half have driers. Above 350 acres all farms have combines and driers.

A better understanding of the distribution of combines and driers may be obtained by studying them in relation to grain acreage (Fig.231). In several cases under 25 acres of grain on a single holding seems to justify the possession of a combine. There is an inexplicable reduction in the percentage of both combines and driers between 25 and 75 acres of grain but above this level these implements are obviously of great advantage and at 150 acres of grain all farms have them.

There are marked differences between owner occupied and tenant occupied farms with respect to this equipment. Tenant farmers own more combines and more driers than owner occupiers. This is a complete reversal of every other comparison between the two types of holding. It may be that tenants because of reluctance to invest in fixed equipment and buildings can afford to invest in mobile machinery. A more likely reason is that tenant farmers are low on storage space particularly since yields have increased under the influence of fertilisers. They have very little suitable space for storing grain with too high moisture content and need to dry first before putting on floors or make-shift boxes. Further influences have to be taken into account. On a zonal basis it is clear that there are fewer combines

and driers moving eastwards across the sector (Fig.233). This begins to give a more satisfactory explanation of the above problem. There is less barley, in particular, moving eastwards. Also there is slightly less need of combine harvesting because the climate is appreciably better at least as far as exposure, laying winds and rainfall go. Furthermore the owner occupiers located in zone C strongly weight the data in (Fig.232). Analysis of combines and driers on different holdings by agricultural system (Fig.234) further clarifies the situation. The outstanding system which requires far less combines or driers is dairying. This system is of course dominant in zone C. The combination of these factors does not fully explain why owners are not more mechanised in this respect than tenants, but it at least helps to explain the owner's attitude when he says it is far cheaper to borrow my neighbour's machinery. This is an important consideration. It has been noted that owner occupiers are grouped together in zones A and C. An appreciable amount of borrowing machinery was experienced here, and is not entirely absent amongst tenants in zone B. It is clear that some holdings with a very small grain acreage do not really need to own a combine or a drier. An implement collective or cooperative unit within the region would be highly advantageous. The counter argument, often offered, that in this region such cooperation would not work is obviously refuted by the owner occupier's present practice.

Most farms have a baler or forage harvester where necessary. There is no precise pattern to those who hire balers except that they are all owner occupiers, which to some extent reinforces the arguments above. Only one tenant farmer was without a baler and he was in the process of buying one. The increase in baling equipment is again comparatively recent. Elevators, fertiliser drills, muck spreaders and loaders were well represented throughout the sector and it is difficult to separate farms exceptional in mechanisation apart from the really run-down holdings or milk producers. Nearly every farm possessed the following: ploughs, combine drill, harrows, discs, rollers, grass cutter and turner or tedder, binder, corn drill, seed-root drill, potato planter, spinner, riddle, grinding pulping and milking machines.

It is difficult to interpret the data as there is so much old machinery never or very little used, lying around most farm yards. It is nevertheless clear that on some tenant farms there is a tendency to over invest in mobile machinery at the expense of labour saving machinery and building lay out in the yard. Most farmers invest a great proportion of their total capital in machinery. Those with low investment include old farmers still using nineteenth century equipment, farmers who are doing very badly, milk farmers, and those farms where stock is dominant and the highest proportion of capital is obviously tied up in the herd.

Age of equipment varies but there is usually a high proportion of machinery under five years old. More sophisticated machinery includes one crawler tractor and a slurry spreader. These instruments are not at all revolutionary but it is significant that they are very exceptional in this region.

Supplies and servicing

Machinery purchase is through the national concerns who have accessible agencies. Servicing falls into five major groups.

1. Independent agricultural engineers. Over 75 percent of farms consulted one firm, Paxton of Pity Me, which has a very good reputation and is used exclusively by many. Just over ten percent used other independent concerns including Tipton and Morley of Newcastle, Orde and Teesdale and Fewsters.
2. Agents for Ferguson, Nuffield, International Harvester, Ford and Brown. Over 36 percent use these agents regularly for servicing outside guarantee.
3. Teeside Farmers agricultural engineers. Only 13 percent use this cooperative concern, a low figure which could change rapidly in the next few years if machinery cooperatives become established.
4. Complete self-servicing. All farmers must do some of their own servicing. This is one of the facets of modern farming life. Thirteen percent of all farmers in the sector are proficient engineers and have establishments on their farms reminiscent of

the old farm smithy and forge. This is an interesting historic twist of some importance because, as indicated, agents are not local and much valuable time can be lost during harvest for want of simple repair work.

5. Local blacksmiths. Local assistance can sometimes be obtained from a nearby garage but only one agricultural smith was encountered and his services were used by only three percent of the farms sampled.

Buildings

Throughout the sector there is much room for improvement of farm buildings. Modern insulation and heating developments are perhaps not general in the country as a whole but it is significant that no developments at all of this nature were encountered on the East Durham Plateau. There are new buildings which are far superior to those of an earlier date but they are never exceptionally good. The buildings can be classified in several ways.

- A. Presence or Absence
- B. Age
- C. Improvements
- D. Inadequacies
- E. Lay-out

- A. Several small farms have no farm house and at best only a few rough sheds. In one case on a long established but run-down farm the sheds were falling to pieces.
- B. 1. Farms over 200 years old with later modifications and additions
About fifteen percent of the total sample farms had buildings predominantly of this age. These were not necessarily the worst buildings either structurally or in layout. In fact the old compact courtyard can work very well today. The buildings are usually of solid stone or several courses of brick.
2. Farms of 50 - 150 years age.

The majority of farms, 61 percent, fall into this group. They represent the worst in structural inefficiency with bad heat loss and difficult lay out. They are difficult to adapt to modern conditions of storage, animal care, milking and machinery.

3. New N.C.B. buildings or substantial proportions of new buildings on owner occupied farms.

This represents only 23 percent of the sample and by far the greatest amount of investment is from the N.C.B.

- C. 1. Farms with the majority of buildings substantially adopted from layouts of all other periods.

More than half (56 percent) of farms had made real efforts to change their buildings but of those only 16 percent had invested large sums of capital and those were all owner occupiers. In all 66 percent of owner occupiers have put up new buildings and these include the best improvements encountered.

2. Owner occupiers who have not successfully improved their buildings.

This includes 33 percent of owned farms. Although many have made some modifications, these have no aim of permanence nor are they part of a comprehensive modernisation plan.

3. Tenant farmers who have modernised buildings with assistance from the N.C.B. or the Ministry of Agriculture.

Over a third of tenant farmers (37 percent) are within this group. Improvements range from re-roofing to new barns and drying houses.

4. Tenant farmers who have not invested in buildings to any substantial degree, because they have not the capital, do not see the point or have other difficulties.

About two thirds of tenant farmers fall into this group, but many have made some modifications which were often intended to be temporary measures but have assumed a degree of permanence.

Old gates supported by binder string form building divides and drain pipes are supported on oil drums to lead water. In one case an old iron bar was used as a lever to raise milk churns into a cooling bath.

D. 1. Those with adequate corn and machinery space.

Only 42 percent of all farms claim that they have adequate space for present needs. None claimed room for much expansion. This situation can of course retard grain expansion. Lack of space to store hay, straw or corn reduces the incentive to increase yields. Machinery provides even more serious problems. An expensive piece of equipment depreciates quickly when left unused in the open for the major part of the year. This is again a factor influencing the decision to improve. There are therefore serious checks on planning for the future. There are many cases of farmers being refused financial aid for building they planned. Sometimes the plans are too small and future occupants have to be thought of. More often there is a lack of specificity. Landowners are not anxious to spend money on specialised buildings because of the philosophy that a building must outlive the present tenant. It must be sufficiently general purpose to cater for some unknown future farmer whatever system he decides to adopt. The result is that there is a profusion of temporarily converted general purpose buildings which are generally of poor quality. In the light of this analysis a reassessment of the initial claim of 42 percent of farms to adequate storage was made. It transpired that only 16 percent of farms are approaching convenient adequacy for the present and there is very little room for expansion.

2. About 57 percent of farmers openly complain that they are seriously short of storage space and as has just been indicated the actual number must be far greater. The shortage can be divided into lack of grain storage and lack of machinery cover,

Fifteen percent were short of storage for immediate crops of corn, hay and straw. Over seven percent of farms had no machinery cover at all. Those with very serious general shortage on more than one count amounted to more than one third of the whole sample, which is an alarming proportion.

E. 1. Those with well-organised buildings old or new.

Some 39 percent of farmers have no complaints about farm lay-out. None of the farms have been work study analysed and on all of them there are obvious improvements which would not only make farming easier by cutting out cross-movement of activity but also save labour and farm export cost. Most of these farms were built with the horse and a large labour force in mind, and not for mechanised or automated farming. Some of the older court-yard systems, however, present more modern convenience than newer scattered buildings.

2. Old farms with difficult lay-out of buildings.

This involves 54 percent of all farms in the sector and represents considerable wastage of labour, time and money.

3. New buildings with bad organisation.

Of new buildings 28 percent (six percent of total sample) are badly organised and those are almost entirely on N.C.B. land. There is a lack of specificity, convenience and structural efficiency. In one case a half open range of buildings was exposed to the north east along its whole length. More often access and integration are the chief aspects requiring improvement.

'Some economists in their concern for the distinction between land and capital exclude such items as buildings from their reckoning' (42). In Britain however there is a marked degree of stability in the pattern of farms in their size distribution and layout and to some extent fixed equipment has taken on the economic characteristics of the land itself (54).

On the East Durham Plateau this would be a dangerous inference, because the more precise division between owner occupiers and tenants masks the situation. Owners put proportionally more investment into fixed equipment than tenants and generally have neater and better organised farms. The influence of the N.C.B. is certainly not related to land quality. A consideration of farm buildings is important to understand the zonality imprinted on the plateau. It is nevertheless impossible to establish any meaningful land quality divisions from building analysis, alone, despite Langdon's assertions (56 p.59).

Amenities *W*

All farms have mains and water together with electricity although the latter has often been installed only in the last four years. Understandably few farms have mains sewage and most use private cess-tanks while chemical and earth systems are still common.

Most farms use the local village for normal shopping, or the mobile shop. If a more important settlement is within equidistant accessibility this will be preferred. For example Thornley is preferred to Cassop Colliery by those farms located between the two. The Co-operative Society is of course an important source of attraction in this part of the country.

Place of shopping for larger items depends on several factors. The farmer's present agricultural system or a recent system now-displaced is important together with geographical location. Durham draws farmers and their wives along the edge of the escarpment with the incentive of banking facilities. Further east and especially if the farm is engaged with beef stock Darlington forms the chief source of attraction, on market day. For farms not engaged in fattening beef the farmer's wife seems to exert more independent choice. West Hartlepool, Sunderland, Stockton, and Middlesbrough are used purely on personal preference and without regard to locational considerations. This applies also to farms which have recently gone out of milk although even here, with the introduction of beef stock, Darlington appears in the wife's shopping list.

In the far east of the sector West Hartlepool exerts the same influence as Durham in the west, for similar reasons, and regardless of farming system, although the beef markets still appear in the lists among beef farmers' wives.

(Fig.238) Seventeen sources of shopping in east Durham.

Local shopping	Larger towns
1. Thornley Wingate Mobile shops 4. Wheatley Hill 5. Cassop Colliery Trimdon Colliery 7. Trimdon Grange 8. Shotton Colliery Station Town Kelloe	1. Darlington 2. Durham. 3. West Hartlepool 4. Sunderland Stockton 6. Middlesbrough 7. Newcastle

SECTION SIXPRODUCTIVITY GROUPINGCHAPTER 1. Land Classification

The idea of land classification contains different meanings for different people. Taken in the context of an agricultural bias however there are two main objects, "firstly to provide a sound basis for land planning and secondly to discover the best use of land in agriculture and forestry" (45).. Classification systems must be designed for specific purposes and attempts to use them for purposes other than those for which they were intended must be viewed with misgivings (44). The literature of land classification shows that seven principles and considerations are essential for the formulation of a working procedure (42).

1. Objectivity is a prime aim which becomes increasingly difficult as a balance is sought between many dissimilar factors.
2. Subjectivity must always be present, but when placed within the framework of a methodological approach it is valid. There is a vast difference between this approach and the assertion that land classification is not an exact science but an art born of practice and experience (54). It may be that visions of developing land classification as an exact science are unduly optimistic (44). Many

physical and chemical laws are not proven with regard to agricultural economics and the advancement of the science must always to some extent depend on inference and perhaps dubious contentions. Rigid standardisation often produces the unknown constant, however, which can be applied with advantage, rather than stagnation for want of absolute knowledge.

3. As already mentioned classification must be for a specific purpose. In a recent survey it was found that the American general purpose system of classification for saline and alkali soils, widely used in the Middle East was of very little practical use in two desert fringe sites in southern Jordan (83).
4. Despite the overall specific purpose there must be levels of relationship between the classification and other systems. The soil map forms a useful basis of interchange and modification.
5. There must be some degree of generalisation in any classification. There is both truth and danger in this assertion. Obviously with changes in very small areas an average assessment must be made. The danger is largely involved with scale and boundary. An average result for a geographical unit, for example the East Durham Plateau

and more specifically the chosen sector in this context, conceals wide zonal variations. The average picture can be unrelated to each specific farm included. A parish boundary or other administrative or mathematically calculated boundary can have similar irrelevance. There must be some sensible balance bearing in mind the overall purpose of classification mentioned earlier. Different levels of generalisation are therefore conceivable. The first level must be within the intelligibility of the individual farmer. The second level must be within the scope of the planner and there is no reason why it should not be shown as a whole and in its composite parts. The detailed local study is still the basis at all levels.

6. The system should be within the range of personnel and facilities that seem likely to be available. This presents one of the greatest difficulties. Costs for soil surveys are usually considered to be high and there is a compulsive search for some simple form of survey, as evident in many writers in the recent A.L.S. report on classification of agricultural land in Britain (84). Such efforts are "almost always disappointing and usually more costly in the long run" (85). The more difficult problem is in connection with personnel and particularly

with soil scientists. Requirements such as soil physics, chemistry, plant nutrition, microbiology, mineralogy, geomorphology, soil morphology, genesis and geography are not usually found in the individual surveyor. The team approach is more than an advantage, vital. Furthermore continued employment with good opportunities for advancement are requisites too uncommon for a satisfactory programme. "One cannot expect to organise good surveys on a temporary basis or simply as a routine service to some administrative programme" (85).

7. Economic data which is transient should ideally be applied to a physical classification which is permanent. Revisions will therefore be possible at the lowest relative cost. The only physical classification likely to be suitable is one based on the grouping of soils in terms which are agriculturally significant (86).

Developing the idea of specificity it is possible to construct maps on the basis of 'actual' and 'potential' aspects of classification. This takes into account both physical and economic aspects of an area of land. A subdivision of the 'actual' classification can be made taking into account non-physical considerations by studying the individual farms as business units ((53) p.61). There is a difference of emphasis between the agricultural geographer and the agricultural economist but there is no reason why these two disciplines

should not be complementary. To some extent at one level it does not matter what system prevails as long as it produces order out of chaos by breaking down the mass of information on land into manageable units. No one system can satisfy everybody ((53)p.63) and it may be somewhat confusing if too many different systems are produced. Nevertheless should different systems be produced concurrently and be both based on and related to the same source map and statistical sample, neither cost nor complexity are prohibitive. If a sample does not work within the bounds of an established system of classification it would be easy to ignore it but this is the negation of classification and is the source of most complaint with past systems.

The one British system that stands out above all others is the tenfold classification of the Land Utilisation Survey. This has been in innumerable ways a most useful work and its benefits have outweighed its disadvantages ((42) p.107). Nevertheless its wide use must be because of the absence of an alternative source of information. Its limitations have been tolerated but have been serious. Basically the classification purports to be of physical origin, for good reasons. But in isolation this ignores vital considerations such as management quality, holding size and location. Furthermore the incorporation of farm system at various uncertain levels has led to confusion. Also the technical and

economic considerations prevalent in the 1930's have greatly influenced its construction and changes since then have been radical. There is finally a lack of precision through inadequate fieldwork, and excessive generalisation ((42) p.108). It meets very few of the requirements already listed and suffers perhaps more than anything from lack of permanence. "Perhaps the most important fault of many so-called land classifications is the failure to separate clearly the fundamental facts and the interpretation from them, on the one hand, from transitory economic, institutional and social conditions, and interpretations from them, on the other. If all are mixed in the basic classification map, interpretation in the light of new conditions is impossible. The whole job must be done again" ((85) p.117).

This criticism of land use as a basis for classification is often linked with physical considerations and the ideas of 'determinism' which are similarly denigrated (e.g. (40)). There is doubtless a reflection of physical conditions in the Land Utilisation Survey but are these the right physical considerations? In a long-settled country like Britain the use of land is to some extent adjusted to natural conditions as has been shown in the agricultural analysis of Sections Four and Five. It has been demonstrated that changing economic conditions cause variations, perhaps in the same direction but to different degrees within established zones. These zones do not show in comparison with the Land Utilisation Survey, but they are

physical zones and are statistically valid. Other factors such as farm size, tenure and management interfere but not to the destruction of the zonal concept as a basis for study. The argument that a physical or land-use classification is not the same thing as a land classification is true, but the 'weakening of the natural association between physical environment and the type of farming pattern' (53) is a misconceived inference because the full association has never been explored. There have been hints at a more valid appraisal of true natural and environmental controls. "The view has been largely adumbrated in some quarters that in the latter day dominance of "economic factors" has superceded that of natural groupings. In fact the reverse is the case. In the field of agricultural production, what is "natural" has in fact proved profitable under the recently prevailing conditions of the world market. Even a high degree of market control and the associated policies of tariffs and bounties has left the pattern of British agriculture, on the whole, a faithful reflex of physical conditions. Within the framework set by physical conditions, there offer, it is true, alternative profitable systems and policies The recognition of the general validity of natural factors in controlling land use carries with it the danger, viz. that we should treat the various minor "natural regions" of Britain as ipso facto land-use regions" (87).

The danger of minor natural regions becoming a basis of classification without proof of their validity is highly relevant. Nevertheless the soil grouping has not been adequately studied in Britain and its potential as a permanent basis of classification has never been realised.

Some systems of classification of land have taken account of soil survey. Kellogg (86) showed concern about lack of method in American classification work, and for the generalised use of systems for purposes other than those for which they were intended. He was completely satisfied with the mapping of natural features such as soils, but deprecated their use as a short cut to overall land classification. He points out that they are two very different concepts. He emphasises that soil conditions are specific, local and permanent. He adds that soil survey must be done in sufficient detail to include all factors affecting use and management of soils and that it should include the effects of different soil complexes or associations. Furthermore information must be transferable to other sites with similar soil conditions. Soil maps have become the starting point of many American State classification systems. The construction of these soil maps is very often apparently non-compatible with Kellogg's requirements but the major derived classification forms may have relevance to the British situation. Hilton (44) has summarised them under the following heads.

1. The Nebraska System (88)

The stages in the classification procedure include the following:

- (i) Delineation of (significant) soil types.
- (ii) Estimation of the proportion of various crops and pasture grown on such soil types.
- (iii) Estimation of average crop yields per acre for the soil management system most commonly used on each soil type.
- (iv) Estimation of net income rating for each soil type by using (a) long term prices and applying these to yields, (b) average total costs per acre for production (including labour, management, equipment, seed, fertiliser and overheads). The latter (b) should be subtracted from the former (a) to arrive at a net income figure.
- (v) Measurement of the acreage of each soil type on the assessment unit.
- (vi) Calculation of the weighted economic rating for the farm by (a) multiplying acreage of each soil type by its economic rating index and (b) then dividing the sum of the products by the total acreage of the farm.

- (vii) ... Estimation of the sale value of the farm (without buildings) by comparing the ratings of farms sold over as long a period as possible.
- (viii) Adjustment of the value to allow for existing farm buildings.
- (ix) Adjustment of the value to allow for the availability of utilities, roads, markets etc.
- (x) Estimation of the final valuation figure.

Difficulties of application in Britain are obvious, From stage (iv) onwards there is the problem of obtaining relevant information. Hilton rejects the system on the grounds that stage (i) is impossible to fulfil in Britain, but it will already be clear and it will be further emphasised below that there is no satisfactory short cut past this stage.

2. The Cornell System (48)

This more lengthy system depends on an examination of facts emerging from long term occupation of a given area of land. It is intended to bring out the relationship between high and low income farms with definite land performance units. It relies on the classification of observable features rather than detailed study of individual

units. The work involved is undertaken by men with local experience but is largely done indoors using maps, photographs and available statistical information. The stages can be represented as follows:

Indicators of farm income

- (i) Type of crops.
- (ii) Size and condition of buildings.
- (iii) Size of dairy herds.
- (iv) Soil and topography.
- (v) Access.

Indicators of income expectancy.

- (i) Past income.
- (ii) Building size.
- (iii) Rates of production.
- (iv) Amount and condition of capital investment.
- (v) Performance characteristics of soil, climate and topography.

A field check is made of farm class and rechecking by discussion with prominent farmers and advisers is undertaken. Classification involves six income expectancy grades with qualifications because of improvement potential or superior management. The limitations of transferring this system for use in Britain are similar to those of the Nebraska system although the Cornell system is

designed for conditions more like those prevalent in this country. Scale and generalisation are almost as impossible for local use as in the Land Utilisation Survey and there are few indications of the quality limitations in the classification system that might conceivably be improved. Neither system can be dismissed without consideration because they are sources of valuable ideas not employed in this country, but to transfer them in tot^o or even in part with major modifications, would result in as many difficulties of accumulating appropriate and reliable data as would a full scale soil survey. They would furthermore suffer from greater subjectivity and the fact that the classification has as a basis many factors as transitory as those employed in the Land Utilisation Survey.

There are significant movements towards a new concept of land classification in Britain as seen in the A.L.S. Report 8 (84). Of the fourteen papers listed most regret the absence of adequate soil maps and indicate that a better system awaits more extensive soil survey. "No really satisfactory scheme can be completed in the absence of soil maps for the whole country, and information which will enable the most permanent differences in land quality to be expressed in terms readily understandable by agriculturalists and land planner alike" (89). The papers can be divided into three categories:

- (i) These admitting inadequacies on physical counts.
- (ii) Those optimistic about the pace of soil survey and classification.
- (iii) Those attempting ingenious short cuts to land classification based on analysis of such things as buildings, land use, farm profits and crop and stock distribution. Hilton produces an attractive paper (+2) with one serious limitation covered in (.7) of the conditions of classification listed above.

The system adopted has appreciated the need for different levels of classification and land was graded under the term "overall agricultural significance", which is intended to include all the factors influencing agricultural evaluation.

1. Physical.

- (a) inherent soil fertility
- (b) drainage
- (c) warmth retention capacity.
- (d) lime and fertiliser holding characteristics.
- (e) tractability
- (f) climatic regime.

2. Physico/economic factors.

- (a) Adaptability to different use.
- (b) Location.

3. Factors affecting farming structure.
 - (a) Size of holding in relation to the system of farming.
 - (b) Quality of layout.
 - (c) Suitability of fixed and other equipment.
 - (d) Standard of husbandry and management.

4. Non-agricultural factor - the opportunity of putting the land to some more remunerative use.

All these factors except 4 have been considered in the present survey of the East Durham Plateau. There are however great differences of approach. Hilton's 'overall agricultural significance' is derived from the above factors to give a classification of 'the surface of the earth involving those things of value lying either above or below the surface including man-made features not easily removable'. Physical characteristics are rightly put as a part and not the whole of classification but after the initial statement of importance there is little reference to them. Parish statistics are the basis of yield analysis and indicate "not only physical land quality but standards of farming as well" (42); a patently dubious contention. The problem of scale and generalisation is already present and Hilton concedes that N.A.A.S. officers will have to build up their own pattern of acreage yields. The need for detailed survey is thus initially important. The move from this point to the use of

national agricultural census statistics is therefore puzzling. Furthermore in analysing grass management the official acreage figures are supplemented by Land Utilisation Survey sheets. Density of livestock related to field crops is established and plotted on a map. It has already been made clear however that apart from errors in June returns there is much confusion in different uses of grass and how the barley fodder can be taken into consideration by this means is mystifying. Hilton allows room for local survey where the above procedure does not work. In fact to be of local significance this means that the whole must be surveyed if only by sample. There is no short cut. The sector pattern, itself based on detailed survey, masks the significant zonal pattern on the East Durham Plateau.

Farming structure quality is inferred from comparison of farm size which is said to be closely related to farm income. On national averages this may be so and the relationship between corn acreage and profits is understandable, but on the East Durham Plateau, particularly in zone A size of cereal acreage does not necessarily increase with total farm acreage. Increased size is in many cases the function of increased pasture and waste land.

The detailed procedure from Hilton's paper provides a valuable plan of analysis and by substituting fieldwork sources for the

various indoor sources in the report, procedure is similar to that adopted in the East Durham Plateau. Stage maps are produced and superimposed to effect a land classification in accord with the previously indicated definition.

Summary of Procedure

1. Map non-agricultural land use at $\frac{1}{2}$ inch scale.
2. Map areas of specialised production. The $\frac{1}{2}$ inch scale is again adopted.
3. Map areas with 75 per cent and over land under grass. Mark the density of livestock (in animal units per acre and grade land from I - V according to the following scale:

Figure 239

I	Over 0.6 units per feed acre.	5 points
II	0.50-0.60 " " " "	4 points
III	0.39-0.49 " " " "	3 points
IV	0.28-0.38 " " " "	2 points
V	less than 0.28 " " " "	1 point

The factor for conversion is gained from the following table:

Figure 240

Dairy cows	1.0	Cattle 1 - 2 yrs.	0.5
Beef cows	0.8	Cattle under 1 yr,	0.25
Bulls (service)	0.8	Ewes (+ lambs)	0.25
Bulls (reared)	0.5	Two tooth ewes	0.15
Other cattle		Other sheep	0.05
Over 2 yrs.	0.75	Rams	0.2

4. Map areas with 65 per cent or more land under tillage and grade according to wheat and barley yields using the following scale:

Figure 241

	Wheat		Barley
I	Over 33 cwts.	5 points	Over 30 cwts.
II	28 - 33 cwts.	4	26 - 30 cwts.
III	22 - 27 cwts.	3	21 - 25 cwts.
IV	16 - 21 cwts.	2	16 - 20 cwts.
V	Under 16 cwts.	1	Under 16 cwts.

5. Map areas with 25 - 64.9 per cent of land under tillage and grade according to (a) density of livestock and (b) yield of wheat and barley if over 10 per cent of the acreage.
6. Using the above data prepare a composite map showing agricultural production by calculating the average of points per enterprise in each area thus:

Figure 242

Grade I	4.20 - 5.00
Grade II	3.40 - 4.19
Grade III	2.60 - 3.39
Grade IV	1.80 - 2.59
Grade V	1.00 - 1.79

The resultant map is called Agricultural Production. It is not clear what the 'each area' signifies and the problem of stable units of survey still remains as much of the above evidence is ephemeral.

7. Prepare a map of farm size as an indication of the quality of farming structure. Areas of 15 per cent and more of units of under 50 acres are downgraded. Areas with 32 per cent occupied by over 300 acre units and dairy areas with 50 per cent and more units over 150 acres are above average conditions.
8. Prepare Overall Agricultural Significance map by applying 7 to 6 and upgrading or downgrading accordingly.

There are obviously many meritable features in the above scheme which is repeated with appropriate modifications to suit county and local conditions. Hilton allows the future development of soil survey room to displace or to use some information from his system. The main criticism of the work is that it starts at the wrong end of the scale and grades and demarcates most effectively at the national level. It has already been indicated that the local level is all important and that generalisation masks and obscures important local differentiation. The national pattern in a stable situation is best built up from an amalgam of grouped local conditions with known true and stable boundaries. Planning in a western European context is not the same as in underdeveloped countries where extensive virgin areas are to be brought into production. Rather it is concerned with greatly improved efficiency on an existing groundwork and the intricate local limitation is of major importance. For example from

statistics it is possible to say that for example two thirds of the heavier clay lands of Britain need improved drainage but the amalgam of local conditions and implications is essential before the large scale planned remedial measures can be put into effect. Taken at a lower level a river drainage scheme must start at the river mouth and progress by stage upstream to be effective, and indeed safe. Hilton's classification is a rich attempt to produce something quickly with available resources. But there is no short cut. Soil survey is the key to boundary delimitation and all classifications are inadequate in its absence. It has a two fold value in that it brings the scale of survey to the proper local level and also provides permanent reference boundaries:

The principal factor in determining agricultural land class will remain for the foreseeable future the quality of the soil itself (46). The soil map is itself a kind of land classification 'but since soil surveys mainly yield information on the physical characters of soil the objects of land classification cannot be attained only through the production of soil maps "(45). The usefulness and significance of soil maps grow in proportion to the area surveyed, for when a large area is covered it becomes possible to correlate the soils of one district with another (90) Experimental work on fertilisers and other soil amendments will be based more and more on information derived from soil surveys

as the area covered increases (91), but extra work as outlined in this thesis is needed both in correlation with existing agricultural data and experimental work ((90) p.231). The historical aspect is important ((90) p.232) and the overall stability interfered with by significant zonal changes ((40) p.65). The achievement of better and more complete data will be possible if and when field experiments are located according to the soil map. The physical aspect is thus re-emphasised despite the move from an environmental approach and thus becomes a control rather than an ipso facto system of land classification. The sum of classification will then include a basic soil map, various analytical stage maps and perhaps an overall agricultural significance classification and land capability map. The development of soil evaluation based on the soil profile can be integrated harmoniously with overall agricultural significance as long as in both cases fertility is the major bias (92). "Yield is obviously the touchstone of agricultural research" (93). To this end some form of soil productivity map is essential, and the idea needs developing beyond the bare plan of stage 4 above.

CHAPTER 2. Land Productivity and Limitation

There has been similar variation and confusion in what exactly shall constitute the unit of productivity. Amongst soil scientists apart from estimation of yield there are two pedological methods of determining the productivity of soils. The first attempts to differentiate as accurately as possible between profile types which are then tested to prove the significance of productivity differences. This might be called "the verification of profile type" (94). The second method consists of determining the properties controlling or influencing productivity. It amounts to the grouping of soils by allocating physical and chemical constants. Relationships between these constants and yields are then estimated. Each factor must be evaluated and its effects on yields ascertained. There are difficulties in both systems. It is often impossible to ascertain the influence of an individual factor amongst a mass of interaction. The difference between the systems is to some extent that between the American and the European approach to soil science or at a specific level between Marbutt and Liebig (92). The difference may be in part a response to geographical background. In Europe, a long-settled and densely populated area, measuring and single value constants which could be interfered with to increase yields and counter deficiency were natural objects of study. In America or Australia more extensive farming methods with ample land resources made the search for widespread fertile soils more important than small scale

reclamation and fertilisation projects (92). Supposing this analysis of the development of the science to be true it is important to realise that in the context of productivity both systems carry inherent dangers and are not satisfactory unless brought together. On the one hand a map of genetic factors such as parent material association or even profile similarity may not have much relationship with productivity. On the other hand "it is dangerous and misleading to use arbitrary constants not determined from field experiments themselves" (95). The surveyor is not in a position to conduct the necessary plot trials for each assumed effective constant. The number of constants and their permutation would in many cases prove impossible to map. Nevertheless the two systems can be brought together in a useful manner.

It is suggested that the system of soil classification adopted in the East Durham Plateau with its agricultural and fertility bias is one such reconciliation. The genetic-horizon approach is not always adhered to in differentiating soil series. Different series have the same horizon development within their different boundaries. The chemical or physical factor inherent in each soil which dominates agricultural response is allowed full influence on boundary demarcation. In this area and perhaps in much of Western Europe, the limiting factors of soils are restricted in number and permutation. The most significant encountered were soil depth, drainage conditions, and to a lesser degree potassium and phosphate deficiency. It is

only when yields actually begin to fall in a sophisticated agricultural society that the number of unfavourable factors working in association are likely to be impossible to project onto a map. Specialised surveys are then called for. Meanwhile the genetic approach is not sacrificed because horizon development is still differentiated within the series and is a useful indication of relationships between significantly varying soils. What happens is that the traditional concepts of phase and drainage class are given more emphasis in boundary demarcation, in accordance with the desired agricultural bias. In the East Durham Plateau this biased system is in any case less forced than a grouping of all, e.g. A(B)C or A.A/(B).(B)C profiles. Spatial differentiation would be very difficult on a basis of horizons, partly because the genetic processes have reached different stages of the same trend within very small areas. Such stages have some, but not dominant, agricultural significance and are grouped as Types within the series.

Having established general principles for the type of soil survey, it is also important to rule out certain existing interpretational systems in current use. One American system widely used in the Middle East has already received comment. In pointing out the limitation based on generalisation and lack of precision the basic concept of putting land into a numerical gradation is itself called into question. A simple I - X system as in Britain is obviously deficient. Any farmer knows whether his land is bad good

or indifferent and for larger purposes such a classification says nothing about specific crop responses. The Land Capability classification of the Soil Conservation Service in the U.S. Department of Agriculture (96) is more suitable in that soil mapping units, capability units, capability subclasses and capability classes are more specific and to a large extent based on limitation. The scheme is non-applicable in detail in Britain because of greatly different geographic conditions and the problem of scale. There are basic differences between an extensive system of agriculture as in parts of the U.S.A. and an intensive-high yielding system as in Britain. In the latter case more local detail and for example the difference between a 33 cwt. and a 40 cwt. per acre yield are of vital importance. Nevertheless several principles from the Land Capability classification are transferable. The interpretations or stages from the basic soil map must be weighted differently to suit local conditions. In Europe where all land that is producing crops will probably continue to do so it is more effective to interpret the soil map in terms of limitation (things that need improvement) rather than graded quality, and in terms of specific crop response rather than an average of different crop responses. This allows for consideration of both actual and potential conditions at the same time. The stage maps are termed interpretations for that is

exactly what they are. They are of restricted use without the original soil map (85) and indeed without the full stage sequence.

At this point the beginnings of a stage programme can be assembled. In each stage the guiding principle is agricultural limitation and prediction (85) .

Stage I.

- (a) Determine the characteristics of the soils (as in Section III).
- (b) Classify the soils with a specific agricultural bias.
This involves very detailed survey noting all the factors affecting the use and management of the soils.
- (c) Establish and plot boundaries on the map and group the soils into agriculturally significant combinations or Zones. This involves the detailed agricultural analysis of Sections IV and V.
- (d) Proceed to interpretational stages.

Stage II.

Plot non-agricultural land use and woodland distribution.

Stage III.

Plot total crop distribution in order to proceed to Stage IV.

Stage IV.

Plot crop ratio by zone.

Stage V.

Graph yields to find distinctive crop breaks and plot as cwt. per acre isopleths for desired crops, in this case as examples barley and wheat. In this case the significant yields were for barley 28 cwt. per acre and for wheat 30 cwt. It was found that the 28 cwt. barley isopleth approximated very closely to the zonal divisions between A and B, and B and C. Wheat did not correspond as well and extended into both A and B although it was very similar to the boundary between B and C. Such correspondence is remarkable as the barley and wheat lines are established from rounded farm boundaries. A field by field history might well show extremely good correlation. This division is an important step although it appears to be repeated in Stage VIII. Had the significant boundary been for example 20 cwt. per acre, as it might well be in some areas, the significance of this stage would be more apparent. As here the significant physical division is close to the economic division, i.e. 30 cwt. for barley and 33 cwt. for wheat - those returns giving adequate cash to provide a surplus over expense and domestic requirements, for investment in the land - the repetition of similar isopleths may seem unnecessary. To some extent this stage V is a proof map justifying the soil grouping, although without initial soil survey the meanings of the divisions are hidden.

Stage VI. Comparison with Hilton's Overall Agricultural Significance.

Plotted farm by farm there was no clear pattern from individual farm gradings. Several difficulties arose. The grassland of zone B probably earned too high a rating in stock density analysis by virtue of an unknown variable barley fodder element. The scheme would seem to reflect physical considerations to some degree but management quality is of great, if unquantifiable, importance and leaves room for excessive misinterpretation. Averaged out by zone the scheme planned zone A in grade II land with a 3.46 rating, zone B in grade III with 3.32, a rating probably far too high, and zone C in grade II with a 3.75 rating. On a farm-size basis only two adjustments were necessary and these involved the downgrading of the small-holdings area north of Hutton Henry and the upgrading of zone D because of consistent very large holdings. In all, this procedure showed what was already obvious. The quantitative values given are for reasons mentioned dubious.

Stage VII. Plot an Agricultural Potential Map.

This involves the development of Stage V. Barley at 30 cwt. and wheat at 33 cwt. to the acre are plotted to give the division an economic meaning. The levels are not precise but common experience is that yields below these result in low investment. The other virtue of this stage results from noting the difference

from Stage V isopleths. In the case of barley there was little difference which suggests that the general purpose fodder barley has reached a fairly uniform level of response to soil conditions. The wheat area enclosed by the 33 cwt. isopleth was much reduced from the 30 cwt. area. It was however still of significant size and showed that as several farmers could achieve this level there is room for improvement in management. That the area still crosses the zonal boundary between A and B is only to be expected. The zonal line is one of physical quality and is reflected in farming system but it is not necessarily the deciding factor of which end of a yield range will be encountered. Adjustments based on zonal considerations are however needed and will be demonstrated in Stage IX.

Stage VIII. Plot an Apparent Soil Suitability map.

This involves comparison of stages V and VII with zonal considerations taken into account. To some extent the management bias of stage VII is ruled out as barley and wheat yields are projected to their widest possible boundaries, in correspondence with the significant yield isopleth if it encloses a large area of 'economic' yields. Normal cartographic interpretation is required with some additions. The wheat or barley † or = key is supplemented by similar symbols for oats and potatoes (omitted earlier to avoid confusion). Also the

zonal dominant crop is entered to allow comparison with its economic + or - status and to allow adjustment in stage IX.

Stage IX. Plot a Land Capability map.

This is produced through the interpretation of the above stages and the consideration of the following adjustment factors.

1. The yield equivalence ratio of wheat to barley 1.11.

This is used to estimate crudely the comparable economy of the two crops. The ratio is derived from costings to produce both crops which show that 50 cwt. of barley give returns almost equivalent to 55 cwt. of wheat. The ratio decreases slightly as the yield of barley decreases.

2. The crop ratio of the zones, i.e. in this case a zone A barley/all other cereals = 2.0. Zone B = 1.7. Zone C = 0.6.

3. Overlay of yield boundaries mapped earlier.

The whole stage involves some degree of zonal (and therefore agricultural system) crop desirability. The resulting map can best be explained by describing some of the reasoning behind blocks 1 - 12 and by back reference to farm studies which is essential at this stage.

Block 1.

This block occupies the scarp area of Strawberry Hill, Silent Bank and Old Cassop. The soils are mainly of the thin Cornforth Series. Yields are consistently below 28 cwt. per acre for both barley and wheat, except in exceptional conditions such as one particularly good year when 42 cwt. per acre of barley was harvested on one farm. Oats yield only about 20 cwt. to the acre and potatoes only 2 tons. Barley is the dominant crop (Stage VIII) and the most 'economic' crop on a yield equivalence basis (Stage IX). Rotation can be planned by reference to the appropriate section. Grazing is of significant importance particularly on the highest land because of subsidence chasms which prevent tractor cultivation. The soil surveyor will leave analysis and prediction here although the advisor will find much information available for future planning.

Block 1a.

Colluvial 1c (Cornforth Series) soils provide deeper and more productive plough layer. Barley yields are on average 35 cwt. per acre although wheat still barely reaches 30 cwt.

Block 2.

A further spur of Cornforth soils with a central core of Kelloe soils cover a greatly disturbed . cracked block of

land (see Stage K). Subsidence chasms are so severe that no tractors are used and the area is devoted entirely to grazing sheep, which itself can be hazardous. It seems likely that much of the block will in the near future be quarried for limestone.

Block 3.

This block represents the nearest approximation to average conditions of zone A. Kelloe soils with varying amounts of thinner Cornforth soils produce good yields of barley although other crops do not do as well. Barley is the dominant crop (Stage VIII) and the most 'economic' crop by yield equivalence.

Blocks 4 and 5.

Taken as a whole this block of land transcends zonal boundaries. In the east (zone V) Haswell and Trimdon soils are dominant. Barley is the dominant crop in both east and west but more so in the west. Both barley and wheat are 'economic' crops and oats too yield over 25 cwt. per acre. The crop equivalence ratio is therefore of importance. The area is divided into two blocks because of this and by back reference to farm studies. Block 4 despite high wheat yields is similar in other respects to block 3. Barley is dominant at a ratio of 2.0 to other

cereals. It is also the most economic crop by an equivalence ratio of 1.06. In the east block 5 is designated and wheat replaces barley as the most economic crop. This does not mean that wheat should replace barley or even that wheat will always give more economic returns. In a dry year both wheat and barley yields improve but barley even more than wheat. The dominance expressed in Stage VIII will probably always remain true but in comparison with other blocks wheat is worthy of comparatively more consideration here and would appear to be more suitable than elsewhere. The boundary line between the two blocks is placed along the zonal boundary which in fact reflects most of the conditions differentiating the blocks. In the south and east of block 5 the 28 cwt. per acre barley line is crossed and barley becomes - in response, which adds force to the suggested emphasis on wheat.

Block 6.

This block allows more expanded explanation of principles involved in the designation of block 5. There is some transition between zone A and B, although its major part is in zone B. The block is designated by the following Procedure. The significant yield lines for barley and

wheat are drawn (Stage V). These are compared with 'economic' yield areas of Stage VII and if, as is the case here, a large area of the good yields is included in the significant yield zone, these yields are projected to their absolute limits. In this case an extensive block of wheat overlaps a similar area of barley response. Taken in balance this provides an area of distinct characteristics. It will be noticed that in progressing from Stage VIII to Stage IX some generalisation of the wheat boundary has been made necessary. In this case this is acceptable because of the close correspondence of the barley 28 cwt. and 30 cwt. return line to the zonal boundary. Where wheat + extends into zone A it is 'planed off' by the zonal boundary. By Stage VIII the apparent suitability of this block is expressed as Barley (dominant 1.85 over other cereals) $\frac{-}{+}$. It is clear that as the only crop giving 'economic' surplus returns (grade I of Hilton's scheme) wheat needs emphasis in planning the block. Barley returns for fields in this block average only 24 cwt. per acre. Oats vary from 20 - 25 cwt. and potatoes 6 tons per acre. Wheat is therefore the crop entered at stage IX, although the qualifications of Stages VIII, VII and V must be borne in mind.

Block VII.

This block is largely in zone A on Kelloe and Cornforth soils

all suffering from bad topography. None of the crops give what could in any terms be called good yields. Consequently the farms involved are studied for explanation. It is found that dairying is of great importance here and grazing dominates other land use. One farm of 450 acres runs 100 dairy beasts on 240 acres of grass. Another farm recently forced out of milk production still runs a milk retail business. The low crop returns are thus balanced by other sources of income. At all stages all crops provide -ve response. Barley is both the dominant and the most economic crop.

Block VIII.

This represents a limited area of Haswell soils, much interrupted by Cornforth soils and exposed limestone. The solid line boundary represents an overlap of barley + into wheat -, the exact opposite of block VI. Barley is the dominant crop (Stage VIII) and is the most economic crop with + surplus potential. The area is small and insignificant in relation to the rest of the sector, but neighbouring land marked VIIIa is on identical soil. Together VIII and VIIIa include all this complex in this particular sector, although the feature is repeated throughout the region, for example at Haswell Moor, High Ling Close and Haswell Common. VIIIa represents obvious

bad management and there is no reason why yields should not correspond with those of block VIII. Such anomalies may still persist despite efforts to reduce management differences in earlier stages. The back reference to the soil map and farm studies should be sufficient to remove such errors.

Block IX.

This is an extensive block representing the core of zone B. Soils are mainly of the ill-drained Haswell Series. Permanent grass is usually poor in quality and all crop yields are below the +ve designation, although potatoes do average 7 tons. (8 tons = +ve limit). Barley is the dominant crop and wheat -ve/barley -ve is less than 1.11 so barley is the most economic crop.

Block X.

This is a variable block not completely analysed because of the difficulty of getting field by field information from the owners of very large farms. On available information however, all crops can yield +ve results but zone D influences are strong and emphasis on grazing is marked. Barley has lost the dominant status of other blocks and is not necessarily the most economic crop. Oats and wheat are dominant and as no equivalence ratio

was established between the two they are both indicated on the map, in order of dominance.

Block XI.

This block has Hesleden, Mainsforth, Haswell and some Kelloe soils. Barley is not dominant over all other cereals but is the major grain crop. It yields over 30 cwt. and is therefore +ve whereas wheat, oats and potatoes are -ve. Barley is therefore still the most 'economic' crop.

Block XII.

Zone D influences are again strong. Oats and wheat dominate as in block X, only here oats are more important and grazing land is more extensive than in any other part of the sector. The block is distinguished by the reversal of the two dominant cereals and the fact that here barley gives a -ve response.

Stage X. Limitation maps.

(a) Permanent limitations.

Steep slopes dangerous for tractor work are most common in zone A. One farmer lost his life on such steep land at Old Cassop in 1964. Elsewhere in the sector the steep slopes are usually of sufficient gradient to prevent any attempt at tractor work. The general effect

of the introduction of the tractor has been to lose quite a large acreage of cultivable land. Many grassed slopes show signs of old ridge and furrow ploughing and have within living memory gone out of cultivation.

Similar results are evident in areas of severe subsidence chasms on the scarp top. Here the whole of the top-land was once cultivated by horse. The introduction of the tractor and the worsening of the subsidence has again resulted in reversion to permanent pasture, or in some cases completely fenced off and unusable land.

Moving eastwards the chasms turn to depressions and hollows where the drift cover thickens. The main effect is to produce ponding and the destruction of any adequate drainage system. Drainage is dealt with more fully later but this particular aspect is mentioned here because apart from drilling down to the rock head through each individual hollow there is little that can be done to remedy the situation.

Other permanent limitations encountered include trespass, damage caused by dogs, coal tip contamination and erosion of isolated patches of land. None of these can be remedied within the bounds of reasonable expense. The inventory of

such limitations must be taken into account and can be presented either in tabular form with particular limitations indicated for individual soils or zone, or, as in this case in the form of a simple overlay which gives more precise location.

(b) Improvable limitations.

Chemical deficiencies, in this case mainly potassium, with some phosphates and lime shortage are marked where they occur with some frequency over a number of years. pH readings can be included and may result in a useful pattern. In the East Durham Plateau there was no intelligible pattern as pH seemed to reflect response to land management and the stage within the crop rotation. Deficiencies marked on the map must be considered in the light of information presented in the soils section of the text.

It will be clear that drainage is one of the major limitations to production in this region. A drainage map constructed in detail is therefore of major importance. Natural assistance to drainage in the form of subsidence chasms is shown. The extent and form of farm drains is indicated with emphasis on the effects of subsidence and the extent of deterioration. Extension of river basin

drainage quality can be plotted to show the best direction of removal of surplus water, and the blockage points so common in this region can be located. The stage X maps constructed show the extent of information that the surveyor can pass on. The overall improvement that could result from better drainage is perhaps beyond the terms of reference of the soil surveyor, but one instance will illustrate the potential in this region. A gas-pipe line sunk to varying depths between 3 and 12 feet on a north-south line throughout the region has had remarkable effects. The breaking of the clay and localised improvement of drainage has resulted in a band of superior grass and cereal growth throughout the region. The differences between land directly above the pipe and contiguous areas is very marked.

The limitation maps are therefore perhaps the most important of the sequence, in that they put requirements for improved zonal and regional farming on a comprehensive basis within the reach of several interested planning authorities. Moreover the comparatively disappointing results in terms of yield on the soils of this region have often been the subject of surprised comment. The limitation maps are sufficient to turn such surprise to wonder that the farmers in fact do so well in the face of great difficulty.

Stage XI. Zonal Summary.

At the end of Stages IX and X there is thus an indication of crop use or preference within the sector. Any crops can be compared in this way. The choice of barley and wheat to illustrate the method is because these are the two major crops of the region. Information from Stage IX can be compared with the zonal map to give an indication written on a map (Stage XI) of overall land quality in terms of crop suitability and yield capability. This is of more importance than grading as 'good' or 'bad' land as it isolates specific crops which respond differently to different soils. Grassland has not been dealt with but similar comparison of hay yields from specific seed mixtures can be incorporated in the system. Permanent grass is more difficult to accommodate. There are wide ranges of interpretation from non-improved rough land which will perhaps never be improved because of topographic difficulty through to fully maintained and fertilised but non-ploughed grassland. A zonal analysis of species and controlled measurement of animal response to standardised grazing could be undertaken but this is probably not worth the effort. A subjective interpretation of grazing quality is possible by visual estimation. In this manner it was seen that zone A provided better permanent grass than zone B and that ⁱⁿ zone C and zone D really good quality grassland obtained. Permanent grassland

is much abused in the East Durham Plateau as has already been indicated, and what is perhaps of more importance than subjective grading of quality is an indication of procedure that will improve the grass quality. This can be done partly from interpretation of farm analysis information and partly from a general land limitation map.

The Stage XI maps included in this thesis are tentative and generalised suggestions. This stage would obviously be open to a flexible usage depending on the detail required for a specific purpose, or on the level of communication (farmer, planner, council, general public) desired.

From this point the work is in the hands of the planner. Results and predictions have been offered on the basis of land use as it is at present, without soil improvement. Some indication of the type of improvement possible is indicated in stage X but this is not related to yield. The experimental plot must be adopted here to see if the response to improvement would justify the expense of improvement. Once such experiments were completed the final prediction and planning maps, stage XII, could be produced. Their production would be outside the sphere of the soil surveyor.

CHAPTER 3. Objections

The main objection to the procedure adopted must be levelled against the analysis of productivity, in terms of lack of precision. Such difficulties can be overcome if a complete field by field history and interpretation were made of the whole area to be surveyed. This was not always possible in this case because occasionally a farmer objected to spending valuable time wandering round his fields and checking his books. This was especially so where the farm holdings were very large. Experimental plots would also supply useful supplementary information. In itself this does not detract from the survey scheme because it is impossible to know which are the best sites for such plots until the survey itself is completed. Some indications will arise at various stages but final location should be withheld to avoid duplication and unwanted plots.

There is increasing subjectivity as maps are used as tools of interpretation. This is an undeniable criticism but set against the desirability/^{of} knowing location and the fact that land use planning must at some stage be set down on maps, this position becomes acceptable. Experimental work with little reference to location or distribution has obvious and more serious limitations. Responses gained at site X can never be transferred to site Y without some cartographic justification.

More difficult limitations arise partly from those already mentioned

and involve the amount of work needed in such an approach as this. The question will always arise whether a procedure can be undertaken with sufficient speed to help agriculture in the near future. This is the criticism frequently levelled at the Soil Survey of Great Britain. There are several approaches that might help to increase the speed of survey. The agricultural bias of the soil survey envisaged is to some degree alien to traditional Soil Survey techniques. Perhaps the crash-trained W.A.A.S. advisor could do the job and, as he knows his region well, do it very quickly. This need not detract from the work of the Soil Survey. Indeed the agricultural soil map could form a type of reconnaissance basis for the Soil Survey to work on.

Further assistance could easily be obtained by gaining compulsory cooperation from farmers. Certain simple standard questions returned along with June Returns, referring to every field on the particular farm would provide a very useful reconnaissance survey for the advisor-surveyor. Such methods of obtaining information have been used in Austria very successfully (97) and there the 'biodiagnostic' method contains more refinements than would be needed here. Simple information about soil structure, texture, colour and depth distribution and drainage conditions throughout the farm, with estimations of response to fertilisers, and crop yields at various stages of the rotation, would be invaluable contributions to speeding the work of the survey. This would place

the system within the means, both in time and money, of the N.A.A.S. The scheme of soil survey and agricultural productivity assessment indicated is suggested as both possible and profitable, for accumulation and use of information likely to assist the development and planning of the agricultural industry of Britain.

SUMMARY

The thesis examines the possible contributions of Soil Survey to Land Use Planning in a region where agriculture is in competition for space with industry and industrial settlement.

The region is defined and described from the point of view of physical factors affecting agriculture. The methodology behind soil survey is discussed and rigid standards useful for an agriculturally biased survey are defined. Analytical methods are briefly described.

Soils encountered in the region are described in their spatial distribution and classified into ten Soil Series with related Types and Varieties. A brief discussion of higher grouping into Soil Associations and World Groups is followed by a more detailed description of profiles at Soil Series level, with special reference to effects on agriculture.

In order to understand the present land use pattern and current agricultural systems, the agricultural history of the region in relation to national trends is traced up to 1960. The soils mapped and described earlier are grouped into agriculturally significant combinations in a sector three miles wide and nine miles long across the region. Three such combinations, or zones, are related to present (1964) farming and correlation is found to be probably significant.

General land classification is discussed and various systems compared. The thesis that cartographic presentation of soil groupings in relation to productivity is to be preferred is tested by producing a series of overlay stage maps. These describe yield productivity of major crops and project maximum yields to their widest spatial extent by back reference to soils, climate, management levels and national economic trends.

The Soil map is thought to be the best basis on which to build an agricultural land classification and from which to communicate information in a readily available form at different levels to farmer and planner. Cojections in terms of time and cost required to adopt such a system of gathering information are countered by the suggestion that N.A.A.S. could well undertake the ~~task~~ given assistance from local farmers.

BIBLIOGRAPHY 1. Authors in order of appearance in text.

- (1) Gibbons, F.R. (1961)
- (2) Vink, A.P. (1960)
- (3) Stamp, L.D. (1949)
- (3a) Lord Radner
- (4) Jones, T.A. (1959)
- (5) Cline, M.G. (1949)
Donahue, R.L. (1958)
Joffe, J.S. (1949)
U.S.D.A. Soil Survey Staff (1960)
- (6) Kubiena, W.L. (1953)
(1958)
Leeper, G.W. (1960)
- (7) Muir, J.W. (1962)
- (8) Vilenskii, D.G. (1960)
- (9) Vink, A.P.A. (1963)
- (10) Maling. (1956)
- (11) Frisby, T. (1959)
- (12) Willimott, S.G. (1965)
- (13) Government White Paper.
- (14) Davies, W.M. (1963)
- (15) Simpson, R. (1964)
- (16) Beaumont, P.
- (17) Smith, D.B. (1958)
- (18) Crampton, C.B. (1959)
- (19) N.E. Development Association (1950)
- (20) Heslop-Harrison, J.W. and Richardson, J.A. (1953)
- (21) Clarke, G.R. (1958)
- (22) U.S.D.A. (1951)
- (23) Ragg, J.M. (1960)
- (24) Duchaufour, Ph. (1963)
- (25) Ball, D.F. (1960)
- (26) Glentworth, R. (1954)

- (27) Bouyocos, G.J. (1927)
- (28) Bouyocos, G.J. (1928), (1928) and (1937)
- (29) Day. (1952)
- (30) Schollenberger. (1927)
- (31) Jackson, M.L. (1958)
- (32) Puri and Uppal (1939)
- (33) Basinski, J.J. (1959)
- (34) Aubert and Duchaufour, Ph. (1956)
- (35) Avery, B.V. (1956)
- (36) Webster, R. and Beckett, P.H.T. (1964)
- (37) Bailey, J. (1810)
- (38) Bell, J.G. (1856)
- (39) Pawson, H.C. (1961)
- (40) Coppock, J.T. (1962)
- (41) Ministry of Agriculture, Fisheries and Food (1960)
- (42) Hilton, N. (1962a)
- (43) Coppock, J.T. (1955)
(1960)
- (44) Hilton, N. (1962b)
- (45) Mackney, D. (1962)
- (46) Ede, A.N. (1962)
- (47) Osmond, D.A. (1962)
- (48) Conklin, H.E. and Berg, S.O. (1948)
- (49) Butt-Evans, J. (1962)
- (50) Reid, I.G. (1962)
- (51) Hogg, N.H. (1962)
- (52) Gregory, S. (1963)
- (53) Cracknell, B.T. (1962)
- (54) Langdon, A.J. (1962)
- (55) Pizer, N.H. (1962)
- (56) Robinson, D.H. (1962)
- (57) Skelton, S.T. (1961)
- (58) Nearpass, D.C. and Drossdoff, M. (1947)

- (59) Jacoby, R. (1961)
- (60) Graham, E.R., Powell, S., and Carter, M. (1956)
- (61) McColloch, R.C., Bingham, F.T., Aldrich, D.C. (1957)
- (62) Salmon, R.C. and Arnold, P.W. (1963)
- (63) MacIntyre, W.H. and Young, J.B. (1923)
- (64) Eriksson, E. (1952)
- (65) Salmon, R.C. (1963)
- (66) Warren, R.G. and Johnston, A.E. (1963)
- (67) Cooke, G.W. (1963)
- (68) Widdowson, F.V., Penny, A., and Williams, R.J.B. (1958)
- (69) Cooke, G.J. (1954)
- (70) Widdowson, F.V., Penny, A. and Williams, R.J.B. (1958)
- (71) Rothamstead Report for 1959.
- (72) Rothamstead Report for 1963
- (73) Widdowson, F.V., Penny, A. and Williams, R.J.B. (1961)
- (74) Hemingway, R.G. (1963)
- (75) Widdowson, F.V., Penny, A. and Williams, R.J.B. (1963)
- (76) Widdowson, F.V., Penny, A. and Cooke, G.W. (1963)
- (77) Cooke, G.W. (1964)
- (78) Jones, H.T. (1950)
- (79) Agriculture (1964)
- (80) Agriculture (1964)
- (81) Boyd, D.A. (1964)
- (82) Cooke, G.W. (1964)
- (83) Willimott, S.G., Birch, B.P., Atkinson, K. and McKee, R.F. (1964)
Willimott, S.G., Birch, B.P., McKee, R.F. and Atkinson, K. (1965)
- (84) Ministry of Agriculture, Fisheries and Food (1962)
- (85) Kellogg, C.E. (1952)
- (86) Kellogg, C.E. (1951)
- (87) Wooldridge, S.E. (1945)
- (88) Ottoson, W.H., Aandahl, A.R. and Kristjanson, L.B. (1954)

- (89) Ministry of Agriculture (1962)
- (90) Robinson, G.W. (1937)
- (91) Muir, A. (1952)
- (92) Visser, W.C. (1950)
- (93) Van der Paauw, F. (1950)
- (94) Visser, W.C. (1950)
- (95) Crowther, E.M. (1952)
- (96) U.S.D.A. (1961)
- (97) Kükler, A. (1952)

BIBLIOGRAPHY 2. Author index alphabetical order.

- (79) Agriculture (1964). "In Brief". Soil Magnesium. Vol.71. No.7. p.343. July.
- (80) Agriculture (1964). "Alternatives to Magnesian Lime. Vol.71. No.8. p.354. Aug.
- (34) Aubert and Luchaufour, Ph. (1956). Projet de classification des sols. VIe Cong.Int. Sc.Sol. Paris. E. 597-604.
- (35) Avery, B.W. (1956). A classification of British Soils. VIe Cong.Int.Sc.Sol. Paris. E. 279-285.
- (37) Bailey, J. (1810). A General View of the Agriculture of Durham. Newcastle.
- (25) Ball, D.F. (1960). The Soils and land-use of the district around Rhyll and Benbigh. (Sheets 95 and 107). A.R.C. Mem. Soil Survey of Great Britain. England and Wales. H.M.S.O.
- (33) Basinski, J.J. (1959) The Russian approach to Soil Classification and its recent Development. J.Soil Sc. Vol.10 No.1. pp.14-26.
- (16) Beaumont, P. Private communication.
- (38) Bell, J.G. (1856) A Report on the Agriculture of County Durham. J.R.Ag.Soc. Vol.17.
- (27) Bouyocos, G.J. (1927). The Hydrometer as a new method for the mechanical analysis of soils. Soil Science. 23. pp.343-53.
- (28) Bouyocos, G.J. (1928). The Hydrometer Method for studying Soils. S.Sc.25.364.
- (1928). The Hydrometer Method for making a very detailed Mechanical Analysis of Soils. S.Sc.26. 235-38.
- (1937). A sensitive Hydrometer Method for determining small Amounts of Clay or Colloids in Soils. S.Sc.44. 245-46.
- (81) Boyd, D.A. (1964). Discussion at Meeting of Fert. Soc. in London 23rd Jan. 1964.
- (49) Butt-Evans, J. (1962). The Influence of Land Quality on Farming System. A.L.S.Tech. Rep. 8. Paper 6 p.48. Min.Ag.Fish.Food.

- (21) Clarke, G.R. (1957) The Study of Soil in the Field. 4th ed. Oxford.
- (5) Cline, M.G. (1949) Basic Principles of Soil Classification. S.Sc.67. 81-91.
- (48) Conklin, H.E. and Berg, S.O. (1948) A preliminary Report on Development in Land Classification Methods. Ming. Paper 688. Cornell Univ. Ithaca. N.Yk.
- (40) Coppock, J.T. (1962) Land Use and Land Classification, A.L.S. Tech. Rep. 6 Paper 10. p.66.
- (43) Coppock, J.T. (1955) The Relationship of Farm and Parish Boundaries. Geographical studies II. pp. 12-26.
(1960) The Parish as a Geographical/Statistical Unit. Tijdschrift voor Economische en Sociale Geografie. 51. 317-326.
- (67) Cooke, G.W. (1965) General principles Governing the Potassium Manuring of Grassland. Potassium in relation to grassland Production. Proc. 1st. Int. Conf. Potash Instit. Jexford. p.79.
- (69) Cooke, G.W. (1954) Nitrogen and Phosphorus Fertilisers in North Western Europe. Trans (proc No.27) Fert. Soc. London.
- (77) Cooke, G.W. (1964) Nitrogen Fertilisers. Fert. Soc. Proc. 80 p.70.
- (82) Cooke, G.W. (1964) Reply. Discussion Fert. Soc. London. 23rd Jan. 1964.
- (53) Cracknell, B.E. (1962) The Classification of Agricultural Buildings. A.L.S.Tech. Rep.8. Paper 9. p.61. Min.Ag.
- (18) Crampton, C.B. (1959) Analysis of Heavy Minerals in certain drift Soils of Yorkshire. Proc. Yorks. Geol. Soc. Vol.32 pp.69-85.
- (95) Crowther, E.M. (1952) Field Experiments as the Basis for Planning Fertilizer Practice. U.N.S.C.C.U.R.Proc. Land Resources. p.221.

- (14) Davies, W.M. (1963) Bringing back the Acres : Sand and Gravel. Agriculture Vol.70. No.5. pp.223-227.
- (5) Donahue, R.L. (1958) Soils. Prentice Hall. N.J.
- (24) Duchafour, Ph. (1963) Soil Classification. A Comparison of the American and French Systems. J.S.Sc. Vol.14 No.1.
- (46) Ede, A.N. (1962) Drainage as a Factor in Agricultural Land Classification. A.L.S.Tech. Rep.8. Paper 5. p.41. .
- (64) Eriksson, E. (1952) Tellus. 4.215.
- (11) Frisby, E. (1959)
- (1) Gibbons, F.R. (1961) Some Misconceptions about what Soil Survey can do. J.Soil Sc. Vol.12 No.1.
- (26) Glentworth, R. (1954) The Soils of the Country round Banff, Huntly and Turriff. Dep. Agric. Scot. Mem. Soil Survey of G.B. Scot. H.M.S.O.
- (13) Government White Paper (1964). The North East. Cmnd.2206.
- (60) Graham, E.R., Powell, S. and Carter, M. (1956) Missouri Agric. Expt. Res. Bul. No. 607.
- (52) Gregory, S. (1963) Statistical Methods and the Geographer. Longmans. London.
- (74) Hemingway, R.G. (1963) J.Sc.Fd.Agric.14. pp.188-195.
- (20) Heslop-Harrison, J.W. and Richardson, J.A. (1953) The Magnesian Limestone Area of Durham and its Vegetation. Trans. Northern Nat. Un. Vol.II.
- (42) Hilton, N. (1962) A new Approach to Agricultural Land Classification for Planning Purposes. A.L.S.Tech. Rep.8. Paper 14 p.109. Min .Ag.
- (44) Hilton, N. (1962) A Review of Agricultural Land Classification Systems in the United States and their possible value in planning the Use of Land in Britain. A.L.S.Tech.Rep.8. Paper 12 p.93.
- (59) Jacoby, R. (1961) Plants and Soil. 15,74.
- (31) Jackson, M.L. (1958) Soil Chemical Analysis. Constable. London.

- (5) Joffe, J.S. (1949) Pedology, Pedological Publication.
N. Brunswick. N. Jersey.
- (4) Jones, T.A. (1959) Soil Classification. A destructive
Criticism. J. Soil Sc. Vol. 10. No.2.
- (78) Jones, H.T. (1950) Magnesian Limestone. Agric.LVI No. 10
Jan. See also (79) & (80).
- (85) Kellogg, C.E. (1952) Soil Survey in Relation to Soil
Conservation. U.N.S.C.C.U.R. Proc. Land Resources p.119.
- (86) Kellogg, C.E. (1951) Soil and Land Classification. J. Farm
Economics. Vol.33.
- (97) Köhler, R. (1952) Soil Survey in Relation to Soil Conservation.
U.N.S.C.C.U.R. Proc. Land Resources. p.130.
- (6) Kubiena, W.L. (1953). The Soils of Europe. Murby.
(1958) The Classification of Soils. J. Soil
Sc. Vol.9. No.1.
- (54) Langdon, A.J. (1962) Buildings and fixed Equipment in
Agricultural Land Classification. A.L.S. Tech. Rep. 8.
Paper 8 p.59.
- (6) Leeper, G.W. (1960) The Classification of Soils. J. Soil. Sc.
Vol.7 No.1.
- (63) MacIntyre, W.H. and Young, J.B. (1923) Soil Sc. 15. p.215.
- (45) MacKney, D. (1962) Soil as a Factor in Agricultural Land
Classification. A.L.S.Tech. Rep.8 Paper 1. p.4.
- (10) Maling (1956) Geomorphology of the Wear Valley. Unpublished
Ph.D. Thesis Durham.
- (61) McCulloch, R. C., Bingham, E.T. and Aldrich, D.C. (1957) Proc.
Soil Sc. Soc. Amer. 21. p.85.
- (41) Ministry of Agriculture Fisheries and Food (1960) Farm Income
in England and Wales 1958. H.M.S.O.
- (84) Ministry of Agriculture Fisheries and Food (1962) Agricultural
Land Classification in Great Britain, A.L.S.Tech. Rep.8.
- (89) Ministry of Agriculture Fisheries and Food (1962) 'Introduction'
A.L.S. Tech. Rep.8.



- (7) Muir, J.W. (1962) The general Principles of Classification with reference to Soils. J.Soil Sc. Vol.13 No.1.
- (91) Muir, J.W. (1952) Soil Survey in Relation to Soil Productivity. U.N.S.C.C.U.R. Proc. Land Resources p.125.
- (58) Nearpass, D.C. and Drossdoff, M. (1947) Soil Sc.63p.69.
- (19) North East Development Association (1950) A Physical Land Classification of Northumberland and Durham and part of the North Riding of Yorkshire. Newcastle.
- (+7) Osmond, D.A. (1962) The Work of the Soil Survey and its possible Contribution to an Agricultural Land Classification System for Britain. A.L.S. Tech. Rep. 3. Paper 13 p.103.
- (88) Ottoson, H.A., Aandahl, A.R. and Kristjanson, L.B. (1954) Valuation of Farm Land for Tax Assessment. Bul.427 Neb. Agric.Exp.St.
- (39) Pawson, H.C. (1961) A Survey of the Agriculture of Northumberland. R.Ag.Soc.County Agric. Survey No.3.
- (55) Pizer, N.H. (1962) The practical application of Knowledge of the soils. A.L.S.Tech. Rep.8 Paper 2. p.17.
- (32) Puri and Uppal (1939) Soil Sc. 47 : 245.
- (3) Radnor Lord. Quoted by Stamp, L.D.
- (23) Ragg, J.M. (1960) The Soils of the Country round Kelso and Lauder (Sheets 25 and 26) Dep. Ag. for Scot. Mem. S. Surv. G.B.Scot. H.M.S.O.
- (50) Reid, I.G. (1962) Land Quality as a Factor in Farm Profits. A.L.S.Tech. Rep.8 Paper 7. p.54. Min. Ag.
- (56) Robinson, D.H. (Ed.) (1962) Fream's Elements of Agriculture. 14th edt. London.
- (90) Robinson, G.W. (1937) The Soil Survey and Advisory Work. Agric. Progress. Vol.XIV. pt.III, p.229.
- (71) Rothamstead Report for 1959 pp.45-46.
- (72) Rothamstead Report for 1963 pp.58.
- (62) Salmon, R.C. and Arnold, P.W. (1963) The Uptake of Magnesium under exhaustive Cropping. J. Agric. Sc. 61. 424.

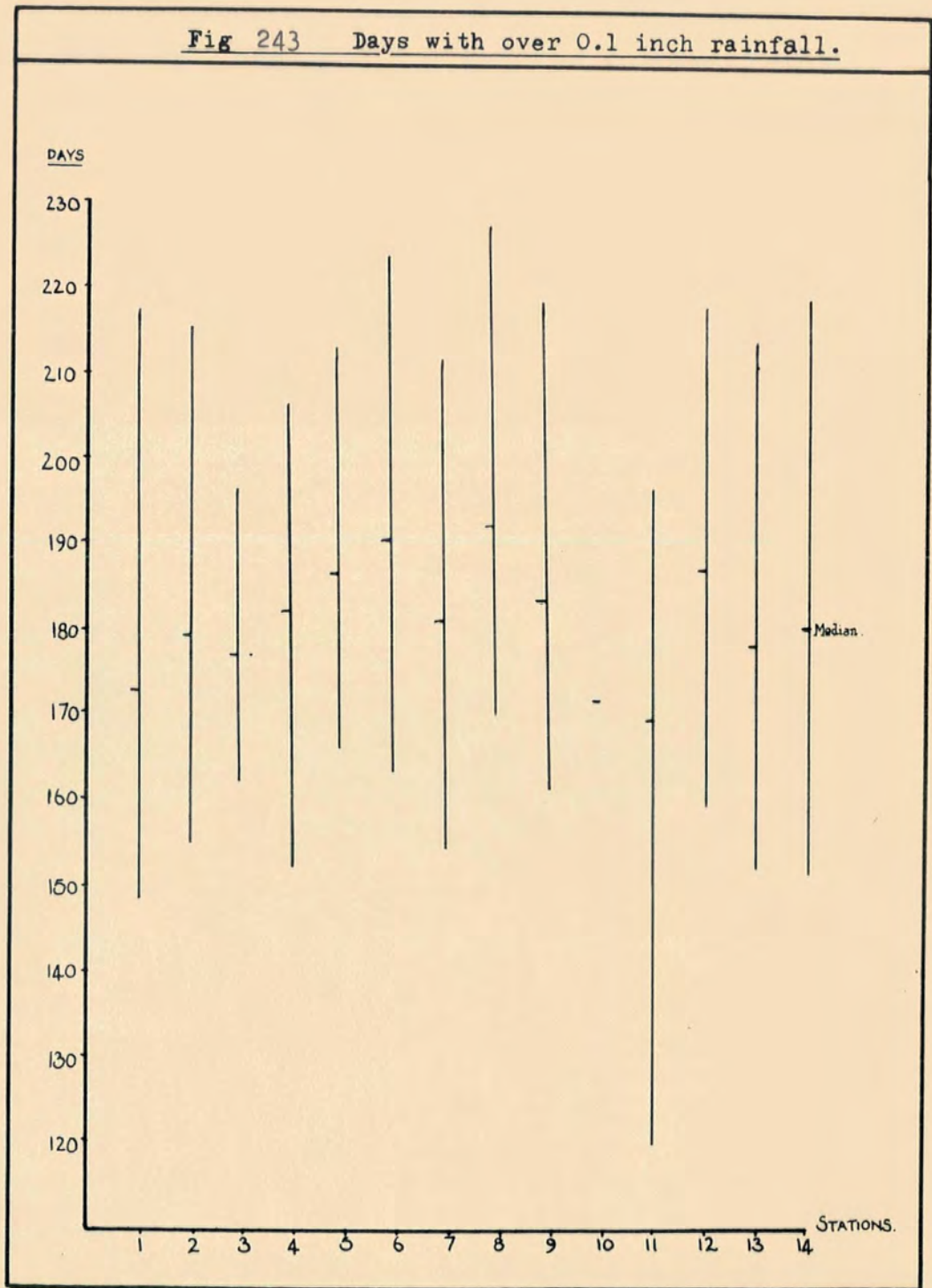
- (65) Salmon, R.C. (1963) Magnesium Relationships in Soils and Plants. J. Sc. of Food and Ag. 9 p.607.
- (30) Schollenberger (1927) Soil Sc. 24.65.
- (15) Simpson, R. (1964) The Agricultural Geography of the Hartlepool Region. M. Sc. thesis Durham.
- (57) Skelton, S.T. (1961) The Trade in Seeds. Agriculture. Oct. 61.
- (17) Smith, D.B. (1958) Observations on the Magnesian Limestone Reefs of North East Durham. Bul. Geol. Surv. of G.B. 15 (v) 71-84.
- (5) U.S.D.A. (1960) Soil Classification a Comprehensive System Seventh Approx.
- (3) Stamp, L.D. (1949) The Planning of Land Use. Agriculture. Vol. LVI. No.9.
- (22) U.S.D.A. (1951) Soil Survey Manual.
- (96) U.S.D.A. (1961) Land Capability Classification. Soils Conserv. Serv. Agric. Handbook 210.
- (93) Van der Paauw, F. (1950) Plant analysis as a means of Evaluation of Chemical Soil Tests. 4th Int. Cong. S.Sc. Vol.1. Paper 56. p.232.
- (8) Vilenski, D.G. (1960) Soil Science. Jerusalem. Israel Prog. Sc. Trans.
- (2) Vink, A.P.A. (1960) Quantitative Aspects of Land Classification. Trans. VIIth Int. Cong. S.Sc. 4. 371-8.
- (9) Vink, A.P.A. (1963) Soil Survey as Related to Agricultural Productivity. J. Soil Sc. Vol. 14 No.1.
- (92) Visser, W.C. (1950) The trend of the Development of Land Evaluation in the Future. IVth Int. Cong. S.Sc. Vol.I Sect.VIII Paper 86.335.
- (94) Visser, W.C. (1950) The quantitative Basis of the Evaluation of Soil Producibility. IVth. Int. Cong. S.Sc. Vol.1. Paper 98 p.373.

- (66) Warren, R.G. and Johnston, A.E. (1963) Proc. Fert. Soc. 72. pp.19-23.
- (36) Webster, R. and Beckett, P.H.T. (1964) A Study of the Agronomic Value of Soil Maps interpreted from Air Photographs. VIIIth Int. Cong. Soil Sc. Abstracts of Papers. Sect. V. Paper 148. p.239.
- (68) Widdowson, F.V., Penny, A. and Williams, R.J.B. Experiments testing P. and K Fertilisers in Lucerne (1952-57). Experimental Husbandry No.10. p.40.
- (70) Widdowson, F.V. Penny, A. and Williams, R.J.B. An Experiment comparing Responses to Nitrogen in four Grass Species. Exp. Husb. No.9. p.34.
- (73) Widdowson, F.V., Penny, A. and Williams, R.J.B. (1961) Rothamstead Expt. St. Rep. for 1961 pp.49-50.
- (75) Widdowson, F.V., Penny, A. and Williams, R.J.B. (1963) Experiments comparing yield, and residual effects on winter wheat, of 1-year clover, rey-grass and clover-rye-grass-leys. J. Agric. Sc. 61 p.404.
- (76) Widdowson, F.V., Penny, A. and Cooke, G.W. (1963) J. Agric. Sc. 60. p.317.
- (12) Willimott, S.G. (1963) The Culture and Application of Liquorice. World Crops. London.
- (83) Willimott, S.G., Birch, B.P., Atkinson, K and McKee, R.F. (1964) The Qatrana and Sultani Dams Projects. Interim Report Amman. Willimott, S.G., Birch, B.P.? McKee, R.F. and Atkinson, K. The Qatrana and Sultani Dams Projects in Jordan. World Crops. June 1965.
- (87) Wooldridge, S.E. (1945) Yorkshire (North Riding) Land of Britain. Vol4 397. Geographical Publications Ltd. for Land. Util. Surv.

APPENDIX I

Rainfall Data 1943 - 1945 and
1948 - 1957

Fig 243 Days with over 0.1 inch rainfall.



Rainfall 1943

<u>Station</u>	<u>Average</u>	<u>1943</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
1. W. Hartlepool Clock	24.7				35 ft.
2. " " Waterworks	24.7	21.91	204	107	35 ft.
3. " Secondary School (24.1)	(24.1)				62 ft.
4. Hurworth Burn Resvr.	26.5	21.05	176	114	357 ft.
5. Hart Reservoir	(21.5)	21.12	167	106	172 ft.
6. Shotton Pumping Station	29.4	26.38	175	118	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	26.66	173	125	521 ft.
8. Seaham Dalton Pumping Station	27.0	25.18	191	118	354 ft.
9. Ryhope	25.4	23.58	178	118	228 ft.
10. Washington Glebe Modern School	(24.9)	23.92		108	160 ft.
11. Sunderland Thornholme.	25.6	24.52	155	115	130 ft.
12. Cleadon Pumping Station	24.4	22.58	169	104	216 ft.
13. South Shields Bents Park	24.2				36 ft.
14. South Shields S. Pier Works	(23.6)	22.22	179	109	17 ft.

Averages in brackets are taken over a maximum of twelve years.

Rainfall 1944

<u>Station</u>	<u>Average</u>	<u>1944</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool	24.7				
1. Clock	24.7				35 ft.
2. Waterworks	24.7	26.39	233	123	30 ft.
3. Secondary school	(24.1)				
4. Hurworth Burn Reservoir	26.5	24.51	199	125	357 ft.
5. Hart Reservoir	(21.5)	25.03	192	118	172 ft.
6. Shotton Pumping Station	29.4	27.84	204	133	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	27.84	193	141	521 ft.
8. Seaham. Dalton Pumping Station	27.0	27.48	224	143	354 ft.
9. Ryhope	25.4	26.38	199	140	228 ft.
10. Washington Glebe Modern School	(24.9)	26.49	170	125	160 ft.
11. Sunderland Thornholme	25.6	27.94	189	136	130 ft.
12. Cleadon Pumping Station	24.4	22.58	167	104	216 ft.
13. South Shields Bents Park	24.2				36 ft.
14. South Shields S. Pier Sorks	(23.6)	22.22	179	109	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1945

<u>Station</u>	<u>Average</u>	<u>1945</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool.					35 ft.
1. Clock	24.7				
2. Waterworks	24.7.	23.63	211	118	30 ft.
3. Secondary school	(24.1)				
4. Hurworth Burn Reservoir	26.5	23.65	183	114	357 ft.
5. Hart Reservoir	(21.5)	22.51	181	119	172 ft.
6. Shotton Pumping Station	29.4	25.98	192	125	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	24.71	186	123	521 ft.
8. Seaham. Dalton Pumping Station	27.0	24.21	201	122	354 ft.
9. Ryhope	25.4	24.44	191	119	228 ft.
10. Washington Glebe Modern School	(24.9)	24.61			160 ft.
11. Sunderland Thornholme	26.6	26.38	182	123	130 ft.
12. Cleadon Pumping Station	24.4	22.59	194	132	216 ft.
13. South Shields Bents Park	24.2				36 ft.
14. South Shields S. Pier Works	(23.6)	23.78	185	117	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1948

<u>Station</u>	<u>Average</u>	<u>1948</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					35 ft.
Clock	24.7				
Waterworks	24.7	24.33	180	108	30 ft.
Secondary School	(24.1)				
Hurworth Burn Reservoir	26.5	28.37	183	123	357 ft.
Hart Reservoir	(21.5)	23.96	187	112	172 ft.
Shotton Pumping Station	29.4	31.69	201	123	402 ft.
Easington Mill Hill Reservoir	(26.2)	28.74	179	115	521 ft.
Seaham. Dalton Pumping Station	27.0	30.28	190	120	354 ft.
Ryhope	25.4	28.48	175	119	228 ft.
Washington Glebe Modern School	(24.9)	26.83			160 ft.
Sunderland Thornholme	26.6	28.30	150	106	130 ft.
Cleadox Pumping Station	24.4	27.98	206	119	216 ft.
South Shields Bents Park	24.2	31.61	198	137	36 ft.
South Shields S. Pier Works	(23.6)	28.47	188	120	17 ft.

Averages in brackets are taken over a maximum of twelve years.

Rainfall 1949

<u>Station</u>	<u>Average</u>	<u>1949</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	15.95	151	98	35 ft.
2. Waterworks	24.7	15.28	157	93	30 ft.
3. Secondary School	(24.1)				
4. Hurworth Burn Reservoir	26.5	17.49	162	99	357 ft.
5. Hart Reservoir	(21.5)	14.67	169	90	172 ft.
6. Shotton Pumping Station	29.4	19.91	175	106	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	18.36	154	91	521 ft.
8. Seaham. Dalton Pumping Station	27.0	17.8	177	102	354 ft.
9. Ryhope	25.4	16.33	160	92	228 ft.
10. Washington Glebe Modern School	(24.9)	18.54			160 ft.
11. Sunderland Thornholme	26.6	16.57	124	98	130 ft.
12. Cleadon Pumping Station	24.4	15.50	161	93	216 ft.
13. South Shields Bents Park	24.2	16.91	165	107	36 ft.
14. South Shields S. Pier Works	(23.6)	15.59	169	94	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1950

<u>Station</u>	<u>Average</u>	<u>1950</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	31.32	217	150	35 ft.
2. Waterworks	24.7	30.09	216	145	30 ft.
3. Secondary School	(24.1)				
4. Hurworth Burn Reservoir	26.5	30.53	204	151	357 ft.
5. Hart Reservoir	(21.5)	27.38	211	138	172 ft.
6. Shotton Pumping Station	29.4	35.06	221	155	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	34.36	203	151	521 ft.
8. Seaham. Dalton Pumping Station	27.0	34.13	223	159	354 ft.
9. Ryhope	25.4	32.9	216	155	228 ft.
10. Washington Glebe Modern School	(24.9)	32.09			160 ft.
11. Sunderland Thornholme	26.6	33.45	194	152	130 ft.
12. Cleadon pumping Station	24.4	30.82	210	144	216 ft.
13. South Shields Bents Park	24.2	31.00	211	159	36 ft.
14. South Shields S. Pier Works	(23.6)	30.43	215	146	17 ft.

Averages in brackets are taken from a maximum period of twelve years.

Rainfall 1951

<u>Station</u>	<u>Average</u>	<u>1951</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	29.42	180	119	35 ft.
2. Waterworks	24.7	38.34	178	120	30 ft.
3. Secondary school	(24.1)				
4. Hurworth Burn Reservoir	26.5	33.57	187	139	357 ft.
5. Hart Reservoir	(21.5)	27.63	183	121	172 ft.
6. Shotton Pumping Station	29.4	30.77	190	139	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	34.56	194	138	521 ft.
8. Seaham. Dalton Pumping Station	27.0	31.27	189	131	354 ft.
9. Ryhope	25.4	30.26	177	132	228 ft.
10. Washington Glebe Modern School	(24.9)	31.63			160 ft.
11. Sunderland Thornholme	26.6	28.57	168	127	130 ft.
12. Cleadon Pumping Station	24.4	28.4	189	121	216 ft.
13. South Shields Bents Park	24.2	28.94	175	125	36 ft.
14. South Shields S. Pier Works	(23.6)	28.80	189	126	17 ft.

Averages in brackets are taken from a maximum period of twelve years.

Rainfall 1952.

<u>Station</u>	<u>Average</u>	<u>1952</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	22.14	189	118	35 ft.
2. Waterworks	24.7	22.91	191	121	30 ft.
3. Secondary School	(24.1)				
4. Hurworth Burn Reservoir	26.5	25.33	197	136	375 ft.
5. Hart Reservoir	(21.5)	21.21	190	120	172 ft.
6. Shotton Pumping Station	29.4	26.32	295	135	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	26.71	205	135	521 ft.
8. Seaham: Dalton Pumping Station	27.0	24.37	206	134	345 ft.
9. Ryhope	25.4	23.15	196	126	228 ft.
0. Washington Glebe Modern School	(24.9)	22.43			160 ft.
1. Sunderland Thornholme	26.6	22.76	195	135	130 ft.
2. Cleadon Pumping Station	24.4	21.85	203	119	216 ft.
3. South Shields Bents Park	24.2	24.49	193	129	36 ft.
4. South Shields S. Pier Works	(23.6)	24.21	204	126	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1953

<u>Station</u>	<u>Average</u>	<u>1953</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	17.17	149	103	35 ft.
2. Waterworks	24.7	17.29	164	112	30 ft.
3. Secondary School	(24.1)				
4. Hurworth Burn Reservoir	26.5	20.76	154	111	375 ft.
5. Hart Reservoir	(21.5)	16.10	172	107	172 ft.
6. Shotton Pumping Station	29.4	22.85	179	116	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	22.81	167	110	521 ft.
8. Seaham. Dalton Pumping Station	27.0	21.67	173	109	345 ft.
9. Ryhope	25.4	20.87	187	116	228 ft.
10. Washington Glebe Modern School	(24.9)				160 ft.
11. Sunderland Thornholme	26.6	19.71	123	106	130 ft.
12. Cleadon Pumping Station	24.4	19.17	173	103	216 ft.
13. South Shields Bents Park	24.2	19.51	150	100	36 ft.
14. South Shields S. Pier Works	(23.6)	19.89	150	102	17 ft.

Averages in brackets are taken from a maximum period of twelve years.

Rainfall 1954

<u>Station</u>	<u>Average</u>	<u>1954</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartleppol					
1. Clock	24.7	26.22	198	131	35 ft.
2. Waterworks	24.7	23.66	194	128	30 ft.
3. Secondary School	(24.1)	27.65	191	150	
4. Hurworth Burn Reservoir	26.5	27.27	203	145	375 ft.
5. Hart Reservoir	(21.5)	23.12	207	124	172 ft.
6. Shotton Pumping Station	29.4	31.78	215	158	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	32.63	209	153	521 ft.
8. Seaham. Dalton Pumping Station	27.0	28.63	210	137	345 ft.
9. Ryhope	25.4	27.76	206	143	228 ft.
10. Washington Glebe Modern School	(24.9)				160 ft.
11. Sunderland Thornholme	25.6	27.04	170	149	130 ft.
12. Cleadon Pumping Station	24.4	29.17	214	144	216 ft.
13. South Shields Bents Park	24.2	29.28	200	140	36 ft.
14. South Shields S. Pier Works	(23.6)	28.84	204	143	17 ft.

Averages in brackets are taken from a maximum period of twelve years.

Rainfall 1955.

<u>Station</u>	<u>Average</u>	<u>1955</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	18.10	160	107	35 ft.
2. Waterworks	24.7	18.42	168	107	30 ft.
3. Secondary School	(24.1)	19.38	161	111	
4. Hurworth Burn Reservoir	26.5	19.38	153	106	375 ft.
5. Hart Reservoir	(21.5)	18.01	171	109	172 ft.
6. Shotton Pumping Station	29.4	20.84	163	106	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	19.94	169	104	521 ft.
8. Seaham. Dalton Pumping Station	27.0	19.78	169	110	345 ft.
9. Ryhope	25.4	18.64	169	104	228 ft.
10. Washington Glebe Modern School	(24.9)	21.17			160 ft.
11. Sunderland Thornholme	25.6	18.61		111	130 ft.
12. Cleadon Pumping Station	24.4				216 ft.
13. South Shields Bents Park	24.2	20.24	151	101	36 ft.
14. South Shields S. Pier Works	(23.6)	18.76	156	104	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1956

<u>Station</u>	<u>Average</u>	<u>1956</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	24.57	172	115	35 ft.
2. Waterworks	24.7	25.76	187	126	30 ft.
3. Secondary School	(24.1)	26.07	174	120	62 ft.
4. Hurworth Burn Reservoir	26.5	26.98	175	121	375 ft.
5. Hart Reservoir	(21.5)	24.45	188	120	172 ft.
6. Shotton Pumping Station	29.4	28.77	185	123	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	26.41	176	118	521 ft.
8. Seaham. Dalton Pumping Station	27.0	25.53	180	118	345 ft.
9. Ryhope	25.4	27.20	182	115	220 ft.
0. Washington Glebe Modern School	(24.9)	26.16			160 ft.
1. Sunderland Thornholme	25.6	27.45		124	130 ft.
2. Cleadon Pumping Station	24.4	25.87	178	115	216 ft.
3. South Shields Bents Park	24.2	27.6	177	120	36 ft.
14. South Shields S. Pier Works	(23.6)	25.96	172	117	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

Rainfall 1957

<u>Station</u>	<u>Average</u>	<u>1957</u>	<u>Days with over 0.1"</u>	<u>Days with over 0.4"</u>	<u>Height</u>
W. Hartlepool					
1. Clock	24.7	21.26	173	122	35 ft.
2. Waterworks	24.7	20.63	171	111	30 ft.
3. Secondary School	(24.1)	22.24	180	124	62 ft.
4. Hurworth Burn Reservoir	26.5	22.09	178	120	375 ft.
5. Hart Reservoir	(21.5)	20.74	198	116	172 ft.
6. Shotton Pumping Station	29.4	25.34	189	131	402 ft.
7. Easington Mill Hill Reservoir	(26.2)	24.15	177	124	521 ft.
8. Seaham. Dalton Pumping Station	27.0	22.33	169	127	345 ft.
9. Ryhope	25.4	20.96	166	121	220 ft.
10. Washington Glebe Modern School	(24.9)				160 ft.
11. Sunderland Thornholme	25.6	22.51	172	128	130 ft.
12. Cleadon Pumping Station	24.4	21.74	185	117	216 ft.
13. South Shields Bents Park	24.2	23.15	169	120	36 ft.
14. South Shields S. Pier Works	(23.6)	21.84	158	119	17 ft.

Averages in brackets are taken over a maximum period of twelve years.

APPENDIX IIa Summary of soil profiles referred to in the text.Profile 1. Cornforth Series

Site. 348603.

Uncultivated margin to field at 300 ft. Meadow grasses, clover and thistle.

Profile.

- A₀ 0- 2 " Mat of roots and humified material.
- A₁ 2 - 7" 10 YR 3/2.5 Very dark greyish brown loam. Good crumb to granular structure. Humus rich, many roots, insects and grubs numerous. Occasional coal fragment and some mag/limestone. pH 7.8
- (B) 7 -12" 10YR 4/3.5 Dark yellowish brown with occasional pieces of limestone. Clay loam with compact structure. Fewer roots, humus and animal life. Coal fragments and a few erratics but stones generally infrequent.
- (B₂) 12 -18" 10 YR 5/4 Yellowish brown clay with yellow and white streaks. Stiff and structureless. Difficult to penetrate with spade. Traces of some humus and very few roots. At base of horizon beds of rounded pebbles and coal fragments.
- C 18 -24" 10 YR 7.5/4.5 Very pale brown to yellow transition to powdered weathered magnesian limestone.

Profile 2. Cornforth Series

Site. 395643.

Slightly sloping ground at 230 ft. Limestone at varying depths.

Profile.

- Ao 0 - 1" Thick mat of roots and humus.
- A₁ 1 - 4" 10 YR 4/3 Dark brown loam with strong crumb to granular structure. Almost stone-free. Network of roots so strong that the whole horizon could be peeled off the limestone.
- c/D 4"+ Hard magnesian limestone with only slight penetration of soil down cracks where weathering and fine powdered limestone evident.

Profile 3. Cornforth Series

Site. 392643.

Altitude 197 ft.

Profile.

- Ao 0 - 1" Thick mat of roots and humus.
- A₁ 1 - 5" 10 YR 3 /2 Very dark greyish-brown loamy sand with strong crumb structure and a dense net of roots. Stones frequent including mag/limestone and coal fragments. Boundary indefinite. pH 7.2.

(B) 5 -11" 7.5 YR 4.5/4 Greyish brown clay loam with weaker structure including crumb, angular blocky and single grain. Few fine roots. Very little humus. Increasing mag/limestone fragments with depth. pH.8.0.

St 11.14" Band of coal fragments.

O/D 14"+ Powdered limestone.

Profile 4. Cornforth Series.

Site. 362615.

Paddock of farm not cultivated for over 100 yrs.

Profile.

Ao 0 - ½" Very thin mat of roots.

A ½ - 5" 10 YR 4/1 Dark grey loamy sand with good crumb to granular structure. Humus rich and almost stone free. pH 7.6.

A/(B) 5 -13" 10 YR 4/2 Dark Greyish brown loam with weaker structure and increasing number of stones. Roots throughout and humus although less than in 1. pH 7.6.

(B) 13 -13½" 10 YR 4/3.5 Dark yellowish brown loamy sand at different levels around the profile. Single grain to very weak crumb. Drainage good. Roots penetrate. Stones numerous. pH 7.7.

C 13½-24" Weathering creamy powdered magnesian limestone 5 YR 7.5/3 Pale yellow. Loamy sand with no structure.

D 24"+ Solid magnesian limestone.

Profile 5. Cornforth Series.

Site. 343553.

Paddock on level to gentle slope. Altitude 300 ft.

Profile.

- Ao 0 - ½" Dense root mat.
- A ½ - 4" 10 YR 4/2 Dark greyish brown clay loam with good crumb to granular structure. Organic matter rich. Stones frequent. Boundary uneven.
- (B) 4 - 17" 10 YR 5/4 Yellowish brown clay loam cloddy structure rich in roots and worm holes. Coal present and recrystallised calcite on limestone fragments.
- C 17"+ 10 YR 5/3 Brown stiff clay with yellow magnesian limestone fragments increasingly dominant.

Profile 6. Kelloe Series.

Site. 346552.

Permanent pasture. 300 ft.

Profile.

- Ao 0 - ½" Dense root mass.
- A 1½ - 5" 10 YR 4/2 Dark greyish brown loam with crumb structure. O.M. rich. Numerous roots good porosity and friable. Adequate drainage but very slight rust mottling along occasional root. Few stones but coal and mag/limestone present.

- (B) 5 -21" 10 YR 5/4 Yellowish brown doddy structured clay loam with mottling along roots. Very small stones increasingly frequent with depth. Tenacious difficult to penetrate with spade. Occasional worm hole but increasing gley with depth.
- C 21"+ 10 YR 5/6 Yellowish brown clay with increasing gleying. Still occasional roots and larger stones now including some boulders. Very tenacious and dries out to very hard block.

Profile 7. Kellow Series

Site. 361610.

Permanent pasture.

Profile.

- Ao 0 - 1 $\frac{1}{2}$ " Thick mat of roots.
- A 1 $\frac{1}{2}$ - 4" 10 YR 4/1 Dark grey silty clay loam with strong crumb structure humus rich and many roots. Almost stone-free but some coal fragments.
- (B) 4 -24"+ 10 YR 4.5/4 Yellow brown clay to clay loam with slight greying along roots. More compact and tenacious. Occasional worm hole and roots penetrating to 24". Mag/limestone fragments increasing in numbers with depth.

Profile 8. Hesleden Series

Site. 364588.

Permanent pasture on gentle slope.

Profile.

Ao	0 - $\frac{1}{2}$ "	Grass root mat.
A	$\frac{1}{2}$ - 3"	5 YR 4/1 Dark grey clay loam with crumb structure, many roots and no stones. Friable. Passing down into 3.
A/(B)	3 - 6"	10 YR 3/2 Very dark grey brown loam to silty loam with more cloddy structure. Similar to 2. Irregular boundary.
(B)	6 - 32"	10 YR 5/3.5 . Yellowish brown with slight red tinge. Clay with prismatic structure. Mag/limestone frequent.
C	32"+	Mixture of triassic till with mag/limestone.

Profile 9. Transitional from Cornforth to Kelloe Series.

Site 340422.

Permanent pasture.

Profile.

Ao	0 - 1"	Thick mat of roots.
A	1 - 4"	10 YR 3/2 Very dark greyish brown loam with good matted crumbs. Humus rich, stone free and friable. Passing into 3.

- A/(B) 4 -10" 10 YR 4/2 Dark greyish brown loam with small crumbs. Roots still abundant. Occasional coal fragment.
- (B) 10-20" 10 YR 4/3.5 Dark yellowish brown loam friable good drainage. At 15" layer of rounded and angular stones and coal fragments. Still occasional roots throughout. Distinct boundary.
- C/D 20-36" 10 YR 5/6 Yellowish brown clay loam, cloddy and prismatic structure. Numerous stones. Humus in root channels. Slight gleying.
- E/D 36"+ Magnesian limestone powder.

Profile 10. Cornforth Series.

Site. 339401.

Pasture last ploughed in 1947.

Profile.

- A 0 - 3" 10 YR 4/2 Dark greyish brown clay loam with small crumb structure. Slightly stony with mag/limestone and coal. Good porosity, friable, high O.M., abundant roots, numerous worms.
- (B) 3 -12" 10 YR 4/3 Dark brownstony clay loam, mainly mag/limestone fragments. Coarse angular structure, compact, moderate induration, firm consistence, frequent roots and free drainage. Diffuse boundary.

C/D 12"+ Passing down fissures, cracks and chasms in broken brecciated limestone with no powdering.

Profile 11. Cassop Series

Site 334400.

Arable. 414 ft.

Profile.

A 0 - 8" 5 YR 4.5/2 Light olive brown clay loam to clay with coarse angular blocky to nutty structure. Almost stone-free. Mellow compactness and frequent fine roots. Sharp boundary.

(B)g 8 - 31" 2.5 Yr 4.5/4 Light olive brown matrix with increasingly severe mottling. Silty clay and cloddy. Tenacious, plastic, very low humus. Very few small roots.

G 31"+ Stiff blue-grey clay.

Profile 12. Cornforth Series

Site 332403.

Arable gentle slope.

Profile.

A 0 - 7" 10 YR 3.5/2 Dark grey brown loam, slightly stony., crumb structure. Porous, mellow compactness, non-plastic. High humus. Free drainage.

- (B) 7 -14" 10 YR 4/4 Dark yellowish brown loam, slightly stony, cloddy structure. Loose compactness. Low humus with some roots. Free drainage. Diffuse boundary.
- C/D 14"+ 10YR 5/7 Yellowish brown stony sandy loam, dominated by magnesian limestone fragments of all shapes and sizes. No structure. No humus or roots. No faunal activity.

Profile 13. Cornforth Series.

Site. 335393.

Permanent pasture at 450 ft.

Profile.

- A 0 -10" 10 YR 4/2 Dark brown almost stone-free loam with large granular structure. Good open porosity and free drainage. Friable. Abundant roots and high humus.
- (B)g 10-17" 10 YR 5/2 Grey brown clay loam, slightly stony and medium sub-angular to blocky structure. Compact, indurated. Low O.M. Very slight mottling.
- C 17-31" 10 YR 4/3 Dark yellowish brown sandy clay dominated by various stones including limestone and carboniferous sandstone. Clay material very plastic but stones provide better drainage than in 2.

Profile 14. Cassop Series

Site. 336393

Permanent pasture.

Profile.

- A. 0 - 13" 5Y 4.5/2 Light olive brown nearly stoneless clay-loam with crumb structure. Good porosity, loose and friable. O.M. High. Roots frequent. Free drainage. Gradual boundary.
- (B)g 13 - 22" 2.5Y 4.5/4 Brown and grey mottled clay with coarse subangular blocky structure. Tenacious and plastic. Low O.M. very few roots. Boundary clear.
- G 22"+ Bright blue-grey and rusty mottled ground water gley.

Profile 15. Mainsforth Series

Site. 417409

Arable

Profile

- A 0 - 10" 10YR 3/2 Very dark grey brown clay loam, slightly stony, crumb to granular structure. Mellow compactness. Slightly plastic. O.M. high throughout. Drainage free. Boundary sharp.
- (B) 10 - 15" 2.5Y 4/4 Reddish brown clay loam with small cloddy structure. Compact and moderate induration. Plastic. Roots very few. Drainage good. Boundary diffuse.
- C. 15"+ 7.5YR 5/8 Brown clay loam with stones dominating the horizon.

Profile 16 Preston Series

Site 244302

Permanent Pasture

Profile

- A 0 - 5" 10YR 3.5/2 Dark grey brown clay loam, stonefree and good crumb structure. Mat of roots throughout.

		High faunal activity. Mottling at base. Boundary diffuse.
G	5 - 18"	Heavily mottled clay-loam with few small stones. Cloddy and plastic. Very few roots penetrating intense gley. Boundary clear, sharp.
St	18 - 21"	Black peat with some inorganic sand.
St	21 - 36"	Gleyed red and grey clay.
St	36 - 84"	Coarse sand in lighter fine sand matrix.
St	84 - 240"	Red-brown laminated clays and silts.
St	240 - 252"	Gravels
St	252 - 294"	Sand and large gravel.
St	294 - 336"	Stiff brown laminated silty clay
St	336 - 528"	Brown clay loam with stones.
St	528 - 564"	Damp sandy clay
St	564 - 618"	Brown clay-loam with small stones.

Profile 17. Preson Series.

Site. 243303.

Permanent pasture. 230 ft.

Profil.

A	0 - 5"	10 YR 3.5/2 Dark grey brown clay loam. Almost stone free, good crumb structure with mat of grass roots. Diffuse boundary.
G	5 - 12"	Very mottled clay loam with cloddy structure. Sticky and drained only along occasional root dannel. Boundary diffuse.
St G	12 - 24"	Bands of peat, clay and sand. Very mottled, little root penetration.

St 24"+ Stiff laminated silty clay with occasional wood fragment.

Profile 18. Ricknall Series

Site. 303245

Arable at top of convex hill, 270ft.

Profile

A 0 - 8" 10YR 5/2 Grey brown clay loam with sticky granular to cloddy structure. O.M. high but few roots. Individual quartz grains and micas characterise the horizon. Boundary clear.

(B)g 8 - 50" Mottled greys, yellows, browns, clay, sticky and cloddy. Stones up to large boulder size. Impeded drainage and increasingly heavy with depth.

G 50"+ Similar to above but mottling more severe

Profile 19 Ricknall Series

Site 305249

Arable lower slope, 250ft.

A 0 - 5" 10YR 5/2 Grey brown clay loam with few small stones. Granular to cloddy. Grass sod throughout. O.M. high. Boundary diffuse.

(B)g 5 - 16" Mottled banded horizon of clays, sands and occasional patches of peat. Increasingly heavy with depth.

G 16 - 108" Mottled clay with stones and boulders. Plastic and sticky, peaty humus in cracks.

St 108 - 240" Laminated silty clay. compact and impervious.

Profile 20. Haswell Series

Site 391426

Pasture in arable system at 520 ft.

Profile

A	0 - 6"	10YR 3/2 Dark grey Brown loam with frequent stones. Sod crumb structure. Slightly compact and sticky but drainage adequate and no mottling.
(B)g	6 - 25"	10YR 5/6 Yellow brown clay loam with numerous stones. Cloddy sticky and mottled. Boundary at 25" on soft yellow Magnesian Limestone.

Profile 21. Ricknall Series

Site. 302237

Arable 265 ft.

Profile

A	0 - 7"	10YR 4/2 Grey brown loam with large granular structure, mellow compactness. O.M. medium. Roots frequent. Boundary sharp.
A/(B)	7 - 11"	10YR 3.5/2 medium loam with some sand. Similar to above but lighter colour. Boundary clear.
(B)g	11 - 20"	Very mottled clay loam with compact sticky cloddy structure.
St	20"+	Laminated clay with gleying continuing to depth.

Profile 25 Ricknall Series

Site 301 234

Ploughed. 260 ft.

Profile

A	0 - 6"	10YR 4/2 Grey brown loam with occasional small stones. Granular to cloddy structure. Firm compactness. O.M. l ^W boundary sharp.
A/(B)	6 - 13"	Similar to above but brighter colour including red component
(B)g	13-18"	Mottled red brown clay loam, compact and almost impermeable.
St	18-66"	Red brown mottled clay
St	66-84"	Sand and gravel
St	84-160"	Clay with stones and boulders
St	160-172	Sand
St	172-460"	Clay with stones and boulders.

Profile 28 Cornforth Series

Site. 332340

Uncultivated 470ft.

Profile

A	0 - 3"	10YR 4/2 Dark grey brown loam with band of coal fragments at base. Crumb structure, light compactness, sod mat of roots throughout.
A/(B)	3 - 9"	10YR 5/2 Yellow brown loamy sand; crumb structure around roots. Limestone fragments and some coal throughout. Transitional

- (B) 9 - 13" 10YR 6/4 Light yellow brown loamy sand with no definite structure. Occasional thick root and increasing mag/limestone frequency.
- C 13 - 24"⁺ 10YR 8/6 Yellow sandy horizon with many small limestone fragments.

Profile 29 Middleham Series

Site 339334

Steep slope uncultivated land at 465 ft.

Profile

- A 0 - 2" 10YR 4/2 Dark grey brown silty loam with mat of roots and some limestone fragments.
- A/(B) 2 - 5" 10YR 4/3 Brown to dark brown loam with crumb structure and roots throughout. Limestone more common. Transitional.
- (B) 5 - 15" 10YR 5/4 Yellow brown loam with increasing limestone. Crumbs around roots. Irregular clear boundary.
- C 15 - 30" 2.5Y 8/4 Pale yellow silty loam with large limestone fragments throughout. No structure.
- D 30"⁺ Magnesian limestone

Profile 30 Middleham Series

Site 339334

Same as 29

Profile

- A 0 - 2" 2.5Y 5/2 Grey brown loamy sand with no structure. Root mat and very frequent limestone fragments.

- (B) 2 - 4" 2.5Y 6/2 Light grey brown loamy sand with numerous small limestone fragments. No structure.
- C 4"+ 2.5Y 8/4 Pale yellow silty loam with large limestone fragments throughout.

Profile 31. Middleham Series

Site 331328

Uncultivated 450 ft.

Profile

- A 0 - 5" 10YR 4/3 Brown to dark brown loamy sand with a mat of roots throughout. Small stone fragments less than $\frac{1}{4}$ ". Some crumb structure developed but easily broke down between the fingers. Earthworms and beetles numerous.
- (B) 5 - 7" 10YR 6/6 Brown-yellow weathered parent material mainly small rounded and pitted fragments of limestone set in a sandy matrix. Crumbs of soil material from 1 passed down to this horizon. The gritty yellow limestone weathered down in places to a light grey colour.

Profile 32 Middleham Series.

Site 329329

As 31

Profile

- A 0 - 15" 10YR 4/3 Brown to dark brown sandy loam consisting of a

mass of roots, soil matter and limestone fragments. Result is a very stony appearance. Large crumb structure in combination with the limestone fragments gave a very open porosity. The limestone fragments were much weathered and had pitted surfaces.

C 15" Thinly bedded, brown compact limestone

Profile 33 Cornforth Series

Site 324383

Permanent Pasture

Profile

- A 0 - 1 $\frac{1}{2}$ " 1OYR 3/2 Vary dark grey brown loamy sand. Britty feel due to the presence of large quartz grains. Large crumb structure. Roots throughout. Porosity ubiquitous and good.
- (B) 1 $\frac{1}{2}$ - 7" 1OYR 3/3 Dark brown loam in which only tap roots found. Quartz grains and occasional small rounded limestone fragmenets most of which smaller than 2". Earthworms and beetles numerous.
- C/D 7 - 10 $\frac{1}{2}$ " Weathered parent material. 1OYR 3/4
- D 10 $\frac{1}{2}$ " + Yellow white limestone. The thin bedded compact rock is one of the basal members of the Permian Limestone outcropping only 50' above an exposure of Yellow Sands. Cavities existed in the rock but there was no calcite infilling.

Profile 34 Cornforth Series

Site 327379

Uncultivated 500 ft.

Profile

- A 0 - 4" 1OYR 4/3 Brown loam, small sandstone pebbles and occasional limestone.
- A/(B) 4 - 9" 1OYR 5/4 Yellow brown clay loam with weak crumb structure. Roots.
- (B) 9 - 12" 1OYR 5/6 Yellow brown loam with large crumb structure.
- G/D 12 - 20" 1OYR 7/4 Very pale brown/^{loam}with numerous limestone fragments.

Profile 35. Cornforth Series

Site 337402

Pasture at 555ft.

Profile

- A 0 - 1" 1OYR 4/3 Dark brown clay loam with rounded sandstone pebbles, coal and magnesian limestone fragments. Mat of roots, somewhat compact.
- (B)/C 1 - 7" 1OYR 5/6 Yellow brown clay loam with only occasional root.
- D 7"+ 1OYR 6/6 Brecciated mag/limestone.

Profile 36 Cornforth Series

Site 344398

Unused 610 ft.

Profile

- A 0 - 2" 1OYR 4/3 Dark brown loam with crumb structure and mat of

A/(B)	2 - 7"	10 YR 4/2 Dark grey brown loam with similar to A but penetrated only by occasional root.
(B)	7 - 10"	10 YR 4/4 Dark yellow brown clay loam, mottled with material from above.
C	10 - 14"	7.5 YR 5/8 Brown clay with nutty structure.
D	14"+	2.5 YR 8/4 Pale yellow limestone, soft and friable.

Profile 37. Cornforth Series

Site 342416.

470 ft.

Profile

St	0 - 2"	2.5 YR 6/4 Light yellow sand blown from sand quarry.
A	2 - 5"	10 YR 3/1 Very dark grey loamy sand with coal fragments. Limestone contributes half bulk.
(B)	8 - 12"	10 YR 7/6 Yellow loam dominated by limestone fragments. Above rock.

Profile 38. Cornforth Series

Site 345506.

Road bench.

Profile.

A	0 - 3"	10 YR 4/4 Dark yellow brown loam with weak crumb structure.
C	3 - 7"	5 YR 8/4 Pale yellow powdery limestone above bedded limestone.

Profile 39. Kelloe Series

Site 375437.

Level ground 460 ft.

Profile.

A	0 - 2"	10YR 3/3 Dark brown loamy sand with weak crumb structure. Mat of roots.
A/(B)	2 - 10"	10YR 4/2 Dark grey brown sandy loam with crumb structure.
(B)	10 - 22"	10YR 5/4 Yellow brown silty loam with infrequent coal fragments. Granular structure.
D	23 - 32"	5Y 8/4 Pale yellow weathered mag/limestone above bedded limestone.

Profile 40 Cornforth Series

Site 333419

510 ft.

Profile

Ao	0 - 1"	10YR 2/2 Very dark brown loamy sand. Mat of plant remains and roots.
A	1 - 4"	10YR 3/2 Very dark grey brown loam with strong crumb structure.
(B)	4 - 11"	10YR 3/4 Dark yellow brown loam with crumb structure.
C/D	11 - 13"	10YR 4/4 Dark yellow brown loam with abundant weathered limestone fragments, above bedded mag/limestone.

Profile 41 Cornforth Series

Site 387665

Sea stack

Profile

A	0 - 7"	10Y ^R 3/4 Dark yellow brown loam with crumb structure and mat of roots
(B)/C	7 - 21"	7.5Y 4/4 Dark brown clay loam with platy structure and very few roots.
D	21"±	2.5Y 8/4 Yellow limestone.

Profile 42. Cornforth Series

Site. 390655.

140 ft. hummocky.

Profile.

A	0 - 3"	10 YR 4/1 Dark grey loamy sand with large crumb structure and root mat throughout.
(B)/C	3 -15"	10 YR 5/2 Grey brown silty loam with humus passing down root channels from above. Limestone fragments increasing in size and frequency down the horizon.
D	15"+	Magnesian limestone.

Profile 43. Cornforth Series.

Site. 406644.

60 ft. edge of cliff.

Profile.

A	0 - 3"	10 YR 2/2 Very dark brown loamy sand with strong crumb structure and a mat of roots.
C	3 - 9"	10 YR 3/3 Dark brown silty loam with numerous limestone fragments and fewer roots than above. Directly over brecciated limestone.

Profile 44. Cornforth Series

Site 340505.

Quarry bench.

A	0 - 4"	10 YR 3/2 Very dark brown silty loam with strong crumb structure and mat of roots.
C	4 -12"	10 YR 3/4 Dark yellow brown silty loam with numerous limestone fragments and only very few roots.
D	12"+	Yellow bedded limestone.

Profile 45. Cornforth Series

Site 341517.

350 ft.

Profile

A	0 - 2"	10 YR 3/2 Very dark grey brown silty loam with strong crumb structure and no stones.
(B)/C	2 -12"	10 YR 4/4 Dark yellow brown silty loam with many rounded limestone fragments and strong crumb structure. Directly over unweathered limestone.

Profile 46. Cornforth Series

Site 347528.

410 ft.

Profile.

A	0 - 3"	10 YR 2/2 Very dark brown loamy sand with dense mat of roots.
---	--------	---

(B)/C	3 -15"	10 YR 3/3 Dark brown loamy sand with limestone fragments. Humus passing down from above.
D	15"+	magnesian limestone.

Profile 48. Shotton Series.

Site 402408.

450' flat.

Profile.

A	0 -12"	10 YR 3/2 Very dark greyish brown loam with few stones including red-stained sandstone. Massive to large cloudy structure. Hard consistence. Medium O.M. Roots throughout. Very slight mottling at base of horizon. Extremely slight calcareous reaction. Clear.
(B)g	12-50"	2.5 YR 4/4 Reddish brown with blue and grey mottling. Small mag/limestone fragments. Massive prismatic structure. Severe mottling along cracks and faces and penetrating some peds. Sticky. Calc.
Cg	50-72"	2.5 Y R 4/4 Reddish brown silty clay loam with occasional red-stained piece of mag/limestone. Slight grey-blue mottling. Strong consistence, compact, sticky, calcareous reaction.

Profile 50. Mainsforth Series.

Site 336314.

Permanent pasture.

Profile.

A	0 - 7"	10 YR 3/3 Dark grey brown sand with occasional rounded gravel. High O.M. and root mat.
A/(B)	7 - 30"	10 YR 4/2 Dark greyish brown sand similar to A but lighter colour and less O.M.
(B)/C	30-40"	7.5 YR 4/4 Brown stony and sandy horizon with peaty lenses and O.M. passing down from above.
St.	40-56"	7.5 YR 5/6 Brown coarse sand with occasional roots.
St.	56-60"	10 YR 6/4 Light yellowish brown coarse sand.

Profile 52. Hesleden Series

Site. 483336

150 ft gentle concave slope.

Profile.

A	0 - 6"	10 YR 4/3 Dark brown sandy loam with small coal fragments. Crumb structure, mellow compactness, sod root mat throughout. Non-calcareous.
---	--------	--

(B)/C 6 -20" 5 YR 5/4 Reddish brown clay loam with strong massive structure. Slightly compact but numerous fragments mainly of mag/limestone throughout. Strong calcareous reaction.

Profile 56. Hesleden/Shotton Series

Site. 402398.

370 ft. arable.

Profile.

A 0 - 7" Dark grey with occasional brown mottles, loam with cloddy to nutty structure. Humus rich Roots common. Boundary uneven.

A/(B) 7 -15" Grey brown sandy clay loam Massive, friable, occasional weathered sandstone. Humus less than above but medium concentration.

(B)g 15-26" Red and grey mottled horizon of clay loam with many small gravels. Incipient columnar structure.

G 26-39" Similar to above but gleying more intense.

Stg. 39-48" Brown gleyed clay similar to lower drift.

Profile 57. Hesleden Series.

Site. H. Henry.

450 ft.

Profile.

A	0 -12"	Grey humus rich sandy loam. Small gravel, granular to crumb structure. Mat of roots at 7" compacted to plough pan.
A/(B)	12-36"	Brown sandy loam with frequent stones and cloddy structure.
(B)	36-48"	Similar to above but more compact and heavier. Less O.M. but roots still penetrate. Boundary sharp.
C/D	48-56"	Indurated upper drift with slight gleying masking red colour. Many small mag/limestone fragments in matrix of sandy clay. Roots still penetrating.

Profiles 101 and 102 are very similar to 56 and 57. Profile 140 similar to 14.

APPENDIX IIb

Analysis of samples, including all profiles quoted in
the text

1. Mechanical analysis.
2. pH and percent total calcium and magnesium carbonates.
3. Organic carbon, organic matter, organic nitrogen and carbon/nitrogen ratios.
4. Cationic exchange data.

Results are presented for distinct horizons only. ~~but where they do not occur in the text graphs are given indicating sampling at two inch intervals.~~

1. Mechanical Analysis.

Profile	Horizon	% Clay.	% Silt.	% Sand.	% F.S.	% C.S.	Loss	Class
1.	1.	17.55	17.42	65.31	45.17	20.14	00.02%	L.S.
	2.	24.20	15.50	60.23	41.59	18.64	00.07	L.S.
	3.	35.73	16.80	47.56	45.28	12.27	00.65	C.
	4.	8.62	20.38	71.39	40.77	30.62	+0.39	L.S.
2.	1.	19.16	19.16	60.57	40.21	20.03	01.11	L.
3.	1.	10.18	15.28	74.52	47.90	26.62	00.02	L.S.
	2.	24.79	15.49	59.69	38.16	21.43	00.03	C.L.
4.	1.	08.80	18.40	72.30	51.50	20.80	00.50	L.S.
	2.	11.80	17.60	69.67	47.71	20.96	00.93	L.
	3.	10.98	21.81	66.23	51.44	14.79	00.98	L.S.
	4.	00.42	21.55	77.04	71.07	05.95	00.96	L.S.
5.	1.	25.99	20.58	51.09	36.09	15.00	02.34	C.L.
	2.	32.22	21.99	43.91	34.00	9.91	01.88	C.L.
6.	1.	18.24	18.02	63.72	45.89	17.83	00.02	L.
	2.	22.70	12.70	61.91	45.98	15.93	02.68	L-C.L.
	3.	31.40	11.46	54.27	40.96	13.31	02.87	C.
7.	1.	25.36	26.06	45.95	33.84	12.11	02.73	S-C.L.
	2.	37.15	17.38	41.84	31.57	10.36	03.63	C-C.L.
8.	1.	23.14	18.23	57.92	41.77	16.15	00.61	C.L.
	2.	24.88	24.37	49.59	39.28	10.30	01.16	L-S.L.
	3.	33.08	13.88	42.02	32.31	09.70	11.02	C.
9.	1.	18.43	18.43	54.83	42.84	11.98	08.31	L.
	2.	19.00	19.00	59.54	44.80	14.74	02.45	L.
	3.	16.00	17.00	64.56	48.48	16.38	02.14	L.
	4.	32.08	18.18	46.54	34.81	11.73	03.20	C.L.

Profile Horizon		% Clay	% Silt	% Sand	% F.S.	% C.S.	Loss	Class
10.	1	30.59	19.00	47.83	37.81	10.02	02.58	C.L.
	2	33.44	15.10	47.70	38.66	9.04	05.76	C-C.L.
11.	1	34.95	21.32	40.84	28.20	11.64	02.99	C-C.L.
	2	47.66	25.80	22.46	20.50	01.96	00.08	S.C.
12.	1	20.67	11.31	62.50	50.74	11.76	05.52	L.
	2	19.65	10.52	65.76	54.41	11.35	04.07	L.
13.	1	26.83	20.40	52.80	40.29	12.61	+0.03	L
	2	35.86	21.98	36.44	23.24	13.20	05.72	C.L.
14.	1	33.11	13.46	52.99	37.36	13.83	00.47	C.L.
	2	36.26	12.41	48.75	37.39	11.36	02.58	C
	3	26.35	26.06	45.95	33.84	12.11	01.64	S.L.
15.	1	25.30	13.45	58.15	41.45	17.00	03.20	C.L.
	2	34.30	16.00	47.20	35.70	11.50	02.50	C.L.
	3	27.90	19.60	51.50	39.60	11.90	01.00	C.L.
16.	1	22.86	14.16	61.00	31.45	29.55	01.98	C.L.
	2	28.60	9.36	59.17	26.07	33.10	02.87	C.L.
	3	32.54	08.43	53.01	31.11	21.90	06.02	C
	4	23.28	06.83	67.09	35.04	32.05	02.80	S.L.
17.	1	25.80	16.49	55.01	33.01	22.00	01.270	C.L.
	2	28.75	14.58	54.25	32.65	21.60	02.42	C.L.
	3	22.50	11.49	66.01	37.01	28.00	00.00	C.L.
	4	50.80	30.30	19.53	17.60	00.93	+0.63	S.C.

Profile	Horizon	% Clay	% Silt	% Sand	% F.S.	% S.S.	Loss	Class
18.	1	27.70	13.00	56.84	38.21	18.63	02.46	C.L.
	2	37.97	18.19	41.68	30.42	11.26	02.18	C
	3	35.86	21.22	40.80	33.71	07.09	02.12	C.
19.	1	30.90	19.90	47.42	32.92	14.50	01.80	C.L.
	2	37.30	20.50	40.64	32.60	08.40	01.40	C.
	3	38.30	20.11	39.10	31.10	08.00	02.50	C.
20.	1	30.09	17.01	51.52	34.52	17.00	01.38	C.L.
	2	34.03	22.01	42.79	31.04	11.75	01.17	C.L.
21.	1.	22.30	15.90	60.55	45.05	15.50	01.25	L.
	2	24.00	14.10	61.90	46.30	15.60	00.00	L-C.L.
	3	33.10	15.90	48.65	33.50	15.15	01.35	C.L.-C.
	4	29.80	22.10	45.42	41.06	04.36	01.28	C.L.
25.	1	20.30	15.00	62.00	41.48	20.52	02.70	L.
	2	20.30	15.00	62.00	41.00	21.00	02.70	L.
	3	31.10	14.80	49.90	35.10	13.90	04.20	C.L.
	4	59.00	23.00	15.50	13.40	02.10	02.50	C.
28.	1	14.00	20.00	65.25	55.73	09.52	03.75	L.
	2	08.40	14.10	73.76	62.51	11.25	03.74	L.S.
	3	04.00	22.60	71.12	62.88	08.24	02.88	L.S.
29.	1	02.00	24.80	70.29	57.80	12.49	02.99	S.L.
	2	11.20	21.00	62.39	52.77	09.62	05.41	L
	3	12.70	24.50	61.73	49.78	11.95	01.07	L $\frac{1}{2}$

Profile	Horizon	% Clay	% Silt	% Sand	% F.S.	% C.S.	Loss	Class
30.	1	07.40	18.00	74.29	65.51	08.78	00.31	L.S.
	2	05.40	17.00	75.12	61.56	13.56	02.48	L.S.
31.	1	09.40	07.00	80.43	60.25	20.18	03.17	L.S.
32.	1	09.40	13.60	74.03	52.03	22.00	02.97	S.L.
33.	1	08.40	15.00	74.51	56.84	17.67	02.08	L.S.
	2	12.40	17.00	65.17	51.84	13.33	05.43	L.
	3	17.20	11.00	69.46	53.46	16.00	02.34	L.
34.	1	14.00	18.00	65.70	54.10	11.60	02.30	L.
	2	24.00	16.40	55.66	46.66	09.00	03.94	C.L.
	3	21.00	21.00	55.88	44.60	11.28	02.26	L.
35.	1	21.20	20.00	56.19	45.60	10.59	02.61	L.
	2	27.00	18.80	50.51	40.63	09.88	03.69	C.L.
36.	1	13.60	12.00	69.02	55.80	13.22	05.60	L.
	2	20.00	12.00	64.99	53.66	11.33	03.01	L.
	3	23.00	11.60	60.83	48.35	12.48	04.57	C.L.
	4	38.00	09.60	48.98	40.02	08.96	03.42	C.
37.	1	04.60	03.00	90.01	51.39	38.62	02.39	S.
	2	08.00	08.00	80.32	54.80	25.52	03.68	L.S.
	3	17.00	12.20	66.80	57.60	09.20	04.00	L.
38.	1	17.00	12.00	66.60	45.20	21.40	04.40	L.

Profile	Horizon	% Clay	% Silt	% Sand	% F.S.	% C.S.	Loss Class	
39.	1	06.50	16.50	67.62	56.48	11.14	09.38	L.S.
	2	14.00	21.00	63.30	49.00	14.3	01.70	L.
	3	18.00	26.00	52.80	42.20	10.60	03.20	St.L.
	4	01.00	45.00	52.20	50.90	01.30	01.80	St.L.
40.	1	07.00	12.00	71.02	54.62	16.40	09.98	L.S.
	2	11.00	15.00	67.36	48.66	18.70	06.64	L.
	3	16.00	14.00	64.10	49.14	14.96	05.90	L.
	4	15.00	15.00	66.78	49.72	17.06	03.22	L.
41.	1	15.00	12.00	59.94	46.18	13.76	13.06	L.
	2	20.00	15.00	54.34	40.36	13.98	10.66	L.
	3	29.00	14.00	52.08	37.64	14.44	04.92	C.L.
42.	1	07.00	27.00	62.50	52.98	09.52	03.50	St.L.
	2	15.00	25.00	57.00	42.06	14.94	03.00	St.L.
43.	1	07.40	22.30	64.43	54.60	09.83	05.87	L.S.
	2	10.20	24.70	60.44	46.80	13.64	04.66	St.L.
44.	1	05.00	22.40	65.90	56.40	09.50	06.70	St.L.
	2	07.00	24.60	62.60	54.80	07.80	05.80	St.L.
45.	1	04.30	25.80	62.40	53.80	08.60	07.50	St.L.
	2	07.40	24.50	63.50	55.40	08.10	04.60	St.L.
46.	1	04.20	22.10	69.70	63.40	06.30	04.00	L.S.
	2	10.40	21.10	65.30	51.50	13.18	03.60	L.S.

Profile	Horizon	% Clay	% Silt	% Sand	% F.S.	% C.S.	Loss	Class
7.	1	15.07	12.84	70.37	43.11	27.25	01.72	L.
	2	19.41	05.84	73.14	48.60	24.54	01.61	S.L.
	3	10.91	06.84	82.11	26.99	54.12	00.00	S.L.
	4	04.52	11.19	83.30	28.23	54.07	00.09	L.S.
8.	1	18.69	14.53	65.89	39.09	26.79	00.89	L.
	2	37.90	35.93	26.17	24.95	01.21	00.10	St.C.
	3	36.00	38.69	25.26	24.55	00.07	00.15	St.C.
9.	1	15.90	14.31	69.77	47.94	21.83	00.02	L.
	2	23.85	15.90	60.24	43.95	16.29	00.01	L.
	3	11.86	06.92	81.20	56.64	24.56	00.02	S.L.
	4	18.77	16.80	64.41	45.94	18.47	00.02	L.
10.	1	06.95	06.95	86.08	24.58	61.50	00.02	S.
	2	07.09	09.11	83.79	29.25	54.53	00.01	S.
	3	09.32	08.29	82.37	32.48	49.89	00.02	S.
	4	06.03	01.00	92.97	09.23	83.73	00.00	S.
	5	04.26	01.06	94.66	12.57	82.08	00.02	S.
12.	1	20.34	18.54	61.13	41.78	19.35	00.99	L.
	2	38.36	23.40	38.22	31.17	07.05	00.02	C.L.
16.	1	19.00	13.06	67.81	40.54	27.26	00.13	L.
	2	21.00	16.00	63.26	41.97	22.29	+0.26	L.
	3	23.00	19.10	57.90	42.00	15.90	00 $\frac{1}{2}$ 00	C.L.
	4	20.00	17.65	62.41	44.00	18.41	+0.06	L.

Profile	Horizon	% Clay	% Silt	% Sand	% F.S.	% C.S.	Loss	Class
7.	1	13.79	12.54	74.02	37.82	36.20	+0.35	S.L.
	2	22.00	12.65	64.99	38.99	26.00	00.56	L.
	3	24.90	12.85	61.75	37.76	23.99	00.50	C.L.
	4	24.23	20.50	54.75	39.99	14.76	00.32	C.L.
01.	1	18.94	13.26	67.79	40.54	27.25	01.11	L.
	2	20.91	16.81	62.26	41.87	20.39	00.75	L.
	3	22.74	19.10	58.15	42.03	16.12	01.16	C.L.
	4	19.78	17.98	62.22	44.00	18.22	00.89	L.
	5	21.86	17.05	61.07	43.47	17.60	01.55	L.
02.	1	13.87	12.02	74.09	38.93	35.15	04.55	S.L.
	2	21.70	13.02	65.27	38.10	27.17	00.89	L.
	3	24.70	13.23	62.05	38.35	23.69	00.65	C.L.
	4	24.17	20.45	55.36	40.80	14.55	00.76	C.L.
40.	1	33.11	13.46	52.99	37.36	13.83	00.25	C.L.
	2	37.22	12.63	50.04	37.40	12.64	00.11	C.
	3	26.78	26.49	46.71	33.90	12.81	00.02	C.L.

2. pH and Carbonates.

Profile		pH.	% Carbonates	Profile		pH.	% Carbonates
	Horizon				Horizon		
1.	1.	7.3	5.5	8.	1	7.2	2.5
	2	8.0	6.5		2	6.3	1.5
	3	8.2	4.5		3	6.6	0.5
	4	7.8	66.0	9.	1	6.4	1.0
2.	1	7.6	6.5		2	6.4	0.0
					3	7.1	1.5
3.	1	7.8	21.0	4	6.6	1.5	
	2	8.2	22.0	10.	1	7.8	13.5
4.	1	7.6	19.5		2	8.1	15.0
	2	7.6	23.0	11.	1	7.9	7.5
	3	7.7	47.0		2	8.0	4.0
	4	7.7	99.0	12.	1	7.8	11.5
5.	1	7.8	7.0		2	7.8	6.5
	2	8.0	12.0		3	7.9	21.5
	3	8.4	73.0	13.	1	6.9	0.0
6.	1	7.4	0.5		2	7.3	3.0
	2	7.8	0.5		3	7.6	50.0
	3	8.1	1.5	14.	1	5.6	2.0
7.	1	7.2	0.5		2	6.4	0.0
	2	8.0	0.5		3	8.1	5.5

Profile		pH	% Carbonates	Profile		pH.	% Carbbnates
	Horizon				Horizon		
15.	1	6.0	0.5	21.	1	6.6	0.0
	2	6.6	2.0		2	6.1	0.0
	3	7.9	14.5		3	6.4	0.0
					4	6.8	0.0
16.	1	7.2	15.5	25.	1	7.1	0.0
	2	7.3	2.5		2	7.1	0.0
	3	6.7	3.5		3	6.7	0.0
	4	7.3	1.5		4	6.9	0.0
	5	-	12.0	27.	1	5.7	0.5
	6	-	9.5		2	4.6	1.5
	7	-	8.0		3	5.6	4.0
17.	1	7.9	3.0		4	8.1	11.5
	2	7.5	1.0	28.	1	7.7	-
	3	7.9	1.0		2	7.8	-
	4	8.1	8.0		3	7.9	-
18.	1	6.1	2.0		4	8.0	-
	2	7.7	1.5	29.	1	7.7	-
	3	8.6	11.5		2	7.7	-
19.	1	6.8	1.0		3	7.8	-
	2	7.6	2.5		4	7.8	-
	3	7.6	2.0	30.	1	7.7	-
20.	1	7.8	0.5		2	7.5	-
	2	8.2	0.5				

Profile		pH.	% Carbonates	Profile		pH.	% Carbonates
	Horizon				Horizon		
31.	1	7.8	-	38.	1	7.8	-
	2	7.8	-		2	7.7	-
32.	1	7.6	-	39.	1	7.5	-
33.	1	7.4	-		2	7.7	-
	2	7.6	-		3	7.9	-
	3	7.8	-		4	7.9	-
34.	1	7.6	-	40.	1	7.4	-
	2	7.7	-		2	7.6	-
	3	7.5	-		3	7.7	-
	4	7.8	-		4	7.5	-
35.	1	7.8	-	41.	1	7.5	-
	2	7.9	-		2	7.7	-
	3	8.2	-		3	7.6	-
36.	1	7.8	-		4	8.1	-
	2	6.9	-	42.	1	7.8	-
	3	7.2	-		2	7.9	-
	4	7.5	-	43.	1	7.5	-
	5	8.2	-		2	7.9	-
37.	1	7.58	-	44.	1	7.5	-
	2	7.6	-		2	7.7	-
	3	7.8	-	45.	1	7.6	-
	4	7.8	-		2	7.9	-
					3	7.8	-

Profile		pH.	% Carbonates	Profile		pH.	% Carbonates
	Horizon				Horizon		
46.	1	7.0	-	57.	1	5.7	4.0
	2	7.9	-		2	6.7	4.0
					3	8.3	2.0
47.	1	5.9	0.0		4	8.6	13.0
	2	6.3	1.5	101.	1	7.3	2.0
	3	6.6	1.5		2	7.8	1.0
	4	8.3	25.5		3	8.5	16.8
48.	1	6.3	6.0		4	8.8	17.5
	2	8.3	24.5		5	8.7	16.0
	3	8.6	28.0	102.	1	5.6	4.0
49.	1	6.4	2.0		2	6.7	4.0
	2	6.8	1.0		3	8.3	2.0
	3	7.0	1.0		4	8.6	13.0
	4	7.3	0.5	140.	1	6.0	2.0
50.	1	5.7	0.0		2	6.4	0.0
	2	6.1	0.5		3	8.2	5.5
	3	7.0	0.5				
	4	6.7	0.0				
	5	8.3	18.0				
52.	1	6.8	2.0				
	2	7.7	15.0				
56.	1	7.4	2.0				
	2	7.8	1.0				
	3	7.8	1.1				
	4	8.7	18.0				
	5.	8.7	16.0				

3. Organic matter, organic carbon, organic nitrogen, C/N ratios

Profile

Horizon		O.M %	O.C %	N%	C/N
1.	1.	8.12	4.72	0.35	13.0
	2.	3.18	1.85	0.19	10.0
	3.	1.87	1.09	0.11	9.0
4.	1.	9.00	4.57	0.51	8.0
	2.	6.17	3.54	0.34	10.2
	3.	2.81	1.61	0.16	10.0
	4.	0.36	0.21	0.01	15.9
5.	1.	5.24	3.05	0.35	7.5
	2.	2.37	1.38	0.14	10.2
6.	1.	4.66	2.71	0.28	9.7
	2.	1.54	0.89	0.01	128.0
7.	1.	8.89	5.17	-	-
	2.	2.72	1.58	0.10	15.0
8.	1.	12.73	7.41	0.16	46.2
	2.	5.36	3.12	0.39	8.0
9.	1.	5.92	3.45	0.34	10.0
	2.	3.92	2.28	0.22	10.0
10.	1.	7.70	4.48	0.31	14.4
	2.	4.69	2.73	0.27	10.0
11.	1.	5.04	2.93	0.31	9.4
	2.	2.35	1.34	0.14	9.1

Profile

	Horizon	O.M.%	O.C.%	N.%	C/N
12.	1.	3.44	2.00	0.23	8.6
	2.	4.75	2.77	0.09	28.0
	3.	1.40	0.82	0.03	27.3
13	1.	5.23	3.04	0.29	10.4
	2.	3.28	1.33	0.02	83.2
14.	1.	3.50	2.15	0.13	16.8
	2.	3.93	2.27	0.19	11.4
	3.	1.68	0.97	0.06	16.7
15	1.	2.72	1.56	0.12	13.0
	2.	2.36	1.37	0.08	15.9
	3.	1.98	1.15	0.05	20.5
16.	1	10.90	6.35	0.41	15.3
	2	6.38	3.72	0.34	10.9
	3.	30.0+	20.0+	1.13	-
17	1	7.65	4.45	0.41	10.7
	2.	2.84	1.65	0.17	9.6
	3.	2.78	1.54	0.08	18.7
18	1	5.40	3.20	0.25	12.8
	2	1.95	1.13	0.06	17.1
	3	0.87	0.51	0.03	14.5
19.	1	5.36	3.12	0.27	11.4
	2.	2.77	1.61	0.15	10.1
	3.	1.46	0.87	0.06	12.5
20.	1	3.72	2.16	0.16	13.6
	2.	2.06	1.20	0.07	16.3
21.	1	3.93	2.29	0.19	11.6
	2	2.49	1.44	0.12	11.1

Profile

	Horizon	O.M.%	O.C.%	N.%	C/N
21.	3.	1.29	0.75	0.06	12.2
	4.	0.99	0.58	0.04	14.4
25.	1	2.31	1.34	0.11	11.6
	2	1.15	0.67	0.07	9.8
	3.	1.94	1.13	0.06	16.9
	4.	1.58	0.92	0.08	11.74
28.	1	9.31	5.40	0.29	18.4
	2	3.93	2.28	0.16	14.4
	3.	1.34	0.78	0.07	11.2
29.	1	19.76	11.46	0.62	18.6
	2	6.93	4.02	0.28	14.4
	3	4.00	2.32	0.20	11.6
30	1	9.03	5.24	0.56	9.4
	2	7.77	4.51	0.36	12.5
31	1	14.60	8.47	0.52	16.3
32	1	7.02	4.07	0.28	14.5
33	1	14.68	8.52	0.92	9.3
	2	9.31	5.40	0.75	7.1
	3	8.74	5.07	0.45	11.2
34	1	9.00	5.22	0.52	10.0
	2	2.71	1.57	0.29	5.3
	3	5.02	2.91	0.21	14.2

Profile	Horizon	% O.M.	% O.C.	% N.	C/N
35.	1	7.86	4.56	0.43	10.5
	2	5.78	3.35	0.20	16.7
36.	1	11.0	6.38	0.38	16.8
	2	7.10	4.12	0.37	11.1
	3	4.88	2.83	0.20	14.1
	4	5.81	3.37	0.30	11.2
37.	1	4.40	2.55	0.30	8.5
	2	8.83	5.12	0.60	8.5
	3	8.22	4.77	0.23	20.7
38.	1	6.72	3.90	0.30	13.0
39.	1	15.72	9.12	0.60	15.2
	2	7.29	4.23	0.46	9.2
	3	3.47	2.01	0.18	11.2
40.	1	16.29	9.45	1.00	9.2
	2	11.59	6.72	0.63	10.7
	3	7.62	4.42	0.46	9.6
	4	3.76	2.18	0.48	4.5
41.	1	11.15	6.47	0.63	10.3
	2	8.93	4.60	0.34	13.5
	3	3.31	1.92	0.13	14.7
42.	1	10.74	6.23	0.41	15.2
	2	5.09	2.95	0.18	16.0

Profile	Horizon	% O.M.	% O.C.	% N.	C/N
43.	1	12.79	7.42	0.44	16.8
	2	9.81	5.69	0.51	11.2
44.	1	13.38	7.76	0.78	10.0
	2	10.03	5.82	0.57	10.2
45.	1	11.81	6.85	0.71	9.6
	2	6.57	3.81	0.45	8.5
46.	1	10.84	6.29	0.68	8.6
	2	9.88	5.73	0.63	9.1
47.	1	3.14	1.83	0.13	14.6
	2	1.75	1.02	0.08	13.4
	3	0.73	0.43	0.03	13.4
	4	0.32	0.18	0.01	20.0
48.	1	3.83	2.23	0.12	17.8
	2	0.23	0.13	0.04	3.4
	3	-	-	0.03	-
49.	1	1.62	0.94	0.07	13.1
	2	1.43	0.83	0.05	16.4
	3	1.11	0.64	0.03	19.6
50.	1	5.33	3.09	0.19	15.8
	2	1.53	0.88	0.04	24.2
	3	1.25	0.73	0.06	11.2
	4	0.13	0.08	0.01	5.14
	5	0.18	0.11	0.01	8.8
52.	1	5.28	3.06	0.33	9.2
	2	1.16	0.67	0.06	9.9

Profile	Horizon	% O.M.	% O.C.	% N	C/N
56.	1	5.42	3.19	0.25	12.3
	2	2.17	1.26	0.05	28.6
	3	2.13	1.21	0.01	118.1
	4	1.90	1.11	0.02	55.5
	5	2.20	1.28	0.01	75.5
57.	1	3.91	2.27	0.09	25.2
	2	1.77	1.05	0.22	4.7
	3	1.73	1.01	0.05	19.3
	4	1.60	0.93	-	-
101.	1	5.42	3.19	0.25	12.3
	2	2.17	1.26	0.05	28.6
	3	2.13	1.21	0.01	118.1
	4	1.90	1.11	0.02	55.5
	5	2.20	1.28	0.01	75.5
102.	1	3.91	2.27	0.09	25.2
	2	1.77	1.05	0.22	4.7
	3	1.73	1.01	0.05	19.3
	4	1.60	0.93	-	-
140.	1	3.50	2.15	0.12	16.8
	2	3.93	2.27	0.20	11.4
	3	1.68	0.97	0.06	16.7

.. Cation exchange data

Profile	Horizon	meq. per 100 gms. soil					% total meq.					
		Total	Na.	K.	Ca.	Mg.	H.	Na.	K.	Ca.	Mg.	H.
..	1	15.07	1.46	1.06	7.88	4.66	0	9.73	7.01	52.3	30.9	0
	2	9.44	1.31	0.69	5.18	2.26	0	13.91	7.32	54.8	23.9	0
	3	7.15	1.30	0.49	3.40	1.94	0	18.22	6.97	47.6	27.2	0
	4	3.19	1.02	0.11	1.55	0.50	0	32.02	3.42	48.7	15.8	0
..	1	25.82	1.65	0.55	21.53	2.08	0	6.39	2.13	83.4	8.0	0
..	1	16.19	2.13	0.87	12.12	1.06	0	13.15	5.39	74.9	6.5	0
	2	12.03	1.63	0.26	9.16	0.97	0	13.54	2.18	76.1	8.1	0
..	1	14.91	2.05	1.54	8.75	2.56	0	13.77	10.31	58.7	17.1	0
	2	9.43	1.64	1.46	4.66	1.66	0	17.41	15.49	49.4	17.6	0
	3	8.70	1.69	0.89	5.07	1.03	0	19.48	10.32	58.3	11.9	0
	4	4.08	1.32	0.11	0.15	2.49	0	32.47	2.81	3.6	61.0	0
..	1	14.56	2.21	1.96	8.60	1.77	0	15.21	13.49	59.1	12.2	0
	2	9.30	1.76	2.02	4.22	1.29	0	18.94	21.76	45.3	13.9	0
	3	8.95	2.23	1.47	4.08	1.16	0	24.95	16.47	45.6	12.3	0
..	1	10.23	1.98	1.14	5.37	1.74	0	19.33	11.13	52.5	17.0	0
	2	5.67	2.31	0.41	2.23	0.72	0	40.72	7.23	39.3	12.7	0
7.	1	14.58	1.99	0.93	9.71	1.95	0	13.70	6.37	66.6	13.4	0
	2	6.13	1.66	0.25	3.16	1.05	0	27.06	4.07	51.6	17.3	0
3.	1	18.62	2.00	3.02	11.69	1.75	0.15	10.11	16.24	62.8	9.4	0.55
	2	12.80	1.57	1.50	6.88	1.78	1.05	12.26	11.71	53.8	14.0	8.20
	3	6.32	2.08	1.41	0.91	0.93	1.0	32.88	22.29	14.3	14.7	15.82

Profile	Horizon	meq. per 100 gms. soil						% total meq.				
		Total	Na.	K.	Ca.	Mg.	H.	Na.	K.	Ca.	Mg.	H
9.	1	9.93	1.96	0.18	5.26	1.44	1.10	19.72	1.80	52.9	14.5	11.11
	2	8.32	2.00	0.15	3.54	1.51	1.20	24.05	1.88	42.6	18.2	14.43
	3	7.43	1.83	0.11	3.38	1.39	0.70	24.71	1.53	45.5	18.8	9.41
	4	6.63	1.58	0.07	3.49	1.40	0.11	23.82	1.17	52.1	21.2	1.65
10.	1	11.81	1.65	1.00	5.73	3.42	0	14.00	8.46	48.5	28.9	0
	2	12.21	1.31	0.51	7.13	3.26	0	10.69	4.17	58.4	26.7	0
11.	1	8.73	1.74	0.16	5.28	1.55	0	19.91	1.87	60.4	17.8	0
	2	8.32	1.26	0.05	4.60	2.41	0	15.14	0.59	55.3	29.0	0
12.	1	8.97	1.26	0.18	5.64	1.88	0	14.04	1.99	62.9	21.06	0
	2	6.59	1.26	0.11	3.60	1.51	0	19.41	1.77	55.5	23.34	0
	3	4.50	1.43	0.52	1.67	0.88	0	31.89	11.44	37.0	19.65	0
13.	1	7.61	1.87	0.15	3.93	1.65	0.90	24.55	2.02	51.6	21.8	11.82
	2	6.24	1.35	0.15	2.35	1.65	0.75	21.56	2.47	37.59	26.3	12.01
	3	6.69	2.17	0.19	2.15	1.58	0.60	32.41	2.86	32.13	23.6	8.96
14.	1	8.47	1.82	0.15	2.29	1.00	3.20	21.46	1.81	27.1	11.8	37.75
	2	8.44	2.09	0.10	3.20	1.84	1.20	24.75	1.21	37.9	21.8	14.21
	3	7.92	2.34	0.15	2.80	2.61	0	29.65	1.94	35.4	33.0	0
15.	1	8.16	1.65	0.16	2.92	0.83	2.60	20.25	2.01	35.7	10.1	31.83
	2	8.14	2.00	0.15	3.44	1.45	1.10	24.56	1.89	42.2	17.8	13.51
	3	7.21	2.65	0.15	3.25	1.44	0	36.80	2.13	45.2	15.8	0
16.	1	4.72	0.95	0.10	3.00	0.66	0	20.23	2.16	63.5	14.1	0
	2	6.11	1.65	0.15	3.70	0.59	0	27.06	2.51	60.6	9.8	0
	3	21.03	0.87	0.07	15.99	4.09	0	4.13	0.37	76.0	19.4	0
	4	8.74	0.83	0.10	6.22	1.58	0	9.49	1.16	71.1	18.1	0

Profile	Horizon	Total	meq. per 100 gms. soil				H.	% total meq.				
			Na.	K.	Ca.	Mg.		Na.	K.	Ca.	Mg.	H
17.	1	3.93	0.95	0.16	2.43	0.33	0	24.33	4.22	61.7	1.00	0
	2	9.82	0.78	0.89	5.80	2.34	0	7.97	9.11	59.0	23.8	0
	3	4.80	0.39	0.12	3.37	0.91	0	8.15	2.66	70.2	18.9	0
	4	6.47	0.82	0.10	4.00	1.54	0	12.76	1.54	61.9	23.8	0
18.	1	8.65	1.13	0.16	5.52	1.83	0	13.07	1.91	63.8	21.2	0
	2	5.02	0.78	0.11	2.84	1.28	0	15.59	2.29	56.7	25.4	0
	3	7.27	1.21	0.13	4.05	1.87	0	16.70	1.76	55.7	25.8	0
19.	1	4.35	1.39	0.18	2.43	0.35	0	31.95	4.13	55.9	7.9	0
	2	8.96	1.41	0.21	5.22	2.11	0	15.79	2.29	58.3	23.6	0
	3	8.50	1.39	0.22	4.53	2.36	0	16.37	2.55	53.3	27.9	0
20.	1	11.15	1.08	0.18	8.23	1.65	0	9.75	1.61	73.8	11.5	0
	2	8.15	1.43	0.16	5.72	0.83	0	17.59	2.03	70.2	10.2	0
21.	1	5.64	1.00	0.10	3.85	0.68	0	17.73	1.80	68.4	11.2	0
	2	7.09	1.17	0.10	5.66	0.16	0	16.54	1.44	79.8	2.3	0
	3	7.93	0.91	0.09	5.34	1.59	0	11.50	1.12	67.3	20.1	-
	4	5.86	0.91	0.11	3.36	1.48	0	15.58	1.96	57.2	25.2	0
28.	1	24.78	1.36	1.20	15.96	6.26	0	5.49	4.84	64.4	25.2	0
	2	18.48	0.92	0.29	12.75	4.51	0	4.98	1.57	68.9	24.4	0
	3	15.51	0.83	0.10	11.25	3.33	0	5.35	0.64	72.5	21.5	0
29.	1	29.13	2.22	3.62	14.44	8.86	0	7.62	12.43	49.5	30.4	0
	2	24.56	1.51	1.18	13.99	7.88	0	6.15	4.80	56.9	32.1	0
	3	22.83	1.70	0.58	14.85	5.70	0	7.45	2.54	65.1	24.9	0
40.	1	33.92	2.04	1.45	15.59	14.84	0	6.01	4.27	45.9	43.7	0
	2	30.23	1.80	0.98	15.89	10.56	0	5.95	3.24	55.8	34.9	0
	3	27.39	1.17	0.51	19.50	6.21	0	4.27	1.86	79.1	22.7	0

Profile	Horizon	Total	meq. per 100 gms. soil					% of total meq.				
			Na.	K.	Ca.	Mg.	H	Na.	K.	Ca.	Mg.	H
1.	1	29.35	6.89	2.54	12.00	7.92	0	23.48	8.65	40.8	26.8	0
	2	26.30	4.69	1.60	11.88	8.13	0	17.83	6.08	45.1	30.9	0
	3	22.17	1.72	1.12	11.50	7.83	0	7.76	5.05	51.9	35.3	0
2.	1	25.44	3.56	0.93	17.29	3.66	0	13.99	3.66	67.9	14.3	0
	2	22.83	2.52	0.39	16.69	3.23	0	11.04	1.71	73.1	14.1	0
3.	1	30.43	7.34	2.00	14.00	7.08	0	24.15	6.57	46.0	23.2	0
	2	25.45	8.09	1.46	12.13	3.77	0	31.79	5.74	47.6	14.8	0
4.	1	28.91	3.11	1.31	14.75	9.74	0	10.76	4.53	51.0	33.7	0
	2	27.00	1.72	0.33	13.88	11.57	0	6.37	1.22	49.6	42.8	0
5.	1	28.70	2.20	1.63	14.25	10.62	0	7.67	5.68	49.6	37.0	0
	2	22.61	27.0	0.63	13.86	5.69	0	11.94	1.59	61.3	25.2	0
6.	1	34.56	2.61	1.33	17.88	12.75	0	7.55	3.88	51.7	36.8	0
	2	27.2	1.43	0.71	15.88	9.15	0	5.26	2.61	58.5	33.7	0
7.	1	6.68	1.21	0.18	4.82	0.39	0	18.21	2.67	72.0	5.9	0
	2	6.21	1.44	0.17	4.11	0.49	0	23.09	2.88	66.1	7.9	0
	3	6.83	1.48	0.12	4.54	0.68	0	21.66	1.87	66.5	10.0	0
	4	4.92	1.22	0.08	3.36	0.27	0	24.74	1.56	68.2	5.5	0
8.	1	8.40	1.39	0.18	5.44	1.38	0	16.60	2.13	64.8	16.5	0
	2	2.58	1.61	0.16	0.80	0.00	0	62.41	6.43	31.1	0.0	0
	3	7.23	2.17	0.33	3.50	1.23	0	30.07	4.59	48.4	16.9	0
9.	1	6.88	1.34	1.15	4.03	1.35	0	19.57	2.22	58.6	19.6	0
	2	10.13	2.22	0.13	6.50	1.29	0	21.88	1.26	64.1	12.7	0
	3	10.06	1.75	0.12	7.46	0.74	0	17.28	1.27	74.1	7.3	0
	4	8.57	1.65	0.12	6.04	0.75	0	19.29	1.49	70.5	8.8	0

Profile Horizon	meq. per 100 gms. soil						% of total meq.				
	Total	Na.	K.	Ca.	Mg.	H	Na.	K.	Ca.	Mg.	H
50. 1	7.93	1.61	0.41	5.13	0.78	0.20	20.29	5.16	64.7	9.8	0
2	7.36	1.65	0.10	4.77	0.83	0	22.46	1.38	64.8	11.3	0
3	7.08	1.83	0.10	4.50	0.65	0	25.79	1.44	63.5	9.2	0
4	4.81	0.82	0.06	3.55	0.37	0	17.16	1.01	73.6	7.8	0
5	4.65	0.87	0.10	3.39	0.28	0	18.72	1.02	73.0	6.1	0
52. 1	12.57	1.21	0.18	9.23	1.94	0	9.68	1.42	73.5	15.4	0
2	12.31	1.17	0.14	8.17	2.82	0	9.53	1.14	66.4	22.9	0
56. 1	15.13	4.67	2.18	5.93	2.35	0	30.86	13.74	39.2	14.1	0
2	11.83	5.87	1.41	2.80	1.75	0	49.53	11.91	23.6	14.7	0
3	11.84	5.87	0.51	4.13	1.33	0	49.52	4.29	34.9	11.2	0
4	9.77	3.59	0.51	4.14	1.52	0	36.65	5.22	43.5	15.6	0
5	9.27	4.89	0.60	2.67	1.09	0	52.75	6.45	27.7	10.7	0
57. 1	9.68	4.07	0.48	5.02	1.11	0	42.04	4.91	41.4	11.5	0
2	10.93	4.24	0.54	5.10	1.05	0	39.15	4.94	46.7	9.6	0
3	15.63	8.04	0.68	5.00	1.91	0	51.00	4.38	32.3	12.3	0
4	12.60	5.54	0.58	4.27	2.21	0	45.52	4.76	41.1	8.5	0
P. 1	9.49	1.00	0.37	6.51	1.60	0	10.53	3.90	68.6	16.9	0
2	11.71	1.00	0.64	9.10	0.96	0	8.54	5.46	77.8	8.2	0
3	14.48	0.96	0.57	10.86	2.08	0	6.60	3.97	75.0	14.4	0
4	14.04	1.04	0.46	10.70	1.83	0	7.43	3.27	76.2	13.0	0
5	15.20	1.17	0.38	10.64	3.00	0	7.72	2.52	69.8	19.7	0
6	10.32	1.39	0.25	7.40	1.27	0	13.51	2.47	71.7	12.3	0

APPENDIX III. Farming System Classification.

~~There is a difficult~~ problem of definition involved in classifying farms according to the system adopted. Boundary lines between one system and another are almost impossible to establish. Not only is it impossible to obtain detailed information in terms of cash from many farmers it is also difficult to establish in general terms how much of a particular crop is sold off-farm or used as fodder on the farm.

The system of differentiation adopted was that of the Department of Agricultural Economics Newcastle University.

1. Livestock fattening with Cash Cropping.

The main source of output is in the form of livestock with thirty per cent or less of output from crops.

2. Cash Cropping with Livestock Fattening.

Cash Cropping assumes greater importance at more than thirty per cent of gross output.

3. Milk with subsidiary enterprises.

The contribution of milk to the gross output is twice that of any other single enterprise.

4. Mixed.

At least three enterprises including milk contribute fifteen per cent or more to the gross output.

5. Arable without stock .
6. Grazing without crops.
7. Miscellaneous.

Farms not included in 1 - 6.

Groups 1 and 2 are further subdivided according to the type of animal and the method of feeding. A summary of types includes:-

1. Fattening with Cropping.
 - (a) Stores fattened.
 - (b) Single suckled calves reared and fattened.
 - (c) Multiple suckling.
 - (d) Pail feeding.
2. Cropping and Fattening.
 - (a) - (d) as in 1.
3. Milk
4. Mixed
5. Arable.
6. Grazing
7. Miscellaneous.

APPENDIX IV

Summary of Selected Farm Studies

including all farms referred to in the text

FARM STUDY TWO

HESLOP. OLD CASSOP.

The farm

Until recently 219 acres, then 14 acres sold for sand quarry. All the land tilled. 60 acres 5th year grass for hay; 58 acres barley; 20 acres oats. A little wheat, the rest grazing.

Only one farm. Tenant on H.C.B. land. Worked here for 12 yrs. Previously a farm labourer within 10 miles.

Labour

None except casuals at harvest.

Machinery

One very old tractor (bad tyres), drills, discs, harrows, combine. No bailer, no drier.

Bought from Paxton, Young, Hepple. Combine biggest help since war. Last horse 5 years ago.

Soil

Drainage old and not very efficient. Some tile, some stone. Hedges not well kept because of lack of time, working so much land.

Lime occasionally low in clay. Potash very low especially in lower fields. Yields 1 ton max. barley. 30 cwts. max. wheat.

Crops

Attempt three white crops with roots. Now no roots. Potatoes fallen through but in any case clay land and heavy.

Sows at 12 stone to the acre. Tried less but failed. 7" drill width. Cross sown twice brought improvement.

Sells all crops immediately; none processed. Sow in the middle of April and later. Harvest late Sept. Oct. Always late because of amount of work. Supplied by English of Houghton. Pedigree seeds from Nickerson of Grimsby; No storage.

Top dress with high N. Cross bone May 25th. Some nitro-chalk. Top dress grass with Cross Bone high N. Occasional barley smut.

Animals.

Out of dairying three years (12 Ayrshires). Many misfortunes including grass staggers.

Now let grazing. 38 on farm from Castle Eden and Tursdale. In winter let sheep grazing. About 100 ewes from Northumberland and local. Few Poultry for self.

Buildings

One 24 stall byre. 2 barns for storage and cattle. 1 granary. 1 old farm house. Most buildings old but added to since took over. Stone and brick. New farm house.

Agencies

Spares as mentioned and at Darlington. Sell corn to English of Houghton. Attends no markets.

Amenities

Mains electricity, water, sewage, Bus ½ mile away 2 hrs. Shop school Thornley. Extras Durham. Dry year by far best (much clay land)

Arable without stock.

FARM STUDY THREE

PILMORL FARM, OLD CASSOP.

The Farm

233 acres. 67 acres grass for hay.
 43 acres grazing including 11 acres rough
 85 acres corn; wheat - 6 acres : barley - 58 acres
 oats - 22 acres.

12 acres roots. potatoes - 4 acres : turnips - 8 acres.

16 acres rough.

Owner since this April. (Late Church Comm.) One farm. 12 years as tenant. Previously farm work at Castle Eden.

Labour

One hand, 23 yrs., Thornley, stable.

Machinery

Two tractors, 1962 and 1964. Power take-off combine, drier, bailer, elevator, grass mower, tedder, turner, binder, disc harrows, combine drill, other drills, rollers. Well maintained on the farm.

"Hydraulic system best thing in machinery since war". Ploughing up and down steep slopes.

First tractor in 1942. Last horse 1950 but little used in late years. Kept only to keep labour happy.

Machinery very high proportion of investment.

Soil

Drainage during war-pipes and some very old stone drains. Fencing hedges supplemented by barbed wire, pig-netting, straight wire and occasionally electric fence.

Potash was very low throughout particularly on clay land. In dry year clay best in wet year limestone area best.

Crops

3 yrs grass, 4 years corn on clay, 4 yrs. corn and then roots on lime. Followed grass with winter wheat for this year and failed through wire-worm. Believes in and maintains and plans rotation. Yields recently 1 ton then added high N. fertilizers to get extra 5 cwt. Nitro chalk 21% N. top dressing with some Cross bone. Using stored benefit of many years compound dressings. Potatoes sold off immediately (no storage). Corn sold at regular periods to give regular income. As much as possible stored. Turnips used on farm. Hay sold completely. 1/10 crop processed on farm for beasts. Sowing period 13 - 22 April. Main period clover sown 2nd May field resown 6th May. Harvest last year 8th Sept. combined. Sometimes go on into Oct.

Seed supplied by English of Houghton. Seed potatoes from Timperly in Cheshire. Sell to English, Northern Farms and Foster and Armstrong. Capelle wheat, Pallox Aster oats, Varda Freja barley. Cross bone No.1. Cross Bone no.1. Fisons 52. Top dress and surplus on grass & rough. Storage in bins of own construction in wood. Only trouble this year with wire worm.

Animals

1 cow for own milk.

23 bought in locally (Mr. Bell) occasionally at Hexham. Bought at 6 months and onward and mainly Friesians and HerefordX.

Sheep 50 old ewes from Scotland kept two years. Sell lambs fat in June till finished. At Castle Eden.

Sheep out all year but hand fed. small proportion concentrates. Clip and sell. Dutch Barn recent, rest of buildings very old but well kept. 3 byres 8, 6, 4 stall, loose boxes, rough assortment giving reasonable but not quite sufficient space. Layout almost chaotic.

Agencies

Maintain own machinery. Buy at Paxtons and Hepples.

Amenities

All mains. Durham chief town for shopping and banking.

Special considerations

Pitfalls filled in not as serious as some.

Classification

Cropping with fattening stores.

down badly drained. Hedges well kept. Some ploughed out and pay to take out more. Thinnest soil very poor, rest good average. In wet lime soil best; in dry, clay.

Crops

4 grain (oats, 2 yrs. turnips; barley) 3 yrs. ryegrass. Occasional wireworm. Barley yields 30 cwt. to 2 tons except on thin soil. Wheat 2 tons. 10 tons oats and barley fed with concentrates on farm. 80 - 90 tons dried and sold immediately. Floor storage. Sown by end of April. Start in March. Harvest finished by the end of Sept. Compound fertilisers and top dressing of Nitro chalk. Top dress grass. Strip graze. No serious failures.

Cattle

Dairy herd. 20 + followers 20 or so.

14 in milk. Friesians and Ayrshires. X with
Angus A.I.

Flying herd. Calves all off at 18 months for beef. Wellfield CWS collects milk. Strip graze 3 yr. ley or 1 yr. ryegrass. Wintered in open hemmels. Cows tied in byre. Concentrates in winter high protein at 1/4 with own fodder. Vita milo conc. No disease. No sheep. 1 pig. 2 - 50 hens for door sale.

Buildings

Well equipped with barns and storage and new barn to be built.
Half new and rest old in brick and stone. All have been modernised.

Agencies.

Own servicing and local. Buy and sell at Hexham.

Amenities

Mains water and electricity, private sewage. Regular bus service.
Shops at Kelloe and Durham.

Classification

Tillage and milk are equal. Mixed.

FARM STUDY FIVEBELL. OLD CASSOP.The farm

200 acres with only 90 - 96 tillage.
20 acres wheat,
25 acres barley
7 acres turnips,
6 acres potatoes.
c 30 acres oats

Rest rough pasture and seeds.

Only one farm in family for 92 years. Present farmer took over in 1948. Land belongs to the Church Commissioners.

Labour

Two men and one boy, all from within one or two miles. Stable.

Machinery

2 Nuffield tractors with usual gear. No combine, no drier. Last two horses used 20th May 1964 and sold 24th May same year.

Soil

Drainage bad in Cassop vale but although flooded sometimes below Silent Bank the water clears rapidly. Some tile drains.

Fencing mixed - hedges supported with fence and barbed wire. Best maintained in district.

Crops

Two or three whites and then seeds. Wheat, oats, roots - or-seeds. Best field where clay and limestone soils mixed and adequate depth, e.g. behind farm buildings on the upper slopes and down below Silent Bank.

1 ton to 25 cwt. wheat with 30 cwt. very occasionally.

About half used on farm and the rest sold. Sold all hay last year at a good price and bought some in cheaper.

Started to sow 1st April then delay but finished by middle of April and potatoes in in May.

Harvest last year late. Finish 13th Oct. because some oats failed to ripen. Usually Sept. Oct.

Supplied by English. Dixon Brown for potatoes and clover. A few pedigree. New seed potatoes every year. Capelle wheat, Blonda oats, Proctor barley. I.C.I. potato fertilizer and Fisons used all over with a little Cross bone. Oat eel worm about 10 yrs. ago. Wire worm when ploughing out old pasture but now cleared.

Animals

Main occupation dealer on quite a large scale. Large turn over of cattle. Over 200 beasts in a month. Tries to buy fat but not always. Sells fat. Buy if possible locally to avoid auctioneers fee. Then Scotland, Ireland and Hexham. All markets in fact used. Less sheep than cattle.

Buildings

Mainly very old. Some solid some delapidated. Wood and brick with some stone. Not well designed and lay out chaotic. Storage very limited. Buildings not very well maintained.

Amenities

Mains water, and electricity since 1956.

Classification

Cattle and sheep dealer with arable.

FARM STUDY SIXSTEETLY FARMS OLD WARRINGTON

Total of 800 acres with 200 acres actually on the limestone. Bought out by quarrying company within six years. All grass for varying sheep and cattle. Very badly affected by pitfalls. Lost three sheep that week.

350 acres arable in the bottom.

Buildings not adequate. Drier, combine, 5 tractors. 8 men mainly local.

2 tons grain. 10 tons. potatoes.

FARM STUDY SEVEN.CASSOP DEAN HOUSE FARMThe Farm

162 acres. 30 tillage, 20 barley, 10 oats, 8 turnips,
2 - 5 potatoes, 20 rough.

Rest ploughed and seeded for up to five years.

Owner for six years. Previously at Quarrington Grange till
sold to Steetly.

Labour

Two local, 35 and 20.

Machinery

2 tractors, baler, 10 combine, no drier. Not a high
proportion of investment in machinery.

Soil

Bottom land not well drained. 10 tiles. Low well kept hedges
with supporting wire. Some hedges pulled out. Potash low. 10 lime
deficiency.

Crops

No fixed rotation. Barley sown at 9 - 10 stone, yield 30 cwt. Wheat yield 25 cwt. Oats sown at 13 stone.

Sow early April, harvest late September. Use most of the crop on farm. Use any seed including own.

Storage on floor. Use slag consistently, I.C.I. 52 and a little Cross Bone but not favour. Top dress but very little Nitro-chalk. No trouble with crops.

Animals

Dealer. Sheep more than cattle. 100 ewes lambing and sell off when ready.

Cattle any breed, stores and fat beast. House most in winter.

Buildings

Adequate. Byre new others quite old. No really modern insulation.

Agencies

Paxton for servicing. Haswell and Castle Eden for fat cattle. Darlington and Hexham for stores and occasionally Sp. Auckland.

Amenities

Water and electricity mains. New house. Shopping local with a little in Durham.

Classification

Fattening and cropping stores and sheep.

FARM STUDY SEVENCORBIE FARM HARTLEPOOL ROAD THORNLEY-CASSOPThe Farm

45 acres. 9 acres wheat
 6 acres oats
 4 acres barley
 2 acres roots. turnips
 24 acres down to seeds 3 - 4 yr.

Owner for 9 yrs. farm work for 12 years local.

Labour

Works farm alone.

Machinery

Combine, baler, tractor, with gear. Drier possible next year. Never use horse. Very high investment in machinery.

Soil

Generally medium loam. Near the farm buildings limestone near the surface and outcropping. Fields have no special drainage as lie on good slope. Hedges very well maintained supplemented with electric fence.

Potash may be low. Quality of land similar throughout.

Crops

No rigid rotation. Depends on finance, the price of seed, the market and the previous crop. Tries to clean regularly and to obtain plough out subsidy. Barley sown at 11½ stone yields 30 cwt.

Wheat 30 cwt. All grain kept till the price is right. 1/3 used on the farm. Sow 2nd week April. Harvest late Sept. early August.

All pedigree seed Barley Falles, wheat Capelle, oats Blenda, Condo seeds. Floor storage adequate for needs.

Cross bone fert all time; High K and high P.

Follows grass with wheat with success. Three yrs. ago take all in wheat.

Animals

Fattening on average 20 stores. Occasionally rear calves. Strip graze. No sheep. Thinking of trying this winter. Pigs, 4 - 5 sows with litters. Poultry 300 in battery.

Agencies

Paxton for servicing. N Farmers take seed. Haswell, C. Eden marts. Darlington for pigs.

Buildings

All old but re-roofed and modernised since came. All very well maintained. Perhaps short of barn for hay.

Amenities

Main road. Mains amenities. Mobile shop and Thornley.

Classification

Cropping and fattening.

FARM STUDY LIGHTHILL TOP FARM QUARRINGTON HILL, CASSOPThe Farm

95 acres in total. 65% returned. 13½ rough grazing, 26½ waste.

Barley 16½ acres.

Oats 4½ acres

Turnips 1½ acres

Cabbage 1½ acres

Potatoes 1¼ acres

Rest of the 65½ acres in grass.

Only one farm, owned, in family for 40 yrs.

Labour

Farmer and son. Casuals at potato picking time.

Machinery

2 tractors, combine, baler, drier, all usual tractor gear. Supplied by Paxton and Tipton and Morley of Newcastle. Best improvement has been the combine drier system. The baler has saved on labour. Last horse 3 years ago. A very high proportion of investment in machinery.

Soil

Lower land tiled but the drainage is still poor. Subsidence has seriously disturbed and ruined the tile system. Hedges and fences with barbed wire and pig netting. Potash generally fairly low. No lime deficiency save in the bottom land which has received corrective doses.

The heavier clay land yields the best by far in dry years when it is earlier because it has stored water and the lighter land is dry too long.

Crops

3 corns followed by roots. Oats, 2 barley, potatoes or turnips. Then into first year ley. Barley, Pallas sown at 13 stone in wet gives 38 cwt. per acre. Oats, Condor at 11 stone give 30 cwt. Most is sold after storing for the right price. Use $\frac{1}{3}$ on the farm. Sown normally in the first week of April, this year the third week. Harvest late September since using combine. Earliest ever 1941-2 13 Aug. All approved field seed from Northern Farmers. Stored in sack. This year bins to be bought. Fertilizers - Barley, High N Fisons 52.3 cwt: Grass grazing 52.2½ cwt + FYM: Hay, 51.2½ cwt: Potatoes (Arron big) 51.20 cwt.: Turnips, Fisons 45.4 cwt.: Cabbage, 52.4 cwt.

No real diseases but slugs a serious pest.

Cattle

Dairy herd of 15 mixed breeds, mainly Friesian. 9 in milk. Strip graze with a back fence to allow recuperation. Brought in for whole of winter. Concentrates. Sell off bull calves straight away. Buy odd cows but rear most on farm. Wellfield C.W.S. collect milk in

churns. No diseases. No sheep. Poultry for own use.

Buildings

Mainly old but modernised periodically. Room for everything except straw, therefore in fortunate position.

Agencies

Teeside Farmers and Northern Farmers take most of the grain.
Darlington mart.

Amenities

Water and electricity mains. Delivery from the village but bigger things from Durham.

Special Considerations

Pitfalls apart from destroying drainage also cut off about 10 acres of reasonable land and prevent even grazing. One is recorded as 130 yds. deep at least.

Classification

Mixed.

FARM STUDY NINECARRS FARM TOM KELLORThe farm

166 acres: 97 barley
 8 oats
 10 potatoes
 4 kale
 10 woodland

Owms and works this farm for 1 yr. as well as working two farms for father at Low and High Kaisy.

Labour

1 man living on the farm.

Machinery

2 tractors and gear with drill rest of machinery borrowed from father. Share in combine and drier on other farm. As yet not very much invested in machinery.

Soils

Needs drains cleaning because water from steep slopes floods lower fields. Started last 30 yds. of top field but effect not yet

assessed. Hedges very old and unkempt. Field L low in P. and K. Field X is the best.

Crops

No system yet established. Barley at 9 stones yield 15 cwt. after very late sowing. May. This year at 12 stone. Field approved seeds from Fowler and Armstrong. High N fertilizer Fisons 52. Low storage at present.

Cattle

9 cows Dairy. Ayrshires. Ordinary grazing but will strip when established. C.W.S. collect milk. 73 ewes and 2 tups. Very old and to be sold off and abandoned this year.

Buildings

Very old, solid but unsatisfactory.

Agencies

Seed from West Cumberland Farmers and Forells. Markets Sedgefield and Darlington.

Amenities

Mains water and electricity.

Classification

Mixed with emphasis on arable.

FARM STUDY TENKELLOE LAWThe Farm

16 acres + 5 acres round the disused colliery.

50 acres barley

50 acres grazing leys.

50 acres silage

Rest permanent pasture.

One farm only. N.C.B. land. Farmed since 1945.

Labour

One man living on farm. 25 yrs. old.

Mechanisation

2 tractors with gear. Combine, drier with bins, baler. Combine bin system biggest improvement but system towards easier labour saving practice has obscured much of the influence. Horses still on farm but pensioned off. Not a big proportion of investment in machinery.

Soil

Drainage only moderate damaged by subsidence but not bad enough to stop ploughing. Sink hollows rather than cracks. Hedges with

fencing and wire. All in good condition. Two fields of thick soil need lime.

Crops

Worked round in five years. Wheat, 34 cwt: barley 32 cwt. Books kept and costed. Sell $\frac{1}{2}$ keep $\frac{1}{2}$ (40 tons + 40 tons) Likes to sell before December 25th. Sow in first 20 days of April. Harvest late September. Pallas and Varca barley. Stored in two 25 cwt. bins. 30 tons I.C.I. No.2 fertilizer. Basic slag. Top dress with nitro-chalk. No trouble now but gave up wheat because of persistent take-all.

Cattle

Single suckle cows. 12 with calves and 4 heifers in calf. Attempting to twin for 8 - 10 weeks because not much profit in single suckled. Rear 40 - 50 by pail. Angus x Shorthorns. Cows grazed on permanent pasture. Use large amount of concentrates. House all in winter except cows. Rear own replacements. Own bull. Sell before 18 months but aim to keep one year only. New Forest disease at present prevalent (Blindness). 100 ewes at 2,3,4,5 years old. Sell in August as stores. Fits in with the grazing capability. Sell at Hexham and Tow Law. Mules. Clip own. Left out in winter. Swayback. Fed on silage and barley in winter. No pigs. Few hens.

Buildings

New and solid, N.C.B. but inconvenient and facing wrong way.

Include Ganary and stone barn for 1000 bales.

Agencies

Paxton for servicing and Dixon, Brown Tates. Harts Hexham and Tow Law. Castle Eden, Stockton fat stock.

Amenities

Mains water and electricity.

Classification

Fattening with cropping single suckle stores and fat and multiple and pail fed.

FARM STUDY ELEVENWINGATE HOUSE FARMThe Farm

1 = 160 acres rented from late Bishop Wilkinson.

2 & 3 = 126 acres N.C.B. land.

Three farms worked. 30 - 40 acres wheat normally but not

always able to sow and the barley rises in acreage correspondingly. 50 - 60 acres barley or more when wheat is low. 20 - 30 acres oats once about 40 acres. 18 acres potatoes. 10 acres roots. Farm 1 in the family for three generations. 2 & 3 worked since nationalisation.

Labour

4 men. 3 locals, one travels. Stable. Casuals at potato picking and thrashing.

Machinery

3 tractors, combine/drier, combine potato planter, baler, usual gear. Supplied by Paxton and Teesside Farmers. First tractor 1936, combine 3 - 4 yrs. Still rents horse for drilling turnips. Last horse sold last year. High proportion of investment in machinery. Too much as locked away for much of the year taking valuable store space.

Soil

Drainage affected by active subsidence. Mainly old but kept running and well-maintained. Fencing mixed but well kept. Because of fertilizer practice P & K are high. Lime regularly all but land near limestone. Fisons 42 16:10:10 on corn drilled at 2½ cwt. or sometimes 3 cwt. Potatoes get 8 cwt. down the spout of compound

and FYM. Swedes 8 cwt. 18% K broadcast plus basic slag. Very little top dressing and N. Chalk. Grass high N compound on new leys. All muck ploughed in at the end of a ley.

Crops

Plough round the farm in 4 - 5 yrs. then 3 - 5 yr. ley except where cannot take the stock (isolated N.C.S. land) where 1 yr. mixture. Barley Field approved or use own dressed seed sown at 10 st. yield 30 cwt. Wheat Champlin, sown at 12 st. yield 30 cwt. and sometimes more. Oats Field approved and own sown at 12 st. yield 30 cwt. All wheat sold after storing for best price. Half the barley sold in Autumn. Half the oats sold. The rest of the barley and oats sent to Teeside Farmers where compounded into cake for use on the farm. Sow last week in March and the first two in April. 1964, 7th April to 19th April main sowing then wet. Harvest late Sept. Oct. Storage on the floor.

Cattle

Fattening. Shorthorn X Angus, Friesian or Friesian X Hereford. Bought in and multiple suckled. Have had 100 on the farm but 80 better. Calves sold from 12 months onward. Breed own replacements. Angus bull. Ordinary grazing. Marts Castle Eden, Stockton, Sedgerfield.

Sheep

60 ewes 2 tups. Suffolk. Sell when ready throughout the season, all fat.

Pigs.

Went out of pigs but starting again with 12 Large White X Landrace, in a new unit. On farm 1. Intention to sell as weaners.

Poultry

200 deep litter.

Buildings

Mainly old with bad design. New ones needed. Built drier house self.

Agencies

General.

Amenities

Electricity and water mains. No sewage. All machinery electric including infra-red lamps. Main shopping local but bigger things from Darlington.

Classification

Cropping with fattening, multiple suckled.

FARM STUDY TWELVEKELLOE HALL & HOLE HOUSE FARMSThe Farm

300 acres. 270 returned. Barley 104 acres; Oats 24 acres; wheat 36 acres; Kale 1 acre; Turnips 4 acres; Potatoes 20 acres; Seeds the rest; Rough 47 acres. Both farms worked as one unit. N.C.B. land farmed since 1936.

Labour

3 living on the job. Difficult to replace. Casuals for potatoes and turnip hoeing.

Machinery

4 wheel tractors and one crawler. Normal gear. Combine, drier, baler, thrasher. Machine milking. Supplied generally spares from Paxton. Combine drier system the best thing since the war. Last horse 4 yrs. ago. Large proportion invested in machinery.

Soil

Drainage. 1 wet field marked, due to subsidence. Rest good. Not seen any tiles. Fences general.

Fertilizers: Spring corn - Fisons 52 at 2½ - 3 cwt. drilled.
 Winter corn - low N top dress in spring N chalk.
 Oats - High P
 Potatoes - high K at ½ ton.
 Grass 1st and 2nd year high N compound, last
 year nitro chalk.
 Lime every 7 yrs.

Crops

4 - 5 whites and may never see potatoes. Hole House. 2 corn,
 3 yr. seeds, roots. May follow grass with wheat. Field approved seed.
 Barley at 12 st. yields 35 cwt. to the combine. Wheat at 12 - 13 st.
 25 cwt. last year but generally 30 - 35 cwt. Oats 30 cwt. Potatoes
 7 - 8 tons. Not at Mole house since farm buildings taken over by
 M.J.B. for tipping. Use only oats on farm with concentrates. Rest
 sold off if possible after keeping till February.

Sow mid-March to April. 10 acres of potatoes in February. Harvest
 late Sept. 1959 finished 2nd Sept. Really short of storage. Room
 for 120 tons on floor and in bins. No trouble.

Cattle

Dairy. Two herds at present - Ayrshires and Friesians but going
 all Friesian. 40 cows with 30 in milk. Wellfield C.N.S. collects.
 Started rearing own replacements. Previously sold off after subsidy

time. Strip graze with one fence. Winter in byre. A.I. All clear.

Sheep

100 ewes. Scottish X Suffolk tup. Sell all lambs when ready throughout the season. Sell at Sedgfield. Sell stores at Hexham and Darlington.

Pigs

No.

Poultry

Few for farm use.

Buildings

Mainly old but well maintained. Replacement byre being built in lieu of Hole House buildings.

Agencies

Main road. Mains electricity and water. Travelling shop. Darlington at mart time.

Classification

Mixed with emphasis on milk.

FARM STUDY THIRTEENSOUTHERN LAWThe Farm

186 acres + 30 acres at Acre Ligg (all barley and to be abandoned this year).

Wheat 36 acres, Barley 56 acres, Oats 7 acres, Potatoes 16 acres, Roots 4½ acres, Grass 66 acres. At present two farms, N.C.B. land. Started here in 1953. Previous owner went bankrupt.

Labour

One man and one boy ... local. Easy to find labour.

Machinery

Combine and last year drier. 3 tractors with usual gear. Combine/drier system best thing since war. Machinery is certainly the biggest single investment since the war.

Soil

The limestone soil and loams drain themselves. One or two clay fields with clay partially drained. Could improve a lot with drainage. Post and barbed wire fencing. Completely refenced since took over as no fences previously.

pH as low as 3.9 on clay land. Mostly down to about 5. P & K all low.

Wheat good on heavy land and barley. Barley good on the limestone. Loam best for all yields.

Crops

Variable rotation. Wheat, barley, roots, 2 corn, 1 yr. ley. Barley sown at 12 - 13 st. yields 30 cwt. Wheat at 12 st. yields 2 tons. Oats 25 - 30 cwt. Potatoes 9 tons a good crop. Keep 8 - 10 tons on farm. The rest sold straight away but since conversion may store till price is right.

Sown in early April Harvest mid-September. Seed supplied by Foster and Armstrong. Sack storage. Recently a new place built for storage so now adequate. Fertilizers: Barley, Fisons 52 20:10:10 drilled at 2½ - 3 cwt. ; Wheat, 6:15:15 on top in autumn and top dressed with Nitro-chalk; Grass 20:10:10 at 5 cwt. in spring or if clover Nitro-chalk. No trouble except weather.

Cattle

Gone out of dairy cows in the last 6 months. Had 20 Friesians in milk. Now beef. Friesians and Friesian X. Buying in calves at present at 4 - 5 months for fattening. Brought in for winter and fed on barley, and oats. No fixed age for selling. Still has 7 Friesians heifers of old dairy herd.



Sheep

No.

Pigs

No.

Poultry

No.

Buildings

All new and well arranged. Built by N.C.B. with a new farm house and cottage.

Agencies

Paxton. Fewsters for Fergusons. Dalton of Mainford for corn. Marts. Darlington for stores. Castle Eden for fat.

Amenities

½ mile to main road. Mains electricity. Gravity feed water. Shopping local at Trimdon larger things from Sunderland. School at Trimdon.

Classification

Cropping with fattening.

FARM STUDY FOURTEENLOW RAISBY AND HIGH RAISBYThe Farm

430 acres and 20 acres rough. Barley 135 acres; wheat 20 acres; Oats 20 acres; Turnips 7 acres; Kale 7 acres. Two farms worked as one unit with a few acres of isolated N.C.B. land in the same unit.

Low Raisby N.C.B. farm. High Raisby, Raisby Hill Quarry Co. 15 acres separate grazing land belonging to the N.C.B. High Raisby worked for 25 yrs. Low Riasby for 12 yrs. N.C.B. for 30 yrs.

Labour

7 Coxhoe, Kelloe, Trimdon. 2 left this year but easy to replace. Very few casuals.

Machinery

5 tractors with usual gear. 2 bag combines and drier, baler, 2 corn drills forage harvester, grass cutter. Binder and 2 green crop loaders no longer used. Mill and spin fertilizer distributor. Machinery supplied by Teeside Agricultural Engineers and Hepples. Unused machinery not sold off because of present low prices. Combine/drier system has been the biggest improvement since the war. Once it took 30 men to take the harvest. Now no casuals are employed.

Still have horse which was last used in the previous year and in the winter for silage. A very high proportion of investment is in machinery.

Soils

The land marked on the map next to Kelloe Hall farm has been drained and this year a further field is to be drained - marked wet. The rest is free draining. Fields are mainly bounded by hedges which are not in very good condition. Of special interest in the soil is land on the top farm which has been used for gardens and allotments and treated with ashes for a long time. This land is very light and can be ploughed at any time.

Crops

The system attempted is simply to put the roots in the dirtiest fields. A rotation has been planned on the following lines:

200 acres 2 yrs grass 4 yrs corn.

150 acres 3 yrs grass 3 yrs corn.

At present at best the system is a few years grass and a few years corn with the occasional cleaning crop.

Using own seed Barley sown at 12 st. yields 20 cwt. and very rarely 30 cwt. Wheat at 12 or 9 st. yields 20 cwt. Of the grain $\frac{1}{3}$ kept the rest is sold after storing for the best price. Storage is loose in buildings. A new building has recently been erected for

the job. Sowing varies from March to April, but the light land is usually sown in March. Harvest in August when sown early but more normally September.

Fertilizers: 3 cwt. Fisons 52 on the corn; 3 cwt. Fisons 51 on the grass; Wheat Fisons 51 then top dressed in spring. The only trouble is from leatherjackets.

Animals

Dairy herd. 100 cows (55 and followers). Ayrshire X Friesians and Ayrshires. Angus bull for heifers A.I for cows. 42 in milk. Wellfield C.W.S. collect. Bull calves sold off. Rear own replacements.

Sheep

100 ewes. Mules. Sell off lambs when ready. Clip own.

Poultry

300 in battery cages to be transferred to Carr House Farm (on the map)

Buildings

All except one old and rather inconvenient.

Agencies

Corn to Cumberland Farmers and Morelles. Sheep bought at Tow Law

and sold at Sedgefield and Stockton. Bull calves sold at Darlington and privately.

Pigs

20 for fattening. Sell at Sedgefield and Stockton.

Amenities

Main road. Mains water and electricity. Shopping - mainly delivered but Darlington for big things when at Market.

Classification

Mixed with $\frac{1}{2}$ return from milk and $\frac{1}{2}$ from crops.

FARM STUDY FIFTEEN

THORNLEY NOOR FARM

The Farm

128 acres: Barley 48 $\frac{1}{2}$ acres; wheat 23 $\frac{1}{2}$ acres; roots 4 acres with cabbage; Leys 22 acres; Permanent grass 11 acres. One farm only. 1964 the fourth year working it. Previously farmed at Ferryhill. N.C.B. land in a very dirty condition when took over.

Labour

1 man local.

Machinery

Well mechanised in land machinery but not so much on labour saving around the farm machinery. 2 tractors with usual gear. 1 combine/drier, 1 baler. Very high proportion of investment in machinery. Never used horse on this farm. Elevator perhaps the greatest improvement in that it has saved a great amount of lifting by hand.

Soils

On top near the limestone the soils are free draining. In the lower heavier land, Brickworks fields, the clay is badly drained although there are tiles down at about 3' 6" to 4'. This would seem to be too deep. Mole draining would help a lot. Fencing is mixed and some of it is poor. No electric fencing. Deficiencies. On the whole the drier side of the farm gives the best yields.

Crops

Rotation. See soil analysis figures. Potatoes and roots, wheat, barley, ley, barley. Yields: Barley 28 cwt; Wheat sown at 2 cwt yields 30 - 35 cwt; Roots good; Potatoes 8 - 10 tons. Potatoes used mainly Peaks with Dr. Mackintosh, Ulster, Supreme, Home Guard. Uses own seed and field approved. Opal spring wheat. Bought from

Northern Farmers, Ferrens or AOT. Sells all wheat after storing on the floor till March.

Fertilizer: 4 cwt. 15:10:10 (I.C.I.) on corn
 10 cwt. 10:10:18 on potatoes.
 10 cwt. 10:20:20 on roots
 10 cwt. 15:10:10 on cabbage
 5 cwt. 10:10:18 on leys then top dressed with
 S. Ammonia.

Basic slag used on permanent grass and on leys in autumn. Only trouble rather patchy take-all but this field rested from wheat. Perhaps not so bad because use spring wheat and not winter variety.

Animals

Cattle 18 fattening stores various.

Pigs 163 buy stores and fatten in two pens. More restricted for finishing. Mainly in the open with cover. Feed for animals is a mixture of 1 ton concentrates with barley.

Poultry just a few for own use.

Buildings

1 drier/store new. The rest is very old, but all have been improved and some completely converted. Sufficient for the present and not worth investing in more especially as this is a tenanted farm

Agencies

Paxton, Teeside Farmers, Ferrens. Marts. Buy cattle at Darlington and pigs privately. Sell fatstock at EMC Darlington. Pigs sold fat at Carlisle.

Amenities

½ mile to the main road. No fields restricted all accessible. Mains electricity for the last three yrs. Mains water. Shopping at Thornley and Cassop. Bigger things at Darlington.

Classification

Fattening with cropping. Stores and pigs.

FARM STUDY SIXTEENTHORNLEY HALL FARMThe Farm

362 acres: 85 acres Barley; 21 acres Wheat; 27 acres Oats; 21 acres Potatoes; 18 acres Swedes, rape and kale; 9 acres Fallow; 65 acres seeds. The rest permanent grass. One farm worked for 27 yrs. N.C.B. land. Rent increased considerably this year.

Labour

3 with a boy, all local. Casuals for potato and harvest.

Machinery

Combine/drier, baler, 4 tractors (1 in very bad condition) with usual gear. Combine drier is the biggest labour saving system since the war. Last horse used in 1958. Large proportion of investment in machinery.

Soil

Mostly free-draining. Hedges, post and wire, fencing all mixed. Potash low occasionally. Where the soil is thinnest less crops. Serious subsidence and pit-falls still active in the more easterly section of the farm, near the Hartlepool road.

Rotation

3 whites, roots or seeds. e.g. Cassop Field - barley, oats, seeds, potatoes, wheat, barley, swedes, oats undersn.; Marley Hill - wheat, rape, oats, wheat, 4 seeds, oats. Oat eelworm and a little potato disease in this field. ; 16 acres - oats, seeds, potatoes, wheat, oats, swedes, barley, oats, seeds.

Barley Field Approved	sown at 11 - 12 st.	yield 28 - 30 cwt.
Wheat Capelle	sown at 10 st	yields 30 cwt. once 35 cwt.
Oats		20 - 25 cwt.
Potatoes ½ redskins, ½ Mackintosh and Peaks		6 tons.

Use a high proportion on the farm but sell 150 tons waiting for the price. Early April sowing, Harvest second half of Sept. and early Oct. Generally supplied with seed. Stored on the floor in old byre and horse boxes.

Fertilizers: corn 15:10:10 I.C.I. No.4.

Potatoes I.C.I. No.1.

High N on three yr. seeds.

Ammonium sulphate on 1 year ley. Very rarely top-dress with NitroChalk. F.Y.M. spread at the end of a ley and ploughed in.

Cattle

Beef stores fattened. 32 cows Hereford X and Angus X 35 calves and own Angus bull. Single suckled but one has 4 calves. 31 yearlings. Normally sell off at 12 - 18 months. Replacements bought in including Irish. Normal field grazing.

Sheep

160 ewes, 160 lambs half bred, Hules and Suffolk X. 2 tups Suffolks. Sell lambs when ready or keep on to finish off roots. Clip own.

Poultry

On farm.

Buildings

Mostly new buildings apart from an old stable and forge, and old byres. New granary, new Dutch barn and lean-to. New large shed. Buildings convenient and storage usually sufficient for corn although some may have to be sold.

Agencies

Paxton, general. Marts Haswell, Castle Eden. Buy in from Hexham.

Amenities

Main road. Mains electricity and water. Shops at Thornley and Sunderland.

Classification

Cropping and fattening. Single suckled calves.

FARM STUDY EIGHTEENWHITE HOUSE FARM THORNLEYThe Farm

52½ acres: Barley and oats 20 acres; Leys 8 acres; permanent grass 20 acres; Rough and House 4½ acres.

No labour. N.C.B. land. In the family 60 yrs.

Machinery

Tractor and simple gear. The rest is hired. Last horse used 10 yrs. ago. Not a very high proportion of investment in machinery.

Soil

Drainage generally good as the land is near the limestone. Clay in parts but the lighter land gives the best results especially in a wet season.

Crops

A rotation was at one time practised but now at best the land is periodically cleaned. Yields: Using Field approved seeds, Barley sown at 12 st. yields 25 cwt. Sown in late April, harvest September. Most of the grain used on the farm. Floor stored. Parker of Blackhill, Consett supplies seed.

Fertilizers compounds combined with barley only 2 tons on the whole farm. No trouble.

Animals

Dairy herd. Mixed mainly Shorthorns with Ayrshires and Friesians. 9 cows, 7 in milk. Top grade milk collected by Northern Dairies of Middlesbrough. Open field grazing. Wintered indoors. Large

concentrate feed in winter. Replacements reared and bought in for the last 4 yrs. when TT became compulsory. AI used mainly Angus except for rearing. Bull calves sold at 12 months.

Buildings

Solid and built within the last 50 yrs. but not convenient or planned.

Agencies

General but infrequent. No marts attended.

Amenities

200 yds. to the main road. Has electricity and water. Shopping at Thornley and Wheatley Hill. Bigger things at Durham and Stockton.

Classification

Milk with subsidiary enterprises.

FARM STUDY NINETEEN

WEST FARM, OLD WINGATE

The Farm

120½ acres: Barley 30 acres; wheat 11 acres; oats 5 acres;

Potatoes 5 acres; Turnips 2½ acres; Leys 25 acres; Permanent grass 15 acres; Rest rough. One farm worked. N.C.B. land. Farmed in partnership for one year only but in the family for 30 years.

Labour

1 man with casuals. Casuals are very easy to find for this farm.

Machinery

1 Ferguson, 1 Nuffield tractor, Bag combine, Bag drier, Disc harrows, mould board plough, Drill fertilizer spinner, grass cutter, binder, Mill, Corn drill, Combine drier and baler best thing since the war. Last horse used 8 yrs. ago. High proportion invested in machinery.

Soil

Drainage wet near the road where marked on the map. Fencing general. Yields similar but the wet fields are the worst.

Crops

Barley after barley. Never follow barley with another corn. Field Approved seeds one year followed by own seed. At 12 st yield up to a ton, barley. Spring wheat similar. Yields lower than winter wheat but can always ~~sell~~ for biscuits. Potatoes 6 tons per

acres. Keep $\frac{1}{3}$ of corn. Dry and wait for the price, but some sold straight away. Sown mid-April, Harvest Sept. Granary stored. Sold to Teeside Farmers and Milnes of Chester. Fertilizers - General having tried all kinds of compounds using advice of fertiliser firms. Top dress with Nitro-Chalk. Local tip ruined a clover field by choking the crop with paper. Otherwise no trouble.

Animals

15 stores. Angus X Hereford. Buy as calves sell as stores. Was in milk till 3 - 4 yrs. ago when found difficulty in getting permanent labour. Open field grazing. Lets grazing to local farmer.

Poultry

80 layers for local sale.

Buildings

Mostly very old. One new. Storage is good enough but machinery has to stay out all the year.

Agencies

Paxton and local blacksmith for servicing. Seed to Walton and Teeside Farmers. Warts. Buy at Darlington sell locally.

Amenities

Mains water and electricity. Shopping Wheatley Hill Co-op.

Classification

4. Cropping with store raising.

FARM STUDY TWENTYTHE FARM, WHEATLEY HILLThe Farm

160 acres: Barley 50 acres; Potatoes 7 acres: Grass the rest.

One farm worked. N.C.B. land. Worked in family for 35 yrs.

Labour

3 men. 2 boys. Two of the men mostly work on the milk rounds.

Machinery

Tractor and usual gear. Forage harvester. Drier but no combine, hired. Last horse used a year ago. The main investment is in stock and buildings.

Soil

Drainage is generally poor because of mining subsidence. It has

been tiled. Worst drainage marked on the map. On analysis potash generally low and phosphate very low. Yields similar on all the fields.

Rotation

No strict rotation. Policy to keep the grass near the farm. Some fields fragmented and a good distance from the farm. Near the farm 3 yr. ley with 2 or 3 yrs. of barley. Away from the farm barley and 1 yr. ley. Pallas seed followed by own sown at 12 - 14 st. yield 20 cwt. Mackintosh potatoes (out of redskins) 7 - 8 tons. All grain sold after storing for the price. Sowing started 2nd week April, Harvest Sept. Floor storage. Sold to Maddicks of Stockton.

Fertilizers: Basic slag, superphosphate, muriate of potash. Mainly placed on the grass to build up the required units. Top dress with compound 2 4 tons of Nitro-chalk per year.

Only trouble Redshank.

Animals

Dairy herd of Ayrshires and Friesians. 30 in milk with followers. M.M.B. collect on exchange basis to return bottles for two milk rounds. Cow house milking system. In for winter and fed on concentrates and silage. Bull calves sold off straight away. Replacements reared and bought. Poultry - 200 hens nearing the end of laying when they will be finished with.

Buildings

Old and badly laid out. In stone and brick.

Agencies

Paxton for servicing. Maddicks take the grain. Marts - Darlington, Carlisle and Penrith for beef.

Amenities

Mains water and electricity and sewage. Shops in the village. Directly on the main road.

Special features

Fragmentation. Silage used last year but this year entirely hay.

Classification

Milk with subsidiary enterprises.

FARM STUDY TWENTY ONELOW CROWS HOUSE FARM WHEATLEY HILLThe Farm

157 acres: Barley 80 acres; Oats 20 acres; Wheat 60 acres; Hay 40 acres; Permanent pasture 47 acres.

One farm but 14 acres of isolated land at Thornley worked for over 100 years. The rest farmed since 1929. All H.C.B. land.

Labour

2 permanent and stable. With casuals.

Machinery

Tractor and combine. No arier. Baler perhaps this year. Normal gear. Large proportion invested in machinery. Last horse 3 yrs. ago.

Soil

Bad drainage because of subsidence. Filled but broken and shifted. Hedges all over farm. Biggest deficiency was in lime. Put two tons to the acre last year. Similar yields from all fields.

Rotation

Finished with potatoes because the land too heavy to harvest them. 3 years ley followed by corn. New pedigree seed from Webbs pre-dressed used regularly. Barley at 12 st. to the acre with 4 cwt. compound cross bone yields 50 cwt. now. Yields were previously around the ton mark but now more planning and better fertilizer practice has brought great improvement.

Dryish year is by far the best. Keep $\frac{1}{3}$ of corn about 15 - 20 tons. Sell $\frac{2}{3}$, about 40 tons. Sold at best price after storing on the floor. Webbs supply the seed.

Fertilisers: 4 cwt. compound down the spout. Top dress the grass with Eaglescliffe compound. Attempt to keep a balance of F.Y.M. and compound. No high nitrogen. No serious trouble.

Cattle

56 average beasts but up to 70. Rear to store or beef. Mixed breeds. Buy in and breed a few self. 70 Masham ewes with Suffolk tup. Sell lambs fat. Breed own replacements. Clip own wool despatched to Henry Bell of Hexham (Wool Mkt. Bd.)

Buildings

Well maintained and reasonably arranged buildings. Fairly modern. Farm house new.

Amenities

Mains water and electricity. Shopping in the village.

Agencies

Various agents. Marts - Haswell, Castle Eden and local.

Classification

Cropping with fattening.

(4)

FARM STUDY TWENTY TWO

WEST FARM OLD WINGATE

The Farm

144 acres: Wheat 21 acres; Oats 21 acres; Rough grazing 42 acres; Potatoes 7 acres; Turnips 6 acres. Less corn and more grass than usual.

One farm worked since 1905 in the family. N.C.B. land.

Labour

One man with casuals.

Machinery

2 tractors Massey Ferguson with the normal gear. Deteriorate rapidly and replaced frequently. Baler pick-up. Grass cutter, elevator. No combine/drier as short on storage. No silage made. Baler has made the biggest difference since the war in saving labour. Last horse used 3 yrs. ago. High proportion invested in machinery. Increasing investment each year.

Soil

Drainage bad generally because of subsidence. Some recently installed but too deep. Generally on the shallower soils the drainage

is free. Mixed hedges and post and wire. Well maintained. Several fields analysed and generally low in potash. The wheat field east of the quarry has the deepest soil and gives the best yields.

Rotation

7 - 8 acres planted every year and circulated round the farm to clean. The land is generally very clean. Never follows grass with wheat because the seed bed is too dusty.

Yields - Barley at 12 st. gives 30 cwt. in the best field.

4. Wheat pedigree at 11 - 12 st. gives 30 cwt. on the best and 25 on the rest.

5. Wheat at 14 st. about a ton.

Oats one ton.

Potatoes 5 - 6 tons.

Sell all the wheat mostly after keeping till spring. The rest used on farm. Started sowing spring wheat on April 16. Harvest August Sept. because the land is dry. Seed from Bibby's, Webbs, Teesdale Farmers, Kenton Bridon. Floor storage- limited.

Fertilizers : Fisons 52 on corn Fisons 45 and 46 on potatoes, roots. Basic slag on turnips too. $2\frac{1}{2}$ - 3 cwt. down the spout on spring corn.

Winter wheat not much but top-dressed with compound. This year basic slag will feature high in the fertilizer programme. Saving a little to pay for machinery and buildings. Will be applied on grass.

No trouble.

Animals

Generally 50 but up to 70 a yr. Hereford X; Friesian X Angus bull. Shorthorn; Aberdeen Angus; Friesian. Buy in Friesian calves at 4 - 5 months, sell fat. Buy in at suckle sales and rear own replacements. One doubled suckled but now single suckled. 13 calves bought in and pail fed. Great amount of concentrates used in the winter. Normally brought in for the winter to loose boxes, yard, byre. In good winter some left out.

Own bull. Good reputation with showing beasts. Sell top quality to good butchers. Almost every yr. lose 1 beast + John's disease. Went out of pigs two yrs. ago. Poultry - 700 free range till laying then in deep litter. Sell at the door and old hens sold as fatstock.

Buildings

Old, bad. Old granary. New fold yd. 12 yrs. Well enough lay out, machinery left out. Refused grant for 3 bay 12' implement shed.

Agencies

Orde and Teesdale of Darlington and Paxton for servicing and machinery supplies. Seed to Waltons of Gainford and Teesdale Farmers. Marts - Buy Darlington,, Tow Law and occasionally Hexham. Sell Castle Eden and Haswell.

Amenities

Mains water and electricity. Shopping in Wheatley Hill and Wingate. Main stuff Darlington and occasionally Stockton.

Classification

Cropping and fattening, single suckle and pail feed.

Special

Trouble with trespass and dogs, therefore no sheep.

FARM STUDY TWENTY THREESMALL HOLDING SOUTH OF OLD WINGATE, DURRIESThe Farm

40 - 50 acres. No farm house. Two brothers live in council house Wheatley Hill. 15 acres barley, 10 acres wheat, 6 acres potatoes, 15 acres grass. Sheds for building. Nothing substantial. Very well farmed. Awaiting a farm.

FARM STUDY TWENTY FOURWINGATE GRANGE FARM, WINGATEThe Farm

370 acres : Barley 106 acres; Oats 35 acres; W. wheat 23 acres; Potatoes 12 acres; Turnips 11 acres; Fallow 9 acres; Seeds 107 acres; Permanent pasture 65 permanent pasture. Just returned 50 acres of seeds to permanent pasture.

One farm worked for 30 years, N.O.B. land.

Labour

2 men one lad and casuals. Stable.

Machinery

4 tractors, baler, two combines but one cannibalised, baggers, drier, combine corn drill, two 3 furrow ploughs, rotavator, other usual gear. Baler by far the biggest labour saver since the war. Last horse used 13 yrs. ago. High proportion of investment in machinery.

Drainage

Has been tiled but broken by subsidence. Own ditching machine and cleared out 2½ thousand yards of main gutter last yr. which started the drains flowing in places. This yr. 3 thousand yards to be done.

A few hedges but mainly pig netting with a single barbed strand. Lime is regularly low and the barley land is regularly tested and dressed thus taking lime round the farm. 6 fields to the north were ploughed out from rough land but are not very good.

Crops

Occasionally bought pedigree seeds but last time leatherjackets took the lot. Mainly field approved seed. Barley at 12 st. gives 1 ton.; wheat $\frac{1}{2}$ a ton to 2 tons depending on the winter. Wheat follows the fallow. 3 yrs. grass, 2 corn, potatoes/turnips/fallow, 2 corn, 3 grass. Potatoes 6 - 7 tons. Leather jacket has been a persistent problem. Sell all barley. Sell $\frac{3}{4}$ oats. Store for price. Sell all wheat. Floor stored.

Fertilizers

Corn down the spout - 3 cwt. high N. Crossbone on barley. 10:10:15 on oats. Occasionally low N on winter wheat then 2 cwt. Nitro chalk. Grass 3 cwt. 10:10:15. Basic slag on pasture and some seeds. Sow start 7 - 8 April. Harvest last September.

Animals

No cattle but buying some in this back end. Sheep 120 ewes Suffolk X White face, mainly Mules, some Swaledales. Suffolk tups 2 both died this yr. so need replacements. Used to lamb in January now in Feb. - March and a second drop in April. Rear to fat. Buy

in replacements. Buy at Scots Gap Tow Law. Sell Castle Eden, Haswell
Clip wool to the board. Small investment.

Poultry

9 hens for farm use.

Buildings

Old with new rooves. Not in bad condition. 5 large places
corresponding to 32 stall byre. Most of machinery kept indoors.

Agencies

Paxton. Corn to Byers of York and from Byers of York. Clover
mixture from Kenton. Marts mentioned in sheep section. Stockton
used occasionally Stockton and private.

Amenities

Mains water and electricity. Shopping Wingate and West
Hartlepool.

Classification

Cropping with sheep.

FARM STUDY TWENTY FIVERODRIDGE COTTAGE FARMThe Farm

79 acres: 14 Spring Wheat; 7 roots; 6 Barley; 6 Oats; 7 Potatoes;
Rest new leys. One farm. Owner occupied. In the family since 1895.

Labour

1 man and one boy.

Machinery

Not highly mechanised. Tractor with normal cultivation gear
but no combine or drier. Other machinery is hired. The tractor is
the biggest boon since the war. Not a lot invested in machinery.
Last horse used in 1956.

Soil

All the farm is tiled but odd patches where subsidence has
interfered there is wetness. On most of the land it is policy to wait
till the ground is dried to some depth before ploughing or other work.
This is perhaps the reason for poorer yields on neighbouring farms.
The majority of the farm is hedged but dividing fences in large field
are wire. Lime is occasionally low but other things seem O.K. A
dry year is preferred.

Crops

4 - 5 yrs. seeds, potatoes, 2 corn, roots, 2 corn, back to grass. Pedigree Spring wheat at 12 st. yield 35 cwt. to 2 tons. Field App Barley at 10 - 11 st. give 30 - 35 cwt. Potatoes 9 - 10 tons. Very good potato land. All yields high. All oats kept on farm. The rest is sold after storing for the price. Sow first in 64 in 2nd week of April. Harvest late Sept. Spring wheat from Kenton Bridon. Barley London seeds. Stored in the sack and threshed for sale.

Fertilizer

Basic slag and $3\frac{1}{2}$ - 4 cwt. compound on all maiden seeds. 3 - 4 cwt. compound broadcast on corn, but not after potatoes. FYM on roots. LCI on potatoes. Fisons and Cross bone on grass with a little Nitro-chalk. No trouble.

Animals

Dairy herd of Ayrshires 21 in milk working up to 26. C.M.S. collects milk. Stall dairy. Paddock grazing. Slow start out with rain cannot keep up with the grass. Bull calves sold straight off. Heifers reared. Own Ayrshire bull. Winter indoors. Concentrates after working up with oats. Last year lost all calves as bull dog calves because of new bull. One cow has New Forest disease.

Buildings

Old and new but designed and laid out to own plan, but low on

corn store.

Agencies

Paxton for servicing. Corn to Teeside Farmers and Foster and Armstrong. Market Darlington.

Amenities

Mains water electricity and sewage. 200 yds. from main road. Shopping at Wingate, Stockton and Middlesbrough.

Classification

Milk with subsidiary enterprise.

FARM STUDY TWENTY SEVEN

THE GRANGE TRIMDON GRANGE

The Farm

75 acres: Barley 28½ acres; Wheat 3 acres; Potatoes 5 acres; Turnips 5 acres; Seeds and yr. 8 acres, 1st yr. 4 acres, P.G. 5 acres, Rough Ground 19. One farm A.C.B. land farmed since 1937, in family since 1907.

Labour

Since out of milk one year only one casual-semi permanent.

Machinery

Tractors and usual cultivation gear. Combine bagger but no drier. Baler. Tractor biggest improvement since the war. Last horse used 3 - 4 yrs. ago but still 4 horses on the farm for showing. Small farm and large proportion of investment in machinery.

Soils

Drainage. Wet places along valley marked on the map. Piped but subsidence. Pitfalls frequent and still active. Generally drainage good as near the limestone. Fencing mixed. Yields similar on all the land.

Crops

Strict rotation. Potatoes, turnips, 2 corn, seeds, corn, back to roots. Yields: Pallas and Varda barley at 12 st. 25 - 30 cwt. Capelle wheat 25 cwt. Dubar standard, Mackintosh, Majestic potatoes 5 - 6 tons. All new seed.

If pigs on the farm keep about $\frac{1}{3}$ corn on farm. April sow Sept. harvest. Average year preferred not too wet not dry. Supplied generally. Sow much pedigree seed every yr. and follow with own. Floor storage waiting for the price till Dec. or Jan. unless need money. Fertilizer practice. Compounds on the lot. Round the farm with potato manure. Broadcast at $2\frac{1}{2}$ - 3 cwt. for corn and 10 - 12

cwt. for roots. Top-dress with compound only if backwards. Once used superphosphate to a large degree. Next yr. will use superphosphate again on all the land. Basic slag round $\frac{1}{4}$ of the farm. Limed six fields 3 yrs. ago. All the corn is dressed and no trouble with disease.

Animals

Cattle out of dairy one year. Now raising stock to 50 - 55 average but low at present because of the beef situation. 6 cows single suckling. 30 young stores. Friesian X. Sell following year as stores. Use A.I. In for winter using own oats and concentrates. Free from trouble. Buy in and rear own replacements. Open field grazing with occasional strip grazing. Sheep - None this year but will stock up for the winter. Poultry - 100 deep litter.

Buildings

Mainly old but new hay sheds and a new Dutch barn. Storage not sufficient but not too badly off.

Amenities

Directly on the main road. Mains water and electricity. Shopping Trimdon Grange and Darlington.

Agencies

Fewsters and Teeside Farmers and general agents. Marts - Darlington mainly but Hexham and Hawes occasionally mainly for the ride.

Special features

Although out of milk still run retail milk round which brings in £10 - £11 a week and is an essential part of the business. Buy in milk from the M.M.B.

Classification

Cropping and rearing single and multiple suckle and stores, with retail milk round.

FARM STUDY TWENTY EIGHTNORTH SIDE FARM TRIMDONThe Farm

116 acres : Barley 28 acres; Oats 3 acres; Turnips 6 acres; Seeds 28 acres. One farm, N.C.B., worked for 32 yrs.

Labour

Casuals only.

Machinery

Two tractors with usual cultivation gear. No combine/drier. All the rest hired. Last horse six yrs. ago. Although comparatively little machinery this still represents a high proportion of investment.

Soils

Drainage is not good. Much of the land is piped but this has been ruined by subsidence. Mainly hedges but mixed and not very well maintained. On analysis 3 yrs. ago the grassland was deficient in lime.

Rotation

Keep clean but by no means strict rotation. Roughly 5 - 6 yr. cycles. Yields - Proctor Union and Varda Barley at 12 st. 22 cwt. Oats 15 cwt. Very poor potato land therefore not use them. Use all the oats on the farm and keep 1 ton of barley. Sell the rest after storing for the price. Sowing on the 1st April, in by the end of Sept. Bulk storage.

Fertilizers: Broadcast 3 cwt. high N compound and top dress with Nitro-chalk. Grass top-dressed with Nitro chalk. No trouble from disease.

Animals

Fattening stores. Shorthorn X Friesian X Angus. 25 on the farm on average. Buy in and rear own replacements. Single suckle, with the odd one pail fed. Usually buy in a bull. All sold fat. Normally free of trouble.

Buildings

Mainly old and brick, one byre stone. Not a convenient lay out. The rooves are good. Low in machinery storage space, but plenty of granary room.

Agencies

Does all servicing on the farm by self. Maddicks take the corn. Marts - buy at Darlington and sell at Hedgfield.

Amenities

½ mile to the main road. Mains water and electricity. Shopping in the village and occasionally at Darlington.

Classification

Cropping and fattening, single suckled and stores.

FARM STUDY TWENTY NINEDAIRY FARM TRINDON COLLERYThe Farm

45½ acres: 9½ acres wheat, 7 acres barley; 15½ acres seeds; 8 acres permanent grass; 4 acres rough grazing. One farm with 32 acres of own land and rest N.C.B. Farmed for 24 yrs.

Labour

Casual only because work in conjunction with a friend mainly.

Machinery

Grass cutter, plough, harrows, turner, manure drill, seed drill, tractor. No combine/drier hired or use friends. Hired combine baler has made the biggest difference since the war. Last horse 7 yrs. ago. High investment in machinery because it is continually being replaced. Always bought new.

Drainage

N.C.B. field not so good because fairly heavy and pipes disturbed. Rest of the farm is not bad and fairly dry. Mainly hedges and very well maintained. Lime analysis regular and deficiencies kept up. Similar yields throughout.

Crops

Rotation. 3 yrs. grass, barley, wheat, barley, back to grass. Field approved and once grown seeds new every year. Barley at 12 st. 28 cwt.; wheat at 12 st., 30 normal but once 45 cwt. Keep 20% sell 80% after storing for the price. Floor stored in byre. Sowed in 1st

week in April. In by late Sept. General suppliers.

Fertilizers: Compounds broadcast at 3 cwt. Round the farm with potato manure and high N. If needed top-dress with nitro-chalk. Winter wheat top-dressed at 3½ cwt. Muck and sewage goes on the grass land and goes round the farm in 3 yrs. Generally clear but three yrs. ago severe leatherjacket trouble but cured in time with Diddimack.

Animals

Dairy retail business, buying in milk. Fatstock. Fatten stores Friesian X bought in as calves. 10 on farm usually. Sell fat. Open grazed. Brought in for the winter and fed on concentrates. Poultry - 4 - 500 brought in from range to lay on litter.

Buildings

Good. New Dutch barn built self. Good storage.

Agencies

Servicing self. Sell generally to various agents. Parts - Sedgefield and occasionally Darlington.

Amenities

On main road. Mains electricity and water. Shopping in the village.

Classification

Cropping with fattening.

FARM STUDY THIRTYSMALL HOLDING TRIMDON COLLIERY

36½ acres of very badly used land. All down to grass this year and full of weeds. When was ploughed far too shallow and untidy giving good growth of weeds which now choke most of the grass land. A few stores fattened and the rest of the land is let for poor grazing. Good land ruined. Good drainage, within three feet of the limestone.

Buildings - ramshackle sheds. Equipment negligible.

Out of milk about six yrs. ago because could not tolerate the Ministry regulations. Out of arable this year. Out of farming next year? No labour. Fences poorly maintained. Rented land reverting to scrub.

FARM STUDY THIRTY ONEGREEN HILLS FARM WHEATLEY HILL JUNCTIONThe Farm

230 acres: Barley and oats 65 acres; Roots 1 acre; Seeds 55 acres

for hay and the rest for grazing. One farm, N.O.B. land, worked since 1948.

Labour

2 - one on the farm, and one travels one mile.

Machinery

Tractor, baler, drill, elevator, 40 combine/drier.

Soil

Yields similar except on the moor which was brought under cultivation in 1949, and is still very poor. Use a lot of lime.

Fencing mainly post and wire.

Rotation

Not strict at all. Rather confused. Sow mid April, in by late Sept. Field Approved seed bought in regularly. Keep all the oats, $\frac{3}{4}$ of the barley sold. Sell straight off. Seed from Forster and Armstrong, Morgans of Shincliffe and Jebbs. No storage whatsoever. Fertilizers - regular compounds Fisons 52 and ICI. Crossbone high N and Jebbs high N. Nitro chalk topdressing. Luck on the grass. Rain wash from the woods ruined crops at the top fields for two seasons.

Cattle

Dairy herd of Friesians 16 in milk. 50 - 60 multiple suckled fatstock including older dairy cows which give sufficient milk for multiple suckling. Rear own replacements mainly with own Hereford bull but a few calves are brought in. Friesian and Lyrshires. Open grazed. All in for winter. Sell fat.

Sheep

50 ewes, 68 lambs. Sell when ready fat at Haswell and Castle Eden. Clip own sheep.

Agencies

Paxton for servicing. Dobson takes the grain. Hawdon colliery takes some oats and hay. Marts - Haswell and Castle Eden generally but occasionally rough beasts go to Gateshead.

Amenities

Mains water and electricity. Shopping at Wheatley Hill, Darlington and Newcastle.

Classification

Mixed farming.

FARM STUDY THIRTY THREEWEST WOODBURN FARM WINGATEThe Farm

104 acres: Barley 22 acres; Roots 15 acres; Oats 6 acres; Wheat 6 acres; Seeds 10½ acres; Wood 6 acres; P. Grass 37 acres. One farm owner worked since 1930.

Labour

1 lad. and casuals. 47 for potato picking last year.

Machinery

2 tractors one ten years old and one older, diesel and paraffin. Baler, muck spreader, binder and the usual cultivation gear. No combine/drier. All the corn is contract combined and dried except the wheat which is done with a binder because the straw is required. Hydraulic lifting gear and power take-off, drills and normal sowing gear.

High proportion of investment in machinery for a farm of this size. Changing old paraffin tractor for a diesel this year, but could really work another 50 acres with the machinery on the farm. Combining has made the biggest difference since the war in saving labour. Machinery is bought reconditioned and new. The last horse was used 7 years ago.

Soil

Drainage is shown on the map. Most of the farm has been piped but this has been ruined by serious subsidence which results in ponds forming after even light rainfall and some of them are now permanent and forming peat. Hedges are predominant and are along all the roads. Occasional wood fences and post and wire. The soil has been analysed and is generally good. The fields at the top near Trimdon Colliery are particularly good for potatoes.

Rotation

No strict rotation. Sow down to temporary grass and then plough up for potatoes then 2 barley, roots, barley or wheat and back to seeds. Yields - Field Approved seeds from Northern Farmers, Barley at 10 st. gives 25 - 30 cwt; wheat at 12 st. 20 - 25 cwt.; Potatoes average 6,7,8 tons but near Trimdon have had 10. Barley and oats kept on the farm. Wheat is stored in the stack and threshed in spring to sell at the best price. Started sowing on 15th April. in by the end of September.

Fertilizers : ICI High N No. 4 for the corn, C.C.F. No. 1 and nitro-chalk; Broadcast at 3 cwt. on barley, 2½ on oats; wheat top dressed with Nitro-chalk; Potatoes ½ tone no. 1 C.C.F.; Grass has basic slag and is topdressed with Nitro chalk and compound after the first grazing; Muck is used on turnips or on potatoes when they follow stubble. No trouble.

Animals

On the way out of milk. Working down to 4 Friesian cows. Milk collected by Jellfield C.W.S. Dairy stall system of milking with pipe and bucket. Always keep the calves. Now building up fatstock. 5 Hereford X on multiple suckle using A.I. Also buy in and rear on the pail. Normal open field grazing. In for winter and heavy concentrates with barley and oats. Sheep - 43 ewes with lambs (83). Mixed breeds but going to concentrate on compact Mules. Suffolk tup. Lambled 2nd week in March but will be earlier next year. Sell as fat lambs. Clipped own wool last year, but not this year - contract. No trouble. Pigs - 12 sows and boar. 1 Landrace, one Essex but mainly Large Whites. Keep for bacon, but if pushed sell as pork. Use infra-red lamps when in pig but they are otherwise in loose boxes.. Poultry just for the farm.

Buildings

Very reasonable.

Agencies

Paxton for servicing. Northern Farmers and Forster and Armstrong of West Hartlepool take the corn. Marts - sell at Haswell and Castle Eden. Not much private.

Amenities

175 yds. to the main road. Mains water and electricity.

Shopping at Wingate and West Hartlepool.

Classification

Mixed farming at present, but moving towards fattening with cropping.

FARM STUDY THIRTY FOURWOODLANDS CLOSE FARM HUTTON HENFYThe Farm

155 acres: Barley 52 acres; Oats 6 acres; Roots 8 acres; Leys 58 acres; P. grass 7 acres. Rough including woodland 20½ acres.

One farm owner. Worked for 6 months by present farmer but in the family for at least 100 yrs.

Labour

1 man local. No casuals.

Machinery

2 tractors, baler, grass cutter and usual cultivation and sowing gear. No combine as the neighbour does it all. Most of the machinery is new, having been purchased within the last five yrs. Vacuum slurry

tank. The baler is the biggest labour saver since the war. Last horse used in 1963 but still have one on the farm. Not a very large proportion of investment in machinery. Most in stock.

Soil

Fairly good drainage except where pit subsidence causes ponding. No outlet possible. All piped and they still run. Pipes and horseshoes are cleaned up one at a time periodically. Hedges mainly on the boundaries but some fields are split with post and wire. Field X on the map analysed with pH 4.9 Phosphate medium and Potash low after being down to permanent grass. Field Y has better yields generally.

Rotation

Not strict. Mostly barley for as long as possible. Roots, 2 - 3 yr. ley and 3 - 4 yrs. barley. Pedigree seed all round then follow with one field a year pedigree and once grown own seed. Varda Barley at 12 st. gave 30 cwt. last yr. This yr. at 10 st. In past on a ploughed out pasture at 9 st. gave 2 tons. Winter wheat gave such consistently low yields that it is no longer grown. All the grain is used on the farm after storing on the granary floor. Parkers of Bristol supply the seed through an agent.

Fertilizers - 3 cwt. down the spout of high N 16:9:9 for the corn. 5 cwt. of 7:7:10 and F.Y.M. for the turnips. Top dress as needed for

example one field got 1½ cwt. this year and the other very little.

New enterprise is spreading liquid slurry from the pig boxes. Housed on concrete and liquid runs down chute into large concreted well behind the piggery. Transported by vacuum tanker and spread at 1,000 gallons to the acre on leys. Occasionally top dress grass with Ammonium sulphate but this will probably cease when the slurry process gets under way. Corn top dressed occasionally with ammonium sulphate.

Trouble from leatherjackets cured with Gammacol.

Animals

Gone out of milk last September, 14 mixed beasts in milk. Now 27 beasts. 1 cow, 2 steers and 4 heifers under 18 months and 6 steers and 14 heifers from 18 months to two yrs. Mixed Aberdeen Angus, Shorthorn and Hereford. Sell fat. Once reared own now buy in. Multiple suckled on the one cow as she can take them. Brought in for winter and fed on barley and turnips. No concentrate. Open field grazing. Sheep - 1 tup Blue face Leicester, 79 ewes Swaledales, 1 hog, 110 lambs, 120 lambs from the hills from 1st Nov. to 1st April, then back to the hills after fattening on turnips. Buy in hogs in winter to finish off the turnips and sold fat. Lambs sold fat. Lambing on 1st April. Clip own. Perhaps bring some large ones in for the winter and try early lambing this year. Pigs - 9 in pig, 20 sows 1 boar Large White, 230 on the farm at present but this fluctuates.

Breed own up to pork fatstock stage. Mainly Large Whites but two Landrace X sows. Poultry - 25 for farm use. Free yard range.

Buildings

Old and brick but roofing maintained. Improved and modified in stages to suit the changing system.

Agencies

Paxtons, Neashams, and Gills. Harts - Darlington only, for selling as fatstock goes to EMC. Buy in all over the north of England.

Amenities

Almost on the main road. Mains water and electricity. Shopping at travelling shop and Darlington and W. Hartlepool.

Special Considerations

The aim of this enterprise is to gear all the grain to the pigs which supply the slurry for the grass which feeds the sheep. There will be no room for cattle in the future. The land is not good for potatoes havin only 4,5,6 tons to the acre. so potatoes are no longer included in the rotation.

Classification

Pigs and sheep with crops geared to the livestock.

FARM STUDY THIRTY SIXSLACKLEY HILL FARM HULTON HENRYThe Farm

99 acres: Barley 11 acres; Oats 9 acres; Potatoes 3 acres; Ryegrass 2 acres; New Leys 5½ acres; Old grass 13 acres; Reseeds for P.G. in boggy field 7 acres. One farm worked. Owner. Farmed since 1937 when moved from Wynyard.

Labour

One lad from Trimpleton.

Machinery

Combine, baler, 1 new tractor and two very old useless ones. Binder, rotavator, ploughs, discs. Combining and baling have made the biggest difference in labour saving since the war. Last horse 3 yrs. ago. A high proportion of investment in machinery considering the size of the farm.

Soil

The farm lies in extremely hummocky land. The tops are in places clayey where the top soil has been stripped off. In other places more extensive tops are quite thickly covered with a good loam

while the lower slopes leading to main drainage courses are stripped and expose heavy clayey soils. There is therefore no simple pattern. A main water course can be distinguished through the farm but as on neighbouring farms there are depressions which seem to lead nowhere in particular. There is also the interference of a long pitfall depression in one field. This is fenced off but still interferes with the drainage. The main water course is apparently blocked outside the farm and needs regrading to the coast which would be very expensive. At present therefore although drains on the farm are kept clean they fill back in the valley bottom. This means that the bog field is very wet and unmanageable. It is doubtful whether this is a recent thing though for the field has quite a depth of peaty soil developed over it.

Boundaries are mainly in hedges but post and wire is being used for all new divisions. Only one field was noted as needing lime recently but this is no real indication as the farmer's understanding of chemicals and their use is limited. He does not bother with analysis. The stronger land seems generally less good. This may be due to the difficulty in cultivation but this is doubtful; it is by no means very strong; it may be rather that the lighter land has more mature soils and where there has been movement the light soils of lower places is thickened by accumulation.

Crops

The land "was not strong enough for wheat" therefore the farmer changed to barley. If present practice is any indication it is not that the land is not strong enough but that it is overworked. Wheat gave about a ton per acre and was abandoned. Rica seed, cross-drilled at 10 st. give 25 - 30 cwt. Once 36 cwt. after long grass. Onward oats give one ton. Pedigree seeds are followed by once grown of own and others bought privately.

Rotation is at present not in a very definite state. It is working towards 3 - 4 yrs. grass, turnips, barley, turnips, barley, oats, seeds. Alternating to a large extent. Most of the corn is used on the farm and more bought in. Hay is bought in also. Seed is however sold from the Pedigree as once grown.

Sowing this year late April. One field of turnips was precision drilled and largely failed because of the dry period and over working the land. It was resown in the last week of June.

Apart from the Pedigree, seed is bought in privately. Last year from H. Bell of Old Cassop. Stored in various places including a granary loft and boxes.

Fertilizer practice consists of varying amounts of ICI, CCF 1 with occasional topdressing of the same fertilizer. The farmer does not believe in chalk or nitrogen. Muck is spread on ploughed land and the old grass gets CCF 1.

Cattle

Dairy herd of Friesians. Once 18 in milk but now down to 10. A.I. used. Stall milked. Strip grazed on ryegrass but otherwise open field. Beef. Use own calves. Once sold all but for the last two yrs. keep them and rear to fifteen months. More corn is sown and more calves kept in summer. 12 - 15 are pail tea. Only trouble is recurring mastitis.

Sheep

20 ewes Grey face and Scotch. 42 lambs. Suffolk tup. Sell lambs fat. Stopped clipping own sheep this year. Buy in own replacements, mainly old ewes.

Pigs

One sow but when she pigs will probably go out of pigs.

Poultry

30 hens in the yard for farm use. Was in the battery business but now out.

Agencies

All the servicing done self. Parts - Darlington for cows, Castle Eden and Haswell for beef and privately.

Amenities

Mains water and electricity. Shopping at Station Town and Wingate and travelling shops. Main shopping at Darlington.

Classification

Varies from mixed farming to milk with subsidiary enterprises. The latter seems likely to dominate.

FARM STUDY THIRTY SEVENEDDER ACRES FARM SHOLTONThe Farm

176 acres: Barley 48½ acres; Wheat 15 acres; Kale 3 acres; Turnips 4 acres; Potatoes 7 acres; P.G. 10 acres; Seeds 32 acres including rye; Oats 32½ acres; Rough 23 acres. One farm worked since 1937. Up in the dales before that. In process of buying from the N.C.B.

Labour

3 sons and casual labour.

Machinery

2 tractors, thrasher, normal cultivation gear. No combine orier.

o forage. Elevator binder, rotavator. Tractors have made the biggest difference since the war. The last horse was used 15 yrs. ago. Big proportion of investment in machinery. The farm was in a very poor condition when they took over. In fact the first year's work was rent free.

Soil

The fields near the road are very bad. The drains through the neighbouring tip are now blocked. The field was freshly drained 5 yrs. ago but the outfall is blocked. All the rest of the land is field drained and seems quite good although gleying is evident in the pit near Round Hill.

Hedges and post and wire are used for fencing. Some hedges are planned to be ripped out. Occasionally some fields are low in lime. The best yields are from fields in series 10.

Rotation

White crops followed by roots. No more than three years of successive barley. Pedigree and once grown seed followed by own. Barley at yields 30 cwt. up to two tons with 1 ton as a bad crop. Potatoes yield 7 - 8 tons with ten tons on old grass. Wheat yields 30 cwt. Sowed this year in the second week in April. In by the end of Sept. Elsons, Hunters for the Pedigree and Laddicks for the once grown. Lack storage. Not combine much. Eaglescliffe compounds High N on corn 2 - 3 cwt. broadcast. Top dress winter wheat with

compound and nitro-chalk. Potatoes high potash with muck at 8 cwt. 1½ cwt. on the grass. Muck the kale and turnips generally but not this yr. All crops sprayed and no trouble.

Animals

Dairy herd of mixed Friesians and Shorthorns. 10 in milk. Stall milking. Wellfield collects. Keep all calves. Use A.I. Beef. Buy in as calves to supplement own but in future will rear their own. Calves are pail fed and sold fat. Some were fattened grazers in the past. In future replacements will be own. Herefords, and Aberdeen Angus. Total stock is 15 cows and 30 beast for beef. Poultry - 200 deep litter and penned. Eggs sold at the door. 100 turkeys from June to Christmas.

Buildings

Mainly very old including old donkey mill. But they have good rooves and are put to a very good use. The yards and paths have recently been concreted. The courtyard design of the buildings round the yard is a convenient system. Hay has to be stacked but most of the machinery is stored.

Agencies

Paxton. Teeside Farmers, Maddicks, Northern Farmers. Wait for the price. Markets - Darlington, Hexham, Haswell and Castle Eden.

Amenities

½ mile to the road. Mains water and electricity. Shopping
Shotton Colliery, West Hartlepool and Sunderland.

Classification

Mixed farming. Working up to more corn and more beef than in
the past.

FARM STUDY THIRTY EIGHTWELLFIELD FARM, WINGATEThe Farm

c 150 acres. Only 20 acres down to commercial barley for sale.
The rest is down to ryegrass and barley for the cattle. Belongs to
the Geo. Thomson farms - Vicarage Farm Dairies. Has a farm manager
and a milk foreman. 3 labour but variable.

Machinery

Very well mechanised. Forage equipment as silage used for all
ungrazed crops.

Soil

Much of the farm has been heavily ashed in the past and is well drained. Surface drainage is generally good even where the land is heavy because here the steepness of the land assists runoff. The heavy land is mainly on steep slope and may be the result of soil erosion.

Animals

The farm is geared to a variable dairy herd. It is a specialised unit. 62 in milk.

Crops

Keep clean with potatoes following long pasture. Only one field sold. The rest for grazing and silage.

Buildings

Old and brick generally not well kept. New dairy. Storage mainly as silage.

Classification

Milk unit of larger fragmented enterprise.

FARM STUDY FORTYCATCHGATE FARM AND BRIDGE HOUSE FARM CASTLE EDENThe Farm

200 acres: 50 acres winter wheat; 40 acres barley; 15 acres roots; 45 acres seeds and silage; 45 acres permanent grass. Two farms worked as one unit. Catchgate and Bridge House. Also takes in the old Thacmyres Farm. Owned by Castle Eden Estates. Worked for over twenty yrs.

Labour

3 permanent and casuals.

Machinery

Well mechanised. Tractors with the usual gear, combine and erier, baler, forage harvester, chemical sprayer. Machinery changed regularly and therefore of all ages. The combine and the baler have made the biggest difference since the war. A horse was used in 1963 but this was given by the Brewery and used only for the one season. Before that a horse was used regularly over ten years ago. Investment is roughly half and half in stock and machinery.

Soils

The land is somewhat heavier in the west part of the farm and

the eastern section gets away earlier and works more easily. The farm is tile drained throughout and although the drains are old they are effective and spasmodically maintained.

Crops

Rotation. Wheat, 2 barley, roots, barley and down to grass, but this varies according to the season and the previous market prices. For example this year there seems to be less wheat sown locally so a larger acreage of winter wheat was sown as late as February. Yields - Using Field Approved seeds: Wheat at 12 st. yields 30 cwt. generally but 2 tons have been taken; Barley at 12 st. 30 cwt. usually. All the grain is sold either straight off or after waiting for the price. Storage is on the floor. Sowing of the winter crops carried on to February, but spring crops went in very early, starting on March 20th. Grain is sold to the agent offering the best price or to those supplying the seed.

Fertilizers

Compounds bought from ICI, Shepherds, Fisons, Eaglescliffe..
Wheat. 6 cwt. C.C.F. broadcast, 3 cwt. 10:10:18. Top-dressed with 3 cwt. sulphate of ammonia. Barley. 4 cwt. high N broadcast, Top dress only if required.

Roots - 5 cwt. high K broadcast. Grass varies. This year the permanent grass received 2 cwt. complete compound and 2 cwt. of sulphate of ammonia. Short lays receive 3 cwt. of sulphate of ammonia, 5 cwt. of complete compound and ammonia to follow as necessary. Lime is applied when analysis shows the need. This year one field had three tons to the acre.

Animals

Cattle - Dairy herd of Friesians. 35 in milk, 10 out of milk and 10 dry in calf. 40 heifers and two bulls. Milk is delivered to North East Dairies. Trip grazing is used early on in the season but it is not a tight system. The cattle are allowed a fairly wide strip. The cows only are brought in for winter and fed on silage. Replacements are bought in and calves sold straight off. Own bulls for calving. A three point parlour system is in use for milking.

Sheep - From October to May varying number of Half bred ewes are brought in tugged and sold with lambs at foot. They are bought in Scotland and sold at local markets or privately.

Poultry

100 hens in a loose deep litter system.

Buildings

Mainly old and not at all convenient. They have been converted but not very well and temporary measures have remained and assumed a degree of disorganised permanence. The farm house is comparatively new.

Agencies

Paxton and Fewsters and general. Grain is bought and sold generally. Markets are Hexham, Darlington and Castle Eden and general.

Amenities

Directly on the main road. Mains water and electricity. Travelling shop for groceries and West Hartlepool for larger things.

Classification

Milk with subsidiary enterprises.

FARM STUDY FORTY ONE

MILL FARM HUTTON HENRY

The Farm consists of three small fields in grass or hay and one very large field, perhaps a remnant of an open field system, divided

into sections of wheat, barley, turnips and hay. The farmers is over 80 yrs. old but still works the land with one lad who is over 60. Machinery consisted of a very old tractor with no power take-off and very old horse equipment modified to the tractor. Old wooden wagons with the proprietor's name painted on the side were indicative of the age of farming this unit still mirrored. Hay was baled and stored in many and varied buildings. Contract baling. Weeds had smothered many of the turnips in one section and most of them were ploughed in. The buildings were, however, despite being old, very well kept and painted. The land was in good order apart for the weeds already mentioned. 10 fattening calves included Aberdeen Angus and Friesians.

The soil at the top of the farm was light to medium loam with clay and wetter land in the one field at the bottom which was devoted to grass. Went out of milk several years ago and now almost entirely arable with a little fattening.

FARM STUDY FORTY TWO

RODRIDGE FARM HUTTON HENRY

The Farm

121 acres: 15 acres wheat half sown in February; 35 acres

barley; 6 roots; 95 hay or grazing. Works this farm in partnership with father and Hart Bushes Hall Farm with father-in-law. Owner occupier since 1948 but worked the land as tenant before this.

Labour

One permanent.

Machinery

Two good tractors and one poor tractor with the usual power assisted gear. Chemical sprayer. Baler. No combine or drier. Muck spreader and baler the best improvements since the war. Last horse used for the milk round seven years ago but the last horse on the land was over ten yrs. ago. There is not a very high proportion of investment in machinery on this farm.

Soils

All the land is drained but the bottom field in common with low land on Blackley Hill Farm is wet because of blocked outfalls on farms lower down the water course. 90% of the fields are bound by hedges. One field only was short of lime this yr. and this was corrected. Two fields give better yields than others and these lie on the intermediate land between the heavy soils of the west part of the farm and the light loams of the east part of the farm. It is difficult to explain why the lighter loams do not give far better yields than the rest of the farm.

Crops

Using a new rotation of 3 corn, roots, and 3 grass with field approved seeds yields are: Barley at 10 st. 30 cwt.; Wheat at 12 st. 30 cwt. with 2 tons at the best. All the wheat is sold off the farm and the barley is all used as feed. Sowing of spring crops was late in April.

Fertilizer practice is very variable but involves broadcasting basic slag, compounds and topdressing with nitro-chalk.

Animals

Dairy herd of pedigree Friesians with 20 in milk and followers. Milk round in the village still run from the farm though bottling is done at the dairy. Strip graze. Wintered on own barley and supplements. Pigs - 40 bought in weaners reared to pork.

Buildings

These are by far the best buildings in the district. They are conveniently arranged and modified to present requirements for many of them are old, but they are very well maintained and painted. The yards are all tidy and concreted.

Agencies

Paxton and Fewster for servicing. The wheat goes to Northern

Farmers Trading Association or to Foster and Armstrong. Markets include Darlington as the main one.

Amenities

Main road, mains water and electricity. Wingate for groceries and West Hartlepool for the larger things.

Classification

Milk with subsidiary enterprises.

FARM STUDY FORTY SEVEN

The Farm

365 acres: Owner occupier. 45 acres wheat; 12 acres barley; oats 77 acres; 32 acres potatoes; Rest divided in varying proportions between permanent grass, rough grazing and temporary grass and fodder crops. Organised as J.O. Brewis and Sons.

Labour

Five permanent employees.

Machinery

3 tractors, one rotavator, combine, pick-up, baler, and the usual gear.

Soil

A mixed area with well drained sands and gravels in knolls, and mixed drifts, usually well drained. They are mixed but behave very much like the better drained soils of the western drift and are therefore grouped in the same series. Mottling is evident in places and complexity occurs where drainage courses and streams cross the land. Here small pockets of poorly drained soils occur.

Animals

Dairy herd and well known Hesleden herd of 130 Friesians. 200 Scotch white faced sheep and 80 store pigs bought at 8 weeks and sold for pork at 12 weeks.

Classification

Mixed.

FARM STUDY FORTY EIGHT AND FORTY NINEHULAM AND SHERATON HALLThe Farm

Rented by J.H. Murray. 464 acres and with two 900 acres. Rented N.C.B. Very little arable, for example 26 acres at Hulam and 2½ acres

at Sheraton Hall.

Labour

Combined Force of 8 men.

Fully mechanised with a combine and baler at each. Mr. Murray is an auctioneer at Haswell and therefore handles stores mainly Irish in origin. Up to 500 animals can be grazing at the same time. Over half of the Hulam farm and $\frac{3}{4}$ of the Sheraton Hall farm are under grass. Wheat and barley are grown as commercial crops but oats are used on the farm. 100 pure Border Leicesters and 1,000 mixed sheep on the combined farms.

Classification

Fattening stores.

FARM STUDY FIFTY ONE TO SIXTY

SMALL HOLDINGS HUTTON HENRY

51. 13 acres Grass, oats and turnips. Pigs and calves reared.
52. 22 acres. Grass, oats and turnips. Calf rearing.
53. 23 acres. Grass, hay and potatoes. Milk.
54. 8 acres grass for pigs and poultry.

55. 40 acres grass for milk. 15 in milk 15 followers.
56. 24 acres grass and potatoes. Milk and calf rearing.
57. 25 acres. Oats and grass. Pigs.
58. 22 acres grass calves reared.
59. 32 acres arable wheat, oats, potatoes and grass.
60. 27 acres all grass poultry.

