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W I T H I N C O U N T Y D U R H A M

by R.E. HEBDEN.

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ABSTRACT

For a series of functions or services, the movement of people living in County Durham has been obtained. The functions studied were car driving tests, employment at coal mines, hospital treatment for ophthalmic and general surgery specialities, season ticket distribution for professional football clubs and student attendance at technical colleges. This data forms the basis for mapping urban fields and defining specific unlands for each of the chosen functions.

Each function is then studied in detail in an attempt to establish the variables that affect the pattern of urban fields and specific unlands. This is set against central place theory and the operating of a central place system. The variables recognised from this analysis are population distribution, distance, the power of attraction of centres and the distances of centres from each other. These variables are initially checked by sample studies of centres and small settlements.

The next stage is the building of a stochastic model of the system. A ratio called the interaction index is used to remove the influence of the population distribution and thereby simplify the model. This model is then tested by a multiple regression computer programme. The results show the importance of distance as a variable, the problem of adequately defining the level of a function at a centre, and the equilibrium nature of the system by the failure of the centre network to be statistically significant.

The analysis also shows that the interaction index fits into a social physics system and does remove the distorting affect of population distribution.

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A native of the Great Wen, my interest in towns dates back to my childhood and has been nurtured academically ever since. Through school, undergraduate and post-graduate studies, towns and their influence have figured in my researches. To all my geography teachers I owe a debt of gratitude. More especially I am indebted to Dr. David Thorpe of the Geography Department of Durham University, my supervisor in this particular study. It must be an unusual task to supervise someone who is of an older generation and technically a colleague. That we found a 'modus vivendi' is evidenced by the fact that this thesis has been completed.

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Durham City

R.E. Hebden.

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1. AN OUTLINE OF THE SETTING OF URBAN SPHERES OF
INFLUENCE WITHIN COUNTY DURHAM.

The North East of England has fairly well defined bounds. To the west the Pennines form a physical boundary breached mainly by the Tyne gap and a routeway along the Tees valley and over Stainmore. To the east is the North Sea, while the Cheviots pinch out the coastal plain to the north. The south has the North Yorkshire Moors forming a potential boundary with the Northallerton gap between the Moors and the Pennines. Within this gap the boundary is not so well defined, physically, though in practise the administrative unit of the North Riding of Yorkshire provides a good line. The town of Northallerton commands a rural area between the North Yorkshire Moors and the Pennines. Its influence declines towards Scarborough, York and Harrogate, and the administrative boundary allows for this (see fig.1.1).

Within North Eastern England are two major concentrations of population - Tyneside and Teesside. Tyneside has the regional capital of Newcastle upon Tyne for its focus. The coal trade and its estuarine position were the basis of growth of this area to become a conurbation. Combined with this is a sub-region, Wearside, focused upon Sunderland. While physically separated from Tyneside, its original growth is similar and it is so close to Tyneside that, at this stage, it can be considered as part of that conurbation.

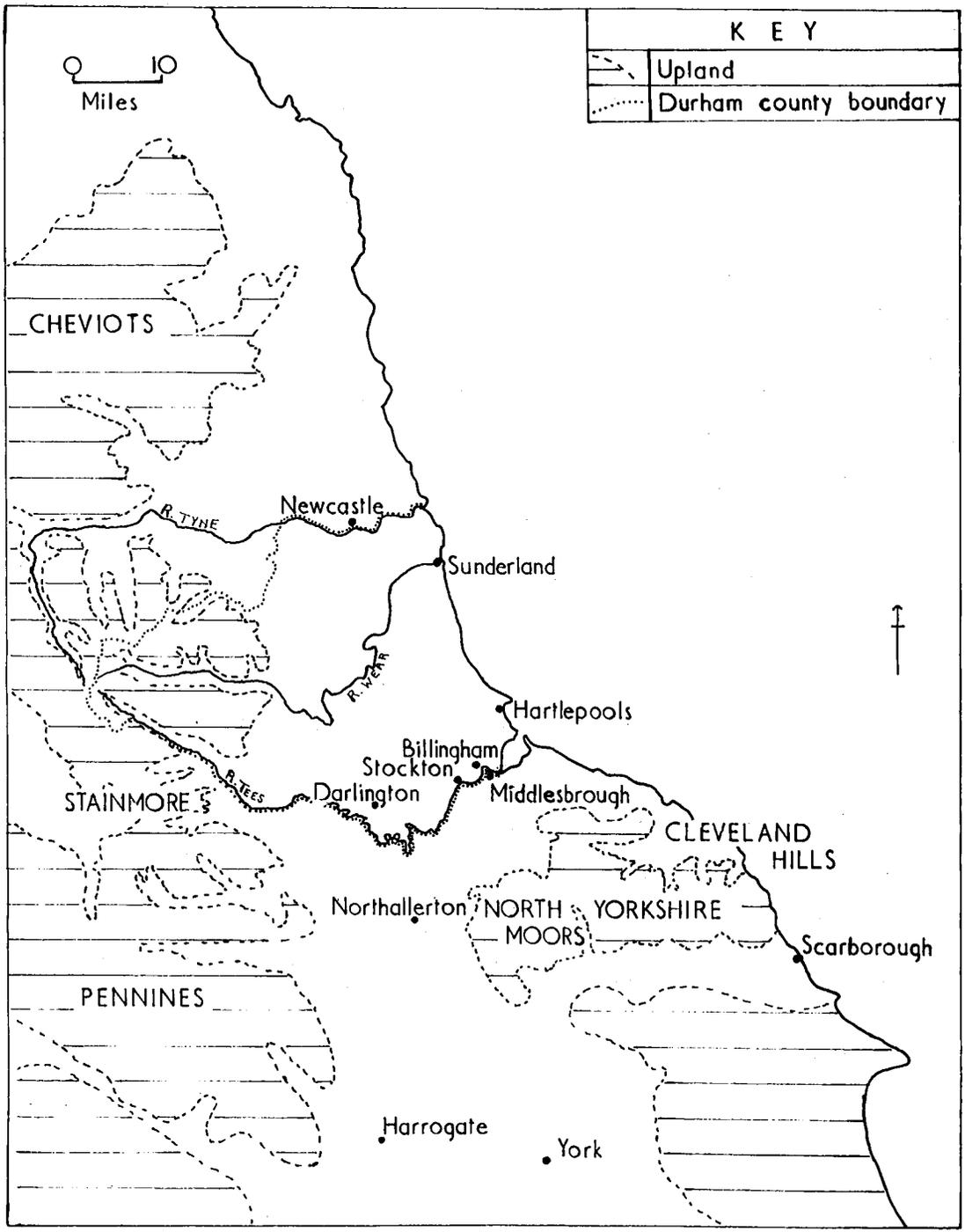


Figure 1.1 THE NORTH EAST OF ENGLAND - LOCATION MAP

Teesside has more recent roots. While the three towns of Darlington, Hartlepoons and Stockton have origins probably as early as Saxon times, they remained separate entities until this century.¹ It is from the railway, initiating the growth of Middlesbrough from a few decrepit fishing huts into an industrial port in 1830, that Teesside has sprung. The iron ore of the Cleveland Hills, the coking coal of South West Durham and the anhydrite of Billingham, each in turn, helped with the growth of Teesside. However, it is only since 1967, with the establishment of the Teesside borough, that the competing units have recognised their common interests, though Darlington is still separate and Hartlepoons a borough in its own rights.²

This study takes the geographic County of Durham for its potential boundaries. The significance of the word 'potential' will quickly emerge. The county occupies a central position in the North East region. To the west it includes the Pennines with the whole of Weardale and part of Teesdale; to the east is the sea. The northern boundary, along the Tyne for much of its length, includes the southern part of Tyneside. The Wearside sub-region is wholly within the county. Southwards the boundary follows the Tees, hence part of Teesside is within the county. No study which includes parts of Tyneside and Teesside can ignore the whole. Hence the county boundary is a potential and not the actual border to the area of study.

This is the broad regional setting. To this must be added

some indication of the settlement network of the county. There are three major urban concentrations within the county area - Tyneside, Teeside, and Wearside. These have already been referred to and although they are aligned along their respective rivers, the modern development of communications had led to their growth away from these rivers. For example, Boldon and Whickham are not river-side settlements but both now form part of Tyneside. Communications have also led to the spread of dormitory functions to the nearby settlements. Cleadon is dormitory to South Shields, Ryhope to Sunderland and Elwick to Teeside.

Besides the conurbations three other settlement types can be recognised. Of these, mining and quarrying have marked the landscape most. Lead, limestone and building stone brought miners and quarrymen to Weardale. The settlements along the valley and the growth of Stanhope and Wolsingham as towns resulted from this.³ But over most of the county it is coal-mining that has most marked the landscape. North of a line from Blackhall on the east coast, through Fishburn, Chilton and Shildon, to Evenwood, coal-mining brought its own settlement pattern. In some cases an original village was used. A mine was opened by an already existing village and a block of terraced houses was added to this rural core. So Trimdon, Lanchester and Chopwell grew within an already existing settlement network. In other cases, the mines were opened in the middle of moorland or countryside and a new settlement was created. Such settlements as Craghead, Fencehouses and Whitburn Colliery resulted.

But the mining picture is not quite so simple. A further division is needed. The exposed coalfield, west of the Permian Limestone, was developed first. The mines were small and widespread; so was the resulting settlement pattern. On the concealed field, deeper mines were needed and so a more advanced technology had to be developed. The result was large mines and the settlement pattern is of large units, but fewer of them compared with the exposed field. Thornley, Murton and Wingate could be called towns in comparison with Greenside, Burnopfield and Hamsterley in the north west of the county.⁴ (see fig. 1.2).

Outside the mining area and mainly in the south of the county, a rural element may be found in the settlement network. This is composed of hamlets often made up of a number of farms and a group of houses. This is particularly well illustrated in the area immediately west of Darlington where a scatter of hamlets is still to be found, for example, Bolam, Headlam and Ingleton.

The third element is an urban element. It consists of a number of towns whose growth may be related to two developments. The first is the influence of the Prince Bishop and his administration in the pre-industrial revolution period. He encouraged the growth of Gateshead as a town, to form a rival to the independent Newcastle at the Tyne crossing. He had his ports at Hartlepool and Bishop Wearmouth (later to become Sunderland), again partly to rival Newcastle. He established residences at Durham, Bishop Auckland, and Stockton at various times, thereby raising their status to

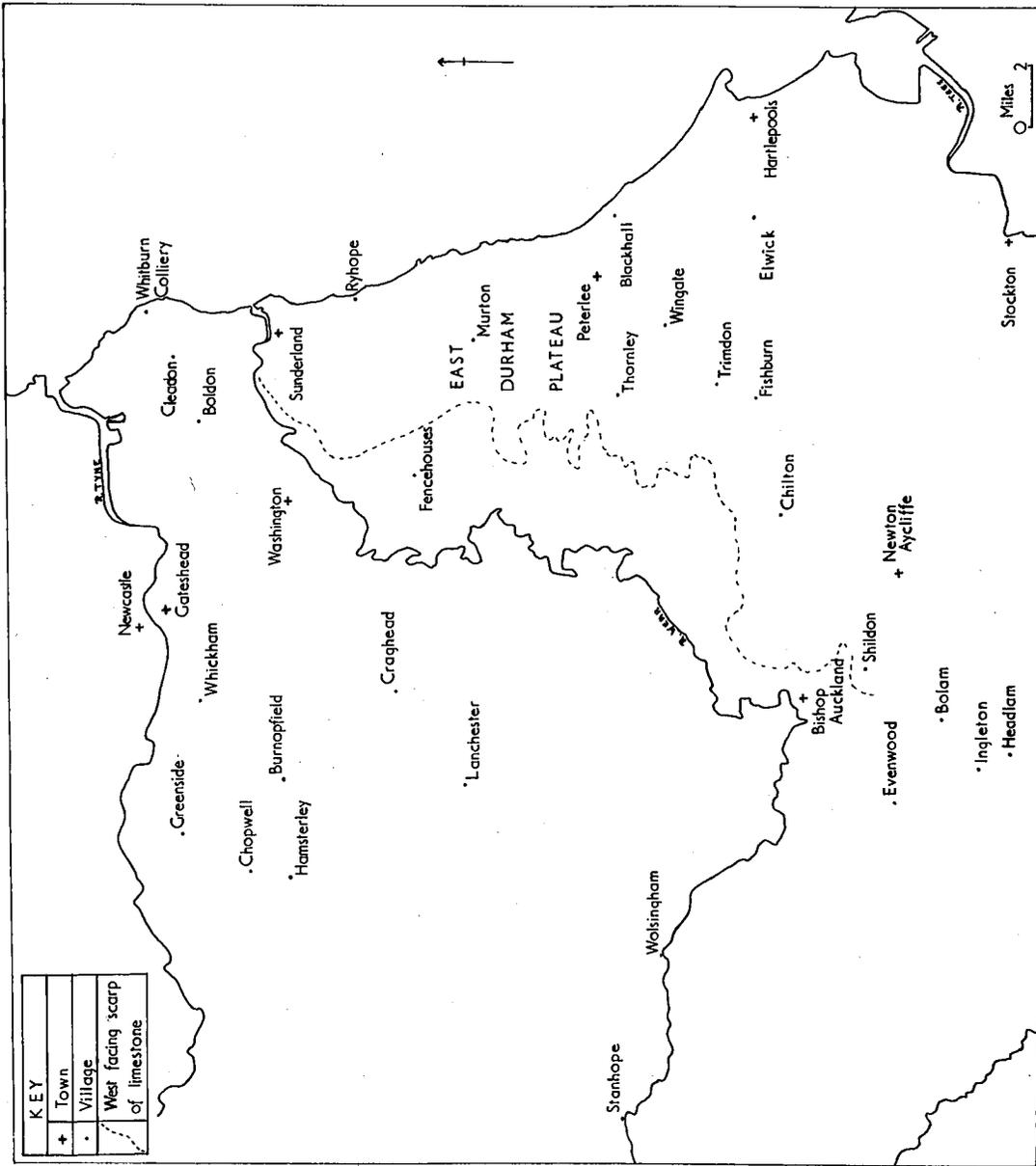


Figure 1.2 DURHAM COUNTY : LOCATION OF EXAMPLES OF DIFFERENT SETTLEMENT TYPES

towns. Darlington, a Saxon burgh, was already the market centre of the rural area of the middle Tees and did not need the Bishop's help to develop its town status⁵. While many of the towns in this network have been absorbed by the conurbations, some of them still exist as separate units.

The second development is partly political. With the decline of the North East's major heavy industries and coal mining, unemployment and a stock of outdated buildings have characterised the area. A 'growth zone' in central Durham was declared by the 'Hailsham Report' and new towns have been deliberately built to provide an improved urban environment and to attract new industries to specific points. Hence Newton Aycliffe, Peterlee and, more recently, Washington, have been designated as new towns⁶.

Three conurbations, dormitory growth, a variable mining element, a pre-industrial urban element and a political urban element have all contributed to the present urbanised region of County Durham.

Urban Spheres of Influence

There have been a number of studies of urban fields made in Britain. In general they have concentrated on towns which are discrete centres surrounded by countryside.⁷ Such studies have been mainly in areas characterised by marked variations in population density. The towns or centres have corresponded to high peaks in the population density surface while the surrounding countryside is at the lower density areas of the overall system. The towns tend to develop facilities used by people living in the

surrounding areas as these are the most convenient locations for services i.e. at the density peaks. They therefore tend to acquire varying levels of status according to the number of different types of services or facilities they provide.

County Durham does not fit into this general pattern, particularly that part of the county which is on the coalfield. Here towns are far from being discrete centres. The population distribution gives an overall high density pattern without the peaks and troughs of the free standing town and its surrounding countryside. Further the presence of the densely populated conurbations on the borders of the county i.e. Tyneside, Teesside and Wearside, have resulted in the development of a good communications system interconnecting these areas. As this system crosses the county it provides people living in the settlements within the county with the possibility of high mobility. With recent major road improvements to link the fringing conurbations the private motorist now has a road system which gives a great deal of choice as between centres. One might therefore describe the Durham coalfield with Teesside as a single urbanised region rather than an interconnected system of separate towns.

The inter-relationships which form the urban field of a town or the patterns of movement which are found within an urbanised region can be summarised under three major headings. Firstly, there is the personal movement of members of the general public. Secondly, there is the physical distribution of goods such as

from Wholesalers to Retailers. Thirdly, there is the circulation of ideas by such means as local newspapers, local radio or by telephone.

These three types of movement or interconnections are different in several ways. For example, the first group is concerned with the movement of people whereas the other two are not. Such movements of people to towns or within an urbanised region will be the concern of this thesis and a possible classification of these movements, particularly for services is:-

- a) The purchase of goods i.e. shopping.
- b) The use of personal services e.g. hairdressing, restaurant.
- c) The utilisation of professional services e.g. solicitor, driving test.
- d) The participation in crowd entertainment e.g. cinema professional football.
- e) The utilisation of public specialist facilities e.g. medical, educational.
- f) The journey to work.

Studies of the relationship between town and tributary area have used all three major types of movement or interconnection i.e. of people, goods and ideas. Within personal movement there has been a tendency to concentrate on services, leaving journey to work as a separate type of movement. This is reasonable in a study of town-country relationships. After all, the commuter may be considered to some extent as a member of the urban community who lives in the country. But in an urbanised region like County Durham this distinction is not so clear cut. Many physically

distinct settlements exist and function as places of residence for people working elsewhere. Hence Boldon exists within Wear-side but supplies workers to Sunderland, South Shields and Newcastle. Whickham provides a similar example in north west Durham. Such settlements may be said to provide the service of residence. They are not arranged however in a simple way around a dominant work centre but send out workers to a variety of different centres. Hence in this thesis there is a need to consider the journey to work alongside service movements since it is of a similar character to such movements within County Durham.

Any information collected about the range of trips or movement types must be such that the relationship between centre and tributary area can be ascertained. Three possible sources occur - the individuals making the trips, knowledgeable agents controlling important functions, and records of movements required for some organisational reason. For an area as large as county Durham, sampling a population of $1\frac{1}{2}$ millions was beyond the means available. The use of knowledgeable agents for the study of urban fields has been used by various authorities but was rejected for this study because of the complexity associated with an urbanised region⁸. Who, in such a situation, are the knowledgeable agents? Hence for these and other reasons, this thesis will rely entirely upon records of movements from organisational sources.

The studies of movement in County Durham that follow should be seen within this framework. They are all based upon detailed

records obtained from specific organisations. This may be further justified in that the patterns of movement which exist in a densely populated urbanised region are themselves highly specific. The use of services, except the most basic, occurs relatively infrequently and can be related to certain age groups or certain interest groups within the population. To analyse such specific movements across the whole range of the population would require a large number of interviews to cover the age groups and interest ranges. Without this subtle variations within an urbanised region would not emerge. But such information on a small unit basis is not reliable and so the records of movements from organisational sources with their emphasis on centre-tributary area relationships are used.

The selection of the types of movement actually studied depends upon four basic criteria. No survey could be complete but at least one of each group classified earlier should be included. However two are deliberately excluded. These are the purchasing of goods and the use of personal services. This is done for two reasons. Firstly, a considerable amount of work on shopping trip generation in the study area has been carried out in recent years.⁹ Secondly, these activities are possibly less specific in terms of interest group and age group than any of the other movements. Such services can be studied from lists held by suppliers but the procedure for collecting this data is different from that of the other services. A quantitative element in terms of what has been purchased by each individual is introduced. This is not so with the other services.

A second factor influencing selection is the availability of comparable data and thirdly that it is available for the greater part of the county area. An organisation with a membership list exists in one area. Similar organisations in other parts of the county have lists but refuse access to them and so prohibit the study of this group. Or such lists might be accessible but the organisations might not be comparable. Any group of organisation must be shown to form a coherent unit offering a comparable service within the group and a distinctive service which separates them from all other groups.

The fourth factor is one of competition. Particularly within the public sector, services have administrative arrangements whereby it is almost impossible for members of the public to select the centre they wish to use for a service. Thus a local authority and its ratepayers do not form a possible group for study. The ratepayer has no choice as to whether, for example, he pays his rates to Durham M.B. or Durham R.D. The same is true of water supply. The boundaries are clear cut with no overlapping or competition and the public pay their water rates to the authority within whose boundary they live.

To a certain extent this is true of the educational service. The primary school child goes to the local or nearest school. Headteachers know their catchment areas and require the consent of the Divisional Officer before they can accept a child from outside it. At the secondary stage this is still basically true but as catchment areas are now much larger, the chance of the person

living on the border of such an area going to the "wrong" school increases. Also parents tend to operate their right to have some say in the choice of their child's school at the secondary stage. By the tertiary stage of education the catchment area idea is less operable and so competition exists.

The journey patterns or elements finally selected for study in this thesis are - League professional football (participation in crowd entertainment); Hospitals (public specialist facilities); Technical colleges (public specialist facilities); Coal mining (journey to work); and Driving tests (professional service). Of these, hospitals and technical colleges are of special interest in that within each of them distinct grades of activity exist. Some educational and medical facilities are by their very nature used by only a small number of the population. This means that these facilities need only be provided at a few centres compared with other facilities used by a larger number of the population. Hence the need for ophthalmic units is less than that for general surgery. The result is a hierarchical arrangement of facilities within the services which permits a fairly detailed examination of the spatial implications of a hierarchy of centres.

Technical colleges have three levels of course - local, area and regional. Each college is designated as providing courses up to one of these levels. However within a centre may be found more than one college. Hence Sunderland has its Technical College with regional courses and Monkwearmouth College with only local courses. The data has been collected so as to examine the total pattern of

this movement and to study the high level regional courses by themselves. Similarly the hospital services recognise a four stage hierarchy but only the lower two levels have competing centres across County Durham. Hence only these two levels are studied. Unlike technical colleges the provision of the various services is very clear cut in hospitals and the data has been collected so that the two levels of the hierarchy are clearly isolated.

In contrast with these, driving tests provide a uniform facility over the county area. No hierarchy is recognised although the actual number of examiners at a particular centre may differ from that of any other centre. This is a simple demand-supply situation in that the number of examiners is increased to meet an increase in demand at or near the point of demand. The league football pattern is more complex. The Football League clubs can be recognised as a separate and distinguishable group from all other football clubs. The number of professional players on the books of the club, the ground accommodation, the match attendance are all such as to separate this group from semi-professional leagues such as the Northern League. Yet within this group are four clearly recognised divisions with movement of clubs between these divisions from season to season. Here the operation of a continuum within an hierarchical level would seem to work.

Finally there is the journey to work element of coal mining. This does not fit easily into the pattern of interconnection or

movements of the above elements. In many ways it stands between the retail and personal services and the other facilities in the degree to which it is structured in terms of age and interest group within the total population. It is less specific than the other elements selected. This being so, it is possible to examine journey to work patterns from broad sources such as the National Census. If a study in terms of local settlements and a particular journey to work pattern is required then the Census data, which is based upon local authority areas and grouped occupations, is of little use. Unfortunately there are few possible types of journey to work which are sufficiently uniform in character to allow useful study. No private firm has similar plants at various centres within the county. However the continued although declining significance of coal mining in the employment pattern of the county does provide a possible source of examining one journey to work pattern in some depth. It is true that this is basically a rather different type of pattern from that created by the services mentioned above but significantly enough manpower areas will be recognised and these catchment areas are in fact in many ways similar to the service areas which will be established for the other elements. In this case, however, rather than a single focus for movement, there exist several collieries which are the foci of the manpower area. This study of journey to work should be seen as only one element in a number of different journey types existing within the urbanised region of county Durham.

Terminology

As urban geography is a young subject, its terminology is not yet fully standardised. Hence there is a need to state one's terms and to define them at an early stage.

Already the word NETWORK has been used. This refers to the distribution of villages and towns in the landscape. It does not imply a pattern as such. There may be a regular form in the network or it may be a haphazard or random distribution. The network is made up of individual villages and towns. However, to give a population total for them, parish and ward boundaries have to be used. In some cases a parish contains more than one village. Hence the term POPULATION UNIT will be used for a population census area and this may contain more than one village within it. The built-up area of a borough may extend into nearby parishes. In this case the population unit is a continuous area of built-up land with a clear boundary around it which avoids other built-up areas and for which a census population is available.

Towns have a variety of services which they perform for the surrounding area. These services are attractions which result in people making journeys to the towns to make use of these services. Towns which have such services will be called CENTRES and the area from which they attract people will be called the FIELD OF ATTRACTION.

Studies of towns to delimit the field of attraction have used a variety of indices and have found it necessary to recognise an

'umland' and an urban field. The area immediately around the town which shows a large number of indices resulting in journeys to the town is the 'umland'. The whole area from which at least some journeys are made is the urban field. There is a SPECIFIC UMLAND for each service and a SPECIFIC URBAN FIELD for each service. The field of attraction may be a combination of several specific urban fields for one centre.

This study is based on the assumption that a number of centres compete across County Durham. A specific urban field will decline in power of attraction from the centre outwards and will meet other urban fields for the same service from nearby centres. Where two specific urban fields are in equal attraction, then a boundary is drawn, i.e. of a specific umland. In practice, for example, a town like Chester-le-Street is within the urban fields for large electrical goods shopping of Gateshead, Newcastle and Sunderland. The number of journeys involved in one week may be 26, 43, and 31 respectively. Although only 43% of the journeys are to Newcastle, this is the highest proportion of the journeys to any one centre. Hence Chester-le-Street is within the specific umland of Newcastle for large electrical goods shopping. A point of exactly equal attraction can rarely be located on a map. It is by the method stated above that the boundaries have been drawn around centres to delimit specific umlands.

Once a specific umland has been delimited, then the population of the specific umland can be calculated. This can be used as a guide or approximation to threshold values as they are normally

understood.¹⁰ In Central Place Theory it is argued that there is a minimum value which must be attained before a service or function can operate economically at a centre.¹¹ This value is the THRESHOLD. For example, a general hospital needs a population in its specific urban field of about 150,000 people in North East England before it is considered worth the expense of equipping such a unit. 150,000 people is the threshold value for a general hospital.

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7. Examples of the different types of urban spheres of influence studies include Bracey H.E., 'Social provision in rural Wiltshire', London, 1952; Charter H., 'The towns of Wales', Cardiff, 1965; Dickinson R.E., 'Market and market areas of East Anglia', *Economic Geography*, Vol.10, 1954; Green F.H.W., 'Urban hinterlands in England and Wales; an analysis of bus services', *Geographical Journal*, 1950.
8. This method was used by Bracey, op. cit.
9. This work includes Thorpe and Rhodes, 'The shopping centres of the Tyneside urban region', *Economic Geography*, Vol.42, 1966; Thorpe and Nader, 'Customer movement and shopping centre structure; a study of a central place system in Northern Durham', *Regional Studies*, Vol.1, Oxford, 1967, and a M.A. Study in preparation by Corney G. on shopping spheres of influence for department stores using records of the delivery of goods.
10. Threshold values are usually calculated on the basis of fields of attraction. There are, however, some difficulties in this if a social physics view of fields of attraction is taken. This point will be developed in Part 2.
11. Berry, B.J.L. and Pred. A., 'Central Place Studies; a bibliography of theory and applications,' (Philadelphia) 1961 contains a brief outline of Central Place Theory and a lengthy bibliography on various aspects of the theory.

2. THE ELEMENTS - PROFESSIONAL FOOTBALL.

In a study of journey patterns a basic classification of types of journeys would include those for entertainment or recreation.¹ Professional association football was chosen as an example of a journey for recreation in the North East of England, and data was obtained from the Football League clubs of the settlements from which their season ticket holders came in the 1963-64 season.

Over the country as a whole, the attraction of professional association football, as measured by attendance at Football League Matches, has declined in the post-1945 period. However, the North East of England has not followed the national trend.² Although there was a decline in attendances within the North East up to the 1960-61 season, since then there has been a gradual improvement. For the 1963-64 season, attendances at matches were still improving compared with the 1960-61 season.

The Data

Each Football League club in the North East of England, i.e. Darlington, Hartlepoons United, Middlesbrough, Newcastle United and Sunderland, has a list of addresses of season ticket holders. From these lists for the 1963-64 season, the settlements were noted and the totals for each population unit for each club were calculated and mapped. A map with five centres locating five specific unlands by bounded areas was produced (see figure 2.1). This map also indicates the five urban fields.

K E Y	
D	Urban field of Darlington
H	Urban field of Hartlepool
M	Urban field of Middlesbrough
N	Urban field of Newcastle
S	Urban field of Sunderland
U	Urban field of Uxbridge
W	Urban field of Wigan
X	Urban field of Wolverhampton
Y	Urban field of York
Z	Urban field of Zone
○	County/Urban boundary
□	Population unit boundary
▨	Urban area

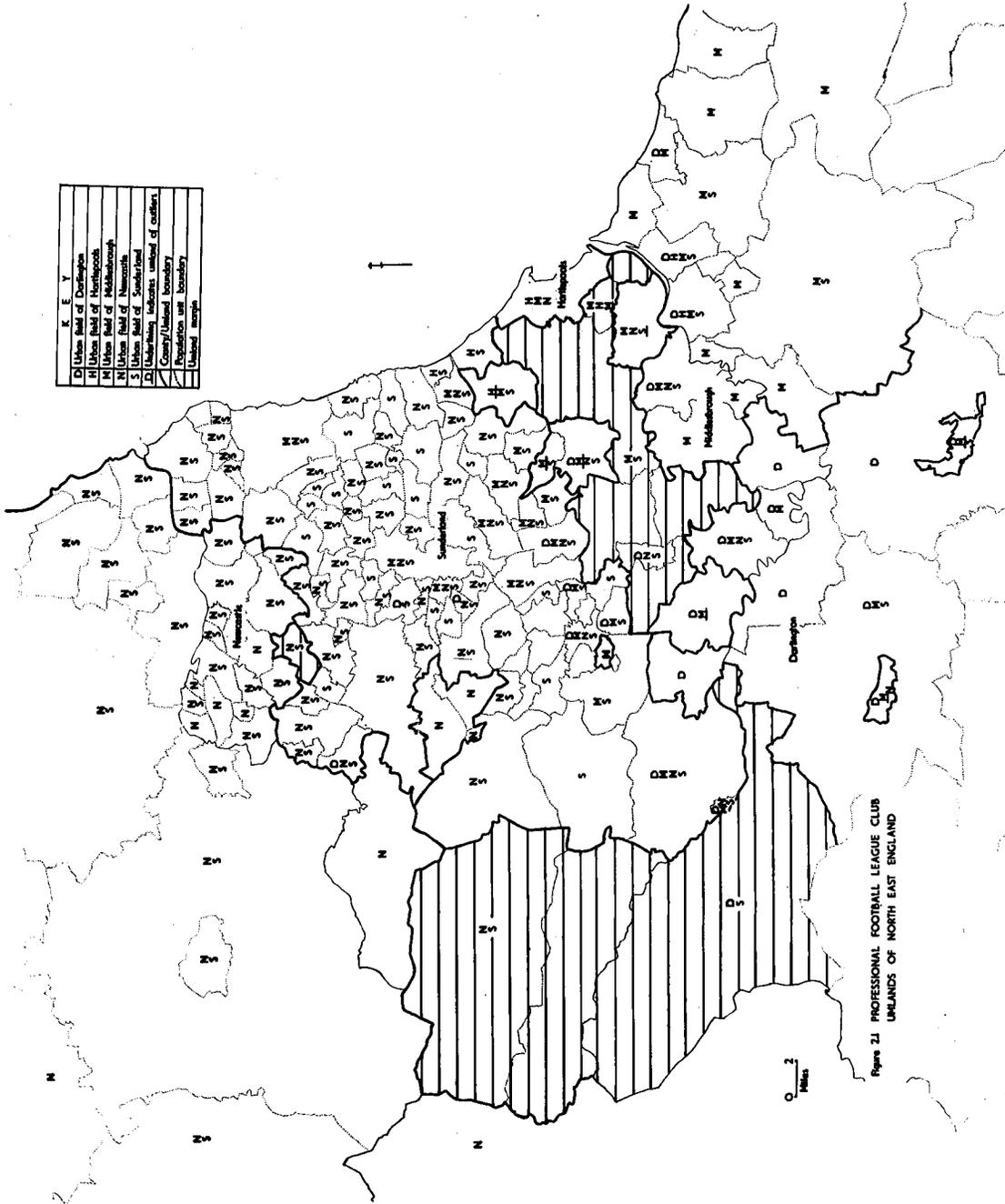


Figure 21 PROFESSIONAL FOOTBALL LEAGUE CLUBS
MIDLANDS OF NORTH EAST ENGLAND

Before these specific umlands and urban fields can be studied, some comment is necessary upon the source of data. Season ticket holders are essentially loyal supporters of a club. This is partly shown by the fact that they buy their tickets at the beginning of a season when a club's success or failure for that season is an unknown quantity.

It can be argued that distance is also a factor in people becoming season ticket holders. Those who travel to matches from outside the club's home town may be delayed by traffic congestion caused by the match itself.³ To ensure a good seat or position after making the journey, they are likely to become season ticket holders. This supposition can be partly tested by a survey of the Sunderland v. Swindon match played on 21st February 1964⁴. This showed that about 70% of the people attending the match were from outside the then borough boundaries of Sunderland.

The data (see Table 2.1) shows a variation in terms of the proportion of home town to total season ticket holders, between division two and division four clubs. However, in neither case does the proportion of season ticket holders from outside the home town rise to as high as the 70% of the attendance at the Sunderland v. Swindon match. This may suggest that loyalty of support is more important than distance with season ticket holders. Even so, this does not explain how this loyalty was achieved in the first place. It may be that distance was a factor at this stage. But it must be added that firm conclusions cannot be based upon a comparison with attendance at a single match.

It is possible that the urban field of each club's total support may not correspond with that of the season ticket holders.

CLUB	DIVISION	SEASON TICKET HOLDERS		b) AS A PERCENTAGE OF a)
		a) TOTAL	b) HOME TOWN.	
Darlington	4	665	588	88%
Hartlepoons United	4	327	278	85%
Middlesbrough	2	1069	476	45%
Newcastle United	2	4229	1842	44%
Sunderland	2	6703	2844	42%

Table 2.1. Season Ticket Holders, 1963-64 Season, N.E. England Clubs.

There may be social differences between those holding season tickets and the remainder of those attending a match. As far as season ticket holders are concerned, they would appear to form a social cross-section of the whole population⁵. This statement needs one qualification in that males dominate, which is not true of the whole population. This social cross-section presented by the season ticket holders may, or may not, be true of football spectators as a whole.

There would appear to be some link between club shareholders and the area from which a club draws its season ticket holders. A study of the home addresses of Newcastle United shareholders shows a similar pattern to that of the specific unland on figure 2.1. Few shareholders live in County Durham whereas with Sunderland none live outside the county area.⁶

The basic situation

The five football clubs analysed here are taken conveniently as a hierarchical group. As Football League clubs they are distinct from all other football clubs in the area. They are not, of course, the only football clubs. Spectators will be found watching games at even the lowest level of club - the village team. The Football League clubs can be recognised as a separate entity from all other football clubs because of their better ground facilities compared with other clubs; their higher proportion of professional players and their higher spectator attendance at matches compared with other clubs. The Northern League represents the next step in the hierarchy below the Football League Clubs, within North East England. Their average match attendance is less than 1000 spectators while the fourth division Football League clubs average several thousand spectators.

Significantly enough, in terms of Central Place Systems⁷, the five football clubs being studied are located within the major urban areas of North Eastern England. In chapter one it was suggested that two major urban areas existed, Tyneside and Teesside. The former contains a sub-region on Wearside. Both Tyneside and its sub-region, Wearside, have their Football League clubs, Newcastle United and Sunderland respectively. Teesside is a less integrated area, with Hartlepool and Middlesbrough on opposite banks of the wide Tees estuary, and extending upstream to Stockton. Darlington may be recognised as a separate town though closely

linked to the Teesside urban area. Again, the Football League clubs are located within this urban mesh at Hartlepoons, Middlesbrough and Darlington. Their location within the Teesside urban mesh is interesting as they occur at or near the limits of the urban area. Table 2.2 indicates the straight line distances separating the grounds of all the clubs within the two major urban areas.

CLUBS	DISTANCE
Newcastle to Sunderland	11 miles
Darlington to Middlesbrough	13 miles
Middlesbrough to Hartlepoons	10 miles

Table 2.2. Straight-line distances separating Football League Club grounds, within urban areas.

Two main issues are to be examined in this chapter. Firstly what form does the individual area of attraction of each club take. Competition between the five centres will be more extensively examined in Part Two of this thesis. Secondly, given a recreational activity of high elasticity of demand such as professional football, what is the relationship between the urban core of North East England and its rural fringe? In fact it would appear that the level of realised demand for football spectating on the extreme rural fringes of North Eastern England is low. The rural fringes of this region are perhaps best thought of as the limits of a 'field' effect associated with each Football League club rather than as parts of unlands delimiting the relative

competitive strength of the North Eastern clubs with the Football League clubs outside the region, e.g. Hull, York, Leeds, Carlisle.

Newcastle United

The specific urban field of Newcastle extends from Berwick-on-Tweed in the North, along the Scottish border to the Solway Firth, whence it follows the coast towards Cockermouth. From there it turns eastwards to the Cumberland-Durham-Westmorland border near Alston. Alston and Derwentdale are within the urban field. Southwards Weardale and Teesdale, from Barnard Castle downstream, are also within Newcastle's specific urban field. The Tees is virtually the southern limit of the urban field though season ticket holders are found in Middlesbrough (19) and Richmond (1) within the North Riding.

The specific unland is clearly defined to the south. Here Newcastle is in close competition with Sunderland for supporters. Starting at the mouth of the Tyne, the boundary follows the river upstream to Felling. Three ferries operated across the river in this area in 1963-64 but there were no road bridges or tunnels. From Felling the north western corner of County Durham comes within the Newcastle specific unland. It may be noted that there were (and still are) several bridges across the Tyne from Newcastle-Gateshead upstream in 1963-64. Gateshead, Whickham, Blaydon and Ryton all fall within the Newcastle specific unland. Stanley appears to be a point of equal attraction (to Sunderland and Newcastle) while Consett is in Sunderland's specific unland.

Further south west, the specific unland boundary is continued to include Derwentdale within Newcastle's area. Within Weardale a boundary cannot be drawn with any certainty. Competition is still with Sunderland, but is marginally to both centres. Here at about 25 miles from both centres the "field of attraction" appears to be weak.

To aid the analysis of Newcastle's area, graphs of interaction in various directions from Newcastle have been drawn (see fig. 2.2). This figure uses straight line distances in miles for the x axis and the interaction unit for the y axis⁸. Three lines have been plotted to illustrate the change in the field of attraction with direction.

Northwards from Newcastle the population density changes from the coalfield area around Newcastle to the farming area north of Morpeth. A thinly populated rural fringe lies beyond this in the Cheviots along the Scottish border. One hundred and sixty two people are needed to provide one season ticket holder within the Newcastle-Newburn administrative area. This may be termed the basic interaction unit. At Bedlington the interaction unit is 490 within the coalfield. Morpeth Rural District with 607 as its interaction unit is in rural Northumberland. Rothbury Rural District is on the edge of the Cheviots and has an interaction unit of 914. Berwick Municipal Borough is right on the Scottish border and at the limits of the urban field. Its interaction unit is 4,059.

Bellingham Rural District is also part of the thinly populated rural fringe and has an interaction unit of 1,321. It is also at

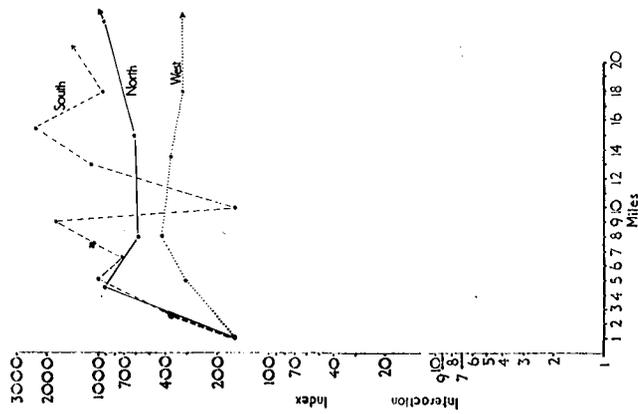


Figure 2.2 Newcastle Football Club Interaction Indices along section lines as indicated

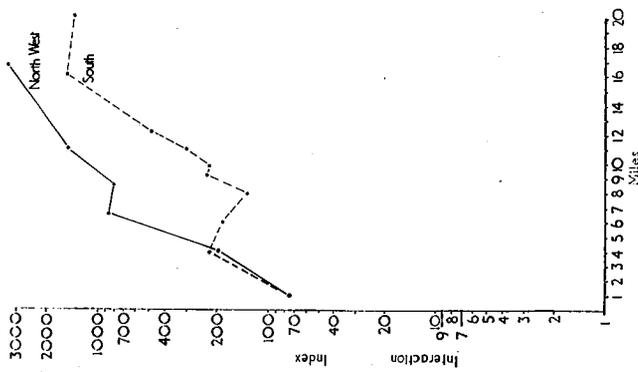


Figure 2.3 Sunderland Football Club Interaction Indices along section lines to the north west and south

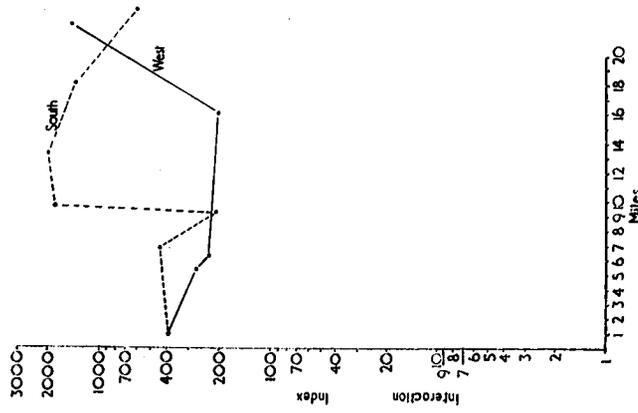


Figure 2.4 Middlesbrough Football Club Interaction Indices along section lines to the west and south

the limits of the urban field. Berwick-on-Tweed is 55 miles in a straight line from Newcastle. The Scottish border via Bellingham is some 47 miles from Newcastle. This gives some indication of the range of the urban field in this direction. The slope or gradient of the interaction units on the graph (figure 2.2) is very gentle.

Westward through the Tyne Gap, the built-up area of Newcastle is soon left and an essentially rural area is crossed to Carlisle. At Cocker-mouth there is an increase in the population density associated with the Cumberland coalfield. The interaction units as far west as Haltwhistle Rural District are consistently between 300 and 400. Then they rise sharply in Cumberland proper to 5,929 at Border Rural District, 71,112 at Carlisle Municipal Borough (with only one season ticket holder) and 2,911 at Cocker-mouth Urban District. The apparent fall in the interaction unit at Cocker-mouth may be related to the increased population density of the coalfield area compared with the rural area of the rest of Cumberland.

The position becomes more interesting when the third line is studied. Southwards only Gateshead (371) and Sacriston (157) have interaction units which are well below 1,000. Yet compared with the other two directions, the Durham coalfield provides an area of dense population as far south as Darlington. Here, however, there is an additional factor not available elsewhere. The unland boundary with Sunderland is crossed at Ouston and so most of the population units plotted are within the Sunderland specific unland

though the Newcastle specific urban field. The slope of this line is greater than the other two.

The implications of some of these points will be considered in another section of this chapter, when more examples and details have been outlined.

Sunderland.

The specific urban field of Sunderland extends from Belford in north Northumberland through Rothbury and Hexham in a south westerly direction and through the Tyne gap to Brampton, just within Cumberland. It then turns southeastwards to follow the Pennine moorland edge. Weardale and Teesdale are within the Sunderland specific urban field. The southern limit is a rather vague area just south of the Tees with interactions in Richmond Rural District (1), Northallerton Urban District (1), Stokesley Rural District (1), and Scarborough (5). Certainly this urban field ends in rural areas, and covers most of what is normally recognised as North East England.

The specific umland is fairly definite because Sunderland is competing with all the other centres. With Newcastle, it competes for south Tyneside. It is successful as far as Felling and then the boundary passes south to Chester-le-Street; it is marginal in Stanley, but Consett is wholly within the Sunderland specific umland. Westwards the boundary includes Wolsingham. Then it becomes indefinite in the Stanhope area. Here it is in equal attraction with Newcastle. Upper Teesdale lacks any interactions but Barnard Castle and the rural area between Barnard Castle and Wolsingham

are in the Sunderland specific umland. The boundary then tends to follow the edge of the Durham coalfield with Bishop Auckland, Shildon, Ferryhill, the Trimdons and Peterlee within the specific umland.

The attraction of Sunderland and Darlington is equal at Newton Aycliffe. No observable interactions occur around Mordon which is an area of scattered rural population on the eastern fringe of Newton Aycliffe. Here the specific umlands of Darlington, Middlesbrough and Sunderland meet. Stillington interacts equally with both Middlesbrough and Sunderland, but Middlesbrough is able to push the Sunderland umland boundary northwards from here, out of the rural area, back on to the coalfield and even claim Fishburn in competition with Sunderland. Hartlepool United then competes with Sunderland to the coast at Blackhall.

Obviously the urban field is much greater in extent than the umland of Sunderland for season ticket holders. The umland is entirely within County Durham. It includes virtually the whole of the coalfield area and the approaches to Upper Teesdale and Upper Weardale. All three New Towns in County Durham - Newton Aycliffe, Peterlee and Washington - are near or on this specific umland boundary, a significant feature in terms of Central Place Theory.

A graph of interaction in two directions (see figure 2.3) from Sunderland helps to suggest an answer to the factors at work when compared with similar graphs for Newcastle. The slope for the Sunderland-Newcastle line is steeper than that of the Sunderland - Hartlepool line. As with Newcastle, the interaction units are

below 1,000 initially. Once the umland boundary is crossed, they rise steeply and are over 1,000. Notice that the y axis of the graphs has a logarithmic scale emphasizing the rapid rate of increase. Washington, within the Sunderland specific umland, has an interaction unit of 198; Gateshead-Dunston, beyond the umland, but within the Sunderland specific urban field, has an interaction unit of 820. Castle Ward, further away still, has a figure of 3,600.

Towards Hartlepool similar figures are Seaham (111), Hutton Henry (500), Hartlepool (1607).

Newcastle is about 11 miles from Sunderland while Hartlepool is 16 miles by crow-fly distances. This suggests that where two centres are close together the rate of change in interaction is greater than when they are some distance apart. If this is applied further to the Newcastle examples, the slight slope of the lines towards Berwick and Carlisle (both of which have Football League clubs) is partly explained by their being 63 miles and 57 miles respectively by road from Newcastle.

This still leaves the question of Weardale and the apparent equal attraction of Sunderland and Newcastle here. In fact 6 interactions take place in Stanhope, 6 in Wolsingham, 1 in Upper Derwentdale to the north and 1 in Woodlands to the south. In Upper Teesdale, above Barnard Castle, no interactions are observable. Hence in Upper Weardale and the surrounding area only 14 interactions are recorded. Within an area of some 320 square miles only 0.1% of the total interactions of Newcastle and Sunderland are combined are recorded. When it is realised that the total popul-

ation of this area is only 14,479, giving a density of 45 persons per square mile, a possible explanation is apparent.

At this distance from Newcastle (about 24 Miles) and Sunderland (about 28 miles) the interaction unit is about 2,000 for both centres. Hence from the rural population at this distance, the potential for season ticket holders for both clubs is only 7 people. Those of the 14,479 people living in Wolsingham and Woodlands are within the Sunderland specific umland leaving 9,168 or a potential of 5 season ticket holders from the remaining area. With such low numbers, the sample is obviously too small to draw definite boundaries.

This study of the detail of part of the inland boundary of Sunderland shows that the data is insufficient in rural areas away from the urban centres to draw definitive boundary lines. In fact in Weardale the umland and urban field limits are almost identical.

Middlesbrough

Middlesbrough's specific urban field can be traced from Hartlepool on the coast to Peterlee and then westwards along the southern edge of the coalfield. Coxhoe, Cassop, Spennymoor, Bishop Auckland and Barnard Castle mark this line. Sunderland and Durham form isolated pockets of support further north of this boundary. From Barnard Castle a scatter of season ticket holders occurs in the Northallerton gap area as far south as Ripon and Thirsk. The Cleveland Hills and the Yorkshire coast southwards to Whitby complete the specific urban field.

A definite specific umland can be delimited northwards. The Tees is bridged at Middlesbrough and Stockton, and Middlesbrough is able to compete northwards with Hartlepool and Sunderland. A rural fringe with no observable interactions occurs north eastwards of Middlesbrough and forms the boundary of the specific umland with Hartlepool. Middlesbrough extends its attraction northwards through Billingham and Sedgfield to Fishburn. Competition with Sunderland is then met with on this southern edge of the coalfield, and the northern limit of the specific umland is reached.

Westwards through Stockton, a rural area around Sedberge is reached with no observable interactions within it. Beyond this negative zone, Darlington is dominant. To the north west of this negative zone competition from Sunderland is met. A boundary occurs at Sedgfield but Stillington to the south has equal attraction to Sunderland and Middlesbrough. South westward a clear boundary with Darlington occurs at Eaglescliffe, and continues more or less wouthwards across the Tees separating the Yarm area from the rural area of Northallerton. Northallerton itself is within the Middlesbrough specific umland, as is Richmond, but it is virtually impossible to draw a boundary within the rural area lying to the north, separating the Middlesbrough specific umland from that of Darlington.

As with Weardale and the Newcastle-Sunderland competition, a rural fringe makes definition of both the specific urban field and specific umland of Middlesbrough difficult in places. In part

this difficulty arises from the nature of the data. In the 1963-64 season, Middlesbrough had only 1069 season ticket holders. Over half of these lived in Stockton, Eston and Middlesbrough itself. In some other season the club might have attracted more support and the larger numbers would have enabled clearer boundaries to be drawn.

But this is not the only factor involved. In every case, the boundary definition breaks down in rural areas with sparse population. One example will suffice. Middlesbrough has an interaction unit of 409. Going west to Darlington the interaction units rise - Thornaby (556), Stockton (817), Elton (706). At Sadberge there are no observable interactions while the next population unit, Darlington, has an interaction unit of 6,076. The interaction unit for Sadberge is therefore over 1,000 while its population is 1,097. One season ticket holder is potentially in this area and it is about the unland boundary of Darlington, Middlesbrough and possibly Sunderland. Mordon, to the north, with a population of 923, also lacks observable interaction. A rural fringe provides an effective limit to the inlands here because of the lack of population.

A similar problem exists to the south. Neither the specific urban field nor the specific unland has a clear boundary here. The next nearest Football League clubs are at Leeds (65 miles by road) and York (51 miles by road). They might be expected to compete with Middlesbrough in the Northallerton gap and the Vale of York. Certainly there are few observable interactions between Middlesbrough

and the Rural Districts of the North Riding. Figure 2.4 shows that the slope of graphs is similar to those of Newcastle United north of Berwick-on-Tweed and west to Carlisle (see figure 2.2).

Certainly there is evidence of links between Middlesbrough and the surrounding area of the North Riding. For the finals of many amateur competitions in the North Riding, the Middlesbrough professional ground is used. Within association football, the North Riding looks north eastwards to Middlesbrough. This is illustrated

by the support Middlesbrough does get from the towns of the North Riding where the local leagues have their strength. This suggestion is further supported by the evidence of a link between Middlesbrough and the Yorkshire coastal zone as far south as Whitby. Here the towns show significant levels of interaction with Middlesbrough while the rural areas do not.

One might have concluded by suggesting that the level of demand and the density of population in the North Riding are such that only a general "field of attraction" operates. Both the specific urban field and specific unland of Middlesbrough are lacking in clear definition to the south.

Darlington and Hartlepool United

As both Darlington and Hartlepool United have certain features in common, it is convenient to consider them together. The basis of this is shown on Table 2.1. Both were fourth division clubs and drew only 10-15% of their season ticket holders from outside their respective town areas in 1963-64. Their season ticket holders were essentially loyal supporters who lived locally. This is

also shown by their specific urban fields and umlands which were small compared with the other three clubs.

Hartlepool's specific urban field has a radius of about 8 miles from the ground in West Hartlepool. Only eight population units interact with Hartlepool. The specific umland is even more restricted. Westwards it fades into the rural fringe around Elwick with no observable interactions. Southwards competition with Middlesbrough results in equal attraction at Greatham, again the rural fringe around the town. Northwards the more rural area of Hutton Henry is within the umland but along the coast competition with Sunderland forces Hartlepool off the coalfield and into the narrow rural fringe at Hart Station.

Darlington has a similar pattern. Because it is competing with Newcastle, Middlesbrough and Sunderland at a greater distance than Hartlepool, its specific urban field and umland are bigger than those of Hartlepool. Its urban field extends northwards to Bishop Auckland and Ferryhill, southwards to Richmond and Northallerton. The specific umland is cut off in the rural area separating these towns from Darlington. Westwards both the specific urban field and umland lack definition. Interactions in Teesdale and south westwards towards Swaledale are very few.

The Centres

The descriptions above suggest there is a relationship between the area a Football League club serves and the size or attractive power of the club. Both Darlington and Hartlepool United were

fourth division clubs in 1963-64 and both had small fields of attraction compared with the other three clubs. It is worth considering measurement of the power of attraction of the clubs. To help, the total attendances of each club in the Football League in the 1962-63 season have been plotted in the order of their final position in each division, at the end of that season (see figure 2.5). This shows that attendances varied with the league division and with the success or failure of the club within its division. In general the top four clubs of each division had attendances equal to the average of the division above.

Season ticket holders would be aware of this situation at the start of the 1963-64 season and their attraction to a club may have been based upon three variables. These were loyalty, the league division of the club and its potential success/failure as measured by its position in a division at the end of the previous season. Table 2.3 gives the data about two of these variables for the north eastern clubs. The point about attraction of a division of the Football League is shown by Table 2.1. The total support for each of the second division clubs is greater than that for the fourth division clubs.

On the basis of division positions, Middlesbrough should have more support than Newcastle. In fact, Newcastle has much greater support than Middlesbrough. Obviously the variables require further investigation.

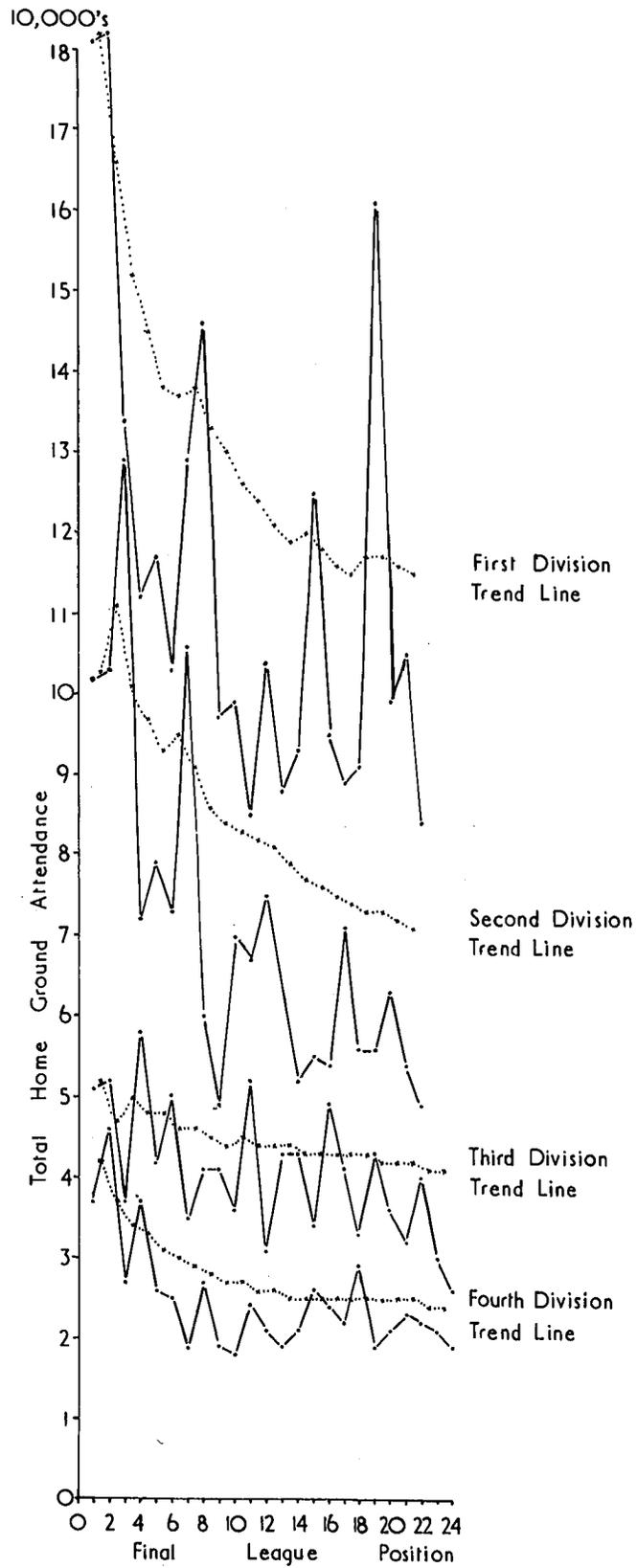


Figure 2.5 GRAPH of FOOTBALL LEAGUE CLUBS
1962-3 by TOTAL HOME ATTENDANCE
and FINAL LEAGUE POSITIONS

Umland Populations

As the boundaries of the umlands are somewhat indefinite in

CLUB	DIVISION	POSITION
Darlington	4	12
Hartlepool United	4	24
Middlesbrough	2	4
Newcastle United	2	7
Sunderland	2	3

Table 2.3. Division and final position of clubs in the 1962-63 season.

places, the data was supplemented by a study of transport. With the aid of a police investigation¹⁰ and information from 'bus companies'¹¹, it was possible to gain a more precise picture. A further factor taken into account was continuity of interaction. If a series of adjoining population units interacted with a centre, continuity was established. If a break in any outward direction occurred with a unit failing to interact being succeeded outwards with a unit interacting, then it can be said there is a discontinuity.

CLUB	DIVISION	a) UMLAND POPULATION	b) TOTAL SUPPORT	$\frac{a}{b}$
Darlington	4	154,355	665	232
Hartlepool U.	4	108,221	327	331
Middlesbrough	2	519,865	1069	486
Newcastle U.	2	1,021,007	4229	241
Sunderland	2	954,273	6703	142

Table 2.4. Umland Populations of North East Football League Clubs 1963-64.

With this extra information and using the principle of continuity as a further guide, vague unland boundary lines were resolved. Table 2.4 was then calculated using 1961 Census data for population totals for each population unit. The fact that Newcastle United can draw support from an unland with twice the population of that of Middlesbrough may be significant in comparing their respective totals of season ticket holders. In fact Middlesbrough requires twice the population to produce a season ticket holder compared with Newcastle United.

The significance of Table 2.4. is illustrated by figure 2.6. on a log-log graph, the five clubs show a high correlation of unland population to total (season ticket holders) support. R has a value of +1.0 and the regression equation is $\log x = \log 0.91 y + \log 2.7068$. Because the number of units is so small one can only conclude that a correlation exists and justifies the consideration of unland populations. The fact that it is a logarithmic relationship partly explains the lack of consistence in Table 2.4 in the last column.

Conclusions

If an attempt is made to calculate a crude hierarchy of centres by giving scores for their division, their unland population and a bonus/forfeit for their position in the previous season¹², a possible result is Table 2.5.

Umland
Population

100,000's

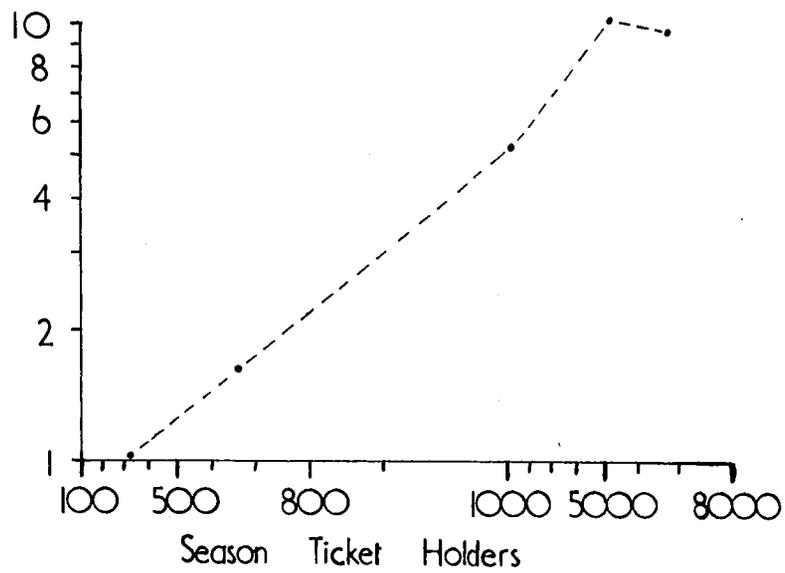


Figure 2.6 Graph of Football League Club Season Ticket Holders compared with Umland Population

CLUB	DIVISION	POSITION 1962-63.	POPULATION RANKING.	TOTAL POINTS	HIERARCHY RANKING.
Darlington	4	0	4	8	4
Hartlepool U.	4	+1	5	10	5
Middlesbrough	2	-1	3	4	3
Newcastle U.	2	0	1	3	1
Sunderland	2	-1	2	3	1

Table 2.5. A possible hierarchy of clubs for 1963-64 season.

This shows that Newcastle and Sunderland are likely to attract more support than Middlesbrough. Middlesbrough's level of support is likely to be higher than Darlington's which is higher than Hartlepool's. This is a near approximation to the position as shown in Table 2.1.

It must be admitted that the data collected has limitations in terms of the actual number of interactions. A higher level of interaction would have given more definite delimitations of specific umlands. However the power of attraction of each centre would change each season, so only one season's data can be considered at a time. This reflects the elasticity of demand with season ticket holders.

This point is reinforced by events since the 1963-64 season. In one season Middlesbrough was relegated from division two to division three, Darlington promoted from division four to division three and Hartlepool United had a reasonable season. In another season, Middlesbrough gained promotion to the second division while Darlington was relegated to the fourth division. As one

Teeside team went up, another went down. There seems to be a balance operating which is the basis of these swings and roundabouts. This may be the total population available on Teesside to support Football League clubs. This point will be considered further in Part Two of this thesis.

This failure to define specific upland boundaries occurs on the rural fringe of the area, on the whole. The North East is separated from all other neighbouring industrial areas by a broad rural belt. The fact that upland and urban fields become vague in this belt suggests that the power of attraction from Tyneside and Teesside is not sufficient to involve the rural fringe in this element.

Finally, on the evidence available, some indication of the local town regions is possible. Newcastle serves Northumberland and north west Durham, west of the Tyne Bridge. Sunderland serves the Durham coalfield area (except the north west), lower Weardale and possibly Teesdale. Middlesbrough serves the Yorkshire coast as far south as Whitby and the Northallerton gap as far as Richmond and probably southwards towards Thirsk and Ripon.

Darlington shares Newton Aycliffe with Sunderland but otherwise is limited by the rural zone around the town. Hartlepool appears to be a peninsula cut off to the north by the coalfield and to the west by Stockton-Billingham, represented by Middlesbrough's upland in this element.

References

1. Examples of classifications of types of journeys will be found in Keyer, Kain and Wohl, 'The Urban Transportation Problem', (Harvard University Press), 1965, and 'Origin-Destination Survey Procedure as adopted in the traffic forecast for Cumberland New Town', Cumberland Development Corporation, 1966.
2. 'Briefing on Football', the Economist, 25 Dec. 1965.
3. 'Report on the future of public transport in Sunderland', Sunderland Borough Council, 1964.
4. Idem.
5. Personal communications with the Secretaries of the five Football League clubs and with various private individuals.
6. Data made available by the club secretaries of Newcastle United and Sunderland football clubs.
7. This phrase is used deliberately following the more flexible approach to Central Place problems as illustrated by Berry, B.J.L., 'Geography of Market Centres and Retail Distribution', Prentice Hall, U.S.A. 1967.
8. The interaction unit is:
the census population of a population unit ÷ the number of people travelling to a centre from that population unit.
This gives the population base required to produce one unit of interaction from a population unit to a particular centre for a specific purpose. This eliminates the influence of the varying distribution of population around a centre.

9. Personal communication with the Secretary of Middlesbrough Football clubs.
10. Report of the Newcastle United v. Blackpool match, 6th November 1965, by Newcastle upon Tyne City Police. Report made available by the Chief Constable.
11. Personal communication with Middlesbrough Corporation Transport Department, Northern General Transport Co. Ltd., Sunderland Corporation Transport Department, United Automobile Services Ltd., Venture Transport Co. (Newcastle) Ltd.
12. The top four clubs in each division (except the first) appear to have attendances equal to that of the next highest division and they are given a bonus of +1. For similar reasons the bottom four clubs of each division forfeit a point.

3. THE ELEMENTS - OPHTHALMIC TREATMENT

One of the problems of delimiting fields of attraction is obtaining data which has home addresses from which journey patterns can be mapped. Admissions to hospital require each patient to be entered in the hospital admissions register with name, address and a variety of other information. The date of admission is given and the end point of the journey, the hospital, is known. While journeys to hospitals do not appear in many journey pattern surveys, it can be shown to be a reasonable pattern to study.

The Data

By carefully choosing a specialty, the population at risk can be the whole population. People suffering from burns or falling and breaking a leg, do not do so from choice. It is usually an accident and this chance or random factor puts the whole population at risk. Certainly there is unlikely to be a social structure as far as accidents are concerned. It must be admitted that certain occupations have a higher risk factor for certain accidents and should be allowed for in the choice of specialty.

Further, it can be shown that there is a hierarchy of services.¹ With the establishment of the National Health Service in 1948, specialties were developed and the country divided into fourteen Regional Hospital Boards to organise the supply of specialties to meet the local demand. County Durham is wholly within the Newcastle Regional Hospital Board. Within this Region, four levels of service can be recognised as a result of demand, or, in medical terminology,

the incidence of morbidity. This hierarchy of services is an administratively imposed one, but based upon population. The regional Hospital Board thinks in terms of each hospital having a catchment area and recognises that this changes with each speciality within a hospital. The catchment area for ophthalmic treatment for one hospital though will contain the same population as that for another such hospital. Table 3.1 indicates the hierarchy as visualised by the Board.

	CENTRES	POPULATIONS	SERVICES
1	ONE for whole region	About 3 million	Cardiology
2	TWO/THREE for whole region	1-1.5 million	Radiotherapy Thoracic
3	ONE within each area of...over 150,000		E.N.T. Ophthalmic
4	ONE within areas of.....below 150,000		General Surgery Gynaecology

Table 3.1. Hierarchy of hospital services, Newcastle Regional Hospital Board.

	SPECIALTY	ADMISSIONS	NUMBER per 100,000 POPULATION
1	Cardiology	10	0.1
2	Radiotherapy	28	0.4
3	Ophthalmology	843	6.9
4	General Surgery	13,006	102.4

Table 3.2. Selected specialty admissions 1957-58, Teesside Area.

The existence of a hierarchy is further demonstrated by the results of the Nuffield Teesside Hospital Enquiry². For each level

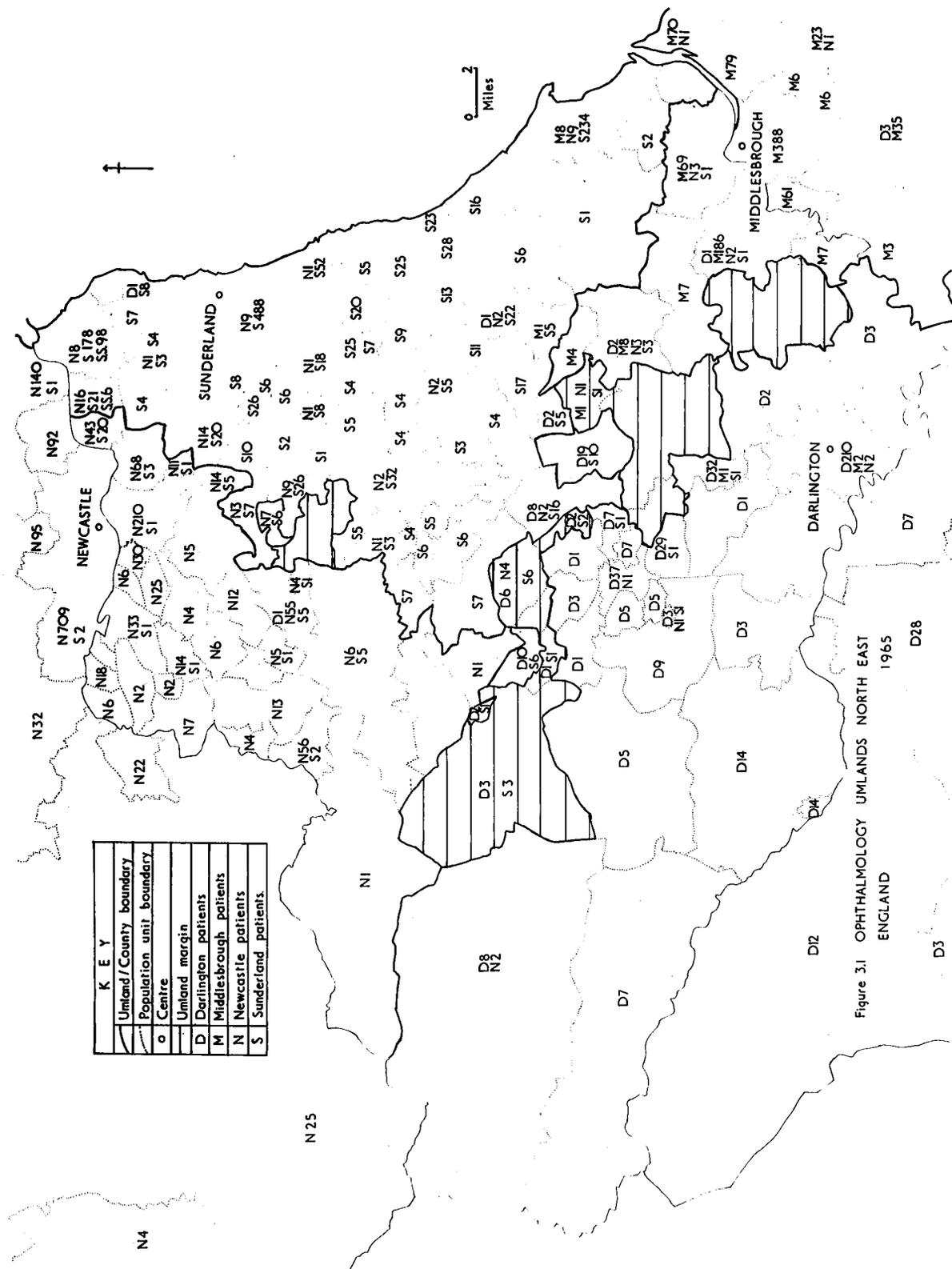
of service in Table 3.1 the enquiry counted total demand for beds during a twelve month period in 1957-58 and related this to the population of the catchment areas of the hospitals studied. A sample of this data is given in Table 3.2. It demonstrates the different demands at the different levels of the hospital services.

It is against this background that the element ophthalmology was selected for study. In terms of the number of centres involved, it had a distribution similar to the Football League clubs. But whereas these clubs had a built-in hierarchical problem of contrasted divisions, this element had a recognised level of uniformity of service from the beginning.

Admissions registers for each hospital with an ophthalmic unit were scanned. The settlements for all admissions for treatment within the ophthalmic unit in the year 1965 were noted³. On the basis of this data fig. 3.1 was constructed, using population units. Most patients stayed in hospital for about two weeks⁴. Hence there is a possibility of one patient occurring twice in one year. Experience shows that this likelihood is statistically insignificant in terms of the data⁵.

The Basic Situation

This element is concerned with a stage three hierarchical group (see Table 3.2). Within the Newcastle Regional Hospital Board area ophthalmic beds are provided at hospitals in Carlisle, Darlington, Middlesbrough, Newcastle and Sunderland. A few beds are also available at South Shields. These will be commented upon later, but ignored for the present.



K E Y	
(Solid line)	Umland/County boundary
(Dashed line)	Population unit boundary
(Circle)	Centre
(Dotted line)	Umland margin
(D)	Darlington patients
(M)	Middlesbrough patients
(N)	Newcastle patients
(S)	Sunderland patients

Figure 3.1 OPHTHALMOLOGY UMLANDS NORTH EAST ENGLAND 1965

Data was collected from all these centres so that specific unland boundaries are potentially more precise than with the professional football clubs.

Within the North East of England ophthalmic units exist at Darlington, Middlesbrough, Newcastle and Sunderland. This is a similar network to professional football with Hartlepool omitted, and Darlington strengthened in terms of its hierarchical position. Again the Tyneside and Teesside locations are found. When considering professional football, elasticity of demand was assumed. In this element, the situation would appear to be different. People requiring ophthalmic treatment can either refuse to have it or go to hospital for the treatment. There is little likelihood of the former and in fact hospital waiting lists suggest that demand or need is such that one can ignore anyone in the former group as being statistically insignificant.

Hence demand tends to be greater than supply. This situation has existed for some time, and the changing demands of professional football are not present here. This suggests that the pattern of unlands and urban fields might be one of centred regions. As each hospital has a recognised catchment area of a given population (150,000+) it is possible that patients are drawn only from that catchment area. It must be admitted that the Regional Hospital Board talks of 'notional' catchment areas and uses them as the basis of planning. It has no mechanism whereby patients are checked at each hospital on admission to see whether they are at their 'right' hospital. But certainly the possibility of a centred region exists

with this element and must be examined.

Also this element presents a further opportunity to examine the rural fringe of the urban areas and add further data to establish working hypotheses on what is operating at the rural fringe.

Newcastle.

The specific urban field of Newcastle extends northwards to include the whole of Northumberland to the Scottish border. It extends westwards into Cumberland but has no observable interactions with Westmorland. South westwards Derwentdale and upper Weardale form the limits of the urban field. A limited number of patients are drawn from the Bishop Auckland area, Darlington and Teesside to give the southern limits of the field. This gives an urban field which is very similar to that of professional football. It does not penetrate south westwards and southwards as far as professional football, but with the exception of the Alston area, the difference is small. Alston shows a marked interaction in football which is missing completely in ophthalmic treatment.

Because the data for Carlisle is available, it is possible to define Newcastle's specific umland westwards to Carlisle as well as southwards towards Darlington, Middlesbrough and Sunderland. Haltwhistle R.D. has a state of balance between Newcastle and Carlisle. From here the boundary turns south east in competition with Darlington, leaving Derwentdale in Newcastle's specific umland, but Weardale within that of Darlington. Just north of Crook the boundary turns sharply north eastwards as competition with Sunderland is met. North west Durham and the rural area of Lanchester remains

within Newcastle's specific umland but Brandon and Durham are outside it. At Pelton an outlier to Newcastle exists. The immediate surrounding area is within the Sunderland specific umland but this village looks towards Newcastle. Birtley, Springwell, Felling and Hebburn form the Newcastle side of the boundary north eastwards and then the Tyne separates Newcastle's area from that of Sunderland as far as the North Sea.

As with professional football, interaction has been graphed in certain directions to indicate changes in the intensity of the field of attraction (see figure 3.2). The interactions northwards vary between 400 and 800 people per interaction unit (interaction index). The slope is virtually nil and the pattern is similar to professional football. The next ophthalmic unit northwards is Edinburgh⁶. Hence potential competition is further away in this element from Newcastle than with professional football. The sudden rise into interaction indices of over 1000 is not evident, here. In fact Berwick-on-Tweed has an index of 451.

Westwards to Carlisle there is a slope (see figure 3.2). As already stated, Newcastle and Carlisle are equally balanced in Haltwhistle Rural District with an interaction index of 1721. Beyond, the interaction index rises rapidly as Newcastle's specific urban field penetrates the Carlisle specific umland. It is worth noting that Haltwhistle R.D. is about 32 miles from Newcastle and about 18 miles from Carlisle. It is also near the point where the specific umland boundary for professional football was postulated. The fact that the boundary is nearer Carlisle than Newcastle suggests,

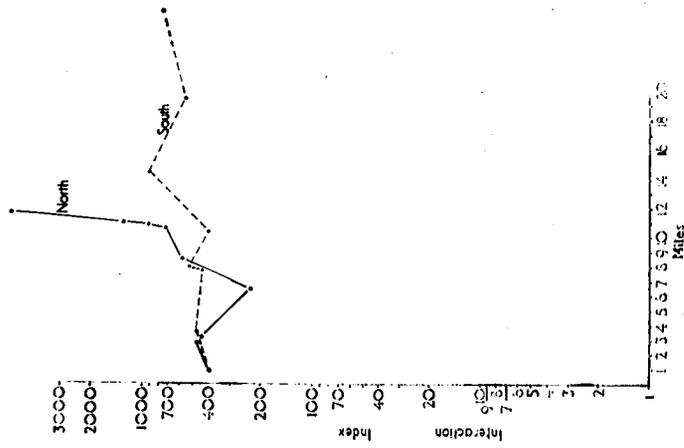


Figure 3.5 Middleborough Ophthalmic Interaction Indices along section lines to the north and south

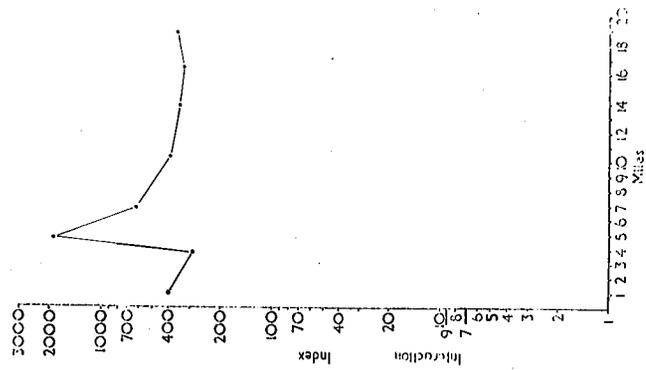


Figure 3.4 Darlington Ophthalmic Interaction Indices along a section line towards Teesdale

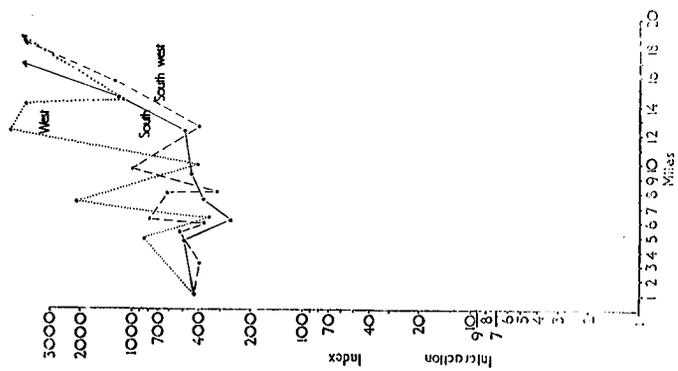


Figure 3.3 Sunderland Ophthalmic Interaction Indices along section lines as indicated

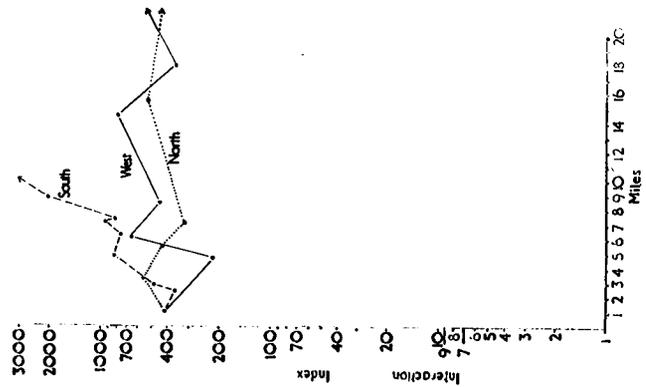


Figure 3.2 Newcastle Ophthalmic Interaction Indices along section lines as indicated

as with the football element, that Newcastle has greater powers of attraction than Carlisle. In terms of hospital beds available, this is true. Newcastle hospitals had some 100 ophthalmic beds in 1965 while Carlisle Infirmary had only 32⁷. This greater power of attraction is illustrated by urban fields. That of Carlisle reaches eastward to Haltwhistle R.D. and no further, whilst Newcastle's penetrates into Cumberland beyond its specific umland.

Southwards Newcastle is in competition with Sunderland and Darlington. The graph of interaction units (figure 3.2) shows a steep slope southwards paralleling the case in professional football. The line is taken through an area of discontinuity⁸. Pelton forms part of the Newcastle specific umland but is separated from the main area by Urpeth. Urpeth is part of Sunderland's specific umland. From the interaction indices it would appear that a zone of equal attraction exists here, rather than a precise boundary line. Four adjacent areas have the indices 841 (Lamesley), 958 (Urpeth), 840 (Pelton), 2108 (Chester-le-Street). Once the discontinuity is passed, the rapid rise of the interaction index into the thousands follows.

As with professional football, Newcastle's specific umland fails to penetrate into the Crook-Willington area. Sunderland dominated this area in professional football. Darlington with Sunderland provide the competition with ophthalmic treatment. This suggests that Darlington as an ophthalmic unit is better able to compete with Newcastle and Sunderland than it was as a Fourth Division football club.

Sunderland

The specific urban field of Sunderland only just crosses the Tyne northwards. Only Newcastle and Tynemouth interact at all with Sunderland. South Tyneside shows Sunderland interacting westwards as far as Blaydon. Then the specific urban field turns south to include Consett and Wolsingham. Then the boundary is found eastward towards the coast with Shildon, Darlington and Stockton forming the limits of attraction. The strong limitation within the geographic county of Durham is in marked contrast to the case in professional football. Only three interactions occur beyond the county boundary.

This strongly suggests that as an ophthalmic unit, Sunderland was less attractive than as a professional football club at the time of the respective data. This will be expanded upon in a later section.

The specific umland is triangular in shape. The sea forms the eastern side of the triangle and the north western side results from competition with Newcastle. In fact if a straight line is drawn linking Newcastle to Sunderland, the line on the map dividing their specific umlands bisects this line. The south western side of the triangle is fairly complex and shows competition with both Darlington and Middlesbrough.

From the mouth of the Tees, Sunderland competes with Middlesbrough. With Hartlepool no longer a separate unit, as in professional football, the whole of the Hartlepool peninsula⁸ is attracted to

Sunderland. The rural zone between Hartlepool and Stockton-Billingham remains the specific umland boundary. As with professional football, Fishburn is attracted to Middlesbrough, but the rest of the eastern part of the coalfield is within the Sunderland specific umland.

West of Fishburn, the boundary position becomes complex. Mainsforth is equally shared with Darlington and Middlesbrough; Darlington is dominant at Chilton-Ferryhill and Sunderland at Spennymoor. From Willington along the Wear valley to Wolsingham, Sunderland and Darlington are of equal attraction. This contrasts with the professional football pattern where Sunderland was able to hold the approaches to Weardale well within its specific umland. The difference results from the stronger power of attraction of Darlington in ophthalmic treatment. The position is made anomalous by the fact that Darlington has a dominance at Tow Law and Crook, across the River Wear but outside the main Darlington specific umland. This point will be considered further when describing the Darlington specific umland.

Figure 3.3 indicates the changing power of attraction of Sunderland in different directions. The slope of the line to Consett shows a marked change in the interaction units at Stanley and Consett compared with Urpeth. In fact once the specific umland boundary is crossed the rate of change in the interaction units is rapid. The same thing is true of the section towards Middlesbrough. The interaction unit remains about 500 people until Hart is reached in the rural zone fringing Hartlepool. The interaction unit rises

to over 1000 people here and on crossing the specific umland boundary into Billingham, the figure rises to 32,000 people. The slope of this section is less than the slope of the Consett line. By implication the specific umland boundary is nearer to Sunderland in the Consett section than in the Middlesbrough section.

The zig-zag nature of the boundary has already been mentioned in the area west of Fishburn. This was studied further by a section from Sunderland to Newton Aycliffe (see figure 3.3). The interaction unit varied from 300 people to 1000 people within the specific umland. At the boundary Cornforth had an interaction unit of 801 people while Ferryhill-Chilton had 1700 people. The former was just on the Sunderland side of the boundary, the latter appearing to be an outlier to Darlington. At Newton Aycliffe, within the urban field of Sunderland but within the specific umland of Darlington, the interaction unit rose to 13,000, a marked fall in the power of Sunderland's attraction. This would all tend to indicate that the Darlington 'outlier' at Ferryhill-Chilton was not in the Sunderland but well within the Darlington specific umland and the apparent 'outlier' was a result of some factor other than sudden or fluctuating changes in the power of attraction at the boundary zone.

Overall one can say that Sunderland's umland covered the limestone plateau, the lower Wear valley with a transition zone at the approaches to upper Weardale, the Hartlepool peninsula and the South Shields peninsula! Compared with professional football, the Bishop Auckland area and the Consett-Lanchester area have been lost. This can be related to the greater competition from Darlington and Newcastle respectively.

Darlington

The specific urban field of Darlington extends northwards to the Wear valley. Crook and Willington are on the northern limit. Upstream Weardale is within the specific urban field while downstream, the urban field turns south eastwards to Spennymoor, Ferryhill and Sedgefield. Stockton and Billingham, and southwards into the Stokesley Rural District, the boundary of the urban field is continued. From Stokesley the attraction of Darlington extends westwards across the Northallerton Gap to the Pennines with a southern limit about Thirsk-Boroughbridge and then into Swaledale. The boundary then follows the Pennines northwards to Weardale again.

Darlington is in competition with Newcastle to the north, Sunderland to the north east and Middlesbrough to the east. Hence in theory a specific umland boundary should be clear-cut on two sides. In fact the boundary poses problems.

The northern boundary is clear between Weardale and De~~w~~entdale. The former is within Darlington's specific umland and the latter within that of Newcastle. Then Darlington and Sunderland form a zone of equal attraction along the Wear valley. However this is complicated by Tow Law and Crook, both within Darlington's specific umland but on the Newcastle side of the zone of equal attraction. There is a similarity here to the position of Pelton in the Newcastle specific umland. These are all cases of discontinuity.

Why these discontinuities occur is a question to which only a tentative answer can be offered. All these discontinuities are small or large villages which are separated from the rest of their

specific umlands by a rural area which is attracted to Sunderland. Is this a case of an innovation wave¹⁰? Certainly the theory of innovation waves suggests information being available first in large towns, then in the smaller towns and finally in the countryside. If the services at Newcastle and Darlington have increased, then the knowledge of this would spread as suggested. At present it would appear to have reached the small town/large village level.

Compared with professional football, Sunderland has a smaller specific umland. Is its service area contracting in comparison with Newcastle and Darlington? Certainly all the discontinuities fringe the Sunderland specific umland.

Eastward the specific umland boundary is a result of competition with Middlesbrough. Again the actual line is far from clear. This time it is because no observable interactions take place where the boundary would be expected. Borth Mordon and Elton are rural areas with population totals of about 1000 people. If the figure of 1000 interaction unit is critical, as implied by examples studied so far, then again these rural areas would probably fail to interact at specific umland borders because of lack of sufficient population to provide an interaction. This position parallels that already studied with professional football for Middlesbrough, Hartlepool United and Darlington.

The westward limit of the Darlington specific umland is examined in figure 3.4. The interaction units westward from Darlington are plotted and show a lack of slope. Interaction remains about the 400 indices. This tends to imply a lack of competition and so an

even power of attraction throughout Teesdale. This is similar to the line northwards from Newcastle already studied.

Middlesbrough

There is very little difference between the specific urban field and the specific umland of Middlesbrough for ophthalmic treatment. This statement must be qualified by the fact that the southern limit of the umland is unknown. Southwards the next ophthalmic unit is at Scarborough. Middlesbrough does interact with Scarborough and Whitby Rural District which form the southern limits of the urban field. Westwards the specific urban field and umland extends across the northern edge of the North Yorkshire Moors. Competition with Darlington then turns the boundary northwards to Yarm and Stockton. Sedgefield, Fishburn and Billingham complete the specific umland. The urban field extends northwards to include Hartlepoons, Trimdon, Newton Aycliffe and Darlington.

Only two details will be considered about Middlesbrough. As with professional football, Middlesbrough is able to compete across the River Tees at Stockton-Billingham and to extend its specific umland to Fishburn. The urban field extends slightly further west and east to include Mainsforth and Trimdon. Again Sunderland's hold on the eastern coalfield area is challenged at this point (see figure 3.5). It is interesting to note the rapid change in the interaction unit once the specific umland boundary is crossed in this section. Fishburn, within the Middlesbrough specific umland, has an interaction unit of 713. Within one mile, but across the umland boundary, Mainsforth shows an interaction unit of 1307, and Trimdon

one of 6052.

The second feature to be noted is the power of attraction within the specific umland towards Whitby. With professional football it was suggested that the specific umland of Middlesbrough extended to Whitby. The ophthalmic data show this clearly (see figure 3.5). The slope of this line is very gentle compared with the line towards Fishburn. This would suggest lack of competition. In fact the next ophthalmic unit is at Scarborough. This is 20 miles from Whitby by road while Middlesbrough is 31 miles away. However the Scarborough unit is small and not able to offer intensive competition with Middlesbrough¹¹.

South Shields

The map of ophthalmic umlands fails to show South Shields. In fact there were 6 beds available for ophthalmic treatment in the two South Shields hospitals. These are normally for local patients who are tended by Sunderland surgeons. In some ways it is an extension of the urban field of Sunderland. This point is of interest in terms of Central Place Theory.

South Shields has an urban field consisting of two population units - South Shields and Jarrow. Within this urban field it is completely dominated by Sunderland (see Table 3.3). At Jarrow even Newcastle has a greater attraction than South Shields. Although ophthalmic hospitalization is at the stage three level in the hierarchy (see Table 3.1) it has within it an urban field which has no umland. From the organisational point of view South Shields is part of Sunderland's urban field, as well as from the broad data.

POPULATION UNIT	PATIENTS TO		
	SOUTH SHIELDS	SUNDERLAND	NEWCASTLE
South Shields	98	178	8
Jarrow	6	21	16

Table 3.3. Urban field of South Shields compared with Newcastle and Sunderland.

The implications of this point are mentioned in the last section of this chapter and will be returned to in the chapter on General Surgery.

The Centres

Four centres are directly involved in this element and there is a reasonable comparison with professional football. The comparison suggests that Sunderland has absorbed the Hartlepool area, but has been unable to compete with Darlington and Newcastle to the same extent that it did as a professional football club. Darlington is shown to be more powerful in ophthalmology than professional football by its larger unland, e.g. successful competition with Middlesbrough in the North Riding of Yorkshire.

A measure is needed of the attractive force of these centres. The usual one for hospitals is the number of beds. This is shown in Table 3.4 with the South Shields beds added to Sunderland. From this it will be seen that a ranking list would have Darlington as unity. Middlesbrough would be roughly twice unity, Sunderland about two and a half times unity and Newcastle about four times unity.

CENTRE	UMLAND POPULATION	BEDS	POPULATION PER BED	TOTAL INTERACTIONS	ATTRACTIVE POWER
Darlington	305,891	24	12,745	591	1
Middlesbrough	473,939	48	9,874	1055	2
Newcastle	1,645,056	100	16,451	2557	4.2
Sunderland	813,847	65	12,918	1591	2.6

Table 3.4. Ophthalmic provision and use, North East England hospitals, 1965.

The attractive power of Newcastle is illustrated by its urban field. This is greater than for any other centre and extends northwards to Berwick-on-Tweed (55 miles) and southwards to Guisborough (42 miles). This is a greater range than any other centre. Both Darlington and Middlesbrough show urban fields within ophthalmic treatment which differ little from their specific umlands. This may result from their low power of attraction.

Umland Population

A test of the validity of beds as a measure of attraction is to compare specific umland populations with the bed ranking of centres. In theory each bed should provide a roughly equal service opportunity with any other bed in any other centre. Hence the populations of the specific umlands should increase in a ratio of 1:2:2:6:4:2 in the order Darlington, Middlesbrough, Sunderland and Newcastle. Table 3.4 shows this is generally true. Middlesbrough appears to be over-provided but this may be accounted for within the nature of the data.¹² Further there appears to be a logarithmic relationship of population of the umland to the total

beds. There is not sufficient data to follow this point through but the ratios stated above could be geometric in progression and the football data also suggested logarithmic relationships.

A further complication in attempting statistical correlations is the nature of the bed occupancy at South Shields. While a maximum of six beds was available at any one time at South Shields, they were not all in use at any one time. On certain occasions less than six beds were in use, and the 'spare beds' used for other types of cases. Hence the figure of six beds overstates the actual demand at South Shields compared with the other centres.

Conclusions

Two sets of conclusions follow from this element. With four centres operating, one finds Newcastle attracting patients from Northumberland and virtually the whole of North West Durham. Sunderland attracts from the Permian limestone plateau, the lower Wear valley and the Hartlepool peninsula. Darlington draws patients from Upper Weardale, and from Upper Teesdale and downstream to Yarm. Middlesbrough continues to hold the Stockton-Fishburn area of County Durham, the North Yorkshire coast to Whitby and the lowland zone fronting the North Yorkshire Moors' escarpment, with the higher dales themselves.

The other conclusion is really in the nature of stating a problem. In the first chapter, the question of a hierarchy or continuum of services and centres was raised. This chapter started with the statement of a hierarchy of specialty. It was shown that a four stage hierarchy was considered to exist within the hospital

service of the Newcastle Hospital Regional Board. Ophthalmic treatment was chosen for study as representing one stage of this hierarchy. Within the detail of this element, it has been found possible to divide the actual centres into another hierarchy/continuum. Although the provision of a bed for ophthalmology requires a certain base population (threshold), the provision of a given number of beds at any one centre varies.

South Shields is the example that illustrates this problem. South Shields has ophthalmic hospital beds but has no specific umland. In terms of the hospital service hierarchy it exists as a centre. In terms of the specific umland study, it does not exist as a centre. If a continuum is thought of instead of a hierarchy, this difficulty may be resolved. Thus a continuum exists for establishment data, i.e. the number of beds provided at any one centre. The hierarchy is concerned with the value, in terms of population, which justified the provision of one ophthalmic hospital bed and appears from the field of attraction data. That is to say, a given population has different morbidity rates for varying specialties.

It may be convenient to think of a specialty and the resulting umlands as a hierarchical problem while the actual provision for a specialty at any set of given centres may be a continuum problem.

References

1. The author gratefully acknowledges the assistance of Dr. Duncan, Newcastle Regional Hospital Board, in obtaining this information.

2. Airth and Newell, 'The Demand for Hospital Beds', Kings College, Newcastle upon Tyne, 1962.
3. The author gratefully acknowledges the assistance of A. MacNay, Statistician, Newcastle Regional Hospital Board, in collecting these data.
4. Airth and Newell, op. cit.
5. Personal communication with A. MacNay, Newcastle Regional Hospital Board.
6. Personal communication, idem.
7. Personal communication, idem.
8. See Chapter 2, Darlington and Hartlepool umlands section, page 32.
9. At this stage this may be defined as South Shields C.B., Jarrow U.D. and Boldon U.D. A further consideration of this will be found in a later chapter.
10. This theory is stated by T. Hagerstrand in, 'The propagation of Innovation Waves,' Lund Studies in Geography, Series B, Human Georgraphy No. 4, 1952.
11. Personal communication with A. MacNay.
12. A 10% check on the data by the Newcastle Regional Hospital Board suggested that the data for Middlesbrough understated actual use. There appears to be no apparent reason for this discrepancy.

4. THE ELEMENTS: TECHNICAL COLLEGES

Within County Durham a variety of technical colleges is to be found. In the academic year 1963-4 there were six technical colleges within the administrative county of Durham. These were at Bishop Auckland, Consett, Durham, Easington, Hebburn and Stockton-billingham. Within the geographical county several county boroughs had their own technical colleges - Darlington, Gateshead, South Shields, Sunderland and West Hartlepool. Data were collected from all of these county and county borough colleges. It was also found necessary to take note of those students who lived in County Durham and went to technical colleges in Middlesbrough and Newcastle. In all thirteen centres were recognised as providing technical college facilities used by students who lived within the geographic county of Durham.

The Data

The data used in this chapter are purely of students who lived in the geographic county and attended any of the technical colleges within it and Middlesbrough and Newcastle county borough areas during the 1963-4 academic year. This information was obtained from three main sources.

If a student attends a technical college of a local authority of whose area he is not a resident, then his residential authority has to pay a fee to the other local authority. For example a student may have lived in Birtley within the Durham County Council area in 1963-4 and attended an evening class at Rutherford College of

Technology that year. As a result Durham County Council paid a fee to Newcastle County Borough for that student. Such a student is known in Durham as an 'out county' student. Each local authority submits a list of its claims for 'out county' students to each other local authority at the end of an academic year.

One major source of data was from the county Durham technical colleges themselves. Student enrolment were examined for each college and lists of population units with the number of students for each college were drawn up. Another major source of data was the 'out county' claims by other local authorities upon the county of Durham¹. From these claims it was possible to make lists of students who attended courses at county borough technical colleges and to locate their place of residence within county Durham. Further each of the county boroughs within the geographical county of Durham supplied the total number of students who lived in their area and went to Middlesbrough and Newcastle technical colleges for courses in 1963-4².

The third source of information was the county boroughs of Middlesbrough and Newcastle³. They filled any gaps in the county boroughs' data and provided a total figure for students resident in their own area and attending their own colleges. With these completed figures it was possible to make a map of the specific umlands of the technical colleges (see fig. 4.1).

The Basic Situation

Within the North East of England three main types of technical college exist. This is characteristic of the national system though

the definition used here for each type is different from that normally used⁴. These three types are the local, area and regional colleges. The normal basis of defining each type is by the level of work at the college. Ordinary and Advanced level General Certificate of Education work with Ordinary National Certificate work is common to all local technical colleges. The area colleges work to Higher National Certificate and Diploma level while the regional colleges have students working to university degree standard or professional equivalents such as A.M.E.M.E. However individual H.N.C. courses are found in what might otherwise be regarded as local technical colleges and degree equivalent work occurs in some area technical colleges. Hence another method of definition is needed⁵.

For this, all thirteen centres were ranked in terms of their overall courses. This information is easily available from the 'Guide to Further Education Courses in the Region, 1963-4'⁶. A hierarchy was constructed firstly by listing all centres with their total number of courses (see Table 4.1). Then all courses of H.N.C. or higher level were totalled for each centre. By comparing these two ranking lists a hierarchy of three stages was obtained⁷.

The result shows clearly that three regional technical college centres existed in 1963-4. These were at Middlesbrough, Newcastle and Sunderland. For this element, all technical colleges within a given centre are combined when considering that centre. Hence Newcastle includes Rutherford College of Technology, the College of Commerce and the College of Further Education during the 1963-4 academic year. Middlesbrough combines Constantine College of

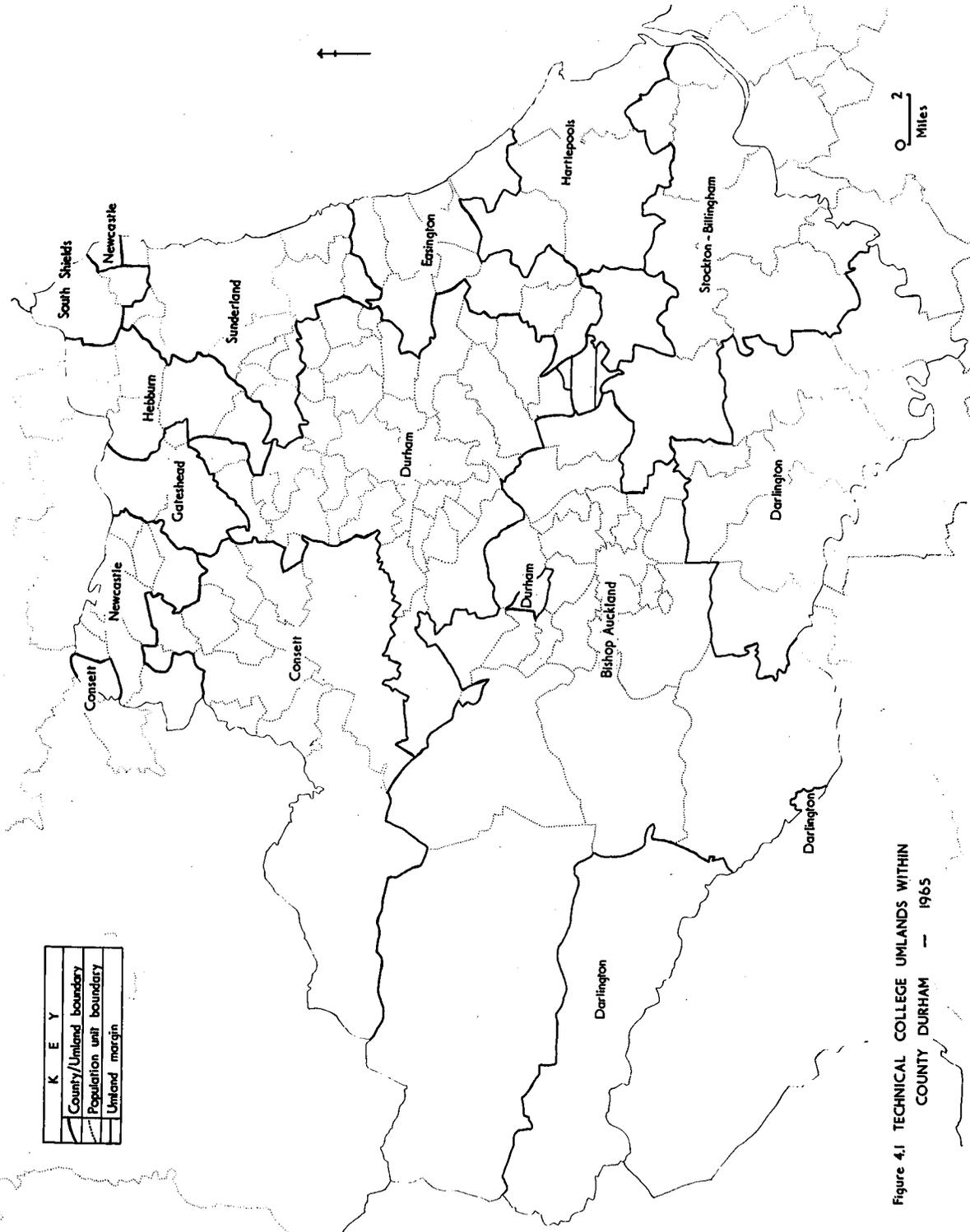


Figure 4.1 TECHNICAL COLLEGE UMLANDS WITHIN COUNTY DURHAM — 1965

Technology with Longlands College of Further Education, and Sunderland combines the Technical College with West Park and Monkwearmouth Colleges of Further Education.

The Students and Centred Regions

In theory the technical colleges have centred regions. Within County Durham the six technical colleges have pre-determined catchment areas and all students wanting a course go to their local college. Should the course not be available at the local college, the student is sent to the nearest college within the county area with that course. If no Durham technical college has the course, then the student may go 'out county'. As each student going 'out county' costs the Durham County Council a fee, they do not encourage 'out county' students.

A.Course totals All		B.Course totals High level	B as % of A	Hierarchy
245	Newcastle	32	13	Regional Colleges
166	Middlesbrough	25	15	
159	Sunderland	17	11	
115	Durham	6	5	Area Colleges
90	Gateshead	4	4	
90	South Shields	3	3	
88	Darlington	4	5	
70	Stockton-Billingham	3	4	
61	Consett	1	1	Local Colleges
57	Bishop Auckland	0	0	
53	West Hartlepool	2	4	
44	Hebburn	1	2	
26	Easington	0	0	

Table 4.1. Hierarchy of Technical Colleges within and bordering
County Durham 1963-64.

At the stage of high level courses, such as the regional technical colleges provide, 'out county' students are to be expected. The degree and professional equivalent courses are only provided at regional level. Demand is such that there are normally insufficient students to justify a course at area colleges.

Such is the theory. Two administrative points affect the theory. The local authorities acknowledge what they call 'free trade' between the whole range of colleges. In effect this means that any authority with an out county student claim will have it accepted by the student's residential county authority. As out county claims are not made until the end of the academic year, there is no check on whether a high level course is being followed which is available within the resident authority's own technical colleges until it is too late to change colleges.

Secondly, the main administrative check on whether a student is attending the nearest local residential authority's technical college for his particular course is when he applied for travelling expenses. Should he apply and be found not to be at his local college, then he will be refused his expenses and transferred to the same course at his local college. If he does not apply for travelling expenses he may slip through the administrative net.

Hence the theory of centred regions for technical colleges has little administrative framework to ensure it functions in practice. To discover what really happens, courses taken by out county students were studied. A small sample appears in Table 4.2. At all the centres the range of courses varied from 'O' level subjects to degree equiva-

lent work. Complete free trade existed in 1963-4 between all the local authorities.

Course	No. of Students	Course	No. of Students
O & A levels	19	O.N.C.	2
Professional	1	Secretarial	9
Pre-nursing	4	Tailoring	3

Table 4.2. Out County (Seaham) Technical College Students and their courses at Sunderland.

In effect, there was a free choice of technical colleges as far as courses would allow⁸. It is for this reason that all the technical colleges within a given centre are combined and considered as one unit. Sunderland Technical College offered the high level courses to which Durham county 'out county' students would have to go. But in fact 'out county' students went to all three Sunderland colleges for a variety of courses in 1963-4.

P.	S.
Painting and Decorating	Shorthand/Typists
Public Cleansing	Storekeepers
Principles of Teaching	Salesmen
R.	Science Laboratory
Retail Distribution - Full time	Technicians
Retail Distribution - Junior Certificate	Science - O.N.C.
Retail Distribution - National Certificate	School Music - Diploma
Retail Management Principles - Certificate	

Table 4.3. Part of the Index of Durham Technical College's Prospectus, 1963-4.

The population of this element is the students. It might be thought they formed an educationally biased section of the general population and any study of their journey patterns would be un-

representative of the general population. In fact this is not generally true. Technical colleges provide a wide range of courses (see Table 4.3) to cover professional and craft training at various levels as well as recreational facilities. Some people go to a technical college purely to learn a sport or improve a hobby. Car maintenance is a very popular course with little social bias. Day release ensures that a great variety of young people with no academic qualifications do some craft or general educational training⁹. Hence it is suggested that the technical colleges provide a field worthy of study. The population is not a narrow educationally biased one and the administration is such that supposed centred regions with predetermined catchment areas may not in fact exist.

The Basic Situation

Potentially there are thirteen centres operating in this element - Bishop Auckland, Consett, Darlington, Durham City, Easington, Gateshead, Hartlepoons, Hebburn, Middlesbrough, Newcastle, South Shields, Stockton-Billingham and Sunderland.

Of these centres Gateshead, Hebburn, Newcastle and South Shields can be said to be part of the Tyneside conurbation. The Wearside sub-region has a centre in Sunderland. In its broadest sense, Teesside is represented by centres at Darlington, Hartlepoons, Middlesbrough and Stockton-Billingham. While only Middlesbrough and Stockton-Billingham are physically part of the Teesside conurbation, the other two centres have very close industrial and

communication ties to the Teesside area¹⁰. Thus each of the major conurbations is well represented by centres.

Also included are a number of centres in the area between the conurbations. Durham City occurs in the middle of the county and is mainly an administrative and university centre. Consett forms a centre in the north west in the old coal mining area. Easington Technical College is situated in the new town development of Peterlee, on the concealed coalfield. Bishop Auckland is within the old coking coal area of south west Durham and is at the gateway to Weardale. So it can be seen that these four centres occur on the Durham coalfield, but each with a slightly different environment around it.

A historical factor also influences the potential situation. The county boroughs established technical institutes and through these, technical colleges, before County Durham. It was the 1950's before the county authority established its technical colleges¹¹. Hence competition from within the county area with county boroughs is fairly recent. In terms of Central Place theory, the newer County Durham Technical Colleges have had to establish their own urban fields within the margins of the older county borough technical colleges' urban fields.

Finally before the details of each college are studied, it must be remembered that the data are for total student numbers. Within Newcastle's total are students at local, area and regional level courses. Within Consett's total are only students at local level courses because Consett had only one high level course. Hence the

competition between these two centres is not at an equal level. This is not a Christaller-type hierarchical comparison but a real situation comparison more akin to a Loschian-type landscape.

Bishop Auckland

A fairly well defined specific urban field is found around Bishop Auckland (see fig. 4.2). Weardale and Teesdale are its westward extent. Northwards the field extends through Esh to Pelton and then the boundary curves southwards through Durham City and Cassop to Trimdon. A small number of interactions occur in the rural zone east of Darlington before the Tees is reached. From here, upstream beyond Darlington into Teesdale, interactions occur to complete the specific urban field. The rural south west and the urban areas of Bishop Auckland, Brandon, Crook, Darlington, Durham City and Spennymoor are all within this specific urban field.

The specific umland shows Weardale as its western limit. Competition with Durham restricts the umland to Wolsingham and the Crook-Willington area in the north. There is an outlier to Durham at Hunwick (see fig. 4.1), but Spennymoor and Ferryhill are within the specific umland. The boundary with Stockton-Billingham occurs within the rural area at Rughyford; with Darlington it occurs in the rural area around Heighington. The rural area around Staindrop is mainly within Bishop Auckland's umland but Darlington attracts students in greater numbers than Bishop Auckland from Barnard Castle and upper Teesdale.

Two features are worth noting here. The outlier of Durham at Hunwick appears to arise mainly from chance, Hunwick being a com-

paratively small population unit. Only one student travelled to Bishop Auckland technical college in 1963-64 whereas if 4 students had done so, Hunwick would have been in the Bishop Auckland unland.

Population Unit	Interaction Index	Population Unit	Interaction Index
Bishop Auckland	121	Middridge	43
Toronto	60	Shildon	35
Byers Green	38	St. Helen Auckland	47
Coundon	42	Witton Park	85
Coundon Grange	20	Witton-le-Wear	86

Table 4.4. Bishop Auckland and Interaction Index in adjoining Population Units.

The second feature is shown by table 4.4. The area around Bishop Auckland has a higher level of interaction per unit of population than Bishop Auckland itself. This remains true in a westward direction into the rural areas, though by Stanhope (146 interaction index) the situation is about normal.

Two reasons can be suggested for this¹². Firstly Bishop Auckland has an attraction for work for people living in the rural area to the west while those living in the town itself are more selective and may choose to work outside the immediate neighbourhood¹³. Secondly the higher level technical college courses are located elsewhere and these courses probably tend to draw from an urban population more than a rural one. The effect of the hierarchical position of Bishop Auckland may be at work here.

KEY	
B	Urban field of Balboa, Auckland
C	Urban field of Caversham
D	Urban field of Dunedin
E	Urban field of East Dunedin
H	Urban field of Helensburgh
S	Urban field of South Dunedin
County boundary	
Population unit boundary	

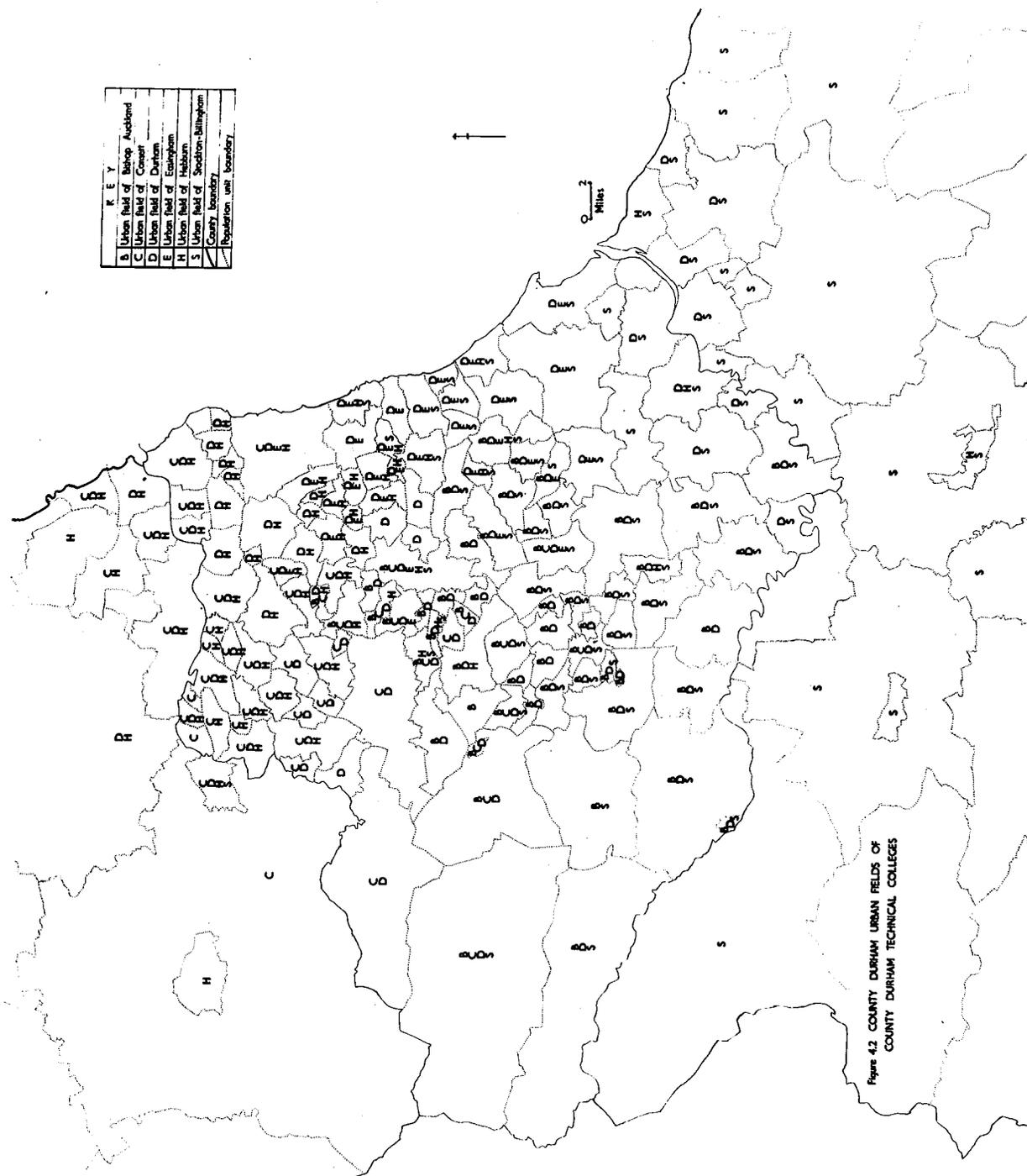


Figure 4.2 COUNTY DURHAM URBAN FIELDS OF COUNTY DURHAM TECHNICAL COLLEGES

Consett

Along the south bank of the river Tyne in County Durham, Consett technical college draws students from virtually all the population units. Thus the specific urban field extends to South Shields. Then the field rapidly contracts southwards. A single isolated interaction at Sunderland is probably chance and it is Birtley and Chester-le-Street that form the effective eastward limits of the field south of the Tyneside conurbation. The boundary then continues southwards to Durham City and Ferryhill (see fig.4.2). From here it turns westward through Bishop Auckland to Weardale. At the Cumberland-Westmorland border the Durham county boundary of necessity forms the boundary of the specific urban field north eastwards to the Tyne, because data on students living outside County Durham were not collected.

The specific umland is almost all the old coal mining area of north west Durham. Upper Derwentdale, the Lanchester area, Consett and Stanley urban districts are within the specific umland. The Tyneside boundary is interesting because here competition with Newcastle is effective (see fig. 4.1). Newcastle is able to attract students from Blaydon, Ryton and Whickham urban districts in greater numbers than Consett. In some ways this repeats the professional football pattern where it was shown that from the Tyne bridge upstream, Newcastle is able to compete effectively with Durham-based centres, possibly because of the number of bridges across the river above Gateshead¹⁴.

K E Y	
D	Urban field of Darlington
G	Urban field of Gateshead
H	Urban field of Hartlepool
T	Urban field of South Shields
S	Urban field of Sunderland
—	County boundary
—	Population unit boundary

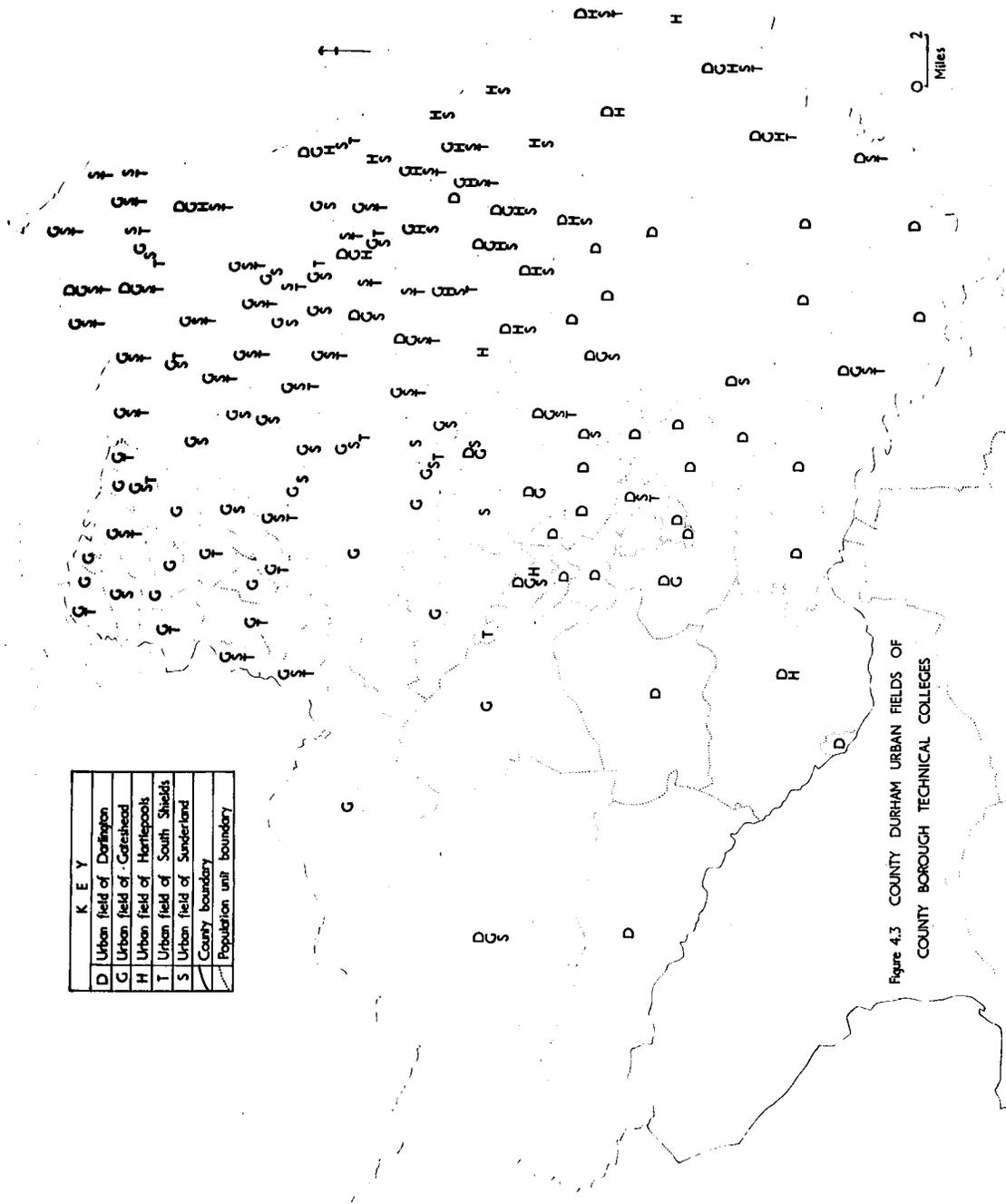


Figure 4.3 COUNTY DURHAM URBAN FIELDS OF COUNTY BOROUGH TECHNICAL COLLEGES

The main exception is at Crawcrook. Here an outlier to Consett is found. This detail is examined in figure 4.4. Ryton village itself has a high level of interaction with both Consett and Newcastle compared with Crawcrook to the west and Crookhill to the east. Ryton is a middle class/professional suburb to Newcastle whereas the other two villages are mining communities. Does the data, at this point, suggest that the middle class/professional person is more educationally minded than the manual/craftsman person of a basically mining community? Later evidence suggests a chance factor is working (see chapter five).

Bearing this in mind, the graph (See figure 4.4) shows that the Crawcrook outlier is more normal than the fig. 4.1 suggests. The slope from Consett is fairly constant if Ryton proper is ignored. Similarly the slope from Newcastle also appears more consistent if Ryton proper is ignored. This outlier supports an earlier suggestion that a zone of transition or margin exists between centres rather than the firm boundaries of the specific unlands. Any random or chance factor operating at these margins can result in apparently anomalous situations.

Darlington

This is the first of the area technical colleges to be studied in detail. Its specific urban field within County Durham extends from Weardale and Teesdale in the west across the county to the coast. The river Tees is the southern limit of the data and the extent of the urban field south of the Tees is unknown. The northern

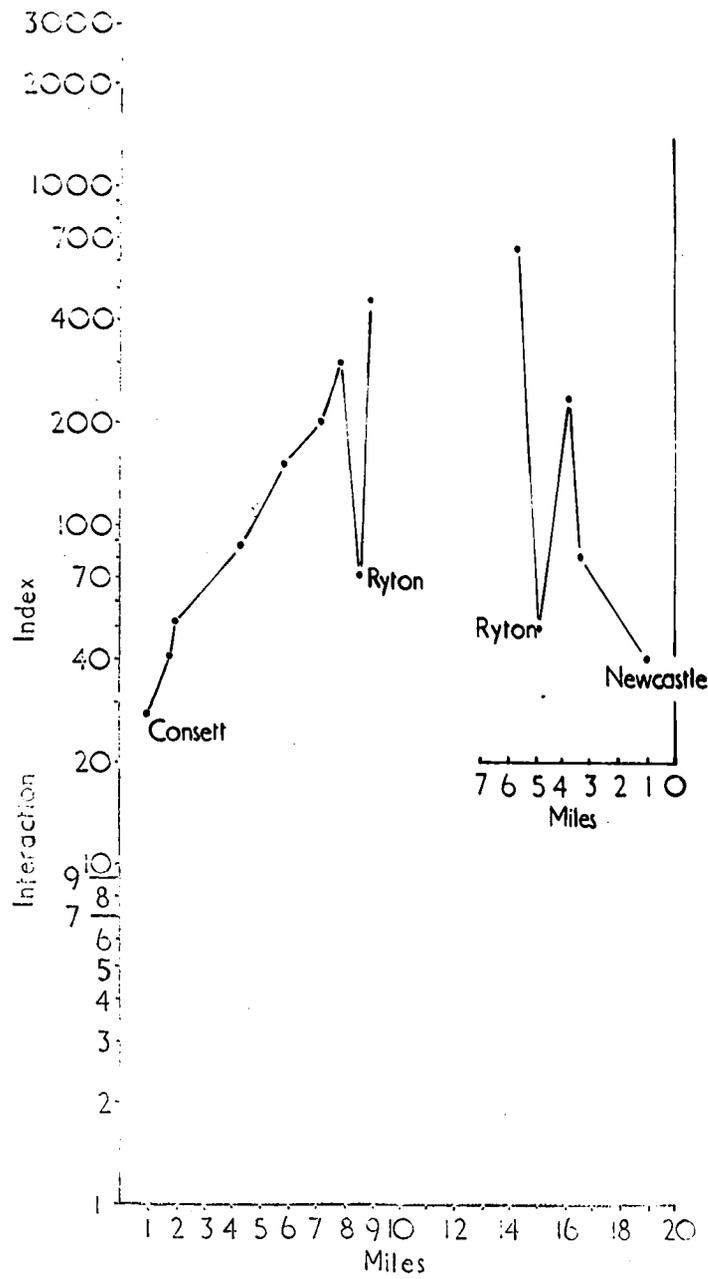


Figure 4.4 Technical College Interaction Indices from Consett and Newcastle to Ryton

limit is a line through Crook, Willington and Brandon and on north eastwards to the coast at Sunderland (see fig. 4.3).

CENTRE	Barnard Castle	Winston	Gainford	Piercebridge
Darlington	54 (15 miles)	4 (9 miles)	19 (7 miles)	2 (5 miles)
Bishop Auckland	25 (13 miles)	4 (9 miles)	3 (8 miles)	2 (9 miles)

Table 4.5. Number of students attending Darlington and Bishop Auckland Technical colleges from settlements along the A 67 road.

In contrast the specific umland is very limited. A familiar pattern of a boundary through the rural zone surrounding a town occurs. Newton Aycliffe is within this specific umland and marks the northern limit. In fact an arc some eight miles in radius, from Darlington town centre, gives most of the specific umland within County Durham.

To this must be added Barnard Castle and upper Teesdale. Teesdale, from Darlington upstream, tends to be within Darlington's specific umland, c.f. the ophthalmic data. A study of individual settlements along the main A67 road which links Teesdale to Darlington supports this (see table 4.5). Further a graph of interaction indices (see fig. 4.5) shows a fairly consistent slope into Teesdale. Continuity of the specific umland because of the south bank of the Tees being within the specific umland is also possible.

The difference between the area of the specific umland and that of the specific urban field may be explained by Darlington being an area type college. It offers high level courses which

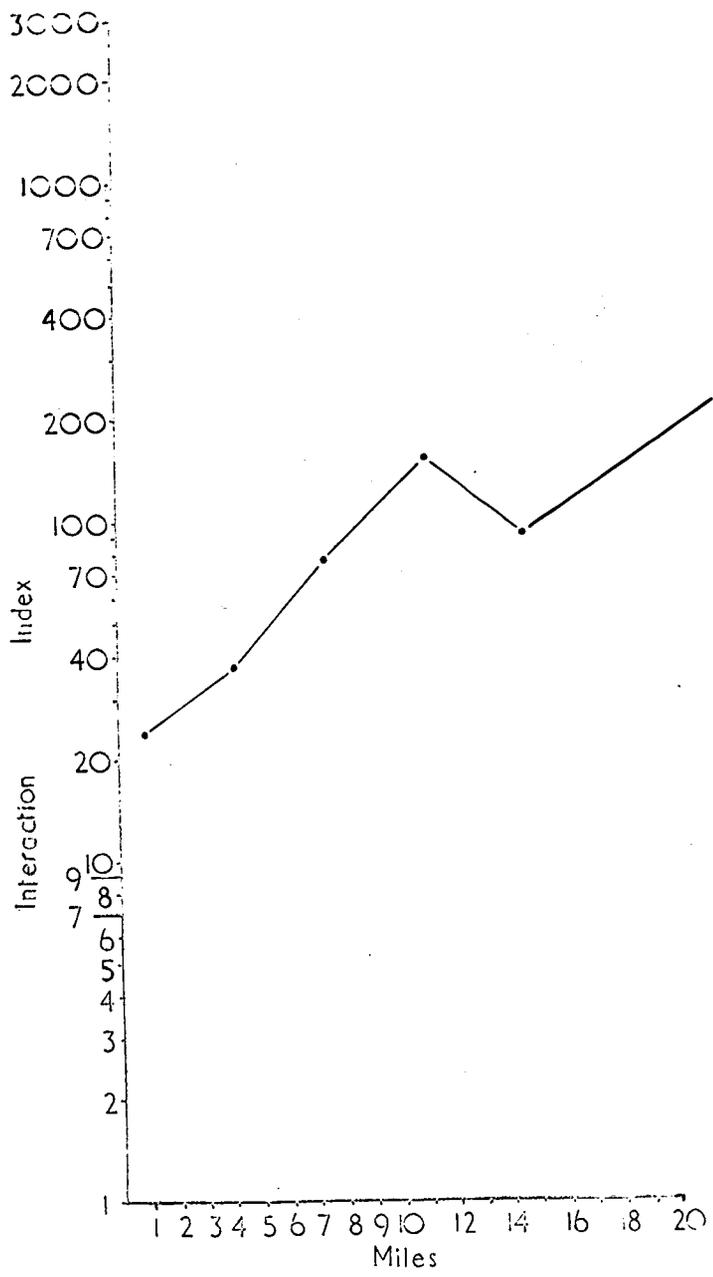


Figure 4.5 Darlington Technical College Interaction Indices along a section line towards Teesdale

attract from a larger area than its local courses do. This point will be considered in detail in the next section.

Durham

Durham is an area technical college and a great deal of information is available about it, which facilitates an analysis of the functioning of an area technical college¹⁵. The specific urban field of Durham Technical college is the whole county area. Very few population units fail to interact with Durham (see fig. 4.2). The specific umland is much smaller in area. In general it is an area within a seven miles radius of Durham City, though westward it extends further into a rural area.

Birtley forms the northern limit in competition with Gateshead. Hebburn competes in the rural area just north east of Chester-le-Street and Sunderland just to the east of Chester-le-Street. Durham then attracts the Houghton-le-Spring and Hetton-le-Hole areas in competition with Sunderland. At Haswell, Basington technical college competes with Durham. This competition continues and gives a north-south specific umland boundary as far as Trimdon. The boundary then turns west, leaving Fishburn in Stockton-Billingham's specific umland and Mainsforth becomes an area of equal attraction between Durham and Stockton-Billingham (see fig. 4.1).

The boundary continues westward leaving Brandon urban district within the specific umland, and outlier at Hunwick (already analysed) and Tow Law just within the boundary. From here northward, the valley of the Deerness is within the specific umland but Consett attracts the Lanchester area. The villages immediately west of

Durham City and Chester-le-Street complete the unland before the boundary turns through Pelton to Birtley.

The area of equal attraction at Mainsforth is the only area on the whole of fig. 4.1 where a boundary could not be definitely drawn. This area would appear to be an important margin to several competing centres having appeared on several maps before.

A special study of selected courses was made at Durham technical college. The object was to establish the influence of the type of course upon the catchment area or urban field of the college. The result is shown by selected courses in fig. 4.6 a-d. The dress-making non-vocational course has an urban field similar to the college's specific unland. It is a low level course typical of courses likely to be found in all technical colleges. The electrical operatives course (see fig. 4.6 c) is organised for the North East Electricity Board and is provided at Darlington, Durham, Gateshead and Newcastle colleges. As a result the map shows a mid-Durham distribution pattern which includes Sunderland. This is an area college type course. The map of A.M.E.M.E. Honours course (see fig. 4.6d) is for a regional college course. It shows students coming from the whole of the coalfield area of County Durham.

As stated earlier, the data for this element is the total number of students at each technical college in 1963-64. Within this total number for a college students attend courses at different levels. For a Central Place analysis of this situation it would be necessary to compare the distribution of students for similar level courses. The present analysis is concerned with the total situation and shows centres with different levels of the same service com-

peting with each other across County Durham. This Loschian type landscape is justified as a line of study because it is a real situation.

This helps to explain why the specific umlands of area and regional technical colleges are likely to be much smaller than their specific urban fields. The local college has courses likely to draw from an area in competition with similar courses at all other technical colleges; this area is its specific umland. The area and regional colleges have courses which attract students in competition with only a few other centres. Hence an extensive specific urban field results but the total number of students involved in these courses at a distance is not sufficient to disrupt the local college specific umland.

Easington

Sunderland and Hartlepoons form the limits of the specific urban field along the coast. Fig. 4.2 shows that from Sunderland an arc can be drawn through Birtley, Witton Gilbert, Ferryhill and Sedgefield to Hartlepoons of some twelve miles radius centred on Peterlee and the complete specific urban field is covered. When the specific umland is considered (see fig. 4.1) Seaham and Blackhall form the coastal limits. Easington college just fails to dominate Seaham and the Hetton-le-Hole/Murton built-up area. Haswell is within the umland as is Shotton, Wheatley Hill, Wingate and Trimdon. Competition with the Hartlepoons just forces the boundary north of Castle Eden village, but Blackhall is within the specific umland.

From this it can be seen that Easington Technical College has a

small specific urban field and umland compared with Durham. As it is only a local college this is to be expected and confirms the analysis made in the section on Durham technical college.

Gateshead

Like Darlington and Durham, Gateshead is an area technical college. It provides another opportunity to test the suggestion made above that area colleges have large specific urban fields compared with their specific umlands. Gateshead's specific umland consists of only three population units - Gateshead, Springwell and Lamesley, but its specific urban field shows interactions as far as Darlington and Stockton.

In detail, the specific urban field interacts with the whole of south Tyneside. All population units in north west Durham interact with Gateshead and this is almost true of all population units on Wearside. Weardale forms the effective south western limit of the urban field and its boundary can be traced from here eastwards through Crook, Spennymoor, Ferryhill, Wingate and Peterlee. This is almost along the southern limit of the coalfield. Interactions do occur south of this line at Darlington and Stockton but these are rather isolated and away from the main specific urban field.

Hence two thirds of county Durham forms Gateshead's specific urban field which is far larger than its specific umland. The smallness of the umland may result from the nearness of Newcastle which has regional level courses compared with Gateshead's area level courses. The large extent of the urban field may result from the area level courses, compared with the local technical colleges which

tend to be found to the south in the county Durham area. It may also reflect the high employment opportunities available in Gateshead, particularly on the Team Valley Trading Estate. Large firms tend to co-operate in day release and sandwich courses organised by technical colleges and the larger Gateshead firms attract labour from much of the Durham coalfield area.

Hartlepoons

The technical college at West Hartlepool was the only county borough college to rank as a local technical college in the hierarchy. Like Gateshead, its specific umland is small, covering only three population units - Hartlepoons, Elwick and Hutton Henry. The specific urban field extends northwards along the coast to Sunderland. A few interactions are observable south westwards from Sunderland at Hetton-le-Hole, Haswell and Bowburn. Then a boundary can be followed southwards through Coxhoe and Trimdon to Stockton (see fig. 4.3).

The smallness of the specific urban field agrees with Hartlepoons' hierarchical position. Although historically an early technical college, its failure to establish a higher status may be related to its peninsularity. There are many similarities here between the professional football pattern and the technical colleges. The Hartlepoons peninsula, cut off to the north by the coalfield and to the west by Stockton, has limited population potential for growth.

Hebburn

A local technical college, Hebburn, has a specific umland hemmed in by South Shields, Gateshead and Sunderland. Felling, Hebburn and Jarrow form the Tyneside part of the umland which then extends southwards through Boldon Colliery and Washington to the Harraton area just north east of Chester-le-Street.

The specific urban field extends for the whole length of the Durham bank of the Tyne (see fig. 4.2). From here it continues along the coast to Seaham. Turning inland at Seaham, the boundary follows a line through Murton, Haswell and Durham City to Brandon. The urban field boundary then turns northwards to Stanley and Rowlands Gill before reaching the Tyne again.

In comparison with Gateshead, the Hebburn specific urban field is limited. This one might expect as Hebburn is only a local technical college.

Middlesbrough

Although a regional technical college centre, Middlesbrough has no specific umland in county Durham. This is not surprising as it is competing with Darlington, Hartlepoons and Stockton-Billingham on Teesside. In professional football it was shown that Darlington and Hartlepoons limited Middlesbrough's attraction to a wedge from Stockton northwards to Fishburn in county Durham. Now, with Stockton-Billingham technical college effectively blocking Middlesbrough's attraction at the river crossing, Middlesbrough is not likely to have a county Durham based specific umland (see fig. 4.1).

Its specific urban field stretches as far north as South Shields

and then the boundary goes south westwards through Harraton (near Chester-le-Street) Durham City, Crook and then on westward to Weardale. The specific urban field includes the whole of Teesside and extends northwards over much of the Durham Coalfield and north westwards into Weardale.

The obvious difference between the urban field in county Durham and the lack of an unland in county Durham illustrates the regional status of Middlesbrough as a technical college centre. The local level courses at Middlesbrough serve a Yorkshire based population. The regional courses serve this local area and a large part of county Durham.

Newcastle

As only students living within county Durham are included in the data, Newcastle can only be studied in terms of its penetration southwards across the river Tyne. Its specific urban field certainly extends over the whole of county Durham with students from as far south as Barnard Castle, Darlington and Stockton. There would appear to be a parallel with ophthalmology, the whole county being within Newcastle's specific urban field. The specific unland occupies most of the Whickham, Blaydon and Ryton areas with an outlier in the east at Whitburn Colliery. Newcastle is a regional technical college centre and shows a vast difference in area between its specific unland and specific urban field.

Whereas Middlesbrough was unable to compete across the Tees with Stockton-Billingham at a river crossing, Newcastle in a somewhat analogous position does compete with Gateshead across the Tyne.

However there are more crossing point upstream on the Tyne than on the Tees. The Newcastle base in north west Durham has appeared in all the previous elements and is confirmed here, even when in competition with Gateshead and Consett. The historic factor of Tyne-side being a community over the centuries while Teesside is a creation of this century may also be influencing this distribution pattern.

Of all the regional technical college centre, Newcastle has the highest rating (see table 4.1). This might also account for Newcastle establishing part of its specific unland in county Durham while Middlesbrough fails to do so. This may well be further evidence of a continuum working within a hierarchical group.

Whitburn Colliery appears to be an anomaly (see fig. 4.7). There is a normal slope from Newcastle towards South Shields with the interaction indices increasing. Then there is a sudden fall to the interaction index of Whitburn Colliery, i.e. a higher number of students are attracted to Newcastle than would be expected at this point. Three possibilities may be suggested to explain this situation. Firstly, Whitburn and Whitburn Colliery are adjacent settlements and most people may omit the word colliery in their address. If this is true, Whitburn should show a higher level of interaction than would be expected. There is some evidence of this in the data for Hebburn, Newcastle, South Shields and Sunderland, but this possibility is denied by the local post office.¹⁶

Another possibility is that the students of Whitburn Colliery are attending a high level course, only provided at Rutherford College of Technology, Newcastle. As Whitburn Colliery is essentially

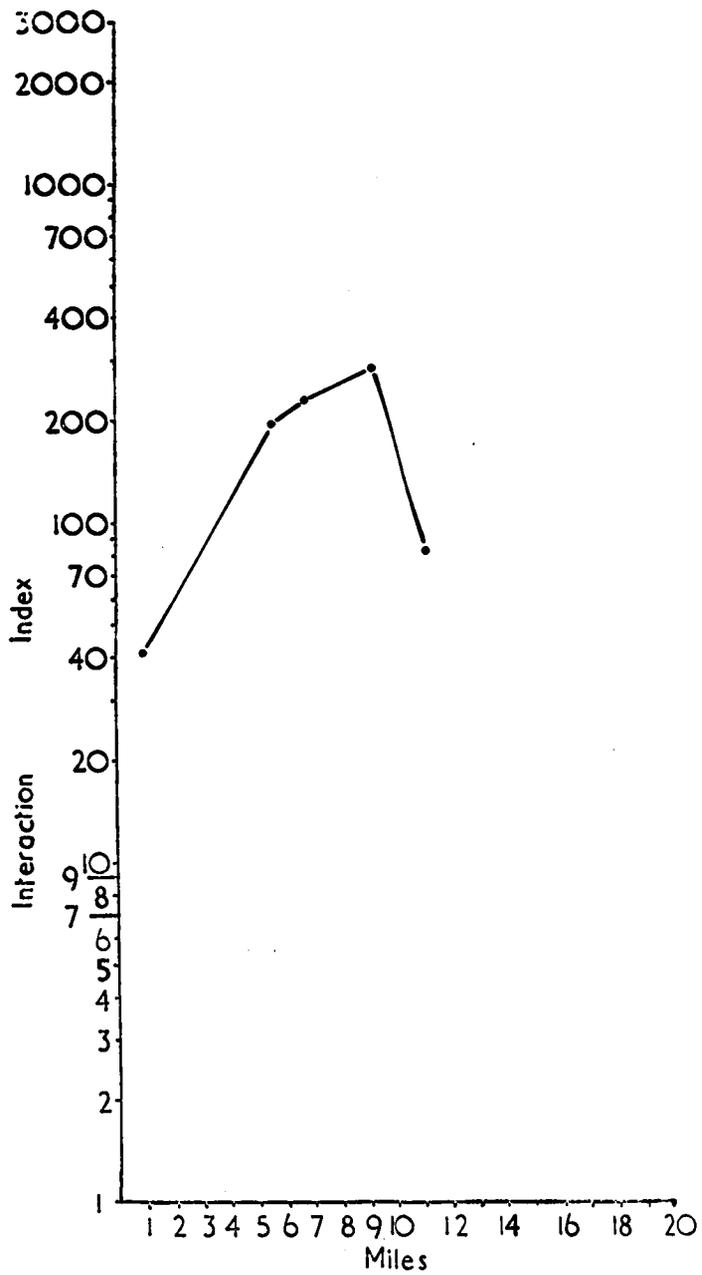


Figure 4.7 Newcastle Technical Colleges Regional Interaction Indices along a section line towards Whitburn Colliery

a mining community, this course is likely to be in coal mining. However, Durham and Sunderland technical colleges are designated to provide the high level mining courses and this suggestion would seem a doubtful one. The third possibility is the operation of pure chance.

The general lack of interactions within Whitburn Colliery, throughout all the elements would appear to suggest the first possibility is the most likely.

South Shields

Although an area technical college, South Shields has a specific umland limited to South Shields and Cleadon. A factor here must be its peninsular position and the closeness of both Hebburn and Sunderland technical colleges (see fig. 4.1).

In contrast the specific urban field spreads over much of county Durham. South Tyneside interacts in virtually all its population units with South Shields. North west Durham remains within the urban field as far south as Lanchester. The boundary then runs south eastwards through Brandon, Cassop and Shotton to the coast at Horden. Interactions do occur with all the large towns south of this line - Darlington, Hartlepoons and Stockton - but they appear to be at the margin of the specific urban field.

As with Durham technical college, a sampling of courses to find the relationship between types of courses and their catchment areas was made¹⁷. Some of the marine courses at the college are found at about three other technical colleges in the country. The resulting catchment areas were world-wide. In contrast the non-vocational course had distributions comparable with the specific umland of fig.4.1.

Thus the results of the Durham technical college survey were confirmed.

Stockton-Billingham

This technical college is organised on the basis of four major departments. Two are based in Stockton and two in Billingham. Hence a single organisational unit has two separate locations. This is the reason for the joint title.

An area college, it has a specific urban field covering the southern half of county Durham. This includes Weardale, Teesdale, Bishop Auckland, Crook, Willington and Spennymoor. From Spennymoor its norther limit is through Ferryhill, Coxhoe, Haswell and Murton to the coast. The data collected also shows that the urban field extends southwards across the Tees into the North Riding of Yorkshire.

The specific unland repeats a pattern seen in previous elements associated with Middlesbrough. From a Stockton-Billingham base, a wedge is found northwards through Sedgefield to Fishburn on the edge of the coalfield. As already mentioned, competition with Durham gives an area of equal attraction at Mainsforth. The rural area to the east and the west of this wedge gives the specific unland boundary with Hartlepoons and Darlington respectively as in earlier elements.

As with other area technical colleges the specific unland is small in area compared with the specific urban field.

Sunderland

Sunderland has a specific urban field which extends over almost the whole of County Durham. It is missing in Upper Teesdale, but Weardale, Crook, Bishop Auckland and Darlington all interact with

Sunderland. The actual number of students here and in north west Durham suggests a weak field of attraction in these areas and a potential limit of the specific urban field.

Sunderland is the only regional level technical college centre which had a complete specific umland within county Durham, Newcastle and Middlesbrough both have parts if not all of their specific umlands outside the county. Sunderland's umland consists of most of its population units adjoining itself with an arm extending south westwards into the Herrington - Penshaw - Shiney Row area and ending in the rural area just east of Chester-le-Street (see fig.4.1).

The small extent of the specific umland is surprising at first, but it fits into the pattern already suggested. The specific umland is related to the attractive power of all colleges and their local college courses. Area and regional colleges increase their urban fields rather than their umlands because of their high level courses.

The Centres

The description of the earlier sections have suggested that the hierarchy based upon courses and course structure in technical colleges is valid. To quantify this further is difficult because many specific umlands and urban fields extend outside county Durham. For example Hebburn technical college is know to attract students from Acklington, Heddon-on-the-Wall and Hexham.¹⁸

Although only one student came from each of these places in 1963-4, it is fairly safe to assume that the more powerful centres of Gateshead, South Shields and Sunderland attracted even more students than Hebburn from Northumberland. Similarly Stockton-

Billingham technical college drew several hundred students from the North Riding of Yorkshire. This would suggest that Darlington and Middlesbrough also drew students from the North Riding. Hence the total interactions listed in table 4.6 are not complete for some seven centres.¹⁹

A plus sign in the table signified this. Even so the table suggests that there is a relationship between the type of college and its student intake.

Hierarchy	Centre	Total Students	Umland Population
Regional	Middlesbrough	+ 4,546	+ 204,273
	Newcastle	+ 11,199	+ 356,390
	Sunderland	+ 6,064	284,609
Area	Darlington	+ 4,477	+ 117,143
	Durham	6,389	180,261
	Gateshead	+ 3,495	109,003
	South Shields	+ 4,859	113,303
	Stockton-Billingham	5,191	+ 130,676
Local	Bishop Auckland	2,567	130,294
	Consett	+ 2,809	100,948
	Easington	2,103	73,679
	Hartlepoons	2,571	99,030
	Hebburn	2,984	116,813

Table 4.6. Total students and umland populations for technical college centres 1963-4. N.B. + sign explained in text.

Local colleges appear to have had a maximum of 3,000 students in 1963-4. The area colleges appear to total 5,00-6,000 students. Even the area colleges with incomplete data have more than 3,000 students postulated as the maximum for local colleges. The figure

for a regional centre in North East England in 1963-4 is not clear from the data. It may have been over 6,000 students with Newcastle well above this figure.

If this hierarchy is examined in terms of urban areas a structuring within areas can be seen (see table 4.7). Besides the thirteen centres already examined, Tynemouth, Wallsend and Whitley Bay technical colleges are found on Tyneside and Redcar technical college occurs on Teesside. These four technical colleges can be shown to be local colleges²⁰.

The Tyneside area has its regional centre (Newcastle), two area colleges both on the south bank as opposed to Newcastle's north bank position and five local colleges. Consett is considered as a Tyneside college because it draws students from virtually all population units on South Tyneside. This is a characteristic of all the south Tyneside technical colleges i.e. their specific urban fields all overlap here. The north Tyneside local colleges are all downstream from Newcastle where the river divides rather than unites the conurbation.

<u>Hierarchy</u>	<u>Tyneside</u>	<u>Central Durham</u>	<u>Teesside</u>
Regional	Newcastle	Sunderland	Middlesbrough
Area	Gateshead South Shields	Durham	Darlington Stockton- Billingham
Local	Consett Hebburn Tynemouth Wallsend Whitley Bay	Bishop Auckland Easington	Hartlepoons Redcar

Table 4.7. Urban areas technical college structure 1963-4.

Teesside has its regional centre (Middlesbrough), two area colleges on the north bank as opposed to Middlesbrough's south bank position and two local colleges, one on each bank and both by the estuary. It is worth noting that Darlington, being further inland and away from the Teesside built-up area, is able to rise to area college status. This would appear to be because of its lack of competition.

Between the two conurbations is Central Durham with Sunderland as its focus on the coast. In many ways this is the Wear Valley area. Sunderland is the regional centre and Durham in its central position in the area college. Bishop Auckland provides a local college for the upper parts of the Wear Valley while Easington technical college at Peterlee serves the local needs of the southern part of the east Durham plateau. This suggested area or sub-region of Central Durham is very similar in extent to the specific umland of Sunderland's professional football club (see fig. 2.1).

The structure is complete in each sub-region but the network is different. Eight centres operate on Tyneside with its one million inhabitants. Five centres occur on Teesside and four in Central Durham both of which have about 700,000 population. The pattern of networks would appear to be a result of the population distribution.

Umland Populations

The specific umlands may be considered to be complete except for those of Darlington, Middlesbrough and Stockton-Billingham, all of which probably have extensions into the North Riding of Yorkshire,

and Newcastle, which has a specific umland extending to Northumberland. With Middlesbrough and Newcastle, the town population has been added to the county Durham umland population in table 4.6.

If the statistics of table 4.6 are tested, a correlation coefficient of +0.8 for the relationship of umland population to total interaction is found. This is statistically highly significant²¹ and follows the pattern already found with earlier data. The specific umlands do, in their total population, appear to be related to the total attraction of their centres.

Regional technical college centres

The evidence so far suggests that the hierarchical structure outlined at the beginning of this chapter is valid. The data does not permit a testing of the hierarchical distributions directly, so two sample surveys were undertaken at Durham and South Shields to demonstrate the point. The totals for the three regional technical college centres do include within them all students doing regional courses. If these three centres are considered by themselves, then interactions away from their actual centres should show the likely pattern of students who are only attending regional courses. At a distance the local and area type course will not affect the general pattern, as shown above. And it is at a distance that the boundaries will occur which are of interest for this study. Further, such a study will present an opportunity to examine Tyneside, Teesside and Wearside competing across county Durham without any intervening competition.

Remembering that what follows is for all courses at the three

regional centres rather than for strictly regional courses, an analysis at regional level of students attracted across county Durham can be attempted. The resulting specific umlands are shown on fig. 4.8. There will be no need to describe the specific urban fields as this has been done already above.

Newcastle Regional

The specific umland is interesting in that for the first time in this study, an element shows the whole of Tyneside attracted to Newcastle. It can be assumed that the north bank of the Tyne is within Newcastle's specific umland. On the south bank the boundary starts between Whitburn and Whitburn Colliery. From here the rest of Boldon is within Sunderland's specific umland but the settlements actually bordering the river - South Shields, Jarrow, Heburn, Felling - are on the Newcastle side of the boundary.

From the Felling area the boundary turns southwards. Springwell is left as an outlier to Sunderland, but Washington, Birtley, Chester-le-Street and Durham City are all on the Newcastle side of the specific umland boundary. These settlements are all along the A.1 road.

South of Durham City competition is no longer solely with Sunderland. The Sherburn area has an interaction with Middlesbrough and from here southwards a 'zone of transition' is found. None of the specific umland borders are clear-cut from this point but they all end in a zone where all three centres appear to be competing. For Newcastle the edge of this zone lies westwards from Spennymoor through Willington, Brancepeth and Lancaster to Derwentdale. Hence the south Tyne bank, north west Durham and Derwentdale form

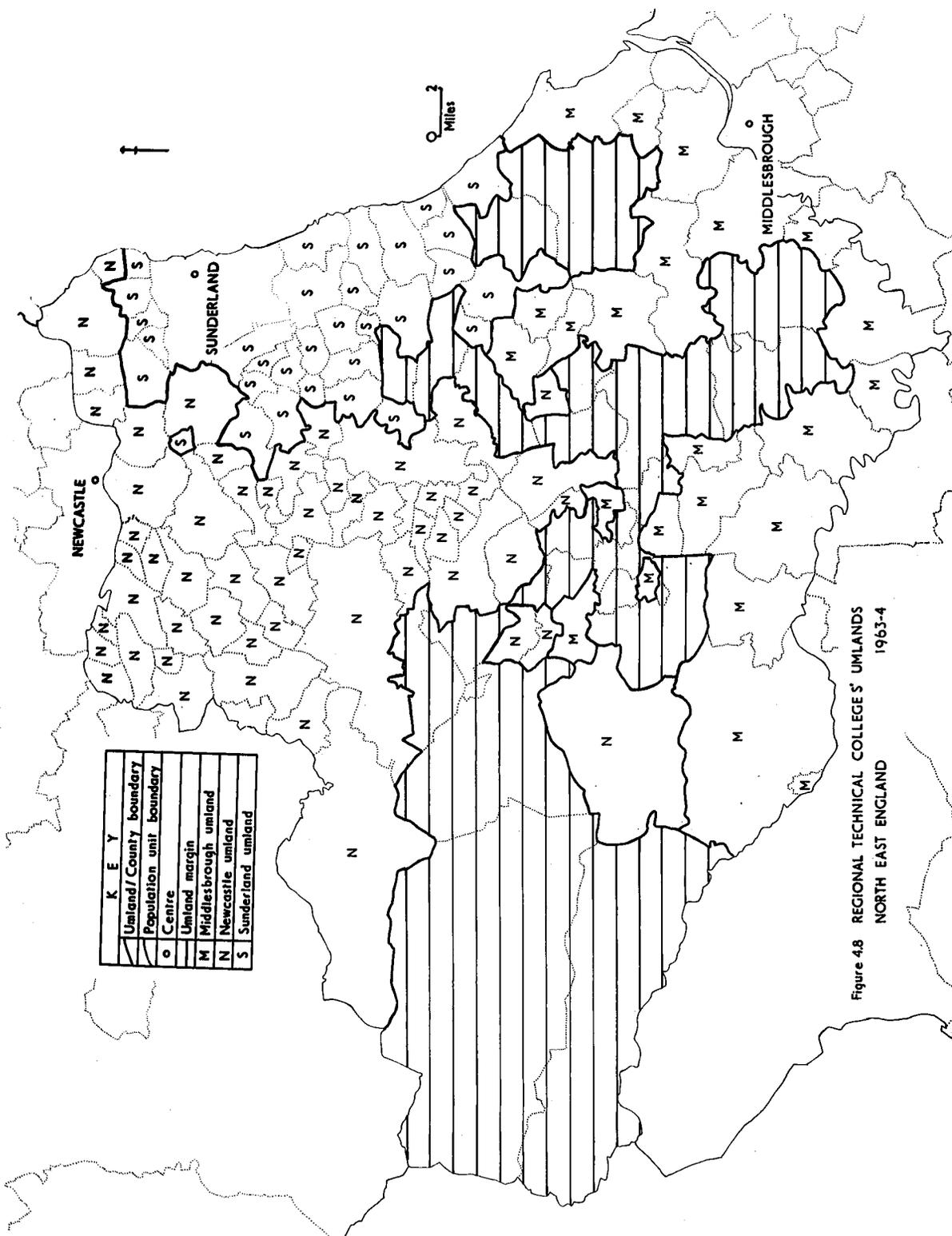


Figure 4.8 REGIONAL TECHNICAL COLLEGE 'UMLANDS' NORTH EAST ENGLAND 1963-4

Newcastle's specific umland.

The zone of transition was examined by a number of section lines from Newcastle (see figure 4.9). The line to Sunderland shows little effect from the Sunderland outlier at Springwell. At Washington the interaction index is 208, while at Herrington, across the specific umland border it is 572. The same situation southwards was examined towards Shildon. On the Newcastle side of the transition zone, the interaction indices were 569 (Lanchester), 818 (Esh) and 614 (Brancepeth). At Willington the index rose to 2547 before the transition zone was entered. Bishop Auckland and Shildon, within the zone, had interaction indices of 6155 and 6510 respectively with Newcastle. The apparent outlier of Newcastle's specific umland at Crook shows indices of 1774 and 3014. Just beyond at Woodlands, 2306 is the interaction index.

Finally a section was studied from Sacriston, south eastwards into the Middlesbrough specific umland around Fishburn. Durham (350) and Shincliffe (1832) were within the Newcastle specific umland. Cassop (5453) was in the zone of transition while Coxhoe (1948) Trimdon (6052) and Fishburn (2853) were within the Newcastle urban field but Middlesbrough's specific umland.

Comment on these facts will be made in the Middlesbrough section.

Sunderland Regional

Of the three centres, Sunderland is the only one with a complete specific umland. It has lost the Hartlepool's peninsula.

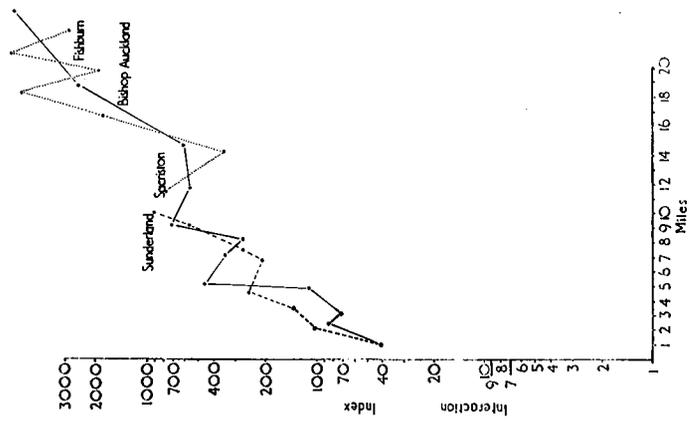


Figure 4.9 Newcastle Technical Colleges Regional Interaction Indices along section lines as indicated

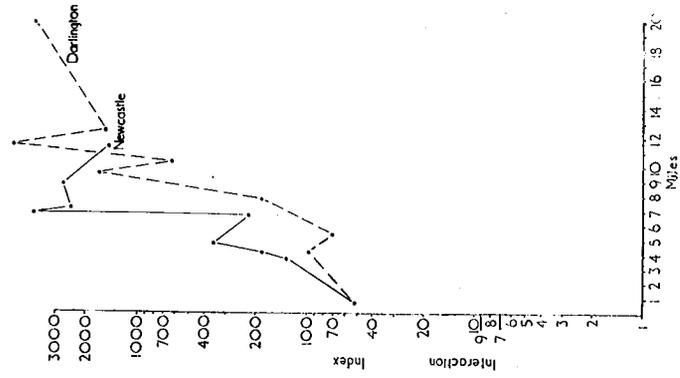


Figure 4.10 Sunderland Technical Colleges Regional Interaction Indices along section lines towards Darlington and Newcastle

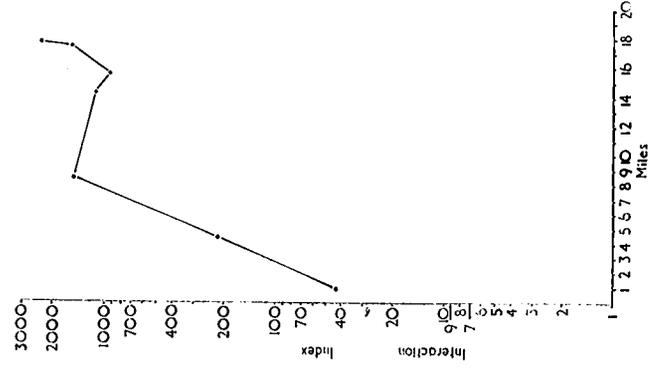


Figure 4.11 Middlesbrough Technical Colleges Regional Interaction Indices along a section line towards Bishop Auckland

to Middlesbrough and shares the South Shields peninsula with Newcastle. The triangular shape is still basically present but much contracted. Only the concealed coalfield and the settlements along the foot of the Permian limestone remain within the specific umland, compared with professional football and ophthalmology.

Towards Newcastle there is an outlier of the specific umland at Springwell. This is examined by a section (see figure 4.10). The basic interaction index is 52 at Sunderland itself. This then rises towards Newcastle at West Boldon (131) and Boldon Colliery (183) with Felling (2589) within the Newcastle specific umland. Washington has an interaction index of 360 and is in the Newcastle specific umland while Springwell's index is 219. Just beyond Springwell at Gateshead the index is 2717. This suggests that the Springwell outlier marks a zone of transition rather than a clear-cut boundary as suggested by fig. 4.8. This suggestion is supported by the analysis in the Newcastle section (see figure 4.9) and the ophthalmology analysis of the Pelton outlier to Newcastle.²²

Southwards a section has been taken through to Darlington. This time the map (fig. 4.8) already suggests a transition zone. This is because the interactions are either very few in number or not present at all or because at least two centres have equal powers of attraction in this zone. Within Sunderland's specific umland the interaction indices are low - Murton 71, Haswell 189, - but once the transition zone is entered they increase rapidly - 1,712 and 5,453. Yet these indices are comparable with Coxhoe (5843) and Newton Aycliffe (4289) which are within Sunderland's specific urban field

and Middlesbrough's specific umland.

Middlesbrough Regional

The specific umland is only defined to the north. Hartlepool now comes within the Middlesbrough specific umland and the familiar wedge northwards from Stockton to Fishburn is maintained. Darlington and Teesdale are also within the specific umland although there are no observable interactions in Upper Teesdale with any centre.

In detail, a zone of transition exists along most of the specific umland border. Much of this zone has already appeared on the ophthalmology map (see fig. 3.1). Starting in the east, the zone occupies the rural area between Hartlepool and Middlesbrough wedge to Fishburn. In this element three interactions are recorded in this rural zone, one with each centre. The total population is about 4,000 and in this area the interaction index for each centre would appear to be about 3,000 plus for Newcastle, 1,000 plus for Sunderland and 3,000 plus for Middlesbrough. Hence a random interaction is likely because of the small total population and the low power of attraction of all three centres in this area. Distance as well as population distribution may be operating at this point.

The same line of analysis is possible for the rural area between Stockton and Darlington. It has appeared on a previous map (see fig. 3.1) and in this element an area of some 3,400 people has only two interactions. Middlesbrough and Newcastle both have one interaction and their interaction indices at nearby Darlington are 599 and 3866 respectively. Hence two students are as much as this area could expect at this distance from both centres.

From Newton Aycliffe the transition zone divides. One branch goes northwards through Ferryhill to Pitlington, the other westwards into Weardale. The westward line appears on the ophthalmic map but is only hinted at on the professional football map where Upper Weardale is equally attracted to both Sunderland and Newcastle. With the regional technical colleges, the problem of trying to resolve a line for specific unlands is made difficult by the low level of interaction within population units and even when a larger number of interactions occurs they are balanced as between centres. For example Bishop Auckland has eleven interactions but they are evenly divided between centres (Middlesbrough 4, Newcastle 3, Sunderland 4). Upper Weardale has five interactions again evenly divided, between centres (Middlesbrough 2, Newcastle, 2, Sunderland 1).

A feature of the transition zone here is that population units with large populations are present. Bishop Auckland (13,465 people) and Crook (9042 people) are both in this zone. As already seen in the section on Newcastle, while Crook is apparently within Newcastle's specific unland, the change in the interaction indices suggests a zone of transition. From Middlesbrough's specific unland the same seems true (see figure 4.11). The apparent set of outliers really indicates the border zone between unlands. It might be helpful to think of this zone in terms of a 'margin' in the economic sense. As the power of a centre changes with each element, so the margin is likely to change its geographic position from being in one specific unland into another. Margin has a less permanent connotation geographically than a zone of transition.

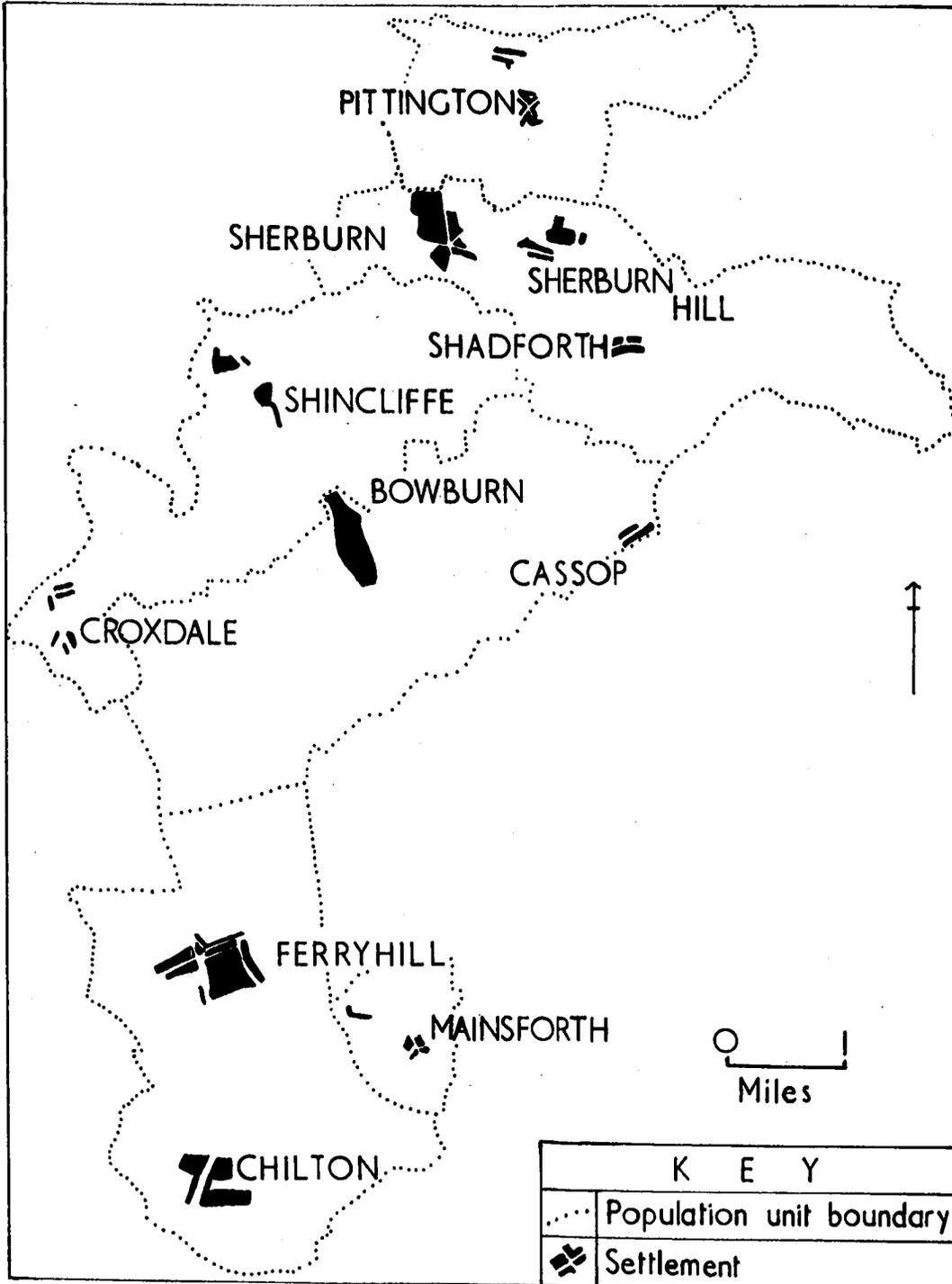
Returning to Newton Aycliffe, the marginal area has a northwards extension. This occurs along the foot of the Permian escarpment as far as Pittington with all three centres interacting in this margin. On the ground a number of mining villages exist in the margin. Within the four population units are found the villages of Pittington, Sherburn, Sherburn Hill, Shadforth, Cassop, Bowburn, Hett, Ferryhill and Chilton from north to south. As the initial data was collected on a settlement basis it is possible to examine the interactions of this margin in some detail (see table 4.8). If there really is a margin, then the settlement detail should retain balance between centres and outliers. If there is no real margin and a clear cut boundary between specific umlands does exist, the settlements will resolve the line of the boundary.

Population Unit	Villages	Students attending regional technical college centres.		
		Middlesbrough	Newcastle	Sunderland
Pittington	Pittington	0	1	1
	Sherburn	1	2	3
Cassop	Shadforth	0	1	0
	Cassop	1	0	1
Ferryhill	Bowburn	0	1	0
	Ferryhill	3	4	2
	Chilton	1	0	0

Table 4.8. Village interactions within an umland margin, central Durham.

A study of table 4.8 with the fig. 4.12 shows Pittington still equally attracted to Newcastle and Sunderland; Sherburn is within

Figure 4.12 MAP LOCATING VILLAGES IN THE EAST
DURHAM MARGIN



the Sunderland specific umland but is an outlier because Shadforth, to the east, is within the Newcastle specific umland. Cassop is equally attracted to Middlesbrough and Sunderland but Bowburn is now resolved into the Newcastle area. Ferryhill is resolved into the Newcastle area and Chilton to the Middlesbrough specific umland. However Chilton becomes an outlier because it is separated from the main body of its umland by Mainsforth which is equally attracted to Newcastle and Middlesbrough.

The margin then does remain and is not resolved even in detail though the sample is small for generalization. The reason for a margin here is the apparent equal attraction between the three centres. The approximate distance of this area from the three centres is, about 11 miles from Sunderland, about 16 miles from Middlesbrough and about 18 miles from Newcastle. If the centres are in equilibrium or balance in this area, then the power of attraction of the centres must increase in the order stated above, if distance influences their power of attraction across a field. Reference to table 4.1 shows this to be so. Newcastle, the centre farthest away from this marginal area, is the most powerful centre in terms of technical college course structure.

The Regional Centres

The one thing that can be stated with certainty about the centres from the regional technical college data is that Sunderland has a smaller specific umland than in either of the two previous elements. This fits the data in that Sunderland is least powerful as a centre in this element (see table 4.9). The area of its

specific umlands have contracted with each element and to this extent there has been consistence. The triangular shape based upon the Permian plateau of east Durham has formed the base and shape of the specific umlands.

CENTRES	FOOTBALL HIERARCHY	OPHTHALMIC HIERARCHY	REGIONAL TECHN. COLL. HIERARCHY
Middlesbrough	3	3	2
Newcastle	1	1	1
Sunderland	1	2	3

Table 4.9. Hierarchical positions of three main centres for three selected elements.

Newcastle is recognised as the regional centre for the North East of England and table 4.9. confirms this. Its specific umlands have always had a base in north west Durham from which to push south-eastwards in competition with Sunderland.

Middlesbrough has had competition on Teesside in the previous two elements. Even so it has maintained a hold upon the Stockton-Billingham area with a northwards wedge towards Fishburn. This is almost the line of the A177 from Stockton to Durham City and a local bus service exists from Fishburn to Teesside²³. Hartlepool and Darlington look towards Middlesbrough when they are not centres in their own rights.

Umland Population for Regional Centres

The two previous elements and local technical colleges showed a relationship between umland population and the power of attraction of a service at a centre. This can not be tested with regional

technical colleges because Sunderland has the only complete specific umland. Newcastle probably has a specific umland extending into Northumberland and Middlesbrough's will probably extend into the North Riding of Yorkshire. But the actual areas involved and so the populations within them are unknown. The specific umland populations of table 4.10 are therefore only the population living within county Durham.

Centres	Middlesbrough	Newcastle	Sunderland
Centre population	157,395	297,564	215,968
Centre interaction	3,637	7,240	4,160
Centre interaction index	43	41	54
Durham umland population	354,272	632,604	194,025
Durham umland population	909	3,959	1,904
Durham interaction index	390	160	102

Table 4.10. Durham umland statistics for Regional Technical Colleges 1963-64.

The interesting feature of this table is the comparison between indices. From a given population, Newcastle attracts students more easily from within its administrative boundaries than Sunderland does. This illustrates the higher number of courses and more high level courses available at the Newcastle technical colleges. In fact the hierarchy group, regional technical colleges, shows evidence of a continuum within it. This parallels the position in ophthalmology.

But even more interesting is the general agreement of the Centre interaction indices compared with the Durham interaction indices. The latter raises the question, why in County Durham, does Middlesbrough require twice the population of Newcastle and four times that of

Sunderland to produce an interaction outside itself? No firm answer can be given at this stage but a suggestion can be made. Sunderland has a specific umland which is close to its centre. The area is triangular with the centre near one angle, but no place is more than ten miles from the centre. With Newcastle, the range of the specific umland within County Durham is about seventeen miles, with Newcastle in the north east corner of the square shaped area which forms that umland. Middlesbrough has a narrow elongated specific umland within County Durham. Further, it is situated at the eastern end of this strip. It is some twenty six miles in a straight line from Middlesbrough to Barnard Castle at the western end of this strip²⁴.

As the range of each centre over its specific umland within County Durham increases so does the interaction index of the umland. There would appear to be the influence of distance here. Middlesbrough students travel greater distances than the other students and so their numbers are inhibited by this fact. This suggestion will be explored further in part two of this thesis.

Conclusions for Regional Centres

The analysis of regional technical colleges has confirmed some previous suggestions. The hierarchical groups for technical colleges is generally recognised and accepted within the education service. Free trade for the high level courses of the regional colleges means centred regions are unlikely and the data suggests that they do not exist. Instead, zones of transition, or margins, appear to exist between specific umlands.

These margins may be a result of several factors. They may

result from a rural population at a distance to the centres. They may result from free competition giving overlapping specific urban fields and so a field penetration from one specific unland into another. They may result from lack of data. A two year period could, in theory, double the potential number of interactions and reduce the interaction index. This might result in interactions taking place in negative areas (no observable interactions) of the present data, and in greater numbers in other areas to resolve the margin.

It must be remembered though that distance may be a variable operating within the data. If this is so, then an increase in the number of interactions for a two year period would show a greater number of students, in proportion, nearer the centre than the margin. The ones and twos of the present margins would become twos and threes. This would not help greatly. A ten year period might be necessary to give statistically significant totals.

Further, the collection of data for two years assumes that the variables present for one year will remain the same for two years. This certainly does not happen with professional football. A club can change its division between seasons. With regional technical colleges, the courses change from year to year and even with hospitals the number of beds available can vary from one year to another. Hence the time factor of one year inherent in the data may be considered to be desirable.

The existence of a continuum within a hierarchical group has emerged once more. The evidence suggests that specific unlands are sensitive to this continuum. While hierarchical groups define a

general area pattern, usually shown by the number of centres involved the continuum affects the margins and the exact location of specific umland areas.

Hence within the hierarchical groups already studied three major cores are recognisable. Newcastle has a core in the north west of Durham, Sunderland on the limestone plateau of east Durham and Middlesbrough near the A177 from Stockton towards Fishburn. From these cores expansion takes place according to the number of other centres operating e.g. Darlington, and the power of attraction of each centre.

General conclusions

One of the problems of applying Central Place theory to real situation is to distinguish the low level services of a centre from the higher level services when the latter have grown out of the former. In the context of this chapter it has been shown that a regional technical college centre has local and area technical college functions as well as its regional function. How do these affect the specific umland and urban field of a regional centre?

The data shows that the regional centre specific umlands have contracted considerably to form their local technical college specific umlands. This would seem to imply that a regional college centre such as Newcastle operates at a local college level when compared with data for colleges at local level. Hebburn has a specific umland even though it is in competition with South Shields, Sunderland and Gateshead. Gateshead at area technical college level manages to have a specific umland even with Newcastle at regional level adjacent to

it. It is not submerged as happened to South Shields in the ophthalmic data. Its comparatively low specific umland population may result from the nearness of its more powerful neighbour.

Specific umlands appear for all centres and their populations do appear to vary with a hierarchical order. Sunderland has a reduced specific umland at local level compared with its specific umland at regional level, but the population within it is still greater than that of any local or area college studied. There is a cumulative effect here, as the study of course catchment areas at both Durham and South Shields showed. To eliminate this effect, a study of particular courses would be necessary. This would need to be carried out over several years for a statistically viable study to result.

The Fig. 4.1 shows a lack of centred regions still. This was anticipated in the regional technical college centres, section, but with the local technical colleges centred regions might have emerged. Even South Shields with Sunderland a regional college only six miles away and Hebburn with county council support but five miles away, has a specific umland extending into the county council areas. This lack of centred regions is further demonstrated by the differences between specific umlands and urban fields. The specific urban fields have been very extensive from the county boroughs. With centred regions, which in this case would be administrative areas, this would not have happened. The historic factor and free trade between technical colleges would appear to be operating.

References

1. The author gratefully acknowledges the assistance of the Director of Education for County Durham and his administrative staff in being given access to this information. Also the Principals of the six county technical colleges for their co-operation in gaining access to enrolment forms.
2. The author gratefully acknowledges the assistance given by the Directors of Education for Darlington, Gateshead, South Shields, Sunderland and West Hartlepool.
3. The author gratefully acknowledges the assistance given by the Directors of Education for Middlesbrough and Newcastle.
4. See Burgess, T., 'A guide to English Schools', Penguin Books, London, 1964.
5. The author gratefully acknowledges the assistance of the Principal, Durham Technical College for help in formulating this problem.
6. 'Guide to further education courses in the region, 1963-64', Northern Advisory Council for Further Education, Newcastle upon Tyne.
7. This hierarchy was discussed with Principals of a number of technical colleges, who all accepted it.
8. The influence of courses upon the catchment area is illustrated in the Durham section.
9. Confirmed by discussions with Principals of a number of Technical colleges.
10. See Fullerton B. and House, J.W., 'Teesside at mid-century', London, 1960.

11. The background to these development in county Durham is to be found in 'Scheme of Further Education', Durham County Council, 1951.
12. Personal communication with the Principal, Bishop Auckland technical college.
13. This could be an example of the influence of an innovation wave. See Hagerstand, op. cit.
14. See chapter 2, page 23.
15. The author is grateful to the Principal of Durham technical college for discussing several problems and allowing a study of individual course catchment areas to be made.
16. Personnel communication, Whitburn Colliery post office.
17. The author is grateful to the Principal of South Shields Marine and Technical College and students of the Bede College, Annexe, South Shields, for help with this study of courses.
18. The data collected at Hebburn technical college was complete and not limited to Durham based students.
19. The data for five of the county Durham colleges is complete, as is the figure for Hartlepoons.
20. See 'Guide to Further Education Courses in the Region, 1963-64', op. cit.
21. The statistical analysis was based upon eleven centres, omitting Middlesbrough and Newcastle because of their inadequate data. With $N = 11$, $R = + 0.8$, a 't' test showed a significance at the 0.01% confidence level.

22. See chapter 3, page 47.
23. Both Favourite Services and Wilkinson Motor Services ran bus services through Fishburn to Stockton.
24. A discussion of the geometry of fields of attraction is found in Haggett, P., 'Locational Analysis in Human Georgraphy', London, 1965, Chapter 2 III.

5. THE ELEMENTS - GENERAL SURGERY

The data upon which this chapter is based is the general surgery admissions to the hospital groups within the geographic county of Durham. From the administrative point of view the county is divided into nine hospital management committee areas. Each of these areas has a general surgery unit, and some have several.

The location and number of these units within Management committee areas depend, in part, upon historical factors. When the National Health Service was formed in 1948, it took over a stock of hospital buildings. This stock of buildings had two basic roots. Voluntary organisations in the Victorian era provided the means to build infirmaries. From these independent sources such hospitals as the Sunderland Royal Infirmary and the Ingham Infirmary at South Shields resulted. The other major source of hospitals was the local authorities, again, as they were developed in the Victorian era. Many local authorities converted their workhouses into hospitals, often known as General Hospitals. A further development was the small cottage hospital early this century. They usually served a local rural population and some were built as Memorial hospitals after the 1914-18 War.¹

The result of this diversity of origin is to provide a variety of hospital locations and varying sizes of hospital. Within general surgery in county Durham this has resulted, for example, in Darlington having in its management committee area only one general surgery unit based upon the Darlington Memorial Hospital. This is in contrast to Sunderland which has five units. One is a voluntary hospital in

origin and is the Royal Infirmary. Nearby are two general surgery units at the Sunderland General Hospital and Ryhope hospital, both local authority converted workhouses in origin. A fourth unit occurs in the Childrens' Hospital in Sunderland. Outside the town but within the management committee area is Leeholm (Easington) Hospital. Again a converted home, it provides a rural located hospital linked for present administrative convenience to Sunderland and having a general surgery unit.

Both of these examples show one large centre dominating for Easington has very few beds compared with the three major Sunderland hospitals. The Durham area contrasts with this in that it has two hospitals with general surgery units, the one at Durham City having 87 beds and that at Chester-le-Street having 28. The result is that both hospitals operate independently in terms of where they draw their patients from. Their origin as different local authority hospitals affects their present source of patients still, even within a united management committee area.

With these contrasts in origin and size, the location of general surgery centres as opposed to hospital amangement areas needs careful consideration. The historical factor influences the distribution of centres as opposed to management areas.

The Data

Each hospital has an admissions register which records the address, date of admission and surgeon for each patient. Each surgeon specialises in a particular field or specialty, of which general sugery is one. For the year 1965, a count was made of each

patient admitted to the county Durham hospitals and treated by a surgeon involved in the general surgery unit.² The addresses enabled totals to be calculated for each population unit. A check on the hospital general surgery totals was made with total figures provided by the Newcastle Regional Hospital Board.³ This showed that the data extracted on the basis of surgeons' names to locate the general surgery specialty was accurate.

This data was complete and not just limited to patients living within County Durham. Hence it was potentially more useful than the data for technical colleges.

Although only nine administrative areas existed for general surgery within county Durham, some twenty two hospitals provided treatment. After experimenting with the data it was finally decided to recognise some thirteen centres.⁴ Basically it was found that when hospitals occurred within the same built-up area they would be combined and thought of as a single centre. For example Gateshead's built-up area has four hospitals - Queen Elizabeth hospital at High Fell, Bensham General hospital, Dunston Hill hospital and Whickham cottage hospital. These all operate over the same area and form a locational unit or centre, compared with the next nearest general surgery units.

In contrast the Durham area has two hospitals with general surgery units, one at Durham City and the other at Chester-le-Street. These both draw patients jointly from some places but each dominates in different parts of the total area. Washington for example sends patients to Chester-le-Street rather than to Durham City. Hence two centres were recognised within this management committee area.

The Newcastle Regional Hospital Board recognised that each district management committee served an area which it considered to be a catchment area.⁵ This area had a base population upon which the level of services to be provided at the hospitals could be planned.⁶ These areas acted as guide lines and no administrative machinery existed to guide patients to the hospitals in whose catchment area they were resident. In fact waiting lists existed for in-patient cases and information was available to patients as to where the waiting lists were shortest. Hence a choice existed for patients as between hospitals and centred regions did not operate.

The Basic Situation

There were thirteen centres for general surgery within county Durham in 1965. These were Bishop Auckland, Chester-le-Street, Darlington, Durham City, Easington, Gateshead, Hartlepoons, Sedgefield, Shotley Bridge (Consett), South Shields, Stanley, Stockton and Sunderland. Since general surgery is at the lowest level of the hospital service hierarchy (see table 3.1) these centres are, in theory, all equal in competition.

Tyneside is represented by Gateshead and South Shields on the south Tyne bank. Teesside has centres at Darlington, Hartlepoons and Stockton. The Wearside sub-region is represented by Sunderland. Hence the major built-up areas have six of the centres. The mid-Durham area would therefore appear to be over-represented by its seven centres. These centres vary in their environmental location. Shotley Bridge and Stanley are within the older coalfield area of north-west Durham. Chester-le-Street and Durham City are in the

central Wear valley area. Easington is on the southern part of the east Durham plateau while Sedgefield to the south-west of it appears as a centre for the only time, in this thesis. Bishop Auckland appears once more at the gateway to Weardale.

Major Urban Centres.	Beds	Mid-Durham Centres.	Beds
Darlington	82	Bishop Auckland	87
Gateshead	114	Chester-le-Street	28
Hartlepoons	96	Durham	87
South Shields	136	Easington	12
Stockton	51	Sedgefield	75
Sunderland	240	Shotley Bridge	108
		Stanley	15
Total	719	Total	412

Table 5.1. Hospital general surgery bed totals by centres. 1965.

Although the number of centres outside the major urban areas seems high if the total number of beds involved is calculated (see table 5.1) the relative significance of the two groupings of centres becomes apparent. The major urban areas have a greater bed total than the seven centres scattered over mid-Durham. Once again the potential attraction of the main built-up areas is greater than that of the other areas.

When the bed totals are studied they show a large range of numbers. General surgery has already been established as a particular hierarchical group within the hospital service specialties. One could anticipate therefore that each centre would provide in general surgery a similar service to a similar population total. However the bed totals range from 15 at Stanley to 240 at Sunderland.

This suggests some variation within the hierarchical group.

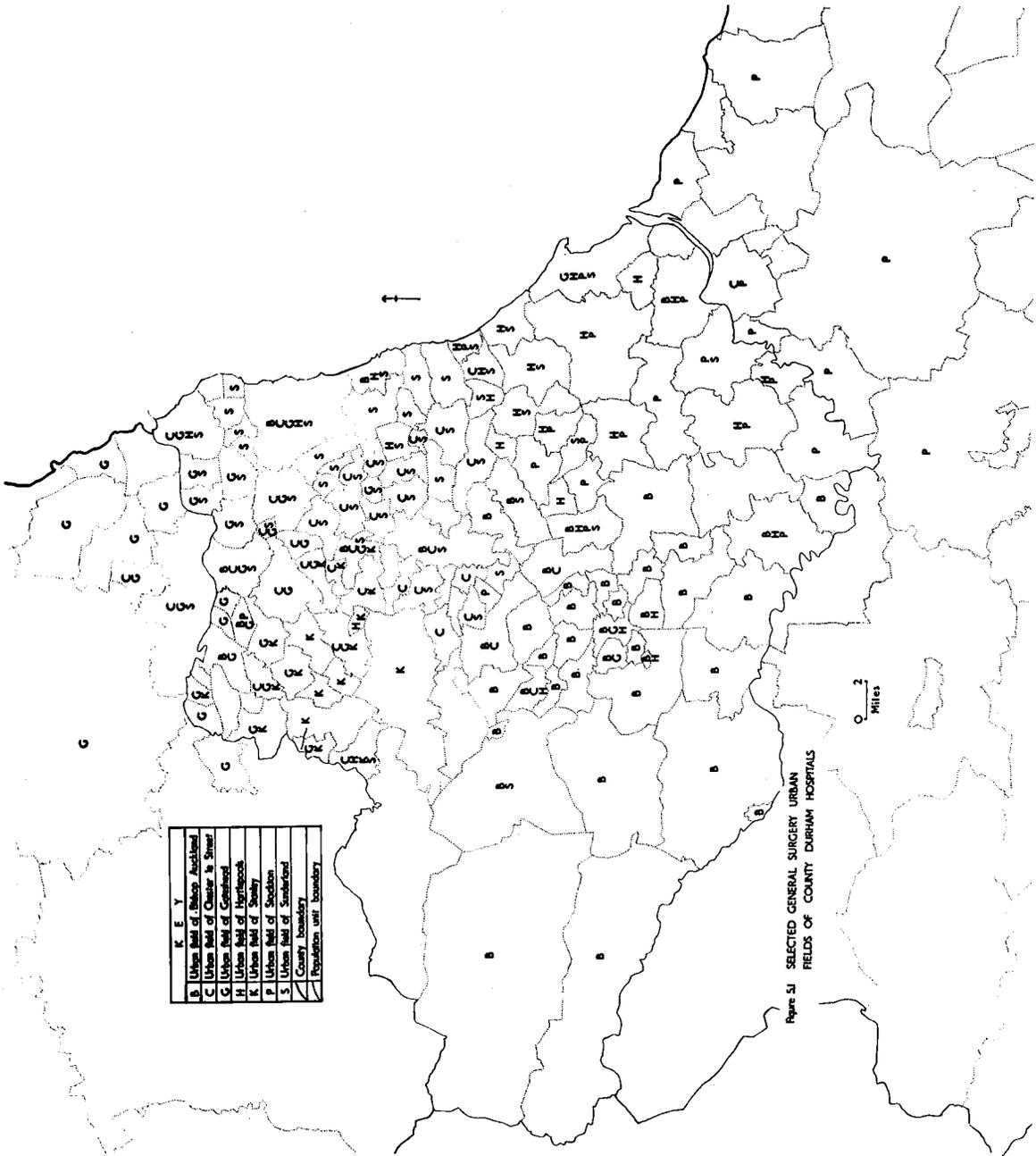
Bishop Auckland.

The Bishop Auckland hospital's general surgery urban field extends across south west Durham. Weardale, Crook, Willington and Durham City form the northern limits. The eastern limit is a north-south line from Durham City to Darlington with the Tees forming the southern boundary of the urban field. Outside the area there is evidence of interactions with Bishop Auckland at the larger centres such as Gateshead and Sunderland (see fig. 5.1) but these tend to form isolated units. It is worth noting that the complete data for 1965 fails to show any interactions with the Yorkshire side of the river Tees other than Richmond. Both Darlington and Northallerton are competing with Bishop Auckland south of the Tees.⁷

The specific umland has many similarities with that of Bishop Auckland as a local technical college. Weardale, Tow Law, Crook, Willington and Spennymoor form the northern limits. The rural area around Mordon is just within the specific umland and then the boundary skirts to the north of Newton Aycliffe and Heighington and into the Staindrop area but then leaves upper Teesdale in Darlington's specific umland.

Chester-le-Street

The specific urban field of Chester-le-Street is almost circular with a radius of about ten miles. The data shows Gosforth as the northern limit, the boundary then curving eastwards through South Shields, Sunderland, Haswell, Spennymoor, Crook and Consett



KEY	
B	Urban field of Bishop Auckland
C	Urban field of Chester le Street
G	Urban field of Gateshead
H	Urban field of Hartlepool
K	Urban field of Kingston
P	Urban field of Stockton
S	Urban field of Sunderland
—	County boundary
—	Population unit boundary

Map S1 SELECTED GENERAL SURGERY URBAN FIELDS OF COUNTY DURHAM HOSPITALS

0 2 Miles

to complete the circle back to Gosforth. This circular type urban field has appeared before e.g. Easington technical college, and tends to be associated with centres of low power or attraction within the network (see fig. 5.1).

The specific umland is limited to six population units and these form an elongated area which gives the appearance of being wedged between the specific umlands of Durham, Gateshead and Sunderland. The geographic centre of the specific umland is in Harraton and this is almost equidistant from the central areas of Durham City, Gateshead and Sunderland (about six miles). Hence the regular geometry of the urban field would appear to have some kind of parallel in the umland.

Although the area of the specific umland is small compared with that of the specific urban field, it is more significant if the number of patients involved is considered. Of the total patients treated for general surgery at Chester-le-Street hospital in 1965 some 81% lived within the specific umland. In these terms, the single patients from Gosforth and Consett are not significant, although they give a large urban field.

It is rather surprising to find Washington within the Chester-le-Street specific umland. In terms of geographic distance, Washington is nearer to Sunderland and Gateshead than it is to Chester-le-Street; in terms of communications access to Chester-le-Street is poor. Given that Chester-le-Street has sufficient power of attraction to have a specific umland, ~~it has to achieve this umland~~ it has to achieve this umland between five more powerful centre -

Durham City, Gateshead, Shotley Bridge, South Shields and Sunderland. Of these centres, Durham City is the weakest in terms of total beds for general surgery. It would seem likely therefore that Chester-le-Street would establish its umland at the expense of Durham City.

<u>Population Unit</u>	<u>Chester-le-Street</u>	<u>Durham</u>	<u>Gateshead</u>	<u>Sunderland</u>
Birtley	96	41	19	-
Chester-le-Street	150	138	4	4
Great Lumley	16	6	-	2
Harraton	28	-	-	17
Pelton	56	17	-	-
Washington	114	83	61	13

Table 5.2. Interactions within population units of Chester-le-Street's umland, 1965.

This is in fact shown by table 5.2. This operating in the general situation is further illustrated at Urpeth. Urpeth is only three miles from Chester-le-Street, yet the more powerful. Shotley Bridge dominates this population unit from a distance of ten miles. Table 5.2 tends to show that Chester-le-Street only just has a specific umland.

Darlington

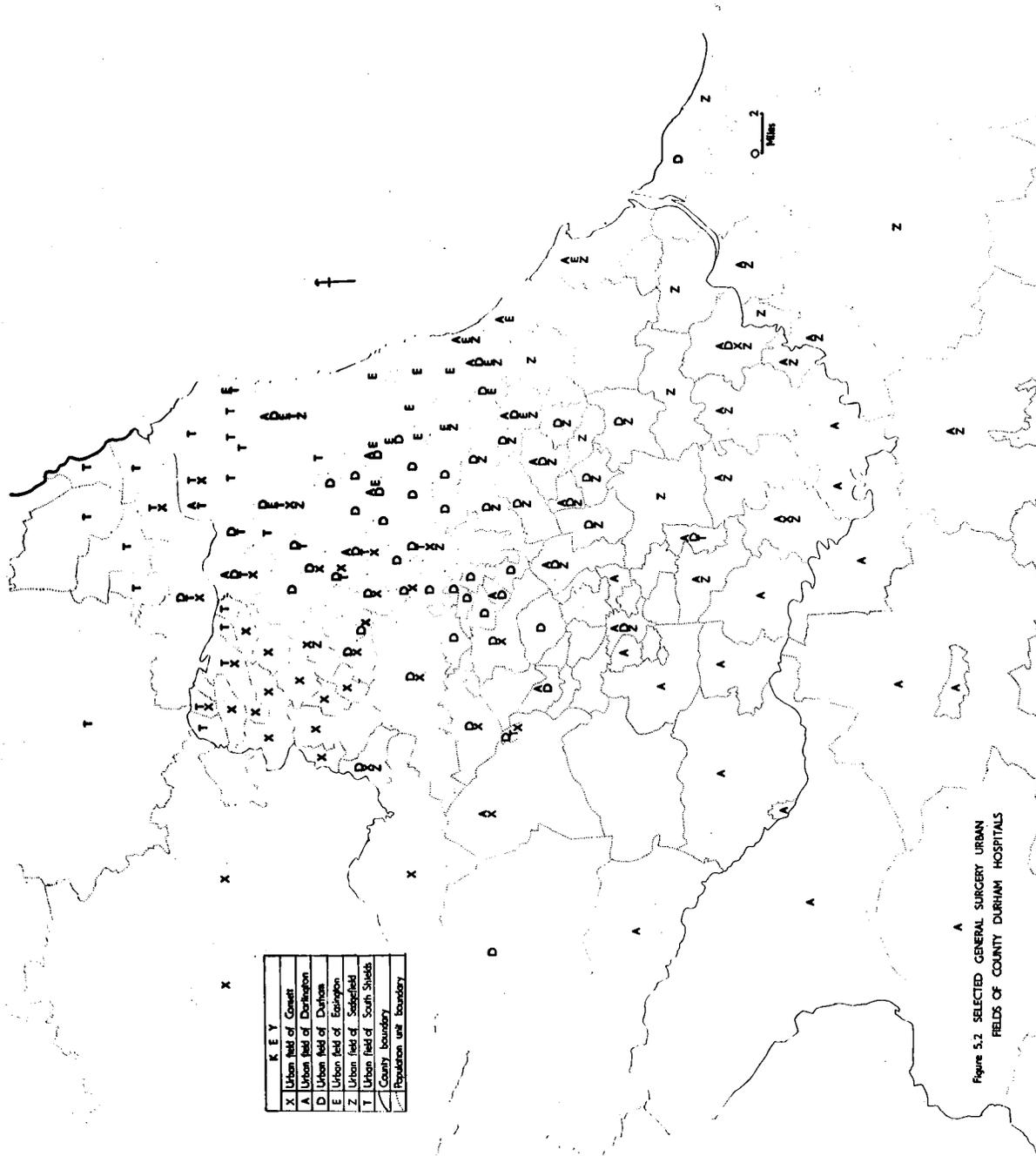
The completeness of the data for general surgery is important at Darlington. With the local technical college element it could only be suggested that Darlington's influence spread southwards across the river Tees. This data shows conclusively that this is true in general surgery. The specific urban field is strong in north west Yorkshire with patients coming from the rural district of Croft, Reeth, Richmond and Startforth in fair numbers. South and south

westwards the field weakens rapidly. Ripon, Leyburn and Thirsk form the limits of the urban field to the south and then the North Yorkshire Moors appear to block the south eastwards penetration with weak attractions at Northallerton, Yarm and Middlesbrough.

Within county Durham, Teesdale is the westward limit of the urban field. Northwards the boundary appears to be a line through Wolsingham, Crook, Brandon and Houghton-le-Spring to the coast at Sunderland. The urban field is weak at the coast but interactions do occur at Horden, Blackhall and Hartlepool (see figure 5.2).

The interesting feature of this specific urban field is the failure of Darlington to draw patients from Weardale. Previously this has been an area of overlap with Bishop Auckland which has been resolved at the specific umland level by Darlington, dominating Teesdale and Bishop Auckland, Weardale. Although Bishop Auckland does have one interaction in upper Teesdale and Darlington one at Wolsingham, this is certainly a reduction from the technical college situations.

The specific umland repeats the local technical college situation (see fig. 5.3). Darlington dominates Newton Aycliffe and finds its boundary in the rural area that separates it from Stockton and Shildon. And, as in the local technical college data, Teesdale forms a westward extension of this specific umland. As table 5.3 shows, the specific umland is continuous along A.67 although the Staindrop population unit is actually within the Bishop Auckland specific umland.



KEY	
X	Urban field of Gossett
A	Urban field of Darlington
D	Urban field of Durham
E	Urban field of Easington
T	Urban field of Sedgefield
	Urban field of South Shields
—	County boundary
—	Population unit boundary

Figure 5.2 SELECTED GENERAL SURGERY URBAN FIELDS OF COUNTY DURHAM HOSPITALS

Settlement	Bishop Auckland	Darlington
Barnard Castle	37	79
Winston	1	9
Gainford	-	16
Piercebridge	1	6
(Staindrop)	(8)	(5)

Table 5.3. General surgery interactions along the A.67 with Bishop Auckland and Darlington Hospitals, 1965.

As data is not available in this study on general surgery units south of the river Tees, the specific umland boundary is undefined in this area. Northallerton is the next centre southwards so Darlington is in competition with it south of the Tees. Darlington attracts 79 patients from the Richmond rural district but only one from the adjoining Northallerton rural district. Both Richmond and Startford rural districts require less than 300 people to provide one patient in general surgery. This suggests they are within the Darlington umland (see table 5.4). Within the specific umland in county Durham the interaction index is generally below 100 while outside the umland it rises rapidly into the thousands. This suggests that at least four and probably five population units in north west Yorkshire are within Darlington's specific umland.

Umland Interaction Indices.		Yorkshire Interaction Indices.		Urban Field Interaction Indices.	
Darlington	54	Richmond M.B.	53	Staindrop	369
Sedberge	61	Croft R.D.	72	Elton	471
Piercebridge	85	Reeth R.D.	114	Etherley	2479
Gainford	89	Startford R.D.	156	Northallerton	
Heighington	128	Richmond R.D.	257	R.D.	3363
				Bishop	
				Auckland	3693

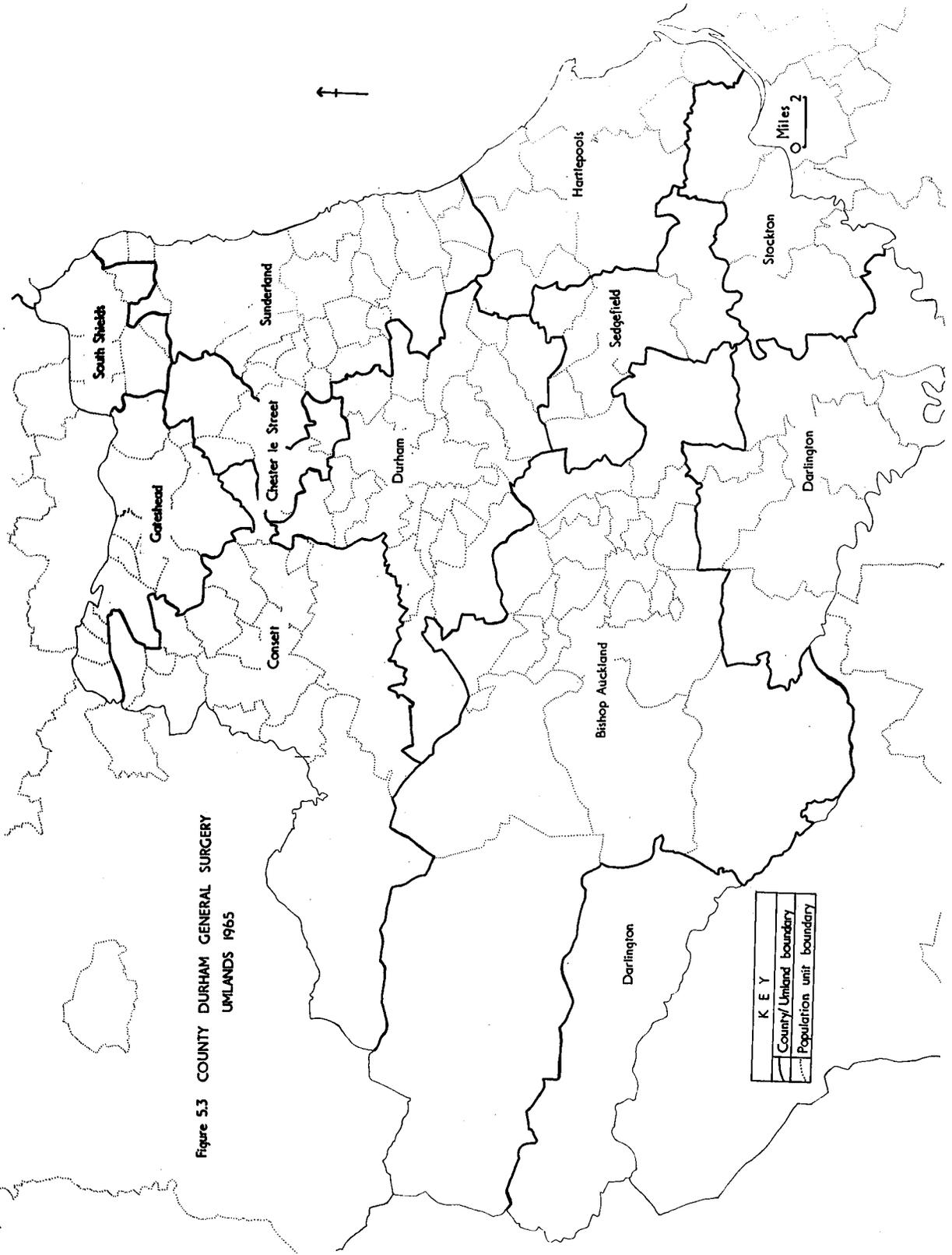


Figure 5.3 COUNTY DURHAM GENERAL SURGERY UMLANDS 1965

K E Y	
	County/Umland boundary
	Population unit boundary

Table 5.4. Interaction indices comparisons, Darlington general surgery unit, 1965.

Durham

As Durham City is in the centre of its county area, it tends to have a circular or elliptical specific urban field. Patients are drawn from along the A.1 road from Newton Aycliffe in the south, to Newcastle in the north. East-west the field extends from Sunderland and Peterlee in the east to Consett and Tow Law in the west. This forms an ellipse some 25 miles north-south and 21 miles east-west. The field extends weakly out beyond this area to Stanhope, Staindrop Billingham and the rural area of Hexham.

The elliptical form is maintained in the specific unland, but the major axis is now east-west rather than north-south. This may be related to competition. With Tyneside hospitals to the north and Teesside ones to the south, the line of least competition is found eastwards. Hence the Deerness valley is within the western limits of the unland with Brandon and the coal mining villages immediately west of Durham City. Northwards, Chester-le-Street forms the limit while southwards the rural fringe between Durham City and Ferryhill-Spennymoor is the effective limit. Eastwards competition with Sunderland limits the unland to the villages west of Houghton-le-Spring and Hetton-le-Hole. Then competition with Hartlepoons and Sedgefield is resolved on the limestone plateau, Thornley and Coxhoe being the limits of Durham's influence.

If competition is a factor in the shape of Durham's specific unland, then a study of the interaction indices along an east-west

line should show a more gentle slope than for places along a north-south line. This hypothesis is tested in figure 5.4. Population units from Durham to Stanhope are compared with those from Durham to Gateshead. Stanhope on the east-west axis shows an interaction indices of 5,000+ at about 19 miles from Durham City while Gateshead, only 12 miles north of Durham, shows an interaction index of 103,000+. The network would appear to influence the shape of Durham's specific umland.

Easington and Stanley

These two centres are combined here because they both fail to have a specific umland. They are also the two smallest centres in terms of total beds (see table 5.1) in general surgery. Chester-le-Street is the next smallest centre with 28 beds, but it has a specific umland. There would appear to be some initial value in terms of total beds between the 12 and 15 of Easington and Stanley and the 28 of Chester-le-Street which gives a centre a specific umland. This general situation repeats the South Shields case in the Ophthalmic element.

Easington has a specific urban field limited to eastern Durham. Patients are attracted from Whitburn, Washington and Sunderland in the north. From here a band of about seven miles width and parallel to the coast forms the urban field as far south as Hartlepoons. Rather surprisingly one patient came from Blyth in 1965, the only patient from outside the rectangle of the urban field.

Stanley has a specific urban field limited to north west Durham. No patients were drawn from Northumberland, for east of the A.1. road or from south of the Lanchester area (see fig. 5.1).

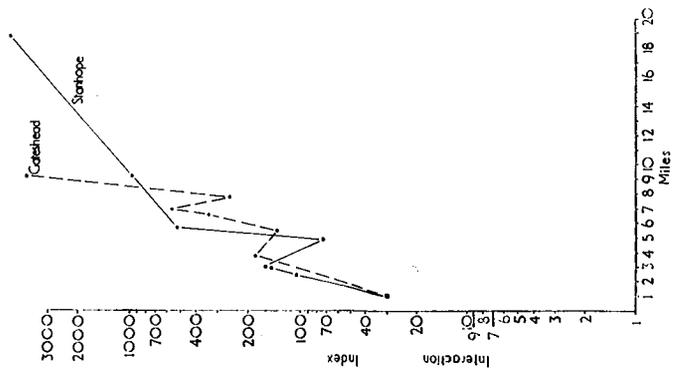


Figure 5.4 Durham General Surgery Interaction Indices along section lines towards Gateshead and Stanhope

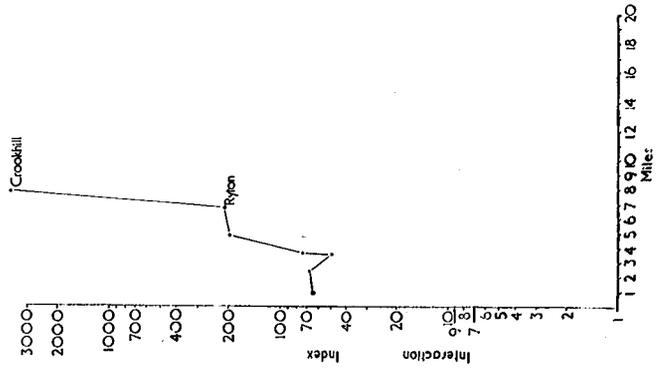


Figure 5.5 Gateshead General Surgery Interaction Indices along a section line towards Ryton

It could be argued that both of these centres represent the historical element in the pattern of centres. Part of the stock of buildings inherited by the National Health Service, they were built to serve a very local need and are too small by modern standards to form viable units. They continue to exist at the margin waiting for enlarged hospitals at Sunderland and Shotley Bridge to replace them.

Gateshead

Gateshead's hospitals drew patients from both banks of the river Tyne within the conurbation. Only Tynemouth and part of Ryton lacked interaction with Gateshead. The power of attraction was greater on the south bank than on the north bank in terms of number of patients but the distribution on south Tyneside was similar to that of the area Technical college. Northwards the specific urban field extended as far as Morpeth in Northumberland though it was weak on the coal-field proper. At the coast, Sunderland showed one interaction and formed the urban field limit to the southeast. Washington, Chester-le-Street and Stanley then formed the southern limits. The field boundary then turned north eastwards to Prudhoe and the Tyne again (see fig. 5.1).

Two points are significant here. This urban field is more limited than the area technical college urban field of the previous element. This might be expected as general surgery forms a low local service probably equivalent to the local technical college courses. The gap in the data at Ryton is also interesting. When studying Newcastle's specific unland at local technical college level, the point was made that Ryton itself had higher interactions than any of the

other population units within the Ryton urban district⁹. The Crookhill area shows no interactions within this data. Could this be a similar problem to that of Whitburn Colliery? Do people give their address as Ryton rather than Crookhill?¹⁰ Over county Durham as a whole there was one general surgery case for every 53 people. With a population of 2951 there seems no reason why in a mining community like Crookhill there should be no cases of general surgery in 1965.

Gateshead's specific umland extends from Felling to Ryton along the south Tyneside bank. It must be remembered however that competition with Newcastle is unknown here because the data for Newcastle is not available for this study. Competition from Shotley Bridge cuts off the umland from the Consett and Stanley areas and that part of the Blaydon urban district which is away from the river. As fig. 5.5 shows the interaction index for population units in Ryton is anomalous. If the three Ryton population units for the river side area are combined then the interaction index is 620. Compared with other areas this seems high for a place within Gateshead's specific umland. It is obviously marginal and could be within Newcastle's or Hexham's umland for general surgery.

The tendency for Gateshead to be blocked eastwards by South Shields and Sunderland and so to extent its umland westward is confirmed here. Again, as with Durham City, the shape of the umland responds to the pattern of the network.

Hartlepoons

A thin scatter of interactions across south east Durham formed Hartlepool's specific urban field. Sunderland formed the northern apex of its triangular shaped area which extends inland in a west of

south direction from Sunderland to Darlington. The river Tees formed the southern line of the triangle to Hartlepoons. A group of interactions did occur in the Bishop Auckland area. They appear to be removed from the main area of the urban field, probably because of the sparse rural population in the Mordon population unit which lies between Bishop Auckland and the Triangle outlined above (see fig. 5.1).

The number of patients involved outside the population units adjacent to Hartlepoons itself is very small. Hence the use of the expression, a thin scatter. Yet Hartlepoons does show interactions with a number of places at a greater distance. Crook, Consett and South Shields all have one interaction with Hartlepoons and beyond the North East patients are recorded from Bradford, Solihull, London and even the Netherlands. While one would not claim these places are part of the specific urban field, they do need an explanation when the limited area of attraction usually associated with the Hartlepoons is considered. At this stage the fact that Hartlepoons is a port might provide the answer. The theoretical implications will be considered in the second part of this thesis.

Having suggested a possibly larger field for the Hartlepoons to operate in, the specific umland (see fig. 5.3) brings one back to the peninsular idea already suggested in professional football and local technical colleges. The specific umland consists of six population units including Hartlepoons itself. The competition with Stockton and Sedgefield shows Hartlepoons in firm command of the rural area to its west. This may result from the existence of two lower powered centres on what has been termed before, the Middlesbrough

wedge. Hartlepoons with its 96 beds is potentially more powerful than either Stockton (51 beds) or Sedgfield (75 beds). North westwards the boundary with Sunderland is pushed onto the coalfield with the Blackhall area looking towards Hartlepoons this time.

The statistical significance of the specific umland is shown by the fact that of the 2430 general surgery patients at Hartlepoons in 1965, 94% lived within the specific umland. The few cases from places like Consett, Bradford and the Netherlands are not significant in the general pattern.

Sedgfield and Stockton

Several times in previous elements reference has been made to a wedge of population units which show attraction to Middlesbrough from county Durham from a Stockton base extending northwards to Fishburn. This is part of the justification for considering these two centres together as they in fact occupy this wedge. Further from an administrative point of view they form a single unit, the north Teesside hospital management committee area.

Sedgfield was a military hospital during the 1939-45 war. When the war ended and buildings were in short supply the needs of Stockton for extra hospital beds were met by taking-over the military hospital. Hence the split into two centres is by chance and not by policy. A new hospital is being built just outside Stockton and it is hoped to transfer all general surgery to this unit from the older Stockton hospitals and the temporary Sedgfield hospital. The latter will be closed in time.

For a village hospital, Sedgfield has a remarkably large spec-

ific urban field. If however it is remembered it is really a temporary relief centre for Stockton, then the result seems more reasonable. From Sunderland a line joining Washington, Durham City, Ferryhill, Bishop Auckland and Darlington would form the limits of the urban field in county Durham. Across the river Tees the specific urban field extends through Yarm and Thornaby to Middlesbrough. As with the Hartlepoons, patients are drawn from outside this area as well - Whitby, Burton-on-Trent and Birmingham for example. Sedgefield is not a port and these few long distance patients are difficult to account for. That road accident cases may involve a transfer into general surgery of a patient at some stage is a possible explanation. However such a transfer would not appear initially in the admissions register, the source of data. This problem is best left at this stage but will be returned to in the second part of this thesis.

Stockton has a similar sized specific urban field to that of Sedgefield's but it is more southerly based. A line from Horden on the coast to Ferryhill forms the northern limit. Then the boundary extends southwards through Darlington, across the river Tees into the Northallerton rural area and then eastwards to Stokesley and the coast at Bretton.

If the two specific umlands are joined together (see fig. 5.3) the similarity with the Middlesbrough wedge is clear. The rural fringe to the east and west with Hartlepoons and Darlington continues to form the boundary. To the north, the boundary extends further than usual because Sedgefield forms a powerful centre within the wedge. Ferryhill, Mainsforth, Cornforth, Fishburn and the Trimdons are now within the wedge. Clear boundaries result within

a previously marginal area because a centre is nearer to that margin. But the new centre has not been able to extend its influence into the Bishop Auckland or Durham City umlands very greatly. Both these centres are slightly more powerful in terms of total beds than Sedgefield (see table 5.1).

Stockton Umland		Stockton Urban Field		Yorkshire Area	
Eaglescliffe	77	Stillington	159	Yarm	105
Stockton	80	Sedgefield	931	Thornaby	121
Billingham	98	Fishburn	951	Stokesley	951
Elton	235	Elwick	1223		

Table 5.5. Interaction indices comparisons, Stockton general surgery unit, 1965.

Just as interesting is the situation southwards from the Stockton base across the river Tees. Within county Durham the Stockton specific umland shows interaction indices of just about 100, while the specific urban field has indices of 150 rising rapidly to 1000 and more. South of the Tees both Thornaby and Yarm show low interaction indices suggesting that they are part of Stockton's specific umland (see table 5.5). The sudden rise at Stokesley to an index comparable with these parts of the county Durham just outside the specific umland supports this. Certainly one of the hospitals in Stockton is called the Stockton and Thornaby hospital.

This suggestion gains support from another source. The data for Stockton-Billingham technical college suggested a strong link with Thornaby and Yarm.¹²

Competition in general surgery would be with Middlesbrough and

Northallerton in this area and on distance alone, the inclusion of Yarm and Thornaby within the Stockton specific umland would seem reasonable.

Shotley Bridge

Shotley Bridge is a suburb of Consett. Its specific urban field is centred in north west Durham with only a scatter of interactions on south Tyneside. In the study of local technical colleges, Consett was linked to Tyneside because of its interactions with virtually all the population units on south Tyneside. This is not true for this element. Wallsend and Jarrow form the limits fo the specific urban field downstream. The boundary southwards from here is a line joining Washington, Durham City, Tow Law and Hexham and then to Wallsend via Newcastle. The urban field never reaches the sea, is weak on north Tyneside and includes that part of Northumberland that lies across the Derwent from county Durham, towards Hexham.

The specific umland is limited to county Durham. It forms an arc around Shotley Bridge at about a seven miles radius, from Chopwell in the north through the Stanley area to the Lanchester area and then west to the upper Derwent valley. This closely resembles the specific umland of Consett in the local technical college element.

South Shields

With the data for South Shields complete for this element, the extent of the specific urban field is fully known. In professional football it was shown that Sunderland was able to compete with Newcastle into south east Northumberland especially along the coast. The Tyne ferry between North and Should Shields appeared to provide

a link and the South Shields general surgery data repeats this pattern with an urban field extending across south east Northumberland as far north as Morpeth (see fig.5.2).

Within county Durham the specific urban field shows its Tyneside alignment by interacting with virtually all the south Tyneside population units. The field spreads south eastwards from Tyneside to Sunderland and Washington, Birtley and Chester-le-Street and as far as Durham City. A few isolated interactions occur with some of the more distant towns such as Newton Aycliffe and Tow Law in county Durham, and Amble and Wooler in Northumberland.

Figure 5.3 shows once more the peninsularity of the South Shields specific umland. Six population units are involved. Competition with Sunderland divides the Boldon area between South Shields and Sunderland. Whitburn and West Boldon are physically nearer to Sunderland than South Shields while the reverse is true of Cleadon and Boldon Colliery. Hence the latter two appear in South Shield's umland. Competition with Gateshead leaves Jarrow and Hebburn within the South Shields umland but Felling within Gateshead's influence. Washington to the south west is attracted to Chester-le-Street.

Sunderland.

Of all the centres studied for general surgery, Sunderland is the most powerful. Within the town four hospitals provided general surgery treatment. There is an immediate demand from over 200,000 people within the town itself which partly accounts for the large number of beds available (see table 5.1).

The specific urban field resembles that for ophthalmology

though it is less in area. Newcastle is the only population unit sending patients to Sunderland from Northumberland. Along the south Tyneside bank, Sunderland draws patients from as far west as Gateshead but not from north west Durham. From Gateshead the urban field boundary goes southwards to Chester-le-Street and then turns westwards to Wolsingham. There are no interactions in south west Durham, the boundary from Wolsingham turning back eastwards to Newton Aycliffee and on to the coast of Hartlepoons. Consett, Middlesbrough and Stockton provide isolated interactions beyond this area. This partial contraction of the ophthalmic pattern (see fig. 8.1) is to be expected. General surgery is at a lower hierarchical level than ophthalmology, and this parallels some of the cases studied in the technical college elements where a centre provided different levels of service.

The area of the specific urban field covers most of the Wear valley drainage area as well as the limestone plateau of east Durham. This pattern has been noted before Sunderland.

Just as the urban field is familiar, so the specific umland of Sunderland has a familiar form. Elliptical in shape, with Sunderland at its northern end, it extends westwards into the Houghton-le-Spring and Hetton-le-Hole areas and southwards through Seaham, Murton and Haswell, to Easington and Peterlee (see fig. 5.3).

As has been noted before in other elements, the new towns of Peterlee and Washington are at the margin of Sunderland's specific umland. This is significant for Central Place theory. A further point is related to Whitburn. Already comment has been made upon the lack of interactions at Whitburn Colliery¹³ and this element

shows no interactions there. West Boldon (64) and Whitburn Village (69) are both within the specific umland and have similar interaction indices. While there is no conclusive evidence, the interactions for Whitburn Colliery could be contained within that of Whitburn and it is on this assumption that Whitburn Colliery has been included in Sunderland's umland.

Centres

A distinction must be made between the centres seen as points drawing patients from a surrounding area and the hospital management committee areas. The Newcastle Regional Hospital Board recognise only the management areas. It is to these areas that they would apply their hierarchical criteria of less than 150,000 people needed to provide the general surgery specialty within an area. But table 6.6 shows that even within the management areas variation occurs as between total beds available and the management area catchment populations. Sunderland had 252 beds to Darlington's 82. Sunderland had a catchment population of 375,949 to Bishop Auckland's 100,854.

Management Area	Bed Total	Population
Darlington	82	157,648
Durham	115	135,562
Gateshead	114	169,054
Hartlepool	96	140,540
North Teesside	126	156,782

Table 5.6. Bed totals and catchment area populations by Hospital Management Committee areas, General Surgery, 1965.
(Continued over)

Management Area	Bed Total	Population
North west Durham	123	136,706
South Shields	139	163,259
South west Durham	82	100,854
Sunderland	252	375,949

Table 5.6. Bed totals and catchment area populations by Hospital Management Committee areas, General Surgery, 1965.

Source: Newcastle Regional Hospital Board.

This may result from a variety of causes, one of which may be the bed occupancy rate. As the total number of patients for each hospital is known, the number of patients occupying a bed in each centre during 1965 can be calculated (see table 5.7). This shows a consistency even though there is great variation between the total number of beds available in any one centre. A regression was calculated for this data and a correlation coefficient of +0.98 resulted which is highly significant at the 0.1% level (t test). The average number of patients occupying a general surgery bed during the course of 1965 was 22.5. So the differences in bed totals as between centres is not the result of differing rates of bed occupancy.

In the section on Sunderland it was suggested that the high number of beds at that centre partly resulted from the town having a population of over 200,000. Internal demand created an initially high bed total. If this is so the bed total of a centre should result from (i) the total population of the centre and (ii) the demand from the centre's urban field or unland population. Figure 5.6 partly tests this. The graph suggests a log-log relationship between total beds at a centre and the centre's population, with

three exceptions. The exceptions are Bishop Auckland, Durham and Shotley Bridge which all have more beds than their centre population suggests.

Centre	Beds	Total Patients	Patients per bed.
Bishop Auckland	87	2061	23
Chester-le-Street	28	566	20
Darlington	82	2404	29
Durham	87	1899	22
Easington	12	307	26
Gateshead	114	2849	25
Hartlepoons	96	2430	25
Shotley Bridge	108	1938	18
South Shields	136	4107	30
Stanley	15	264	18
Stockton-Sedgefield	126	3246	26
Sunderland	240	6509	27

Table 5.7. Bed occupancy rates. General surgery, 1965.

If the conditions for bed totals stated above are accepted, then Bishop Auckland, Durham and Shotley Bridge should have a high proportion of their population in their specific unland or urban field outside themselves when compared with other centres. In earlier elements it was suggested that the unland population was highly correlated with the power of attraction of a centre i.e. number of technical college courses, division of the football league and number of ophthalmic beds. Accepting this hypothesis for the present, table 5.8 shows the relationship of centre population to non-centre population within general surgery unlands. Clearly Bishop Auckland, Durham and Shotley Bridge have a high proportion of their

umland population for general surgery outside their actual centres. Chester-le-Street appears to be borderline maybe because of its marginal position with regard to an umland.

From the Central Place theory point of view it should be noted that Bishop Auckland, Durham City and Consett (for Shotley Bridge) are the largest settlements within their respective umlands. Hence the evidence suggests that large centres have great power of attraction to serve their own internal needs first, and then to serve a specific umland afterwards. Bishop Auckland has a larger specific umland in area than any other centre even though it has less beds for general surgery than Sunderland, South Shields or Gateshead. This can be related to the low internal (centre) demand for bed occupation in Bishop Auckland because of its low population total and as a result a large number of beds are available for external demand i.e. specific umland demand. Thus Bishop Auckland competes with other centres with great power across its urban field to establish a large umland. In contrast 79% of Hartlepoons beds are utilised by internal demand and so a limited umland results.

Centre	A.Umland Population	B.Centre Population	B. as % of A.
Bishop Auckland	118,726	18,465	16
Chester-le-Street	58,988	18,968	32
Darlington	151,448	85,059	56
Durham	95,499	24,153	25
Gateshead	198,049	103,261	52
Hartlepoons	119,663	94,808	79
Shotley Bridge	111,791	27,145	24
South Shields	175,927	109,521	62
Stockton/Sedgefield	181,921	81,690	45
Sunderland	363,563	215,968	59

Table 5.8. Umland and centre populations, general surgery 1965.

N.B. The population figures are from the 1961 Census Report; centres are defined by their built-up area.

Put another way, as Bishop Auckland has more beds available for patients outside the town centre, it can attract with greater power outside itself than Darlington can. In the same way, Durham City with only 87 beds can compete eastwards with Sunderland with its 240 beds, because Sunderland uses a large number of these beds for internal demand, i.e. centre based population demand.

Demand can be seen to be satisfied as outlined above. However, there is the question of supply. Why was a given number of beds established at once centre compared with another at a particular moment in time? This takes us back to the historical factor mentioned in the opening section. Voluntary organisations established hospitals which were as big as their financial sources permitted. The same is true of local authority conversion of work-houses. Supply has generally been limited by finance and rarely equated demand. Usually it was less than demand. This situation continues today as is shown by the waiting lists for all hospital facilities.

The analysis based upon demand with supply lagging behind it would seem therefore a valid way of interpreting the movement of patients from unland areas to particular centres.

Working outwards from the centres themselves to their unlands and urban fields, the similarity with those for local technical colleges is evident. The network of centres is different and this causes some changes, but on the whole the pattern is similar. For example the Stockton-Billingham technical college has an identical specific unland boundary to east and west with that of the Stockton-

Sedgefield hospital group. The rural area continues to form the margin to the east with Hartlepoons and to the west with Darlington.

In the more urban areas centres change and comparison is more difficult. Durham-Easington-Sunderland form a triangle of centres within the local technical college data. With general surgery, Easington lacks an umland. Durham and Sunderland are left to compete in this area. Sunderland absorbs virtually the whole of the Easington technical college umland into its general surgery umland. It also displaces Durham City from Houghton-le-Spring and Hetton-le-Hole which were in Durham technical colleges umland. But then Durham technical college was an area college better able to compete with Sunderland as a technical college centre. Overall though, the result does show Sunderland and Durham City controlling the Wear valley area and the east Durham plateau, if Bishop Auckland and Chester-le-Street are added, a mid-Durham area emerges similar to that in the local technical college element. The only significant changes are the absorption of Washington into the mid-Durham region with general surgery and the loss of Trimdon-Wingate to Stockton-Sedgefield and Hartlepoons on the rather indecisive watershed on the southern edge of the limestone plateau (see figs. 5.3 and 4.3).

Within the elements, Sunderland appears at both the ophthalmic and general surgery levels. It was the study of the Sunderland umland in ophthalmology that first suggested a definite mid-Durham area being an extension of Wearside. At no point does the general surgery umland boundary coincide with that for ophthalmology. The gap is greatest in the south and south west where the competing centres (Teeside for general surgery and Middlesbrough for ophthalmology) are

furthest away (see fig. 8.1).

Umland population

Within general surgery there is a linear correlation between umland populations and bed totals (the power of attraction). A correlation coefficient of +0.97 was found which is highly significant at the 0.1% level. This repeats similar findings with other elements and confirms the hypothesis upon which table 5.8 is based. The total interactions within the specific umlands were tested against bed totals and total interactions for each centre. Both showed correlation coefficients of the +0.9 level.

With such high level correlations certain questions can be posed with some certainty of a statistical answer. At what point, for instance, does a hospital have sufficient beds to establish a specific umland? Two hospitals - Easington and Stanley - lack them, while Chester-le-Street only just achieves one. The regression equation for bed totals(x) and interaction within a specific umland (y) is $x = 0.034y + 20.2$. A specific umland appears if there are 21 beds in a hospital in general surgery i.e. $y = 1$. However, as a specific umland of one interaction is unlikely in reality so that a number higher than 21 beds is needed. Easington and Stanley have 12 and 15 beds respectively and no specific umland. Chester-le-Street has 28 beds and just achieves an umland in general surgery.

The relationship between interaction within a specific umland and the total interaction which forms the urban field, needs to be considered. If a significant relationship can be established then the specific umlands become more valuable as operational units and

the problem of the vague limits of the urban field need no longer concern us. Table 5.9 shows this relationship in simple terms. The data shows a correlation coefficient of + 0.9 which is highly significant at the 0.1% level.

Two features are worth noting about table 5.9. Stockton-Sedgefield has been treated as one unit in tables 5, 7-9. In the descriptive analysis it was shown that both centres operated within the Middlesbrough wedge. At all stages of the analysis since then, if Sedgefield had been treated as a separate centre it would have been anomalous. Once treated with Stockton, it conforms to the pattern of all the other centres. In fact the combined Stockton-Sedgefield data has a specific umland identical with Stockton and Sedgefield's specific umlands combined. Sedgefield is not part of the original building stock but is really a relief hospital to Stockton and as such it is justifiably combined with Stockton.

<u>Centre</u>	<u>A.Total Patients</u>	<u>B.Umland Patients</u>	<u>B as % of A.</u>
Bishop Auckland	2061	1750	85
Chester-le-Street	566	460	81
Darlington	2404	2260	94
Durham	1899	1405	74
Gateshead	2849	2611	92
Hartlepool	2430	2295	94
Shotley Bridge	1938	1868	96
South Shields	4107	3893	95
Stockton/Sedgefield	3246	2973	92
Sunderland	6509	6267	96

Table 5.9. Total umland interactions. General surgery, 1965.

Durham and Chester-le-Street form the major exceptions on table 5.9. If Chester-le-Street did not exist, Durham is likely to control its specific umland (see table 5.2). Although Chester-le-Street is part of the old stock of buildings, it only just achieves a specific umland. Hence this may account for these two centres appearing to be exceptional to the overall pattern.

The relationship between umland interaction and total interaction has been established. The intake of patients from outside the umland is balanced by the loss of patients from within the umland to other centres. This assumes a closed system whereas in fact it has already been shown that urban fields spread to international proportions. Either the occasional foreign patient is balanced by a loss from within an umland to a foreign hospital or the numbers involved at an international level are so small that they are statistically insignificant. The former point could well be met by tourists on holiday on the continent requiring hospital treatment, the latter by the fact that only four foreign cases occur in some 31,000 cases within the data.

The suggestion has also been made that the umland responds to the network of centres. Where centres are close together the umland is constricted, where they are far apart the umland is broad. Sunderland provides a case with five centres spaced around it at varying distances, i.e. South shields at about 5 miles distance, Gateshead and Chester-le-Street at 9 miles, Durham 12 miles and Hartlepoons 18 miles. Hence an irregular shaped umland would be expected around Sunderland with a narrow area to the north broadening to the west and reaching its maximum extent from Sunderland to the south. Fig. 5.3

in fact shows this happens. Figure 5.7 illustrates the differences as shown by interaction indices. It may be noted that the indices bunch into two groups, those from 30 to 175 and those from 250 upwards. The break between specific umland indices and others. The slopes become less steep as the distance from Sunderland to the neighbouring centres increases. The indices remain much the same for each line but the increase in distance alters the shape. This type of analysis was used in this element to suggest extensions to specific umlands into areas outside county Durham.

Conclusions

The completeness of the general surgery data and the attempt to complete specific umlands for all centres provides the basis for a fairly detailed analysis. A set of variables have been isolated from the data. These are the power of attraction of a centre (bed totals) total interaction (total patients), umland interactions (patients living within the umland), umland populations and centre populations. A high level of correlation has been established between all of these except the centre population. This latter variable seems to be linked to a three variable system of centre population, umland population and bed totals.

All this suggests a system in spatial equilibrium. This is supported by the analysis of total patients and patients living within an umland and the consistent bed occupancy rate. Waiting lists existed for all centres which means that all potential resources within general surgery were being used in 1965.

With the influence of the varying hierarchical levels removed

from this data, the specific umlands of certain centres have contracted compared with the local technical college umlands. It was suggested in the previous element that when regional, area and local functions were combined, the resulting attempt to define local umlands would be to locate areas which were slightly too large. The cumulative effect of the students living near to a centre and doing regional and area type courses was to make local courses appear more attractive than they really were. In this general surgery element with no other specialty influencing the pattern, the umlands are adjusted purely to the power of attraction of general surgery beds alone. The contraction of these umlands compared with local technical colleges is to be expected in view of the cumulative effect of regional and area courses upon the pattern of local technical college umlands.

The two centres without specific umlands fit into the general pattern statistically. However, they pose the problem of the hierarchical group. General surgery is associated with a population of less than 150,000 within the catchment area.¹⁴ In fact four specific umlands have populations well above this limit; Gateshead, South Shields, Stockton-Sedgefield and Sunderland exceed this limit. If the populations of their centres are subtracted from their specific umland populations, they do conform to this hierarchical group.

Once more the population distribution appears to influence the pattern. A continuum within the hierarchical group seems probable. Each bed in general surgery is equal to any other bed in general surgery and forms the base of the hierarchical group. The location of a specific number of general surgery beds varies with several factors.

References

1. Personal communication with Dr. Duncan, Newcastle Regional Hospital Board.
2. The author acknowledges the help of the Group Secretaries and their respective Medical Records Officers of the Darlington District Hospital Management Committee, the Durham Hospital Management Committee, the Gateshead and District Hospital Management committee, the Hartlepoons Hospital Management Committee, the North Teesside Hospital Management Committee, the North West Durham Hospital Management Committee, the South Shields District Hospital Management Committee, the South West Durham Hospital Management Committee and the Sunderland Area Hospital Management Committee.
3. Information provided by A. McNay, Newcastle Regional Hospital Board.
4. Graph, map and statistical techniques were tried on various parts of the data by the author to resolve this problem.
5. Personal communication with Dr. Duncan, op. cit.
6. See Newcastle Regional Hospital Board paper SM/W/JK, 1961.
7. Personal communication with A. McNay, op. cit.
8. Idem
9. See page 71.
10. See page 80.
11. Personal communication Newcastle Regional Hospital Board.
12. Personal discussion with the Principal, Stockton/Billingham Technical College.

13. See page 80.
14. Personal communication with Newcastle Regional Hospital Board.

6. THE ELEMENTS - COAL MINING

Journey to work studies tend to be of two types. Either they have examined movement into or out of a given set of areas such as administrative units or have been origin and destination surveys of a sample of journeys to work. The former is found in the Census Reports, the latter is typical of transportation surveys.¹ Obviously both types of study are needed and in many ways their data is similar to the non-work activities already studied in this thesis but they are related more to industrial activity or more general employment.

In county Durham the coal mining industry has a widespread location over the most densely populated parts of the county. At least half of the county area has coal mines and in 1964 there were some 84 collieries which were the focal points for miners' journey to work.² Hence this industry had a journey pattern similar to the more general pattern of journey to work of other studies. Further, since a single employer was concerned there was an administrative advantage in obtaining access to and collecting the basic data.³

Data

The data was collected in 1964-65 when some 68,000 men were employed in the Durham area of the then Northumberland and Durham Division of the National Coal Board at colliery level.⁴ The source of information was National Insurance cards. These were filed by the accounts departments in single colliery units.⁵ Hence one unit of cards provided the addresses of all the miners working

at that colliery. From these, settlements could be listed and the total of miners working at that colliery and living at a given settlement calculated. The result was a list of all the collieries operating in county Durham in 1964, with a list of settlements with the total number of miners living in each settlement, working at each colliery.

A check on the reliability of National Insurance card addresses had been made a year or so previous to this survey. It had shown that they could be as much as two years out of date.⁶ This was because employees failed to notify their change of address to the National Coal Board. As miners tend to be immobile in county Durham, this would give a statistically insignificant error in the data collected. Further, it was found from experience that miners transferred from one colliery to another had their National Insurance cards rapidly reallocated internally because of the new place of receipt of wages. The general feeling was that the data was reliable and suitable for analysis.⁷

Background to Basic Situation

Any interpretation of the data requires an answer to the question, why do miners have journey to work pattern as shown by the data? To help formulate the ideas upon this topic an initial study was made of the data for No. 4. area, situated in South west Durham with the help of the Area Office in Spennymoor.⁸

There is a family tradition in the north east of England of a son following his father into the coal mining industry.⁹ This gives an initially stable labour force. Within a colliery, the development of teams working underground provides manpower links

which further encourage a stable labour force. With the principle of the better paid jobs being dependent upon seniority within a colliery, stability is again encouraged. One result of all this is that the miners, by the nature of their occupation, form closely knit teams below ground and closely knit social or community groups above ground.¹⁰ This was helped above ground by the colliery owners providing housing at or near the pit head.

Since Vesting Day this situation has been complicated by two interrelated developments. The major development has been the decline in the labour needs of the Durham coalfield. This has resulted partly from automation, partly from pit closure due to exhaustion and uneconomic workings and partly from the decline in the total demand for coal in the country as a whole.¹¹ The Divisional policy was to keep continuity of employment for men already working on the Durham Coalfield. Any manpower needs were to be met, wherever possible, from redeployment of the then labour force rather than recruitment of new manpower. In fact in recent years practically no new labour has been recruited other than youths entering through apprenticeship schemes.

The second factor was the opening of a number of new collieries, mainly drifts, since Vesting Day.¹² As a redeployment policy was in operation these were initially manned by miners from closures or transfers from other collieries. The result was a break in the tradition of miners being employed at the local colliery. This raises the question, would the miners accept a longer journey to work pattern? As colliery houses are free to miners while they continue to work in the industry

and as subsidised transport was provided to some of the new collieries, every incentive was given to the men to keep their home base and accept the longer journey to work. With closure of collieries for reasons of exhaustion or uneconomic working, the same policy continued. The miners were found employment in other collieries and transport was sometimes provided to their new collieries with their longer journey to work.¹³

This general description is applicable to the whole coal-field and from it it is possible to postulate the existence of four types of colliery in terms of journey to work pattern. Firstly, there is the colliery with its locally based labour force and few journeying from a distance. This would be typical of the early development of collieries in the last century and lack of expansion has maintained this pattern through to the present day. Secondly, there is the new colliery opened since Vesting Day with its long journey pattern for miners because it was manned-up by the redeployed labour. Thirdly, there is the colliery which has been expanded. This can be measured in terms of capital investment and the result is an increased demand for labour which would be redeployed to such a colliery.¹⁴ Here there should be a mixed journey to work pattern with the original locally based miners supplemented by longer journeys for the redeployed miners brought in with expansion. Fourthly, there would be an intermediate type between these potential extremes.

A decision as to what distance parameters can be used to indicate the above types can only come from an analysis of the

complete journey to work data. Such an analysis may take various forms. The data can be tabulated into successive mile units and the percentage travelling each successive mile unit for each colliery calculated (see Appendix i). From this a series of regressions could be calculated to give a classification of collieries based on the best fit slope i.e. classification is based on the rate of decline of manpower with distance. Alternatively some particular distance may be chosen and collieries classified according to the percentage coming from beyond that distance. Either of these methods would be clearly produce much the same result. With the likelihood of some ten different values or groups being involved, the calculations of regressions seems unjustified and the subjective method is used here. One major problem arises at once and that is, what distance to select. At short distances clearly large numbers of miners are involved. Only beyond three miles does the percentage begin to be small (see Appendix i). Hence this distance was selected and the percentage travelling beyond this distance for each colliery calculated (see table 6.1).

<u>% travelling > 3 miles</u>	<u>No. of colls.</u>	<u>% travelling > 3 miles</u>	<u>No. of Colls.</u>
0 - 5	20	20.1 - 30	12
5.1 - 10	21	30.1 - 40	8
10.1 - 15	10	Over 40	4
15.1 - 20	9		

Table 6.1. Numbers of collieries within groups classified by percentage of miners travelling more than 3 miles.

This table using more than three miles as a distance parameter probably provides the best available basis for classification so far explored. From figures 6.1-3 it will be seen that it is fairly closely related to percentages from even greater distances and so would seem a reasonable basis for classification. When this grouping is set against the four types of colliery postulated earlier, a relatively poor correlation is found (see figure 6.4) Two of the types - new collieries and expanded collieries - are not determined by distance parameters and so can be used to test the groupings of table 6.1. These are shown as a scatter graph in figure 6.4. While the new collieries tend to occur in the larger travelling pattern groups, several do not. With expanded collieries there is almost a random distribution through the distance groups with a bias to the lowest group of 0-5 percent travelling more than three miles.

Several possible reasons can account for this poor correlation. New collieries have tended to be on the south west margin of the coalfield. They have been opened just as several smaller collieries nearby have closed.¹⁵ Although redeployed labour was used in manning-up these collieries, by chance, a local supply of this labour was available. Hence long journey patterns did not result. With the expanded collieries a time factor seems to be working. There are sixteen years between Vesting Day and the collection of the data. In this time a colliery has been selected for capital investment, built up in terms of machines and manpower and then allowed to run. In some cases the result has been a further run-down because machinery has

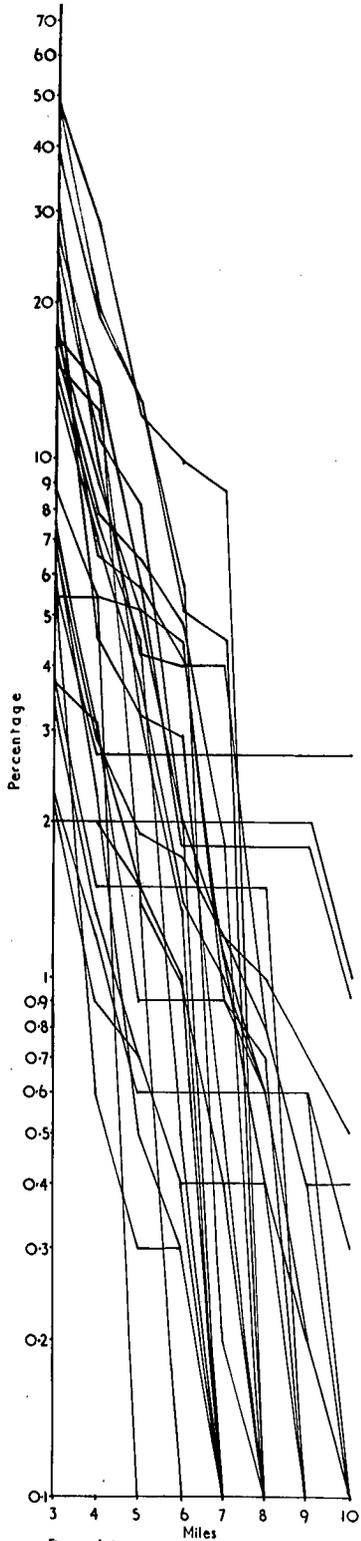


Figure 6.1

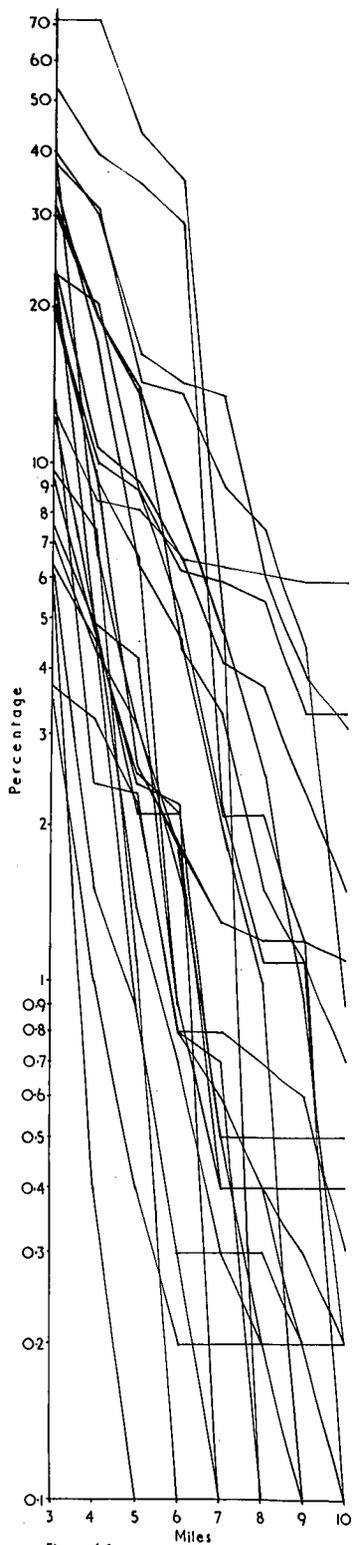


Figure 6.2

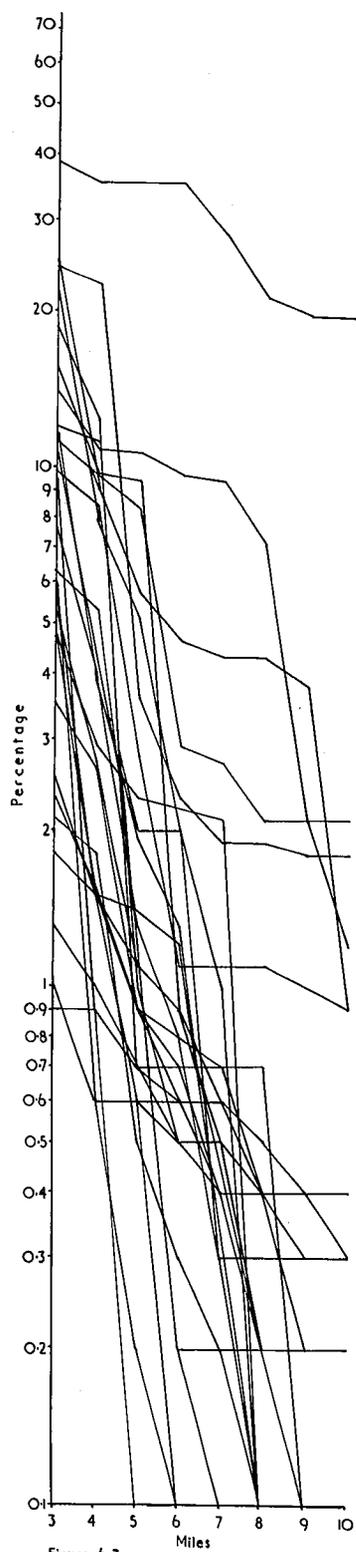


Figure 6.3

GRAPHS for COUNTY DURHAM COLLIERIES showing PERCENTAGE of MINERS TRAVELLING at least THREE MILES in 1964, by mile units.

failed to work on certain faces, it has become uneconomic to continue to work the face and so it has been closed. Miners brought in and travelling long distances are often the first to leave a colliery in these circumstances.¹⁶ The result may be a return to a basically local labour force.

A further variation on this theme is more than one expansion programme.¹⁷ Both East Hetton and Vane Tempest collieries have had two expansion programmes. Yet East Hetton draws 3.7% of its labour force from beyond three miles while Van Tempest has 24.3% from beyond three miles. Obviously the data requires further analysis to produce a meaningful classification of collieries in terms of journey to work.

Distance Factor

A more detailed analysis of the distance factor was attempted. From fig. 6.1-3 it is clear that six miles provides an effective boundary to the great majority of colliery labour catchment areas. In fact only fourteen collieries draw more than 5% of their labour from beyond six miles. The total involved at these collieries represents 2.1% of the total labour force. This suggests that the number actually drawn from distances beyond six miles is small. This is in fact 2203 miners which forms 3.2% of the total manpower. Six miles is shown to be a significant distance and the tradition of living near to the colliery would appear to have carried through to the present to this extent.

This statement generalises the failure of the classification of miners travelling more than three miles with expanded and new

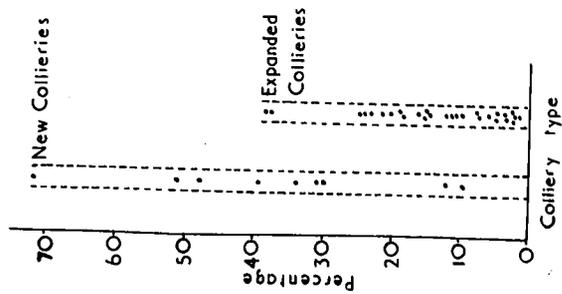


Figure 6.4 GRAPH of MINERS in EXPANDED and NEW COLLIERIES TRAVELLING more than 3 miles

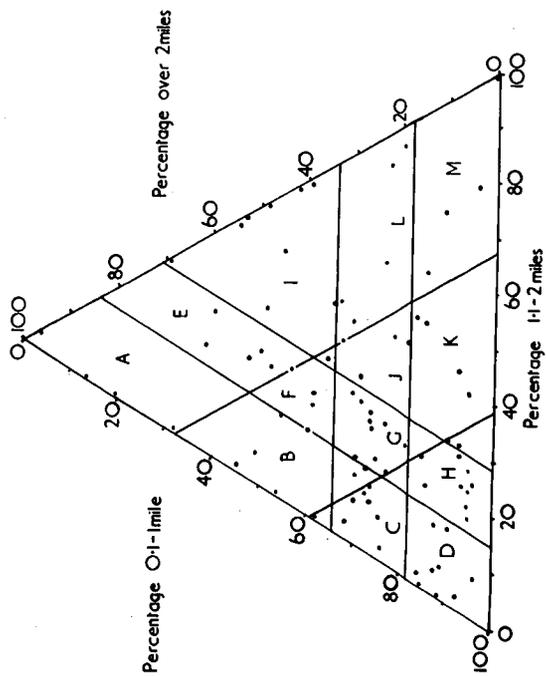


Figure 6.5 TERTILE CLASSIFICATION of COLLIERIES BASED UPON SHORT DISTANCE TRAVELLING

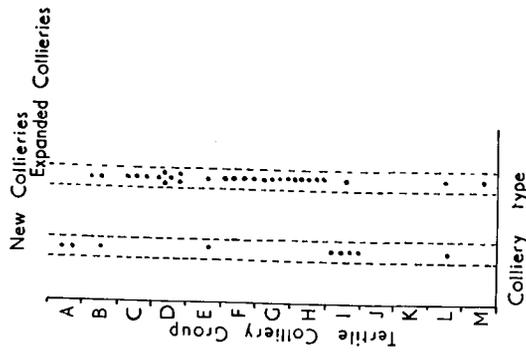


Figure 6.6 GRAPH of MINERS in EXPANDED and NEW COLLIERIES TRAVELLING SHORT DISTANCES

collieries. The bias to the lower travel distances noted then is shown to be general over the whole data. The distance of six miles has been found to be significant in other colliery studies. R.C. Tomlinson noted this when summarising several studies in an article in the Colliery Guardian in 1964.¹⁸ He quotes studies where collieries seven miles or more from a large town failed to attract sufficient labour from that town and also notes the lack of data in empirical studies (such as the present) for miners travelling more than six miles i.e. few miners travel more than six miles.

Within the present data fourteen collieries draw more than 5% of their labour from more than six miles. Of these, five - Fishburn, Middridge, North Tees, Standrop and Westoe - draw more than 10% of their labour from more than six miles. A study of these five major exceptions might aid the analysis. Both North Tees and Standrop were new collieries on outliers of the coalfield. They were sunk in rural areas which lacked an intensive settlement network, so of necessity labour must travel several miles to work. Further, as they were new collieries they were manned up from the main coalfield (see table 6.2). Clearly the form of the settlement pattern in an area will influence the journey to work. Metal Bridge near Ferryhill is another example of this influence, being a drift mine described by its training officer as 'being in the middle of a grass field.'¹⁹

Settlements	Staindrop Colliery	
	Distance	No. of Miners
Crook	7 miles	22
Cockfield	3 miles	3
Evenwood	1 mile	14
West Auckland	1 mile	10
Rest	4 mile average	27
	Metal Bridge Colliery	
Spennymoor	2 miles	39
Ferryhill	2 miles	42
Cornforth	2 miles	16
Chilton	3 miles	8
Rest	3 miles average	34

Table 6.2. Travelling distances by settlements of miners to Metal Bridge and Staindrop Collieries 1964.

Virtually nobody lives nearer than two miles to Metal Bridge colliery. Westoe and Fishburn were both expanding collieries during the period prior to the survey. They were both taking large numbers of transferred miners from collieries that were closing and one would anticipate them having lengthy journey to work patterns for their miners. Middridge was a new colliery with the varied pattern to be expected from the earlier analysis.

The fact that there were so few exceptions to the six mile limit is surprising in view of the Divisional policy. This could be because in 1964 the effects of the closures and transferring of miners were statistically insignificant at that time. It could be that some other factors were operating to counteract the suggested increase in the miners' journey to work pattern. The

former would appear unlikely. House and Knight²⁰ show that nearly 18,200 miners were redeployed within north east England between 1958 and 1964. If only half of them were in the Durham part of the coalfield - and this must greatly underestimate the proportion - they would still represent more than 10% of the total miners in the 1964 labour force. This suggests that an answer to the question lies in trying to find some counteracting factors.

If distance is a limiting factor on journey to work, what happens when miners have to travel longer distances because of transfers? Is the six miles limit a sudden change or does the effect of distance build-up until at about six miles travel becomes unacceptable? Obviously these two questions are inter-related and have a strong bearing upon Divisional policy in terms of where to transfer miners to and the effectiveness of subsidised transport and housing in retaining miners in the coal mining industry.

Leavers Survey

To help establish these other factors a detailed study was made of leavers at two collieries. If the six miles limit is significant, then a study of leavers from collieries should show a tendency for men travelling more than six miles to leave more than men travelling less than six miles. The collieries chosen for this survey were Wearmouth and Westoe.²¹ Westoe had the largest number of 'travellers' i.e. miners travelling more than 6 miles to work, in 1964. Wearmouth is a long life colliery which

has absorbed a large number of transfers in the years since 1964. In particular it has absorbed transferees from the Houghton-le-Spring area which is about six miles from the colliery.²² The leavers are compared with the 1964 manpower which is the only set of colliery manpower figures available in distance units.

Wearmouth	1964 Manpower	1964-6 Wastage
Local	90.3%	84%
Travellers	9.7%	16%
Westoe		
Local	64.7%	67.0%
Travellers	35.3%	33.0%

Table 6.3. Manpower/Wastage comparisons, Wearmouth and Westoe collieries.

Table 6.3. shows that Westoe had little change in wastage as a proportion compared with manpower up to the six miles limit. Wearmouth however, shows that the travellers accounted for a higher proportion of the wastage over the period 1964-6 than the local miners, compared with the 1964 manpower. However, the proportion of travellers at Wearmouth colliery has increased since 1964 and the comparison may not be a valid one. Hence this suggests little difference in wastage beyond six miles as compared with that of local miners. If the age structure is taken into account though, then most of the local wastage is in the under 25 years age group. These are local apprentices who did not stay in the mining industry. If these are omitted then the evidence (see table 6.4) suggests that the travellers have a

higher wastage rate. Other studies have in fact established a log-normal relationship between the length of service and the potential wastage in the mining labour force. The distance variable has always proved more difficult to interpret.²³

Age Group	Sunderland Area	Travellers
50+ years	185 (31.8%)	42 (33.3%)
45 - 49	22 (3.8%)	13 (10.4%)
40-44	36 (6.2%)	19 (15.1%)
35 - 39	34 (5.9%)	14 (11.1%)
30 - 34	55 (9.5%)	13 (10.4%)
25 - 29	57 (9.8%)	12 (9.5%)
20 - 24	82 (14.1%)	7 (5.4%)
< 20 years	110 (18.9%)	6 (4.8%)
Total	581 100%	126 100%

Table 6.4. Age structure of leavers by distance, Wearmouth Colliery 1964-66.

Hence it would appear that the six miles limit is part of a continuous function rather than a marked break in itself.

The reason for this wastage with distance may be the extra distance travelled or it may be a result of changing the place of employment.²⁴ This unsettles employees, breaks the pattern which gave stability to the labour force and results in travellers developing characteristics, as a group, that they lacked before. For example, the seniority principle for face working at collieries means a transferred man goes to the bottom of the list for face work at his new colliery.²⁵ Hence the distance factor is emphasised by the change in status of a miner when he is transferred.

Manpower Classification

The significance of long distance movement to collieries has been considered earlier. A study of short distance movement will be made now. Figure 6.5 shows collieries located according to three factors, the percentage travelling 0.1 to 1 miles, 1.1 to 2 miles and over 2 miles. This can be plotted on a three axis graph. If each of these axes is then divided into three with 28 collieries i.e. one third of the total in each of the three groups along each axes, 19 potential groups are possible. Such groups may be called tertiles and are similar to the more familiar quartile groupings.

Of the 19 potential groups, two have no collieries within them and four have one or two collieries only. If each of these latter collieries is allocated to its next nearest group, thirteen actual groups occur. Such groups are based upon short distance travel and a rigid system of division has been used, avoiding subjective judgements.

The concentration of the points in the bottom left hand side of the diagram is noticeable. This gives a high 0.1 to 1 mile factor but low factors for the 1.1 to 2 miles and over 2 miles axes. Even with a short distance movement classification the dominance of the shortest journey patterns emerges again.

Testing this classification against the 'new' and 'expanded' collieries types of the initial groupings, low correlations appear. New collieries occur in groups A, B, E, I AND L. This shows a bias to the higher range (A,B,E) but also shows a scatter along almost the whole of the over 2 miles axis. This is unexpected.

The expanded collieries appear in ten of the thirteen groups (see fig. 6.6).

With such inconclusive results using a statistical approach, further evidence was collected to see if factors not brought out by actual numbers were operating. A stratified sample of collieries was chosen and their training officers interviewed. At least one colliery from each of the thirteen tertile groups was included. New, expanded, local journey and long journey pattern collieries were included. The stratification also allowed for the collieries to be widely distributed over the county area. The training officers for this sample were then asked to comment upon the journey to work pattern of their colliery as shown by the 1964 data.

Two themes dominated the information obtained from the training officers.²⁶ Firstly, they thought of their colliery's manpower needs as being served by a specific area. Their remarks implied that there existed within the county a number of pools of labour which certain groups of collieries draw upon. Secondly, they frequently referred to men moving from one colliery to another which belonged to the same company before nationalisation. For example, a man promoted to be manager before nationalisation would often recruit former workmates from other collieries of the same company, onto his colliery pay-roll. Mobility within a company group of collieries occurred.²⁷ An attempt was made to reconstruct these manpower areas.

Manpower Areas

Two sources of information were used to trace these manpower areas. If the collieries belonging to one company before nationalisation are mapped as units, then significant breaks should appear on the map (see fig. 6.7).²⁸ In practice only twenty two company groups could be recognised because so many collieries were apparently in individual ownership. The resulting map therefore does not locate manpower areas in itself but does provide a help to further analysis.

The second source of information is within the data. The training officers' comments referred to the 1964 situation and suggested that even then the manpower areas were operating. It has been shown that most collieries have 95% of their manpower living within six miles of the colliery. Hence if only settlements that provide at least 5% of a colliery's manpower are considered, the long distance traveller to collieries should be eliminated. The resulting settlements should indicate the pre-nationalisation areas of movement.

The result of this analysis was that the number of settlements from which a colliery drew at least 5% of its manpower rarely reached ten and in most cases was only three or four (see Appendix). This analysis would seem to have reproduced a situation normally associated with coalfields, where most of the miners lived near to the pit head, a situation true of the Durham coalfield in the last century. In fact this would appear to be still the basic situation in Durham with a veneer of longer journey to work patterns over it.

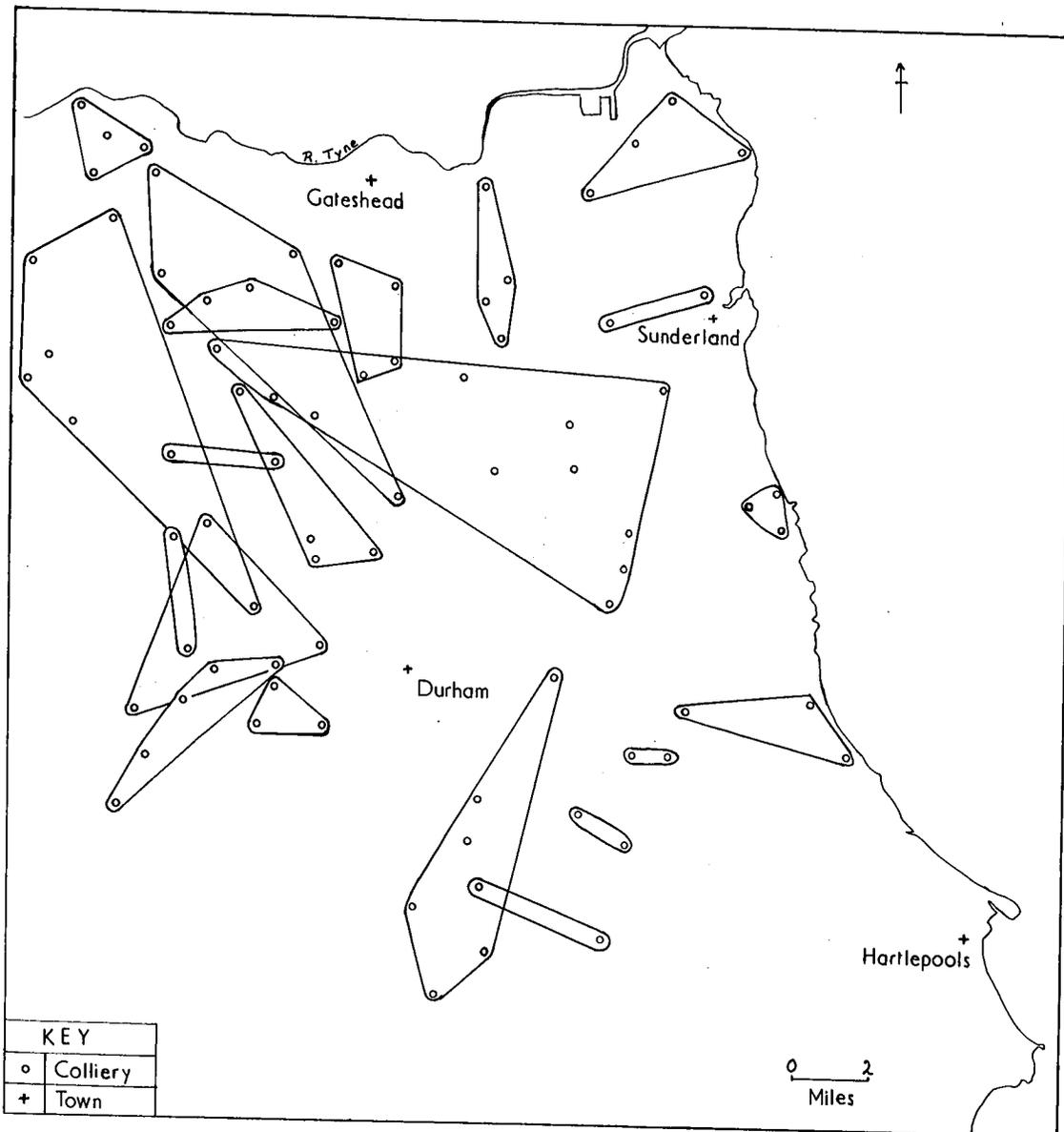


Figure 6.7 COLLIERY PRE-NATIONALISATION COMPANY GROUPINGS

Figure 6.8 shows the pattern of settlements which were major manpower sources for individual collieries. The settlements from which a colliery drew the major part of its manpower are enclosed within a continuous line, this line being the shortest line that can be drawn to enclose all the settlements concerned. If this map and the colliery ownership map (fig. 6.7) are superimposed upon one another then certain blank areas can be located. These form the boundaries between the manpower areas and are located on figure 6.9. The basic boundaries were easily drawn but certain areas did present local problems.

The Chester-le-Street area, the area north east of Durham, Peterlee and the Ferryhill area all lacked clearly defined boundaries. Once the core of each area was examined and the characteristics of its collieries established, then local boundary problems were easily resolved from the colliery data.

Eight manpower areas could be recognised from this analysis. They were Bishop Auckland and Crook, central Durham, the east coast, Ferryhill and Spennymoor, Gateshead and Washington, Hetton-le-Hole and Houghton-le-Spring, north West Durham and finally, the Wingate area. If these areas have any validity, then when applied to the data as a whole the result should produce boundaries which differ from fig. 6.9 only in terms of the base units used. The population units of the previous elements were used at this stage as the basis for drawing boundaries, and the manpower area urban fields and umlands were mapped. The resultant manpower area boundaries i.e. umlands, are shown on fig. 6.10 and their similarity to those of fig. 6.9 is apparent.

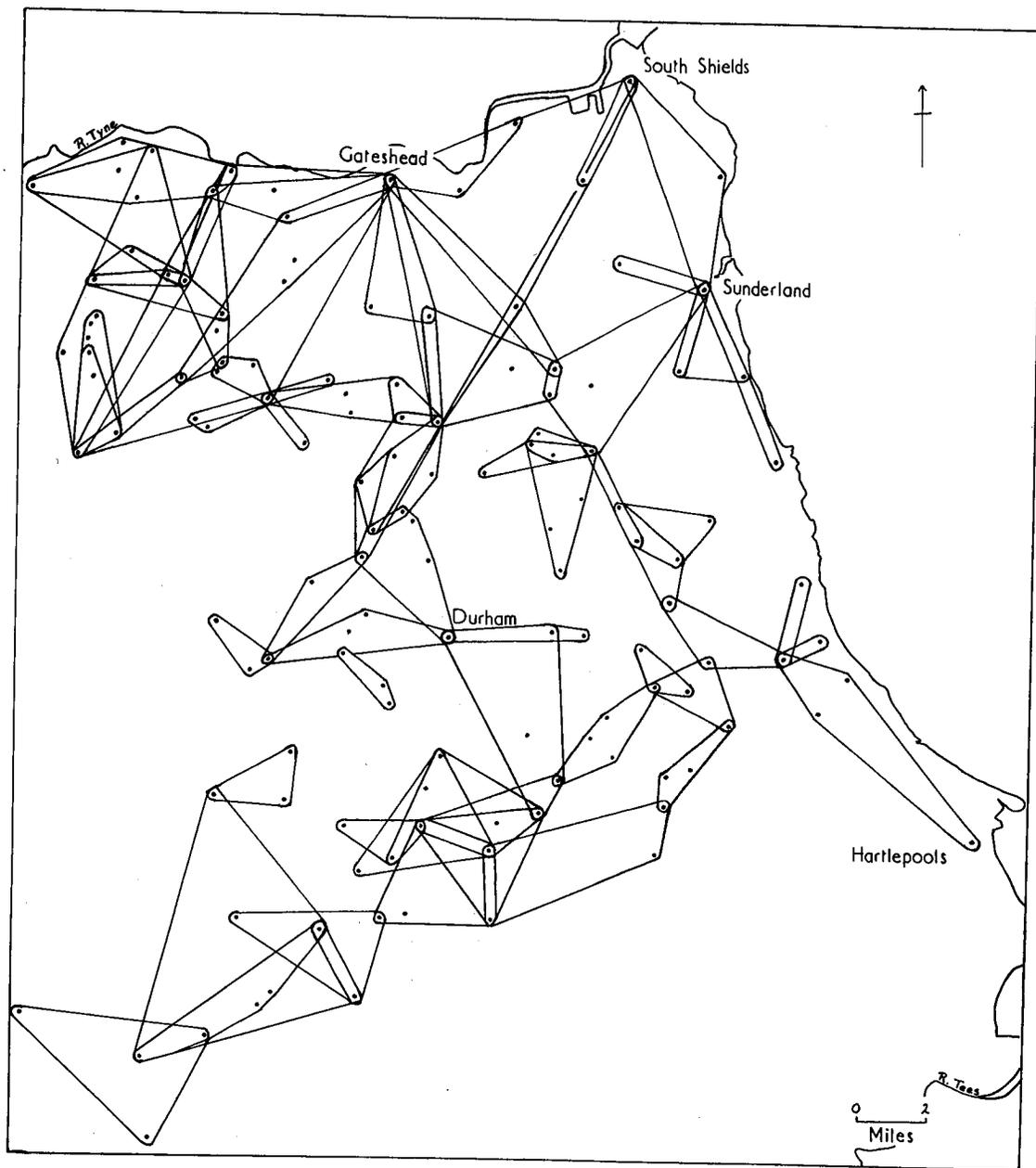


Figure 6.8 COLLIERY SOURCES of MANPOWER SETTLEMENT GROUPINGS

Bishop Auckland and Crook

Seven collieries occurred in this area and with the exception of Brancepeth colliery, they have all opened since Vesting Day. At one time a group of collieries existed in the Crook-Willington area but only Brancepeth remains of these. As this Crook group closed, they provided part of the labour force for the newer drift mines of the Bishop Auckland area. Hence a link between Crook and Bishop Auckland has been established. The 1964 collieries were all fairly small with less than 420 men each.

The similarity to previous unlands of Bishop Auckland is very apparent. No competition from Darlington leaves the approaches to the upper Tees and Wear valleys within Bishop Auckland's areas. Spennymoor forms a separate manpower area eastwards which truncates the Bishop Auckland area in this direction. The northern boundary, leaving the Deerness valley to Durham, repeats a feature seen several times before.

Central Durham

Thirteen collieries existed in this area which is focused upon Chester-le-Street and Durham City. Collieries tended to draw from several local settlements with journey patterns of a few miles involved. The total pattern shows two axes. One is north-south from Chester-le-Street to Sacriston and on to New Brancepeth. The other axis is east-west along the Deerness valley and through Durham City to the foot of the limestone escarpment around Bowburn and Sherburn. Manpower size at individual collieries varied greatly.

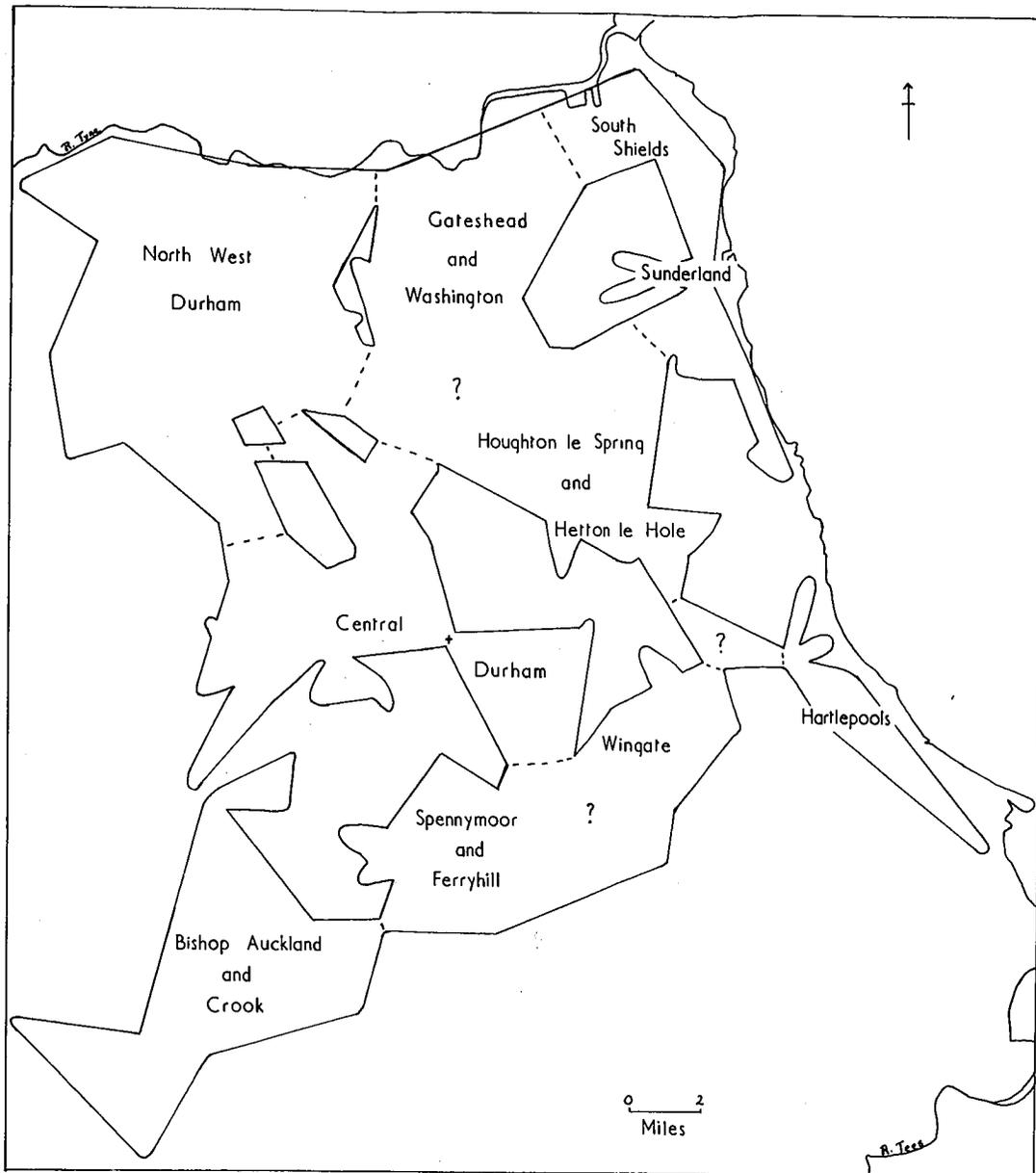


Figure 6.9 COMBINED COLLIERY PRE-NATALISATION COMPANY GROUPINGS
and
MAJOR SOURCES of MANPOWER SETTLEMENT GROUPINGS

The basis of the ellipse noted before for umlands of Durham City is here. The north west boundary leaving Lanchester without and the Deerness valley within the specific umland is familiar, as is the south west boundary skirting Crook, Willington and Spennymoor. The existence of a centre at Hetton/Houghton-le-Spring to the east of Durham limits the manpower area in that direction. Even so, the east-west axis of the area (18 miles) is still greater than the north-south axis (10 miles) and is very similar to the general surgery umland.

East Coast

Fifteen collieries occurred in this group and this is the major area of coal mining on the Durham Coalfield today. As coal mines have closed elsewhere, so mining has become more and more concentrated on these coastal collieries²⁹. Figure 4.4d further illustrates this showing a greater number of students from the eastern part of the coalfield than the west. This has resulted in the increase of travellers into this manpower area. Even so the majority of miners still lack long journeys to work and if the study of leavers is valid, this will remain true as the wastage rate is higher as the length of journey increases.

These collieries have an assured future and their manpower is characteristically over 1000 miners per colliery. They draw upon three pools of labour which form sub-divisions within the overall area - South Shields, Sunderland with Seaham and Peterlee with Hartlepoons.

South Shields has an area of familiar proportions. With

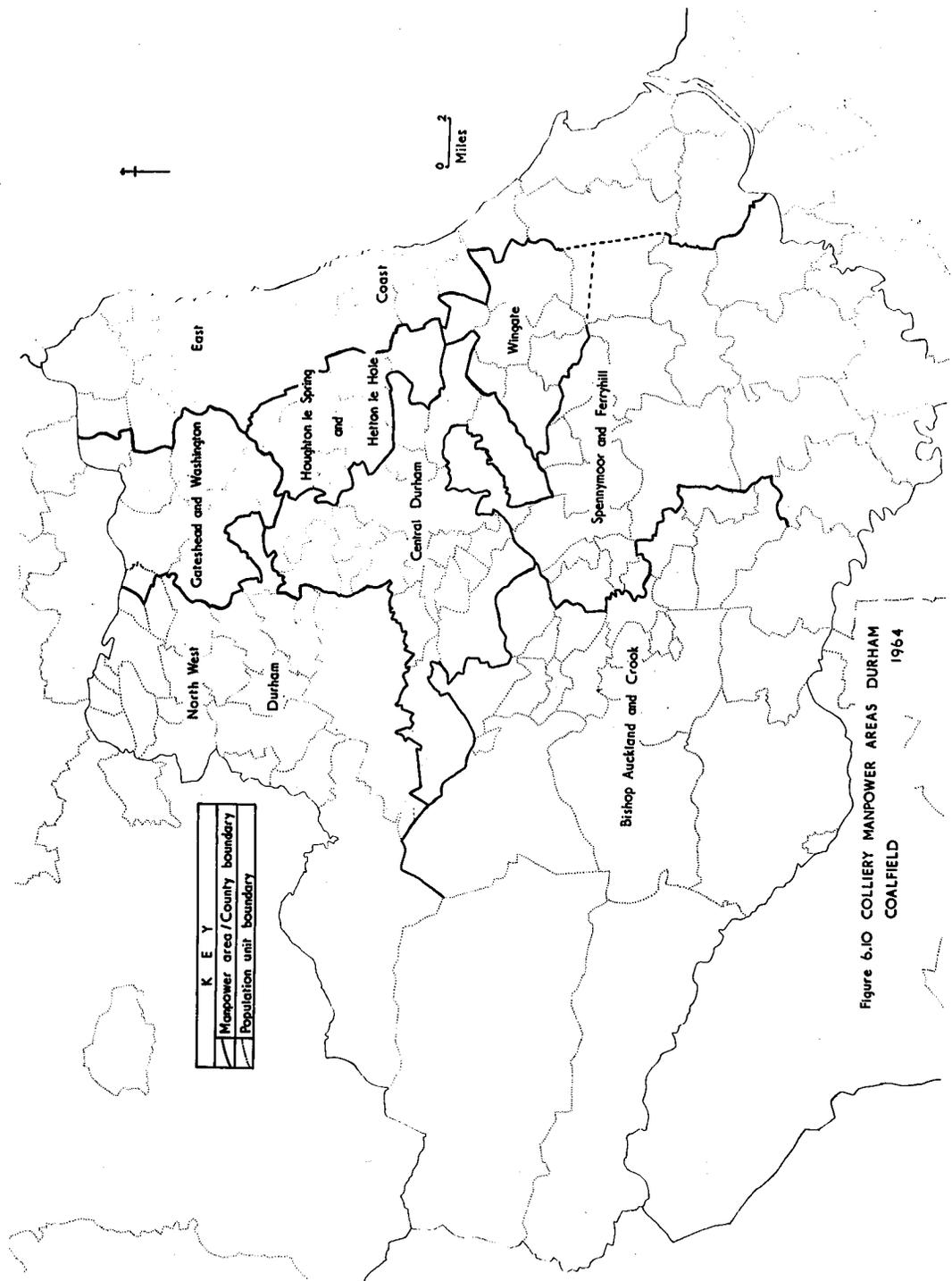


Figure 6.10 COLLIERY MANPOWER AREAS DURHAM 1964
COALFIELD

competition from the Gateshead/Washington area to the west, it occupies a peninsula with Jarrow and the Boldon area as its limits. Sunderland has lost the Hetton/Houghton area compared with previous elements as this now forms a separate area and Peterlee is also restricted inland by the Wingate area which is now separate. From Peterlee there is an extension southwards to include the Hartle-pools area. This results from housing shortages in the post-war period on the coalfield, from miners finding the attractions of living in a large town worth the extra length of journey to work and from good communications along the coast.³⁰ These were supplemented by subsidised transport being provided from Hartle-pools for some 100 miners, about half the total living in Hartle-pools, as shown by the data.³¹

Ferryhill and Spennymoor

There were eighteen collieries in this area with manpower varying greatly between them. Any one of these collieries is linked by manpower to a group of local settlements which includes either Ferryhill or Spennymoor as the largest source of miners.

This is the first element in which Ferryhill and Spennymoor have formed a separate area. It is interesting to note that F.H.W. Green found Spennymoor had a hinterland in his study of motor bus services.³² He found the hinterland was split into two, one area around Spennymoor and another around Wingate, with the Ferryhill area linked to Durham City inbetween. This element shows it occupying what has in previous elements been a margin or border zone between Bishop Auckland, Darlington, Durham City and

Stockton. In terms of Central Place theory, the manpower area is located in a marginal zone of other elements, a position at which a new centre could, in theory, be created.

Gateshead and Washington

This manpower area is dominated by Gateshead and the loosely joined string of settlements known collectively as Washington. This tendency to concentrate population at two large settlements means that the scatter of eight collieries had of necessity to draw labour from several miles away. However, the six miles limit was not broken and four or five miles was the usual limit. Manpower of the collieries varied between 400 and 1400 men.

Compared with general surgery, there is no centre at Chester-le-Street, and Gateshead links up with Washington as far south as the outskirts of Chester-le-Street and includes Birtley. Compared with local technical colleges, Hebburn is missing and Gateshead's area extends eastwards to include Hebburn. It has been stated before that Gateshead tends to have an umland towards the west of its centre because this is the area of least competition. The coal mining manpower area shows what happens when competition eastwards is reduced.

Hetton-le-Hole and Houghton-le-Spring

Both Hetton-le-Hole and Houghton-le-Spring are early settlements at the foot of the limestone escarpment. As coal mining developed in this area these settlements grew and joined to form a continuous urban area stretching from Shiney Row in the north to Easington Lane in the south. In 1964 nine collieries existed in

this area most of which belonged to the Joicey family and miners still refer to them as 'Joicey pits'.³³ Manpower totals and journey patterns vary from colliery to colliery but the limitation of journey patterns to within the two urban districts is most marked.

As with Ferryhill-Spennymoor, this is a new 'centre'. It has formed in an area transitional or marginal to Durham City and Sunderland. According to the relative power of attraction of these two centres, so specific umland boundaries have been drawn through the Hetton/Houghton area in previous elements. Once more, this fits Central Place theory.

North West Durham

The earliest part of the coalfield to be worked, it is not surprising that it was in decline and showed the greatest variety of colliery types in 1964. Sixteen collieries existed in this area with varied journey patterns. At one extreme, Chopwell had 89% of its manpower living within Chopwell itself. In comparison, Marley Hill had a scatter of manpower with a settlement like Consett, seven miles away, providing nearly 5% of the labour force. A common feature was the inter-movement of labour within the area but with virtually no movement in from other areas. Slight links with Chester-le-Street and Gateshead existed, but in general the area was isolated and had very clear cut boundaries.

Consett and Stanley are the two largest centres in this area. The similarity to Consett's previous umlands is strong in all directions but the north. Here there was no competition with

Gateshead or Newcastle and so the north west Durham manpower area extended to the banks of the river Tyne. The eastern boundary shows the extension into Urpeth recorded in general surgery from Consett centre. Also the data shows some attraction of labour from Prudhoe and the Derwent valley part of Northumberland.

Wingate Area

To this day this area is characterised by fairly large mining communities which are very much self contained units. The high streets have a number of shops offering a wide range of goods, and the settlements tend to function as towns rather than villages. This self sufficiency may be related to isolation. This part of the coalfield was developed about 1840 when railways made possible the opening-up of large parts of the Durham coalfield.³⁴ Hartlepool was redeveloped as a port and a railway built into the Wingate area. Other areas looked by rail to Stockton or Middlesbrough, Sunderland or Seaham. Only this south east corner of the coalfield formed part of the Hartlepool's hinterland.

Today it is on the border between the Northern and United bus company services.³⁵ Infrequent services give access to Darlington, Durham, Hartlepool, Spennymoor and Stockton with no apparent focus towards a major centre. As in the two previous areas, a new area has been established at what was a margin in previous elements. Durham, Hartlepool, Stockton and Sunderland have all competed at various times in this area.

All this background information is confirmed by the training officers.³⁶ At one time Station Town, and the Trimdons and

Wingate collieries were all owned by one company. A large number of colliery houses were provided and movement within the company group of collieries was facilitated without need to change residence. The result was the growth of a number of inward looking communities knit together by a company link but marginal in terms of town regions. Six of these collieries were still working in 1964 with manpower varying from 500 to 1200 and showing short journey to work patterns.

General Manpower Pattern

Having defined and described manpower areas it is now possible to calculate inter-manpower area movements. Because of influence of distance, they are not likely to be great. With the greatest job potential in coal mining developing on the east coast in 1964, this area would be expected to attract the highest inflow of labour. Table 6.5 shows the position.

Manpower Area	A.Total employment	B.Manpower Drawn from other areas	B.as a percentage of A.
Bishop Auckland	2824	263	9
Durham	7673	1013	13
East coast	25242	1979	8
Ferryhill-Spennymoor	5364	804	15
Gateshead	6201	1305	21
Hetton-Houghton	6587	558	8
N.W. Durham	8154	685	8
Wingate	5261	780	15

Table 6.5. Manpower Area statistics for county Durham, 1964-5.

With closures dominating north west Durham there was very little likelihood of manpower being attracted into this area. The 8% attraction was low and was shared with Bishop Auckland, the east coast and Hetton-le-Hole/Houghton-le-Spring area. Bishop Auckland and the Hetton-Houghton areas both had colliery closures taking place and were losing rather than gaining manpower. The east coast area shows the highest input of labour from other areas (1,979) but in terms of its manpower (25,242), this input is statistically fairly insignificant.

The highest inputs of labour from other manpower areas occur in Gateshead (21%). Ferryhill-Spennymoor (15%) Wingate (15%) and Durham (13%). These four areas form a zone north-south through the centre of the coalfield between the declining north west Durham and Bishop Auckland areas and the expanding east coast area. Even at this high level of generalisation the distance factor seems to be operating. The miners being transferred from closures to collieries with vacancies were statistically more significant in the mid-Durham zone than in the east coast area. In fact this mid-Durham zone has 52% of the inter-manpower area movement compared with the east coast's 26%. Miners keep to the local collieries rather than make a journey through the mid-Durham zone to the east coast area.

The isolated area of Wingate has a surprisingly high input of labour. 71% of this is from areas to the west and north, showing that even this area has its share of transferees. Closures around Sherburn and rehousing at Peterlee account for over a third of this input, the rest is a scatter of transferees from the older

parts of the coalfield.

Conclusions

It has been possible to show that distance is a factor that affects the journey to work pattern of coal miners in county Durham. There appears to be a general limit of six miles but there is a gradual reduction in numbers employed at any particular colliery by distance as a continuous function. This same generalisation appears to apply to wastage rates as well. With a Divisional policy of redeployment, transfer of miners usually results in a longer journey to work for the transferee. As a result the industry tends to lose transferees at a rate proportional to the extra distance they have to travel. This principle is seen to be working even as between manpower areas, there being a general movement from west to east across the coalfield but the greatest concentration of travellers is in the mid-Durham zone rather than in east Durham on the coast.

The attempts to classify collieries led to a recognition of manpower areas. This follows from miners preferring to work near their home base and the distribution of mining population. Given a large urban centre with a high proportion of miners living there, this forms a focus for a pool of labour. The resulting manpower areas are virtually a description of the major urban areas or agglomerations on the coalfield of county Durham. Most of these agglomerations in fact resulted from coal mining.

The intensity of the settlement network also seems to operate. In South West Durham long journey to work patterns are

associated with collieries in a rural area with an open network of settlements. Even in the mid-Durham zone and in the east coast area the variations in the settlement network appear to affect journey patterns as shown by the leavers survey. The most intensive network of settlements and collieries occurs in north west Durham and this has the least inter-area manpower movement.³⁷

Finally, in terms of Central Place theory, several of these manpower areas appear as 'centres' for the first time and are located in margins of centres studied in earlier elements. This agrees with Central Place theory in that if a service or function is to appear on a landscape in competition with already existing examples of that service or function, it will do so, with most chance of success, at the point where the other centres have the least power of attraction.

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1. See the Journey to Work volume of the 1951 Census: Chicago and London transportation surveys are recent examples of sample basis of survey.
2. The author wishes to thank Dr. Reid, sometime Director of the Durham Division of the National Coal Board, for permission to make this study.
3. The author wishes to thank Mr. C.J. Brittain, sometime Divisional Pensions Officers, for discussion of the possible sources of information.
4. The author acknowledges the assistance of students of Bede and St. Hild's Colleges in collecting the data.

5. The author wishes to thank Mr. J.S. Storer, Assistant Divisional Chief Accountant and the Chief Accountants of the five areas as they existed in 1964, for assistance in organising access to National Insurance cards.
6. Discussions with Assistant Divisional Chief Accountants.
7. Discussions with various accountants, op. cit.
8. The author wishes to thank Mr. R. Peat, Area Chief Accountant, for his comments on the author's memorandum, 'Some factors influencing the mobility of coal miners in county Durham'.
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28. Information obtained from '&Guide to the Coalfield, 1946', Colliery Guardian, London, 1946.
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7. THE ELEMENTS - DRIVING TESTS

As the motor car and motor transport have become more and more important in our society, the need for the whole population over sixteen years of age to be involved in driving tests has increased. Today it is true to say that all social classes own cars though men drive them more than women.¹ The need to study motor transport in terms of both private and public use had led to many transportation surveys in recent years.² Once a past-time of the wealthy, motor car driving is now almost a social necessity. Driving tests therefore involve a very large proportion of the general population at some time or other and this is the basic justification for studying this element.

The Data

As the driving test data was the last to be collected for this thesis, it is the most complete in terms of centres and their regions in county Durham.³ To ensure that all the unland boundaries would be complete, data was collected for all county Durham centres and all centres fringing the county. This means that the boundaries of unlands for driving test centres are complete for the county area and there is no need to make theoretical assumptions as in some of the previous elements.

Everyone who takes a driving test applied for the test on form DL.26 stating, amongst other things, their name, address and two centres at which they would like to be tested.⁴ These forms are filed by the Traffic Commissioners with the record of the result of the test which again shows name, address and the

centre at which the test actually took place. For the four months April to July of 1966, these forms were examined and for each centre a list of settlements with their total examinees was drawn up.⁵ As in previous elements, these figures were then totalled to give numbers for population units.

The choice of the period April to July of 1966 for the collection of the data was made on three grounds. Firstly, the winter of 1965-66 had an above average number of days with snow lying on the roads or icy road conditions. As a result of this testing during the winter period was at a minimum and there was a backlog of tests to be done in the spring. The better weather and light conditions of the spring mean that more time is available for driving tests; after the conditions of the 1965-66 winter these conditions were at a premium to allow examiners to reduce long waiting lists of examinees. Secondly, the spring is the period when learner drivers begin to start courses with driving schools. As a result the June-July period sees a pressure for driving tests as these new learners come forward from driving schools for their tests. Hence April to July always has a great potential for driving tests and in 1966 this potential was under pressure because of the loss of testing time during the winter.⁶

The third factor was that the four months provided data to give a reasonable number of examinees within all population units. In fact no population unit shows no examinees, though Boldon Colliery has only one in this period (see figure 7.1).

KEY	
	County Upland Boundary
	Parish Upland Boundary
	Upland within
	Upland boundary by agreement

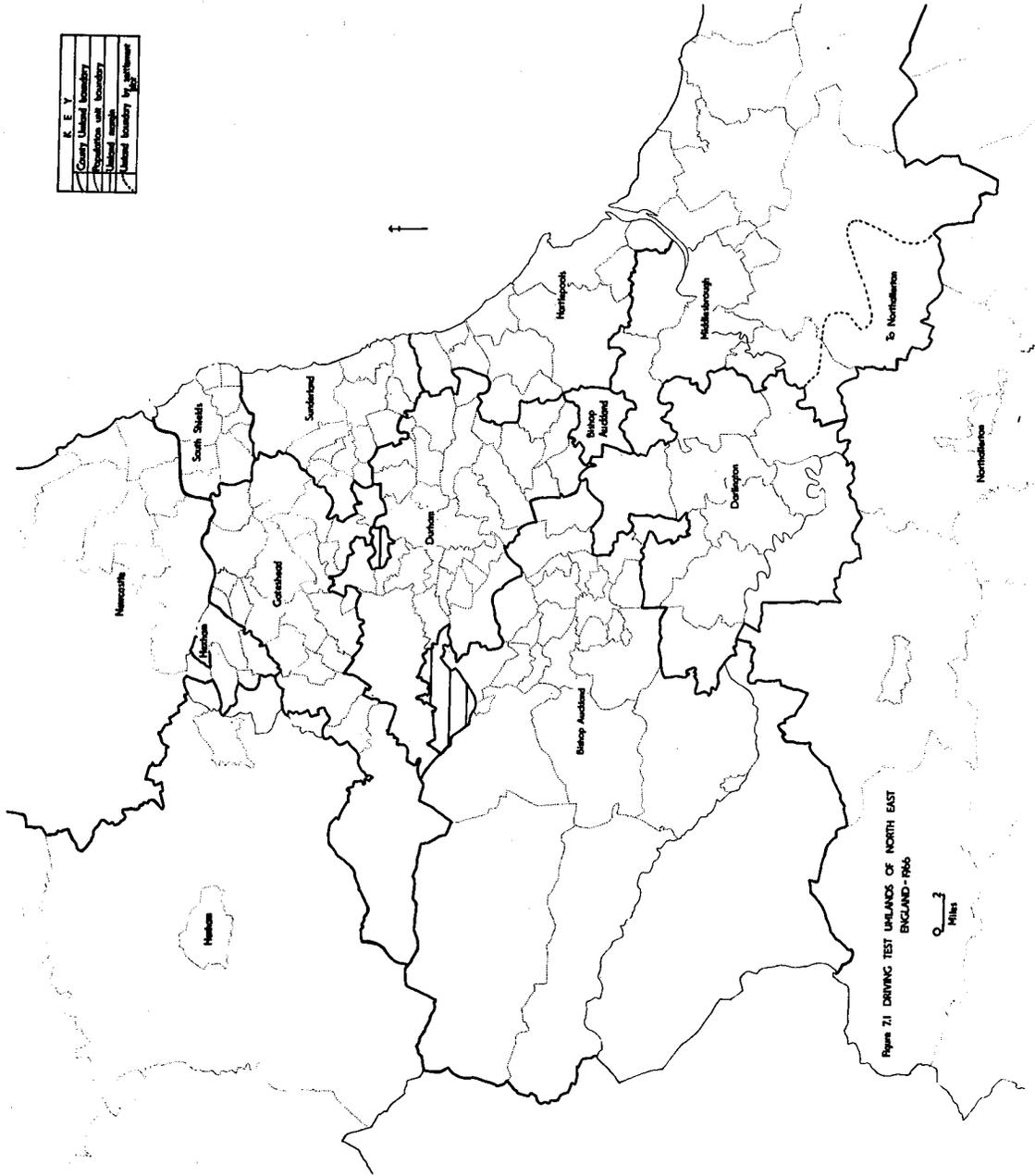


Figure 7.1 DRIVING TEST UPLANDS OF NORTH EAST ENGLAND-1966

The Basic Situation

In 1966 there were seven driving test centres in county Durham - Bishop Auckland, Darlington, Durham City, Gateshead, Hartlepool, South Shields and Sunderland. Beyond them to the north testing was also carried out near county Durham at Hexham, Newcastle and Tynemouth, while to the south, just beyond the county boundary, Middlesbrough and Northallerton were also test centres.⁷ Data was collected for all these centres except Tynemouth. Earlier studies show that the river Tyne is an effective northwards limit to the specific uplands of South Shields and so Tynemouth was omitted from the survey.

There is no hierarchy of services in driving tests. The centres are chosen chiefly because they are at points conveniently placed to meet a demand. This is illustrated by the present discussion as to whether a centre should be established at Stockton. There is evidence to suggest that the Middlesbrough driving test centre is under pressure. Stockton is a possible relief centre as it has a well developed traffic system with sufficient hazards for test courses and is sufficiently large in itself to provide an initial population for testing.⁸

As is shown by table 7.1 there is a link between the size of settlements and the choice of centres for driving tests.

Administrative Unit	Population	Administrative Unit	Population
Sunderland	185,903	Stockton	67,722
Gateshead	124,545	Stanley	55,287
South Shields	113,185	Bishop Auckland	38,935
Darlington	72,086	Consett	37,961
West Hartlepool	69,450	Jarrow	35,747

Table 7.1. Administration Units by population size, county Durham 1961 Census.

The five largest administrative units in county Durham each have a test centre and they are on Tyneside, Wearside and Teesside (as previously defined).⁹ The major gap is in central Durham and as in other elements, Bishop Auckland and Durham City, both in the Wear valley, fill the central Durham gap.

The major omissions appear to be at Stockton on Teesside and at Consett in north west Durham. Hence the need to collect data for Middlesbrough, Hexham and Newcastle to see what happens in these parts of the county.

Once a centre is selected the Traffic Commissioners prefer to staff it with a minimum of three examiners. This allows for some flexibility if one examiner should be ill or on leave, and a change of examiner for people re-taking the test.¹⁰ Table 7.9 shows the number of examiners at each of the centres studied. Hexham appears to have only one examiner. In fact it is worked as a part-time centre and is staffed by examiners from Newcastle. Open on three days a week, it appears to use the equivalent of about 1 full time examiner per week during these three days.¹¹

A similar situation operates at Redcar from Middlesbrough. In this case tests are taken by Middlesbrough examiners as demanded requires at the Redcar centre.¹² The six examiners at Middlesbrough form one unit with Redcar an irregular extension of their work and so the examinees at Redcar have been combined with those of Middlesbrough.

Bishop Auckland has only two examiners and so is below the suggested minimum. This situation has arisen because of the demand for tests in south west Durham. Darlington has three ex-

aminers and works in co-operation with Bishop Auckland. Any excess demand at Bishop Auckland is met by an examiner from Darlington, who has free time, going to Bishop Auckland to help.¹³ In effect five examiners operate between Bishop Auckland and Darlington, each centre needing the equivalent of two plus examiners but there is not sufficient demand to justify three examiners at each centre. Statistically this situation is illustrated by the waiting period (see table 7.2).¹⁴ Darlington had the shortest waiting period of any centre and the combined Bishop Auckland - Darlington waiting period of nine weeks ($11 + 7 \div 2$) is below the average for the study centres as a whole.

As demand increases at a test centre so it is relieved by appointing more examiners or opening another centre. The system is essentially one of the pressure of demand leading to an increase in the supply of driving tests. Further flexibility is added by the fact that the examinee has a choice of centres for the test. On his application for a test, the examinee nominates two centres. He is allocated to the centre that can give him a test in the shortest waiting time. An applicant may even apply for a test at the centre which has the shortest waiting period; that is, he is prepared to be directed to the driving test centre which can offer the test earliest. Hence demand is equalised over the centres as much as possible.

Centre	Waiting Period	Centre	Waiting Period
Bishop Auckland	11 weeks	Middlesbrough	13 weeks
Darlington	7 "	Newcastle	11 "
Durham City	12 "	Northallerton	12 "
Gateshead	11 "	South Shields	9 "
Hartlepoons	12 "	Sunderland	12 "
Hexham	15 "	Average	11.4 weeks

Table 7.2. Driving test centre waiting periods. April - July average, 1966.

Table 7.2 shows that this works well in practice with 11.4 weeks being the overall average during the four months studied.

Centres are only distinguishable in hierarchical terms by their number of examiners. Newcastle has ten and is the largest. Sunderland and Middlesbrough are next with six each and there is little variation as between centres down the ranking list from three onwards, (see table 7.9). No breaks appear except for Newcastle. Only one activity is involved and centred regions might be expected. However, the free choice within the system results in urban fields appearing.

This evidence all suggests a system based upon the pressure of demand. As demand increases, then the supply responds by more examiners being appointed. Demand is equalised as far as possible over the system by the flexible use of examiners between centres. Further the examinees have a fairly free choice of centre for their driving test.

K	E	Y
C	Urban field of Donkeyton	
D	Urban field of Duxton	
H	Urban field of Heston	
T	Urban field of Hildesborough	
T	Urban field of South Street	
Country boundary		
Population unit boundary		

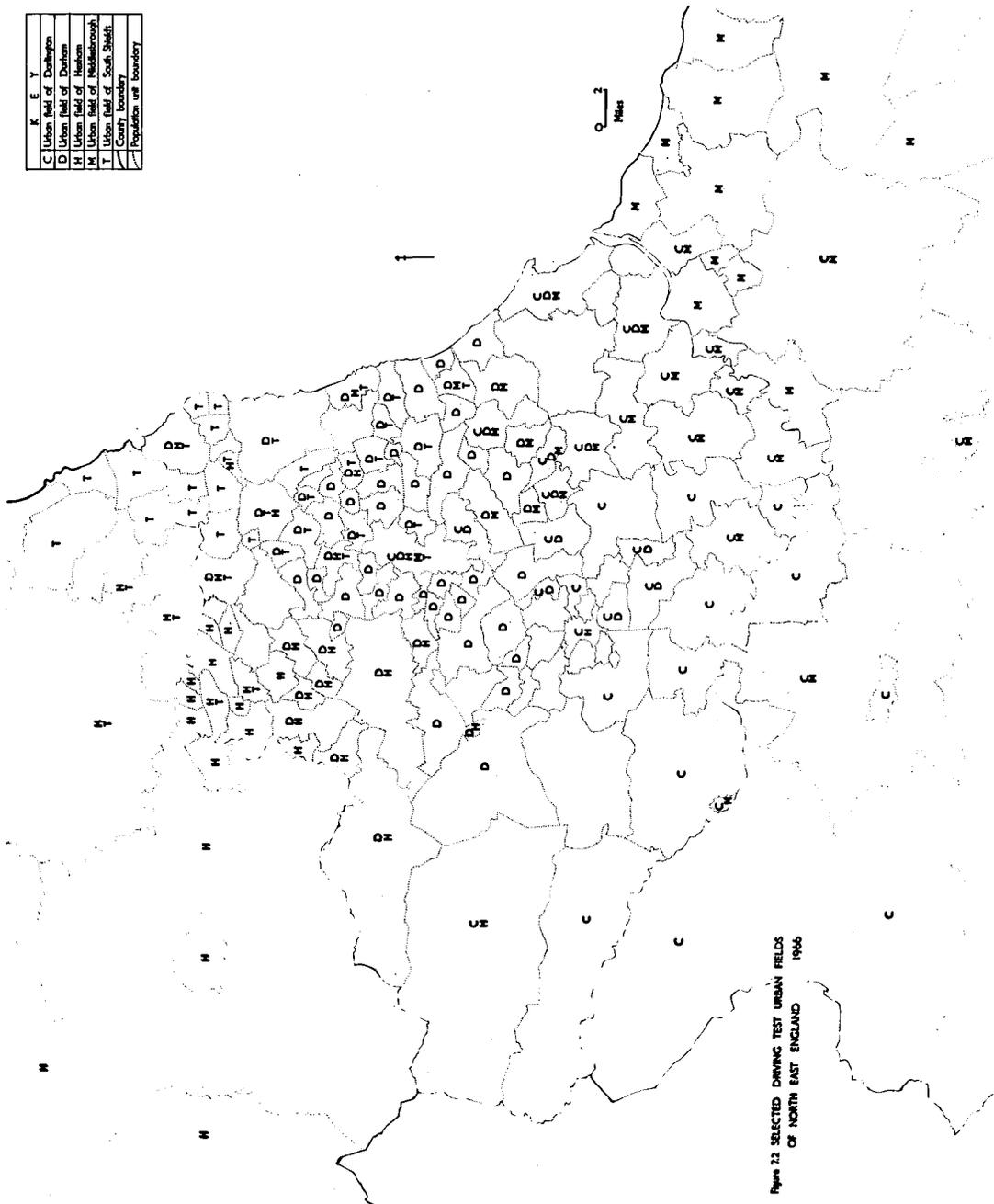


Figure 12 SELECTED DRIVING TEST URBAN FIELDS OF NORTH EAST ENGLAND 1966

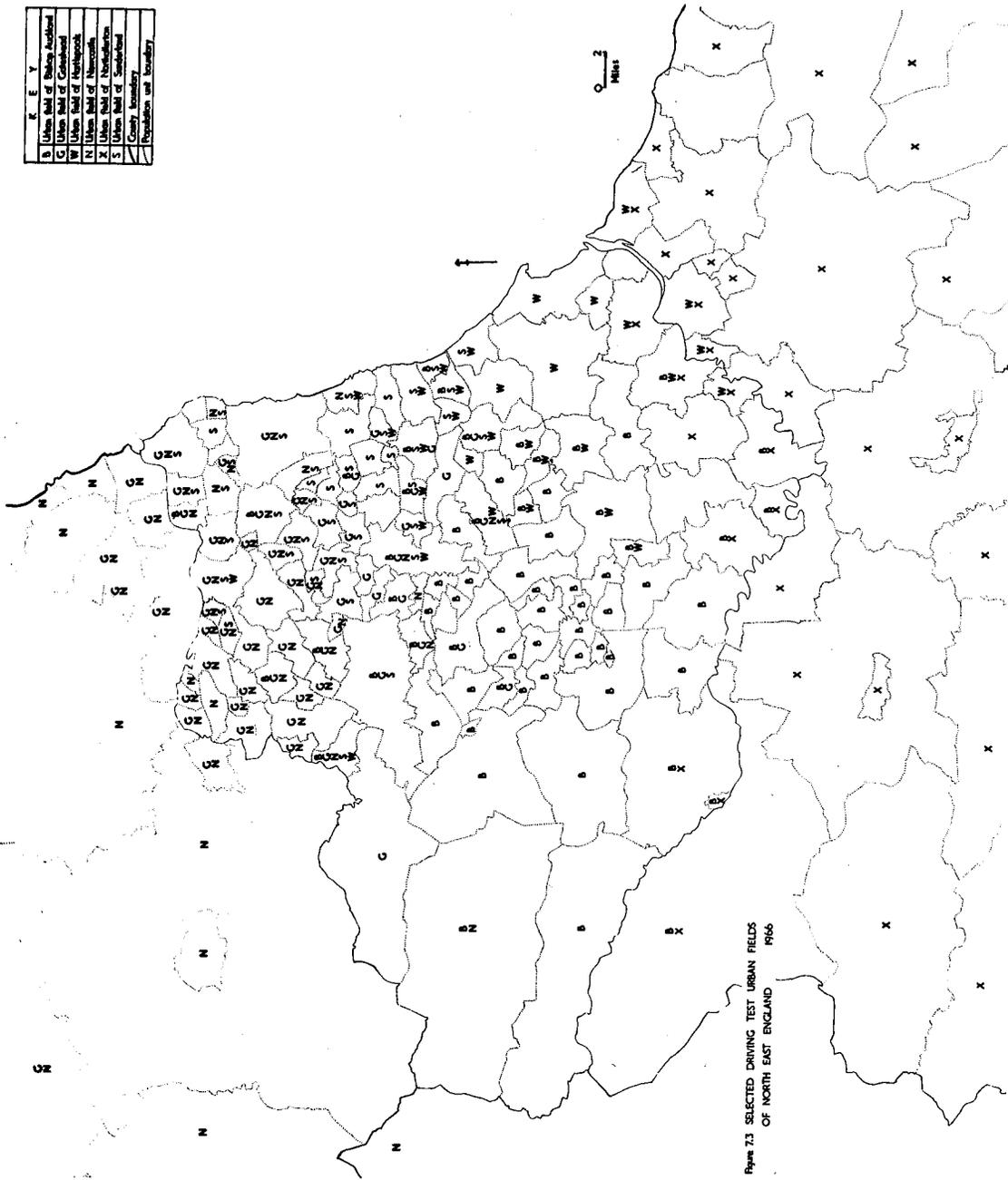
Bishop Auckland

Bishop Auckland's specific urban field includes both upper Teesdale and Weardale. In this element Bishop Auckland shows the power to attract examinees in fair number from upper Teesdale on both the Durham and Yorkshire sides of the river. Northwards there is a scatter of examinees from the Consett-Stanley area but this is marginal. To the north east the urban field extends to Durham city and then the boundary continues eastwards to reach the coast at Horden (see fig. 7.3). For the first time in this study, the urban field of Bishop Auckland shows strength eastwards into the Fishburn Area and south from Fishburn, off the coalfield, as far as Sedgefield. The urban field boundary then reaches the river Tees at Darlington, follows the river upstream to Gainford and then crosses into Yorkshire to include both banks of the Tees in upper Teesdale. Beyond this there is a scatter of single examinees from the larger settlements such as Hartlepool, Newcastle, Seaham, Stockton and Sunderland.

The driving test umland has a familiar northern limit. Weardale is within it and Derwentdale without (see fig. 7.1). Eastwards Durham City competes with Bishop Auckland at Cornsay. However, Tow Law and the Crook-Willington area are within the Bishop Auckland umland with just a slight extension at the expense of Durham City compared with previous elements. The boundary continues to Spennymoor and Ferryhill with its limit at Sedgefield.

Sedgefield appears on fig. 7.1 as an outlier. In fact, there is open country between it and the Chilton-Rushyford area which is

K	E	Y
U	Urban field of Birmm	Ascham
C	Urban field of C	Ascham
W	Urban field of W	Ascham
N	Urban field of N	Ascham
X	Urban field of X	Ascham
S	Urban field of S	Ascham
	County boundary	
	Population unit boundary	



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 of North East England 1966

the eastern edge of the continuous unland area. Also Sedgfield is only just within Bishop Auckland's unland. Of the 43 examinees at Sedgfield, 12 went to Bishop Auckland, 11 to Middlesbrough and 10 to Darlington. This is a border zone or margin. The same may be said of the adjacent population units of Mainsforth and Fishburn. Here Durham City dominates but has less than half of the total examinees. This area has appeared as a marginal area before. The southern boundary of the specific unland is just south of Newton Aycliffe, Shildon and the Staindrop area and then across the Tees to include the Yorkshire bank of the upper Tees.

The unland boundary has many similarities with the major limits of the urban field. Penetration beyond the unland is limited and this is unusual. The eastern extension of the unland to include Sedgfield repeats a feature of the urban field. It also shows Newton Aycliffe within Bishop Auckland's influence. In general surgery and the local technical colleges, Newton Aycliffe has been within the specific unlands of Darlington.¹⁵ The coal mining manpower areas showed Newton Aycliffe within the Bishop Auckland manpower area, but there was then no centre operating at Darlington.¹⁶ In this element, the change to the Bishop Auckland specific unland is decisive and suggests the lack of power of attraction of Darlington as a driving test centre compared with Bishop Auckland. The marginal position of Newton Aycliffe and its significance in terms of locating a new town and central place theory has been mentioned several times already.

Figures 7.4-5 illustrates what happens in terms of the interaction index in the margin towards Comsay and towards

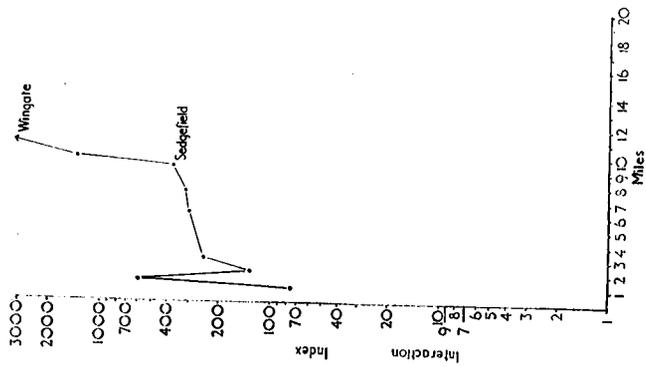


Figure 7.4 Bishop Auckland Driving Test Interaction Indices along a section line towards Wingate

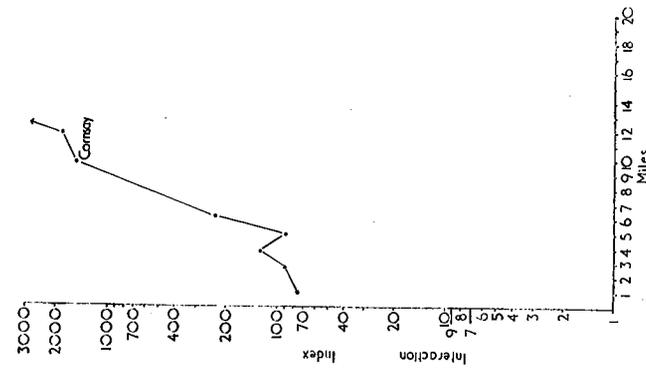


Figure 7.5 Bishop Auckland Driving Test Interaction Indices along a section line towards Consett

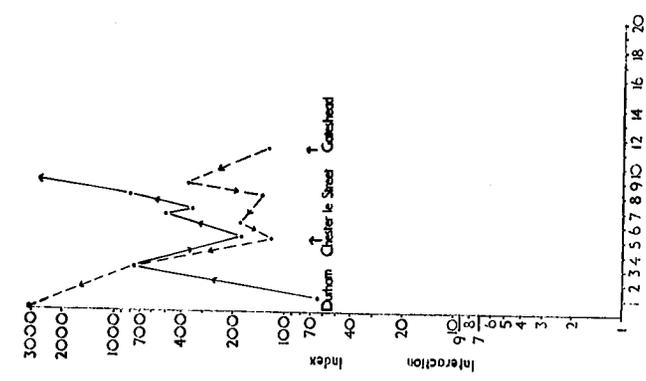


Figure 7.6 Driving Test Interaction Indices along a section line Durham - Gateshead

Sedgefield. As found in other elements, once the margin is reached, the interaction index increases rapidly, in this case from below 250 to between 300 and 1500. Beyond the margin the index is over 10,000 i.e. a population of at least 10,000 is needed in a population unit to provide one driving test examinee at Bishop Auckland.

The distribution pattern suggests that Bishop Auckland is more powerful as a driving test centre in competition with other centres than it has been in any previous element. Competitive power with Darlington is virtually equal though technically Darlington has three examiners to Bishop Auckland's two. Northwards there is no competition from Consett and Durham City, Gateshead and Hexham which do provide the competition are at some distance.

Darlington

The specific urban field of Darlington is rather elliptical in shape (see fig. 7.2). The long axis is east-west along the river Tees. It penetrates westward into Teesdale and eastwards to Middlesbrough and Billingham. Northwards Ferryhill forms the effective limit of the urban field and Darlington obviously has difficulty in attracting examinees from the coalfield area. The Richmond rural area forms the southern limit with examinees from Richmond itself and a scatter of them the villages around Richmond. Beyond this area are single anomalous interactions with some of the larger settlements such as Gosforth, Jarrow, Northallerton and Sunderland. The unland for driving tests is basically a circle around Darlington of radius ten miles (see fig.7.1). Newton Aycliffe has been lost to Bishop Auckland and this breaks

the otherwise compact nature of the umland around the town. Competition with Bishop Auckland limits the northwards and westwards extent of the specific umland.

This last statement is worth further development. Each examiner has a given number of tests he can do each week. People living at a centre have the best opportunity of taking such tests. Other centres are less attractive because they are further away and people coming to a centre from outside have a travel element which is at a minimum for local people. Applying to Darlington, three examiners are competed for by the town's population of 85,000 whereas Bishop Auckland's two examiners are competed for by that centre's 18,500 people initially. As a result Bishop Auckland's examiners have more time available for people living outside the town than Darlington's examiners. Hence the umland of Bishop Auckland is likely to cover a larger area than that of Darlington.

Eastwards the specific umland is limited by Middlesbrough . The rural area just west of Stockton-Eaglescliffe forms the boundary repeating a feature of other elements. Boundary lines frequently occur in rural areas. Southwards the river Tees forms the boundary except around Croft. The main line railway and the A.1.(M) road give easy access to Darlington from this part of Yorkshire and facilitate movement to the town.

Durham City

It was suggested earlier in this chapter that Durham City became a driving test centre to meet the needs of the central Durham area between Tyneside and Teesside.

This suggestion is certainly supported by the extent of the specific urban field. It forms a rectangle, ten miles long from east to west and eight miles from north to south with Durham at its centre (see fig. 7.2). The corners of the rectangle are formed by Consett (NW), Sunderland (NE), Blackhall (SE), and Wolsingham (SW). There is virtually no penetration into the Pennine valleys proper, little power of attraction on Tyneside and very little to the south of the coalfield. Beyond this rectangle, individual examinees occur at the larger settlements such as Billingham, Darlington, Newcastle and South Shields.

The specific unland also shows a rectangular shape although it is contracted compared with the urban field and it narrows towards the west. Although there is no centre at Consett in this element, Durham has only increased its unland compared with the previous elements to include the Lanchester area in a north west direction. Gateshead and Hexham are in competition with Durham City in the southern part of north west Durham and Durham City gains little. At Cornsby, in competition with Bishop Auckland, a state of balance is achieved. Only two interactions occur within this population unit which partly accounts for the indecisive nature of the boundary here (see fig. 7.1).

A similar situation exists at Plawsworth between Durham City and Chester-le-Street (see fig. 7.1). Four examinees are shared equally between Durham City and Gateshead. This occurs in a population unit adjacent to Durham City itself and illustrates the power of Gateshead as a driving test centre (five examiners) compared with Durham City (four examiners). Chester-le-Street is

within a Gateshead specific umland for the first time. Figure 7.6 shows this total situation in terms of the interaction index. The index is below 200 within the Durham Specific umland and rises to 400+ at its boundary. However, at Chester-le-Street the index falls to 182 when it would be anticipated to rise to over 400. The same thing happens from Gateshead across its specific umland to Chester-le-Street. In fact Chester-le-Street has a lower interaction index than Gateshead itself. This point will be discussed in detail in the Gateshead section.

Eastwards the Durham umland boundary keeps to the west of Houghton-le-Spring and Hetton-le-Hole but includes the larger coalmining settlements of the mid-Durham part of the limestone plateau such as Shotton, Thornley and Wheatley Hill. It then penetrates south eastwards to the edge of the coalfield in the Fishburn-Trimdon area for the first time in any element. This suggests that competition in this area from Darlington (three examiners), Hartlepoons (four examiners) and Middlesbrough (six examiners), is weaker than in any previous element. These three larger centres have much internal demand to meet and so only a limited amount of their examiners' time is available for examinees from outside the centre. Durham has four examiners and a population of 25,000. In comparison Darlington has 85,000 people to three examiners, Hartlepoons 95,000 people to four examiners and Middlesbrough 189,000 people to six examiners. While this may explain Durham's power to penetrate south eastwards, it makes the Chester-le-Street position more inexplicable. Why is Durham's power of attraction devoted to penetrating south eastwards to a

distance of ten miles from its centre and not northwards where the upland border is only three miles from its centre?

The answer to this question may lie in the network of centres. The competing centres as far as Durham City is concerned, lie further apart to the south east of the town compared to those to the north of it.

Westwards the upland includes the Brandon area and the mining villages to the west of Durham City as in other elements.

Gateshead

With Newcastle and its ten examiners just across the river Tyne from Gateshead which has only five examiners, the situation in driving tests is similar to that in the technical college element. Gateshead's competition with Newcastle is shown by its specific urban field. Gateshead attracts examinees from all the Tyneside population units but they come in greatest numbers from the south bank between Felling and Prudhoe (see fig. 7.3).

From Prudhoe the urban field follows the county Durham boundary southwards to Consett. From Consett the boundary turns eastwards to Sunderland via Durham City. A scatter of single interactions occurs just east of Durham where the urban field is obviously weakening. The eastern boundary of the urban field lies between Sunderland and Tynemouth.

The specific upland is interesting in that the lack of a centre at Consett gives Gateshead the opportunity of attracting people from north west Durham in competition with Newcastle, Hexham and Durham City. From Gateshead the upland includes

Whickham to the west but Blaydon and Ryton beyond are within the Hexham-Newcastle sphere of influence. The Stanley area and Consett itself are within Gateshead's umland which extends to Healeyfield just beyond Consett. The southern limit is the Lanchester area which is within Durham City's umland. Chester-le-Street is just within the south east corner of the umland which then continues north eastwards from here to include Washington and Felling (see fig. 7.1).

Within Gateshead's specific umland the interaction index is below 400 i.e. less than 400 people are required to result in one driving test examinee. At the umland boundary the index rises to over 400. Gateshead itself has an interaction index of 128. Rather surprisingly four other population units have a lower index within the umland. While it is not unusual for a small community just outside a large town to be more closely attached to that town's services than the population of the town itself, four such settlements is unusual.¹⁶ Springwell and Winlaton are two of the settlements. They are virtually suburbs of Gateshead and so are not exceptional. The other two settlements are Chester-le-Street and its nearby village of Ouston. This is unusual in that it occurs near the border of the umland where it is in competition with Durham City.

This unusual situation was referred to earlier in the Durham City section and is illustrated by figure 7.6. A possible explanation may be in the population characteristics of the Chester-le-Street area. An assumption has been made that the population within the study area over 16 years of age is homogeneous so that

everywhere there is the same demand for driving tests. This homogeneity could be altered by at least two factors. Part of the area may have an unusual age structure giving more people than elsewhere in the 17-65 years age group which is the age group involved in tests. There is no apparent evidence of this. The other factor is that the occupation structure is such as to produce higher demands for tests than would be normally anticipated. This might be associated with the service industries and motor transportation in particular. Fullerton has shown that there is evidence of such a factor working at Chester-le-Street.¹⁸ There is a high proportion of people working in service industries, particularly transport, than anywhere else in north eastern England. Hence the dip shown in figure 7.6 may represent a local change in population characterisation.

The shape of Gateshead's specific umland is interesting in that it is an elongated area with Gateshead itself off centre in the north east corner. If the network of competing centres around Gateshead is considered, the least competition occurs to the south west between Durham City and Hexham. The network of centres would appear to influence the shape of the resulting umland and this repeats a feature already suggested at Durham City.

Hartlepoons

In other elements Hartlepoons has been characterised by peninsularity and a low power of attraction. With four examiners in this element and the lack of a centre hierarchy, it has

a great potential power of attraction in driving tests than with any previous element. However the resulting urban field is still small. There is greater penetration northwards than before but this ends abruptly at Seaham. The urban field extends strongly to Shotton Colliery but only weakly beyond this to Durham City. Cornforth, Sedgefield and Stockton form the westward limits and there is little penetration beyond the Tees to Thornaby, Middlesbrough or Redcar (see fig. 7.3).

The driving test umland is a near repetition of previous elements. Westwards, even with no centre at Stockton, competition with Middlesbrough results in a boundary in the rural area between Hartlepoons and Stockton. North of this, Wingate is within the umland and so are Peterlee and Easington. These latter settlements repeat a pattern shown in the coal mining manpower areas where a link exists between the Hartlepoons area and the coal mines along the coast as far north as Easington. Otherwise penetration northwards to the extent shown in this element has not occurred before.

The peninsular nature of the umland is still apparent and the lack of examinees from far beyond the umland repeats a feature seen at Gateshead. In fact only 7% of all examinees at Hartlepool came from outside the specific umland.

Hexham.

Hexham is included in this element to provide boundaries in north west Durham to the umlands. In previous elements the Northumberland-Durham county boundary along the river Derwent near Consett appeared to be an actual boundary to movement.

There was also some evidence that the Ryton area might look towards Hexham (e.g. general surgery). The collection of data for Hexham gives at least one example of what actually happens.

Hexham is only a part-time centre for driving tests and is operated from on only three days a week with examiners from Newcastle. It appears to use the equivalent of one examiner a week and this gives it the lowest power of attraction of any centre studied. To balance this there is no centre operating at Consett to compete with it in north west Durham and the centres Hexham is competing with are at a fair distance from it (see table 7.3).

Centre	Distance from Hexham.	Centre	Distance from Hexham
Bishop Auckland	27 miles	Gateshead	20 miles
Durham	25 miles	Newcastle	18 miles

Table 7.3. Distances of centres competing with Hexham. Driving Tests 1966.

The resulting specific urban field (see fig. 7.2) is an area covering south west Northumberland with some penetration into Westmorland around Alston, into county Durham around Wearhead and into north west Durham as far as Consett, Stanley and Gateshead. Within Northumberland, Morpeth and Redesdale form the northern limit of the urban field. Carlisle (with three examinees) and London (with one) are the only places outside this urban field with examinees going to Hexham. With its low power of attraction this is not surprising.

For this element only the south eastern quadrant of Hexham's driving test unland is significant. The county Durham boundary

acts as the umland boundary from Wearhead to Consett (see fig. 7.1). Hexham is in competition with Gateshead for much of this length. At Ebchester, Hexham has one more examinee than Gateshead (8:7) and so the Hexham umland penetrates county Durham. This again happens at Chopwell. Just further north at Greenside, Newcastle is just slightly more powerful than Hexham while the Tyne Bank population units of Ryton are split between Newcastle and Hexham. Ryton itself shows a dominance of Newcastle for driving tests but Crawcrook and Crookhill are both dominated by Hexham, (see table 7.4).

Population Unit	Number of Examinees to:		
	Gateshead	Hexham	Newcastle
Crawcrook	4	9	6
Crookhill	-	4	2
Greenside	-	3	4
Ryton	9	44	52

Table 7.4. Driving test examinees in the Ryton area by centres, April-July 1966.

The lack of clear cut boundaries in the Ryton area has occurred before in the technical college element. In general surgery the position was inconclusive. Certainly this element proves the suggestion of earlier chapters that Ryton looks to Hexham and Newcastle rather than Consett or Gateshead. The anomalous statistics in this element within the Ryton area could result from the wrods Crawcrook and Crookhill being omitted by examinees when stating their address and so appearing as Ryton. This would account for the high interactions at Ryton itself. However this would appear to be an unlikely possibility.¹⁹ Another possibility

is that the population of Ryton is different to the surrounding settlements and the demand for driving tests is high. As stated with Chester-le-Street, the survey assumes a homogeneous population and this may not be true of Ryton village itself compared with the surrounding villages. The 1966 sample Census does suggest that Ryton has a greater middle class/professional population than the other wards of the urban district (see table 7.5). This could result in higher car-ownership rates in Ryton village.²⁰

Population Unit	Social Class I and II.	Socio Economic Groups 1-6 and 13
Crawcrook	10%	24%
Crookhill	13%	22%
Greenside	4%	17%
Ryton	25%	36%

Table 7.5. Social class and Socio Economic groups of the economically active, Ryton urban district 1966.

Beyond the Tyne in Northumberland, Hexham's unland ends with its administrative rural district in competition with Newcastle at the border of the Castle Ward rural district.

The data for Hexham shows two things. With no competition from Consett, Hexham is able to attract examinees from the border of county Durham in north west Durham. The other feature is the problem of Ryton and the fact that Hexham or Newcastle attracts from this area rather than Gateshead.

Middlesbrough

Middlesbrough has appeared as a centre in all the sets of data. The dominant settlement on Teesside, it has already been

established that in county Durham a wedge northwards from Stockton is attracted to Middlesbrough. This feature appears in the driving test data but in a more restricted form than in any previous element. The driving test umland includes Stockton and Billingham with Eaglescliffe and then ends in the rural margin to these settlements. Sedgefield has in previous elements been within the Middlesbrough-Stockton specific umlands. In driving tests it is just within the Bishop Auckland umland (see table 7.6). The marginal area noted in other elements at Fishburn-Mainforth has been extended southwards to include Sedgefield in this element.

Centre	Examinees	Centre	Examinees
Bishop Auckland	12	Hartlepoons	4
Darlington	10	Middlesbrough	11
Durham City	6		

Table 7.6. Examinees living in Sedgefield by centres attended for driving tests.

Boundaries are definite, but they are drawn on the basis of a population being split fairly evenly between several centres. Even with forty-three examinees in the four months of the survey, Sedgefield shows little difference in the numbers going to Bishop Auckland, Darlington or Middlesbrough. Even nearby Mainsforth shows thirteen examinees and little difference in the numbers going to Bishop Auckland, Darlington and Durham City.

There is sufficient data to show that this is truly a marginal zone between several competing centres in this element and in the study as a whole.

Middlesbrough has six examiners divided between itself and Redcar. Hartlepool with four examiners, Darlington with three and Bishop Auckland with two are able to compete more effectively in this element with Middlesbrough than in any previous one. Hence the small extent of the Middlesbrough wedge in this element.

The specific urban field is of interest because of two features. Once the driving test umland is defined, the urban field is found to be very weak beyond the umland boundary. In fact only 2% of the examinees of Middlesbrough come from outside the umland area. This may result from the concentration of population on Teesside proper with a quite marked change to a thin scatter of rural population outside Teesside. The Northallerton gap, the Vale of Pickering and the coastal resort area of Scarborough-Whitby are the next areas of population concentration outside Teesside in all directions except to the north. Each one of these areas has its own driving test centre.²¹ As a result Middlesbrough has a network of centres around it which of necessity concentrates its power of attraction to the Teesside area.

Newcastle

The most powerful of the centres, Newcastle has a specific umland concentrated on north Tyneside with a penetration into county Durham in the Blaydon and Ryton areas (see fig. 7.1). This has occurred before and like Middlesbrough on Teesside shows the influence of the river in dividing the conurbation into a north and a south bank element except near an easy crossing point. The Scotswood bridge gives direct access from Newcastle to the

A.695 to Ryton and Prudhoe and the A.694 to Rowlands Gill and Consett. This would appear to provide a communications framework for linking Blaydon and Ryton to Newcastle in competition with Gateshead and Hexham.

Like Middlesbrough, Newcastle has a fairly limited umland. This results partly from competition with a series of other centres along the eastern lowlands of Northumberland. Tynemouth, Blyth, Ashington and Berwick all have driving test centres and compete with Newcastle in the more populous eastern parts of Northumberland.²² This is suggested by interaction indices of over 700 in areas such as Seaton Valley, Bedlington and Morepeth. Even the rural districts outside the Castle Ward rural district have high interaction indices suggesting that they are attracted eastwards to the coastal centres rather than southwards to Newcastle.

The specific urban field extends northwards to Wooler but not quite to the Scottish border. Westwards the Northumberland-Cumberland border, at Gilsland in the Tyne corridor, forms the limit. Weardale, Durham City and Sunderland form the southern limit of the urban field. Although such a powerful centre, the failure to draw examinees from across the whole of county Durham is worth noting. In the regional elements such as ophthalmology and professional football, Newcastle had a specific urban field extending across the whole of county Durham. In a non-hierarchical situation with a competing network of centres in county Durham, Newcastle is limited to an urban field within the northern third of the county.

Northallerton

This centre is included to provide a definite southern limit to the Bishop Auckland and Darlington umlands. In previous elements it has been suggested that these two centres between them extend into parts of the North Riding of Yorkshire with their specific umlands. This element shows this to be true. The population units used are rural and urban districts because the parish unit populations were too small to ensure continuity of interaction across the area. The parishes frequently lacked any examinees because their populations varied between 50 to 300 people, and this is below the interaction index of even the specific umland in many cases. The mesh of population units actually used based on rural districts is broad and in some ways is over-agglomerated but when tested by a settlement plot (see fig. 7.1) proved acceptable.

The Startforth area of upper Teesdale is definitely in the Bishop Auckland specific umland. There is a clear contrast to the south with Reeth, dominated by Northallerton. This confirms earlier suggestions that upper Teesdale comes within the attractive power of a Durham based centre, either Bishop Auckland or Darlington.

Further east the Croft area is shown to be definitely in the Darlington specific umland. The Richmond area to the south, while having examinees who do go to Darlington, is linked to Northallerton whose specific umland it is in (see fig. 7.1). Continuing eastwards Northallerton's driving test umland keeps to the south bank of the river Tees to Yarm. Here, in competition

with Middlesbrough, it just fails to dominate. This boundary continues southwards along the border of Stokesley rural district still in competition with Middlesbrough. The rural district boundary hides a penetration of Northallerton's influence along the foot of the Cleveland Hills into the Hutton Rudby area of the Stokesley rural district but in general the administrative boundary forms a useful guide to the umland border.

In earlier elements attempts were made to define the specific umlands by means of the interaction index. These were successful as shown by this study of Northallerton which confirms earlier suggestions for the limits of Bishop Auckland and Darlington umlands. If the same technique is applied to Northallerton itself it can be shown that Ripon and its rural area are just within the specific umland with interaction indices of 121 and 253 respectively (see table 7.7). The next centre to the south is Harrogate which has a large internal population plus Knaresborough nearby to use up much of its examining power.²³ Ripon lies beyond Knaresborough towards Northallerton.

Umland Interaction Indices			
Northallerton U.D.	60	Richmond R.D.	114
Northallerton R.D.	98	Leyburn R.D.	125
Bedale R.D.	90	Wath R.D.	133
Richmond M.B.	81	Reeth R.D.	141
Thirsk R.D.	100	Masham R.D.	144

Continued over....

Non-Umland Interaction Indices	
Stokesley R.D.	153
Hurworth	175
Startforth R.D.	875
Croft R.D.	1003
Middleton-St-George	1150

Table 7.7. Northallerton driving test centre selected interaction indices. 1966.

South Shields

The similarity between Hartlepoons and South Shields noted in earlier chapters is repeated in the driving test data. Peninsularity between the North Sea and the Tyne estuary is shown by the lack of examinees from the north bank of the river Tyne. Gateshead, Washington and Sunderland continue to mark the effective limits of inland penetration. But as with Hartlepoons, South Shields is better able to compete with Sunderland in driving tests than in any previous element (see table 7.9). The result is an extension of the specific urban field southwards along the coast to Seaham. The main area of the urban field is therefore bounded by a line from just south of Seaham round to the west beyond Washington to Gateshead (see fig. 7.2).

The specific umland is very familiar. The river Tyne forms the northern boundary, the North Sea the eastern limit, Sunderland the southern limit and Felling-Washington the western limit. With five examiners at South Shields competing with five at Gateshead and six at Sunderland, it is not surprising that the whole of the Boldon urban district comes within South Shields' specific umland

along with Jarrow and Hebburn. This can also help to explain why Gateshead and Sunderland both have off-centre locations within their umlands. The competition with South Shields is so strong that they develop their umlands in virtually the opposite direction to South Shields.

Sunderland.

This is the only element where Sunderland can be shown for certain to be operating at almost the same level as the centres around it. In general surgery it had a built-in advantage over the surrounding centres by its large bed total and the early development of the hospital services in the town. In technical colleges it combined local, area and regional functions all in one. But in driving tests its six examiners are comparable with the four each at Durham City and Hartlepoons and the five each at Gateshead and South Shields. Remembering the initially large population at Sunderland, its power of competition with the surrounding centres is limited by its high internal demand.

The result is seen in the specific urban field. The river Tyne from South Shields upstream to Whickham forms the northern limit of the urban field. The boundary then follows a southerly direction from Whickham to Durham City before turning eastwards to reach the coast at Blackhall, just north of Hartlepoons. This is virtually the north eastern quadrant of county Durham. Interactions beyond this area are surprisingly few. Only 8% of examinees at Sunderland came from outside the specific umland.

The driving test umland for Sunderland extends south and west from the town. The competition of Gateshead and South Shields

would suggest this. Durham City and Hartlepoons are not only further away but have less examiners than the other two centre (see table 7.8).

Centre	Distance	Examiners	Centre	Distance	Examiners
Durham City	11 miles	4	Hartlepoons	17 miles	4
Gateshead	8 miles	5	S. Shields	5 miles	5

Table 7.8. Centres competing with Sunderland with distance and examiners for driving tests, 1966.

Hence the Houghton-le-Spring area and much of Hetton-le-Hole is within the umland. Seaham and its surrounding rural area is also within the umland. There is a similarity with the general surgery and technical college umlands, the area being surprisingly limited when the multi-functional basis of Sunderland is considered. However, this shows that in driving tests a low powered function of Sunderland has been successfully isolated.

The Centres

The power of attraction of a centre has been measured by the number of examiners each centre has. This is a valid process if each examiner is of equal operational value. This can be measured from the data by calculating for each centre, the number of tests each examiner completed in the four months period of the survey (see table 7.9). The table was tested statistically and a correlation coefficient of +0.96 was found between the total examiners and total examinees of each centre. The average number of tests by each examiner was 598. When allowance is made for cancellations and bad weather as variables as between centres, plus the result

of the statistical test, it is fair to conclude that each examiner does represent an equal number of test opportunities and this is a valid measure of the power of attraction of centres.

Centre	Examiners	Examinees	Examinees per Examiner.
Bishop Auckland	2	1654	827
Darlington	3	1528	509
Durham City	4	2000	500
Gateshead	5	2318	464
Hartlepoons	4	1745	436
Hexham	1	877	877
Middlesbrough	6	5413	902
Newcastle	10	5493	549
Northallerton	3	1542	514
South Shields	5	2429	486
Sunderland	6	3077	513

Table 7.9. Examiners and Examinees totals by driving test centre, April-July, 1966.

Three centres show a rather high examining rate and are worth further comment. If Bishop Auckland and Darlington are considered as sharing five examiners, which is what happens in reality, the result is a just above average figure as opposed to Bishop Auckland's high rate in that table. Similarly Hexham has one examiner and this is an estimate based upon part-time staffing from Newcastle. If combined with Newcastle, they show a fairly average rate of 579 per examiner and such a combination is justified administratively. Middlesbrough is the remaining high rate centre. The Northern Traffic Commissioners recognise that Middlesbrough is under great pressure and are considering re-

lieving it by establishing a centre at Stockton. The pressure of demand resulting in increase in supply is shown here.

The distribution pattern of the centres and their power of attraction repeats the situation already noted in technical colleges. Tyneside with its one million inhabitants has four centres, two on each bank, dominated by Newcastle and having a total of 23 examiners (see table 7.10).

Tyneside Centres	Central Durham Centres	Teesside Centres
Gateshead (5)	Bishop Auckland (2)	Darlington (3)
Newcastle (10)	Durham (4)	Hartlepoons (4)
South Shields (5)	Sunderland (6)	Middlesbrough (16)
Tynemouth (3)		
Total Examiners 23	12	13

Table 7.10. Driving test examiners totals by urban areas 1966.

Teesside with some 700,000 people has three centres with 13 examiners. Middlesbrough forms the nodal point with its six examiners and its part-time centre at Redcar. At either end of the Teesside urban belt are Darlington and Hartlepoons, and they are both on the opposite river bank to Middlesbrough. Between Tyneside and Teesside is the central Durham area which is basically the river Wear drainage area with Sunderland as its focus at the coast. This area includes the east Durham limestone plateau though in this element this plateau is served by Durham City and Bishop Auckland as opposed to Sunderland. Compared with other elements, part of this area has been lost to Hartlepoons, but part of the Middlesbrough wedge has been gained in compensation. With

a population of about 600,000 there are 12 examiners.

Again as seen in the other elements, the urban areas have an attraction related to their population and the network of centres in part reflects the distribution of population.

Umland Population²⁴

All the umlands of county Durham are clearly defined in this element. If their total umland populations are analysed by a regression against their total examinees, a correlation coefficient of +0.85 is found which is highly significant. With only seven centres in the analysis the margin of statistical error is potentially high and the 't' test result is very important. If the umlands for the other four centres are completed using the interaction index and a regression calculated for eleven centres, a correlation coefficient of +0.95 results which again is statistically highly significant. This evidence supports earlier analyses which have used interaction indices to complete umland boundaries and have then shown a highly significant correlation between the total number of interactions and the specific umland populations.

With the umlands of non-county Durham centres apparently valid, a further analysis is possible between umland populations and umland interactions (see table 7.11). Again the statistical test (t test) showed a highly significant correlation with a coefficient of +0.94. As shown in other elements the umland is correlated to both population and interaction data. Once a specific umland is defined it provides a good indicator of the likely number of people to use a centre for a particular service.

The total specific umland population can be divided by a constant which varies for each service to provide the number of people likely to use that service.

Some people live outside a particular umland but still use that centre for that service.

Centres	Examiners	Umland population.	Total Examinees.	Umland Examinees.	% Examinees non-umland.
Bishop Auckland	2	165,407	1654	1511	8.6
Darlington	3	101,294	1528	1253	18.0
Durham	4	135,070	2000	1131	43.5
Gateshead	5	319,243	2318	2028	12.5
Hartlepoons	4	155,051	1745	1615	7.4
Hexham	1	67,943	877	562	35.9
Middlesbrough	6	431,641	5413	5307	1.7
Newcastle	10	431,994	5493	4382	2.0
Northallerton	3	117,743	1542	1036	32.8
South Shields	5	183,665	2429	1975	18.7
Sunderland	6	298,808	3077	2841	7.7

Table 7.11. Basic statistics for centres, Driving tests, April-July 1966.

Table 7.11 shows that three centres have unusually high percentages of their examinees from outside their specific umlands. A marked break exists between 18.7% and 32.8%. Durham City, Hexham and Northallerton show the largest non-umland based examinees. The two centres with the lowest percentage of non-umland examinees are Middlesbrough and Newcastle. These two extreme groupings provide a clue to the interpretation of table 7.11. The centres with the lowest internal population have the largest proportion of examinees who live outside the specific

umland. As the population of the centre itself increases so the non-umland examinee element decreases in proportion. Bishop Auckland is an exception to this generalisation and a further analysis of this case may help still further in interpreting the data.

Of all the centres in the driving test data, Bishop Auckland is the one which shows the closest alignment of its urban field to its umland. Also in this set of data Bishop Auckland's umland is more extensive in area compared with its specific umlands of any previous element. This explains why the non-umland interactions are so low but does not explain why this situation has arisen in driving tests. The answer to this may lie in the distribution of population around Bishop Auckland. With the strongest competition from the nearest centre, Darlington and Durham City to the east, Bishop Auckland developed its umland and urban field to the west where resistance/competition was potentially less. However, this western area is also the least populated area of county Durham and of the neighbouring counties of Northumberland, Westmorland and the North Riding. With little population, the chance of fringe examinees occurring from beyond the umland but within the urban field must be small (i.e. almost a centred region).

The greatest potential for these marginal examinees lies eastwards within the populated area of the Durham coalfield. But Bishop Auckland has in this element just dominated a number of previously marginal population units to the east of itself. For example, Newton Aycliffe and Sedgefield are shown in other

elements to be within the urban field but not the specific umland of Bishop Auckland.

It would appear that Bishop Auckland is an exception because of its power of attraction (the number of examiners in this element) being just sufficient in competition with [~]Darlington and Durham City in the area of greatest population density within its urban field, to dominate what would otherwise be marginal population units. These marginal population units in this element are within Bishop Auckland's umland. Three variables appear to be operating here, the differing powers of attraction of centres, the distribution pattern of the centres, i.e. the network, and the population distribution.

This analysis can be taken a step further at the general level. Table 7.12 shows the driving test centres in order of population size. As Middlesbrough and Redcar can not be separated at examiner level, they have been combined in this analysis. The number of examinees living within the centre and taking driving tests there (column A) has been divided into the remainder of examinees who were tested at that centre during the study period (column B). The last column (B ÷ A) is an index of the centre's power to operate outside itself over a potential umland and may be termed the external attraction index.

An examination of the population totals and the external attraction index by scatter graphs would show a clear break into two groups. The larger centres from Darlington (85,000) to Newcastle (300,000) show low external attraction indices of from 0.4 to 1.9. The smaller centres from Northallerton (7,000) to

Durham City (24,000) show higher indices from 3.7 to 12.8. The influence of the population of the centre itself upon its ability to compete with other centres across the intervening population units is demonstrated. Even Bishop Auckland fits into this pattern and when its external attraction index is compared with that of Darlington, its ability to develop a specific unland at the expense of Darlington is apparent and has already been shown in reality.

If the analysis of the Bishop Auckland situation with regard to non-unland examinees is reconsidered, further light is now thrown upon it. Durham City (4.3) Darlington (0.4) and Middlesbrough (1.4) all with lower external attraction indices than Bishop Auckland (5.8) are competing with Bishop Auckland at the margin in the Fishburn area. It was earlier shown that Bishop Auckland dominated this margin and suggested this was because of its greater power of attraction.

Centre	Population	A. Centre Interactions.	B. Other Interactions.	B ÷ A.
Newcastle	297,564	3223	2270	0.7
Sunderland	215,968	2134	943	0.4
Middlesbro/Redcar	188,855	2492	3438	1.4
South Shields	109,521	1244	1185	1.0
Gateshead	103,261	809	1509	1.9
Hartlepoons	94,808	1120	625	0.6
Darlington	85,089	1089	439	0.4
Durham City	24,153	379	1621	4.3
Bishop Auckland	18,465	243	1411	5.8
Hexham	9,910	185	692	3.7
Northallerton	6,726	112	1430	12.8

Table 7.12. Population of Centres and their effect on driving test interactions, 1966.

This has now been quantified and shown to be true. Further evidence is found for this in that Durham City with the second largest external attraction index at this margin, dominates the other parts of this marginal area.

Conclusions

The driving test data was collected so as to ensure that specific umlands could be clearly defined, for county Durham based centres. The length of time covered by the survey ensured adequate interaction totals.

Even so, at certain points, umland boundaries are indefinite. Further, even with sufficient interactions occurring within population units, marginal areas still appear. In general surgery it was argued that even with data for several years, interactions at the margins would still be proportionally small and still indecisive. The driving test data demonstrates this to be so. To test this hypothesis further, each centre for driving tests was mapped on the basis of each single month's data.²⁵ Thus four separate maps of a four month sequence could be studied. The result showed little variation in terms of the areal extent of the urban field of a centre from one month to another. Any one month was characteristic of the data as a whole. Hence margins would remain no matter how much data was available.

From this it was been possible to define specific umlands, calculate their populations and the number of interactions

(examinees) within centres, within umlands and within urban fields (i.e. total interactions). The correlations between umland interaction, umland population and total interaction have been statistically tested and found to be correlated at a highly significant level. This is a repeat of tests already made with other elements which produced similar results. The problem of defining an urban field in terms of total interaction and its distribution can be overcome by the use of the specific umland to which it is statistically correlated and which is more easily defined in terms of mapping boundaries.

A series of variables have also been shown to influence the pattern of umlands. The population distribution, the population of the centre itself, the power of attraction of a centre and the network of the centres have been shown to affect this pattern. The extent of the umlands for driving tests beyond the centre, depends in part on how much of the attractive power of a centre is used-up internally. The shape of the umlands is related to the network of centres and follows the line of least competition.

References

1. See the main findings of the National Travel Survey 1964 (Preliminary Report), Part II, 'Personal travel by public and private transport', (Ministry of Transport) 1967.
2. A good summary of American sources occurs in Mayer, Kohn and Wohl, 'The Urban Transportation Problem', (O.U.P.) 1965. 'The Buchanan Report, Traffic in Towns', gives much of the background plus a bibliography, to British thinking. The London Traffic Survey and the Leicester Traffic Survey are recent

additions in this field.

3. The author gratefully acknowledges the help of the Northern Divisional Road Engineer of the Ministry of Transport and the Clerk to the Traffic Commissioners, Northern Traffic Area for assistance in obtaining access to the data.
4. Personal communication with the Clerk to the Traffic Commissioners, Northern Traffic Area.
5. The author gratefully acknowledges the assistance of the staff of the Northern Traffic Commissioners Office in recording the data.
6. Personal Communication with the Clerk to the Northern Traffic Commissioners.
7. Idem.
8. This matter is still under consideration at the time of writing this chapter (1968) Personal communication with the Clerk to the Northern Traffic commissioners.
9. Previous definition has included Darlington and Hartlepoons within the broad Teesside area. See Chapter Four, page 66,
10. Personal Communications with the Clerk to the Northern Traffic Commissioners.
11. Idem
12. Idem
13. Idem
14. These figures on a monthly basis were made available by the Clerk to the Northern Traffic Commissioners.
15. See Chapters 5 and 4 respectively.
16. See Chapter 6.

17. With the Technical College element Shincliffe, just outside Durham City, has a higher interaction index than Durham itself with its own technical college, for example.
18. Fullerton B., 'The Pattern of Service Industries in North Eastern England', Newcastle 1960.
19. Personal communication with Ryton post office.
20. The ward data for the Ryton urban district was made available by the County Planning Officer, Durham County Council.
21. Personal communication with the Clerk to the Northern Traffic Commissioners.
22. Idem
23. Idem
24. All population figures quoted are taken from the 1961 Census.
25. This was done as a class exercise by Bede College geography students who have retained the maps.

8. TOWN REGIONS

As each element has been analysed the previous stages have made it possible to formulate problems more precisely and to suggest answers more positively. The total process ought to result in generalisations which are applicable across the whole range of the data. While each element may be unique in itself, if geography is to be more than mere description, generalisation should be possible showing some consistence at some level within all elements.

To help in this process of generalisation across the whole data, two town regions have been selected for study. The focus here is on the centre (the town) with its various functions, looking outward to its region. Sunderland is used as one example because it occurs in all the elements and has functions at all levels of possible hierarchies. Hartlepoons is the second example, As a centre it has only functioned at low levels and shown marked insularity. But in professional football where a hierarchy has been demonstrated, it exists as a low level function competing with two giant neighbours in Middlesbrough and Sunderland.¹

The picture is made complete by a study of a settlement in an area marginal to specific umlands. A sample survey was conducted of Bishop Middleham which is in the Mainsforth population unit near Ferryhill.² This part of county Durham has changed its umland centre of attraction several times. Bishop Auckland, Darlington, Durham, Hartlepoons, Middlesbrough, Stockton and Sunderland have all competed within this area at various times.³

Sunderland

An attempt has been made to map the 'growth' of Sunderland in terms of its specific umlands (see fig. 8.1). The functions of Sunderland as studied as elements have been ranked in order of their total specific umland populations (see table 8.1). Starting with the lowest ranking element, local technical colleges, a basic area was located on fig. 8.1.

Rank	Element	Umland Population	Rank	Element	Umland Population
1	Professional football	954,273	4	General Surgery	363,563
2	Ophthalmology	813,847	5	Driving tests	298,808
3	Regional technical college	409,993	6	Local technical college	284,609

Table 8.1. Sunderland's elements ranked by umland populations.

The umland of each element was then added in the order of rank from local technical college upwards. Some higher level specific umlands do show contraction at one or two points compared with the combined lower level umlands. To this extent the map is misleading in detail. But no specific umland is less in total area than the combined lower ranked elements to itself so that the error is small and generally insignificant.

What the map shows is the growth of Sunderland's specific umlands in terms of area as the power of attraction or the level of service of the elements increases. The basic area shows an initial tendency to grow just south of west and southwards from the town centre. This tendency continues in all the other elements.

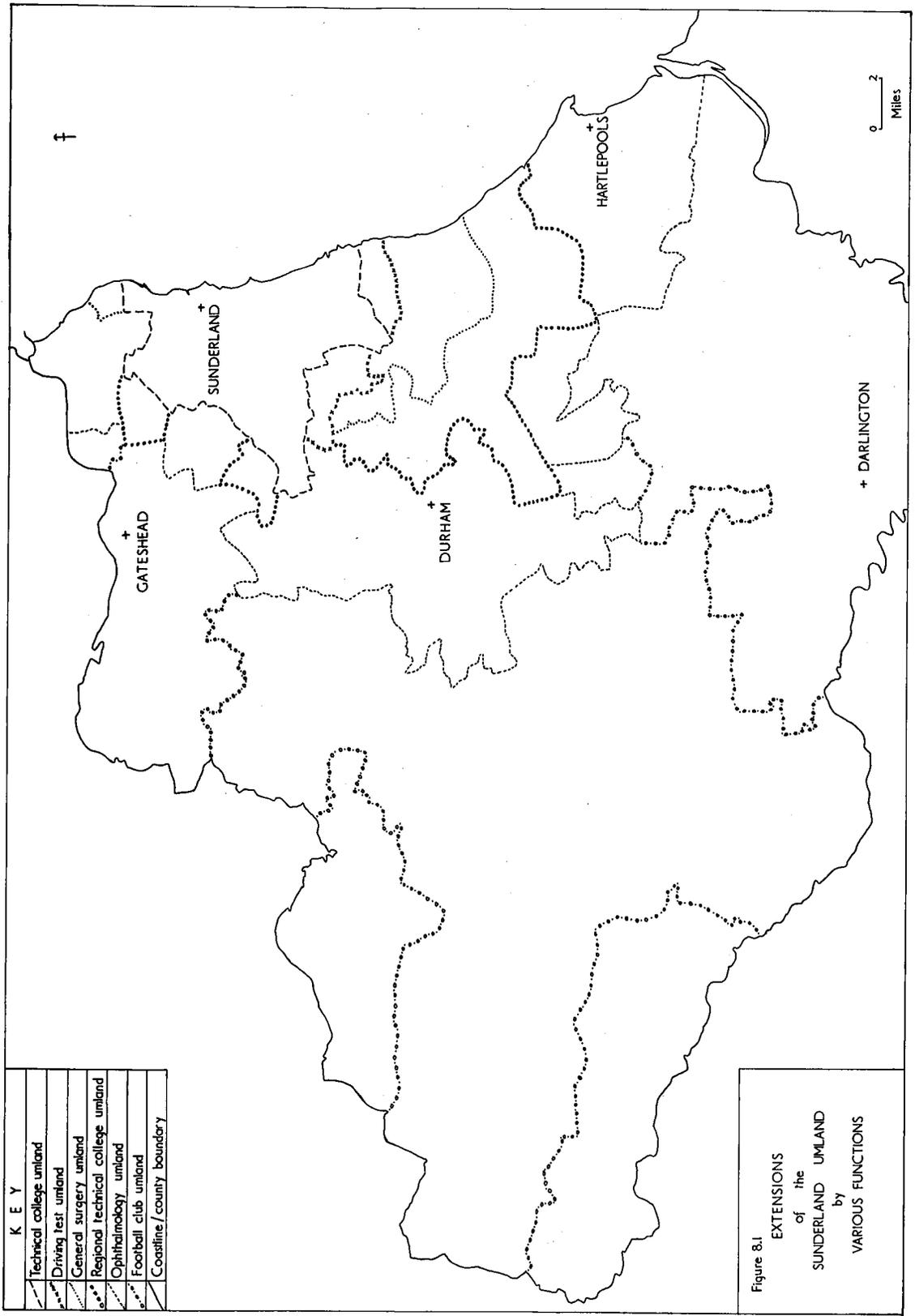


Figure 8.1
 EXTENSIONS
 of the
 SUNDERLAND UMLAND
 by
 VARIOUS FUNCTIONS

Small areas are added to the north and north west of Sunderland with each succeeding ranked element; to the south and west the areas added are much larger.

It was suggested in earlier chapters that the pattern of specific umlands was a response to the spacing of the centre network.⁴ That is, when centres are close together competition is intense and boundaries form at short distances from centres. When the centres are far apart, the result is expansion, the competition from close centres diverting extensions into areas where competition in terms of distance, is further away. If this is so, then in the case of Sunderland, professional football has the largest specific umland and so should have centres separated by the greatest distance and local technical colleges should show the shortest distance between centres, being the lowest ranked element. The elements inbetween should show average distances in a ranked order similar to the ranking order of elements by umland population.

Centre	Miles	Local Tech. Coll.	Driv- ing Tests	Gen. Surg. ery	Reg. Tech- Coll.	Ophth almo- logy.	Prof. Foot- ball.
Chester-le-Street	8	-	-	8	-	-	-
Darlington	27	-	-	-	-	27	27
Durham	11	11	11	11	-	-	-
Easington	10	10	-	-	-	-	-
Gateshead	8	-	8	-	-	-	-
Hartlepoons	17	-	17	17	-	-	17
Hebburn	7	7	-	-	-	-	-
Middlesbrough	25	-	-	-	25	25	25
Newcastle	11	11	-	-	11	11	11
South Shields	5	5	5	5	-	-	-
Total Mileage		33	41	41	36	63	80
Av. Mileage		8.3	10.3	10.3	18.0	21.0	20.0

Table 8.2. Distance of centres competing with Sunderland by elements.

This hypothesis is tested in table 8.2. The median point of the population distribution of each centre's population unit was located approximately. The geographic distances to the nearest mile were then measured between median points of centres. From the specific umland maps the centres in direct competition with Sunderland in each element were obtained i.e. they had a boundary they shared with Sunderland. The mileage of each competing centre with Sunderland for each element was totalled and divided by the number of centres to give the average distance. The result shows a close relationship between the ranking of elements by umland population and ranking by average distance. The failure of professional football to be joint first with ophthalmology is because Hartlepool, although in a different level of the hierarchical structure in professional football, is included in the specific umland map. This is the equivalent of including the general surgery unit of say Stockton-Sedgefield on the ophthalmology map. Being a low level function it would be anticipated that it would be close to other centres, as it is in reality, and so it would reduce the average difference. Hence the shapes of the specific umlands of a centre are shown to be related in part to the centre network with the distance factor operating.

It was also suggested in earlier chapters that the response to competition and the shape of the specific umlands is related not only to the network of centres but also to the population distribution.⁵ In fact, all three would appear to be related. Centres are closest together where population is densest. This is a response to potential demand. When the population

density is low, then the potential demand is low and centres are more widely spaced. If this is applied to Sunderland's unlands then for a given distance, say sixteen miles, the population density should be greatest north of Sunderland, least south of Sunderland and would be between these two extremes west of Sunderland. Figure 8.2. shows what happens in reality. Each population unit on a section line has been measured for distance from its median population point to Sunderland and the population plotted as a cumulative total from Sunderland. The result is a steep slope i.e. a large number of people living there, for the sixteen miles north of Sunderland compared with the sixteen miles west and westward the slope is steeper than for the section line to the south of Sunderland. Population density does vary with the pattern of the network and specific unland shape.

It is difficult to comment upon the hierarchical groups of the elements studied at Sunderland. In terms of their respective unland population totals a ranking list is possible. To compare them in more absolute terms and decide whether they themselves form a hierarchy or continuum is difficult. This problem is illustrated by table 8.3. The interaction index indicates the number of people needed within a population unit to provide one person involved in the element being studied. Hence professional football requires overall 142 people living within Sunderland's specific unland to result in one season ticket holder. The higher this index the more specialised or high level the service or element. While professional football and ophthalmology provide the two highest level elements

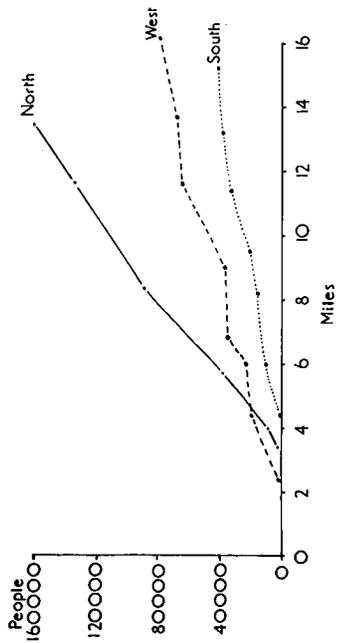


Figure 8.2 CUMULATIVE POPULATION TOTALS for SECTION LINES from SUNDERLAND

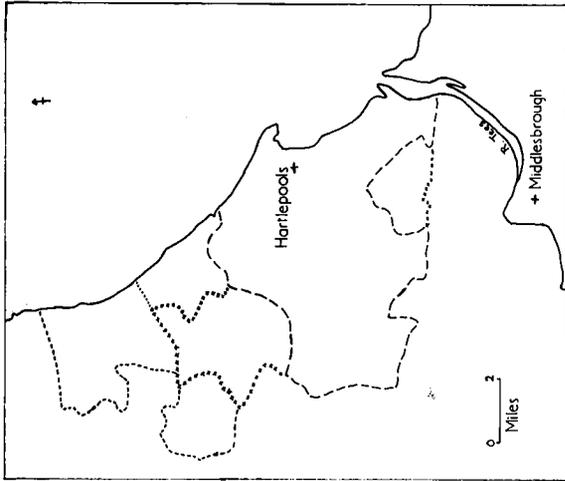


Figure 8.3 EXTENSIONS of the HARTLEPOOL UMLAND by VARIOUS FUNCTIONS

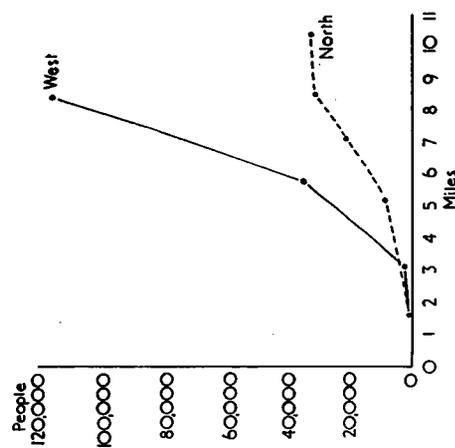


Figure 8.4 CUMULATIVE POPULATION TOTALS for SECTION LINES from HARTLEPOOL

studied at Sunderland, their respective umland interaction indices are very different. It needs three and a half times as many people to produce one ophthalmic case in Sunderland than to produce a football season ticket holder. A further problem is the length of time over which the data is collected. Driving tests were studied for a four month period while all the other elements were studied over a twelve month period. This can be corrected. In 1966 Sunderland had 8116 driving test examinees.⁶ Hence the interaction index can be divided by 2.6 to give a comparable index for one year (figure provided in bracket on table 8.3). Further, can a valid comparison be made between data on local technical colleges for the 1963-4 academic year and ophthalmic cases for 1965?

In theory the high level elements, because they provide specialised services, should require a high total population base (interaction index) for one person to be involved in that service. Using the adjusted driving test interaction index this is seen to be generally true of table 8.3.

Element	Total Interaction	Umland Interaction	Interaction Index
Professional Football	6703	954,273	142
Ophthalmology	1591	813,847	512
Regional tech. College	6064	409,993	68
General surgery	6509	363,563	56
Driving tests	3077	298,808	97 (37)
Local Technical College	6064	284,609	47

Table 8.3. Interaction indices for umlands of all elements for Sunderland.

When it is remembered that the technical college data is a total

of students at a centre and not stratified by courses, the lack of contrast between these two levels of services is accounted for.⁷ Similarly professional football sets an internal hierarchical problem. Darlington and Hartlepool are necessary to define clearly the Sunderland professional football unland but they provide a lower level of service than Sunderland.⁸ Sunderland must operate at both this low level and as a top (first or second division) team. Yet it is not possible to separate these two levels of service from the Sunderland professional football data.

All these complications within the data make generalisation upon the hierarchical structure in terms of the combined elements at one centre, very difficult. But the general trend is apparent in table 8.3. and agrees with central place theory. Where direct comparison is possible as in the hospital services, even with a year's difference in the date of collecting the data, the difference between the high level ophthalmology service and the low level general surgery is very clear.

Element	Service Centres
Professional football (top clubs)	1
Professional football (all league clubs)	3
Ophthalmology	2
Regional technical colleges	1
General surgery	13
Driving tests	7
Local technical colleges	11

Table 8.4. Centres available for each element, within the geographical county of Durham only.

In some ways a measure of the level of a service is provided by the number of centres available for that service (see table 8.4). A large number of centres suggests a low level service or function which must be provided locally. But even this is only a rough guide. Table 8.4 suggests a division into three regional and three local services. It might be argued that there is a clear break here and so there is evidence of a hierarchy of services. However if table 8.3 is studied, it suggests only two high level services. An already suggested the data is too complex in itself in terms of variables as between and within elements to make any firm statement about the hierarchy/continuum problem possible.

Sunderland presents a picture of a regional centre on the estuary of the river Wear. As the power of attraction of elements appear to increase, so do the specific umlands in both area and population. The direction of 'growth' is related to the network of centres operating in any one element and the population distribution. This results in Sunderland's case in specific umlands extending to just south of west and to the south of the town. This in fact follows the line of the river Wear valley and almost extends to the southern limits of the coalfield, keeping the east Durham limestone plateau within the area of service.

Hartlepoons

At no stage of the analysis of the elements has it been suggested that Hartlepoons is anything more than a local centre. This is clearly shown by the range of specific umland populations for the four elements that operate with a centre at Hartlepoons (see table 8.5).

Rank	Element	Umland Population
1	Driving tests	155,051
2	General Surgery	119,663
3	Professional football	108,221
4	Local technical college	99,030

Table 8.5. Hartlepoons' elements ranked by umland population

The difference between the top and bottom ranked elements in umland population is 56,021 people. For Sunderland this difference is 669,664 people or twelve times the Hartlepoons' difference. The elements that do operate at Hartlepoons all occur as low level elements at Sunderland with the exception of professional football. The internal hierarchical problem of football results in a low level function at Hartlepoons.

Figure 8.3. shows the 'growth' of the Hartlepoons specific umlands. Constructed in a similar way to that of Sunderland (fig. 8.1), it shows expansion in order of the ranked elements. The basic area is the specific umland for the local technical college and covers the built-up area of Hartlepoons borough and the immediately surrounding rural area between Hartlepoons and the coalfield to the north west and Hartlepoons and the built-up area of Stockton-Billingham to the south west.

Expansion is north westwards onto the coalfield and along the coast. If this expansion conforms to the suggested general pattern, then the average mileage between centres should increase with the elements in their ranked order. Table 8.6. shows that this does in fact happen. The Sunderland situation is repeated. It should

follow from this that the population density should be greatest to the south west of Hartlepoons compared with the north west for a given distance, say ten miles in this case. Figure 8.4 shows the cumulative population totals along lines of section from Hartlepoons and demonstrates the line of least density of population in north westwards.

Centre	Miles	Local Tech. College	Prof. Foot- ball	General Surgery	Driving tests
Bishop Auckland	18	-	-	-	18
Durham	16	-	-	16	16
Easington	7	7	-	-	-
Middlesbrough	9	-	9	-	9
Sedgefield	9	-	-	9	-
Stockton	11	11	-	11	-
Sunderland	17	-	17	17	17
Total Mileage		18	26	53	60
Average mileage		9	13	13.3	15

Table 8.6. Average linkage of centres competing with Hartlepoons by elements.

This analysis based upon a centre ignores the differing powers of attraction as between centres. Earlier chapters have stressed this and it must be remembered if a complete picture of a town functioning in a regional network is to be appreciated. From a centre/town view point some attempt to rank services (elements) is the nearest approach to the variable power of attraction question. As with Sunderland, this presents difficulties as the data for one element is not strictly comparable with that of another. This problem is illustrated by table 8.7.

Element	Total Interaction	Umland Population	Interaction Index
Driving tests	1745	155,051	89(34)
General surgery	2430	119,663	49
Prof. Football	327	108,221	331
Local technical college	2571	99,030	39

Table 8.7. Interaction indices for umlands of all elements for Hartlepoons.

Apparently the most specialised service offered at Hartlepoons within the limit of the elements studied is professional football. Yet this is third in the ranking order of elements. If driving tests are adjusted to cover a year period instead of four months, they become the most used service with a test to every 34 people within the area of the specific umland.⁹

The conclusion to be drawn from this is that the suggestion of earlier chapters that Hartlepoons functions only as a low level centre, must be accepted. Hartlepoons serves a peninsular area between the North Sea and the Tees estuary, limited by the coalfield margin to the north west and the Stockton-Billingham built-up area to the south west.

Bishop Middlesham

In several elements it has been suggested that there are marginal areas. The occurrence of outliers away from the main umland area in the regional type elements initiated discussion of this problem. It was shown that they were not exceptional but really only part of a general weakening of the power of attraction of a centre at a critical point.¹⁰ This critical point was near the

equilibrium or point of balance in the attraction of two or more centres. Once greater numerical data was available in the more local elements, it was suggested that marginal zones did exist.¹¹ Here people were being almost equally attracted in more than one direction. As the power of attraction of centres and their networks varied between elements, so the people in these marginal areas changed their dominant movement from one centre to another. This situation is most intensively developed in the Mainsforth population unit.¹²

To test this situation further a sample survey was carried out in 1966 of households in Bishop Middleham.¹³ Some 8% of households were interviewed and some of the results are shown in table 8.8. The centres shown are the main ones that have appeared in the descriptions of elements.

Centre	Cinema	Dentist	Shopping	Solicitor	Swimming Baths
Bishop Auckland	-	-	9	3	-
Darlington	1	-	7	1	6
Durham	3	-	3	-	17
Ferryhill	6	1	10	18	-
Middlesbrough	-	-	2	-	-
Newcastle	1	-	5	1	-
Spennymoor	1	21	10	-	-
Stockton/Billingham	10	2	32	1	2
Sunderland	-	-	5	-	-
TOTAL REPLIES	22	28	83	27	25

Table 8.8. Some results of the sample survey of Bishop Middleham, 1966

Some of the services listed are available at nearby villages but these are ignored in the column of centres. However, the total

replies line does give some indication of the extent of the operation of other centres and provides a figure by which to judge the dominance of the major centre of attraction.¹⁴ Stockton appears as the main centre in two of the five elements listed. The other three each have a different centre. If the elements studied in earlier chapters are added to this already varied pattern, the result shows a settlement without any orientation towards a nearby larger settlement. It is truly marginal.

This statement is further reinforced by a similar study of a settlement which is far from marginal. In 1966 a sample survey of about 40% of the households living at White-le-Head was made.¹⁵ This settlement is just north west of Stanley in an area which has maintained fairly consistent boundaries throughout the elements. It is an area centred on Consett within north west Durham.

Centre	Cinema	Dentist	Shopping	Solicitor	Bank
Chester-le-Street	-	-	13	-	-
Consett	7	2	23	-	4
Gateshead	-	4	2	-	-
Newcastle	12	-	41	-	-
Stanley	15	38	89	20	37
Sunderland	-	-	8	-	-
Total replies	34	44	193	20	41

Table 8.9. Some results of the sample survey of White-le-Head, 1966.

This being so, any survey of White-le-Head should show a dominance of either Stanley or Consett. Table 8.9. sets out basically comparable data to that of the Bishop Middleham survey. It shows clearly the attraction to Stanley for all services studied. Three

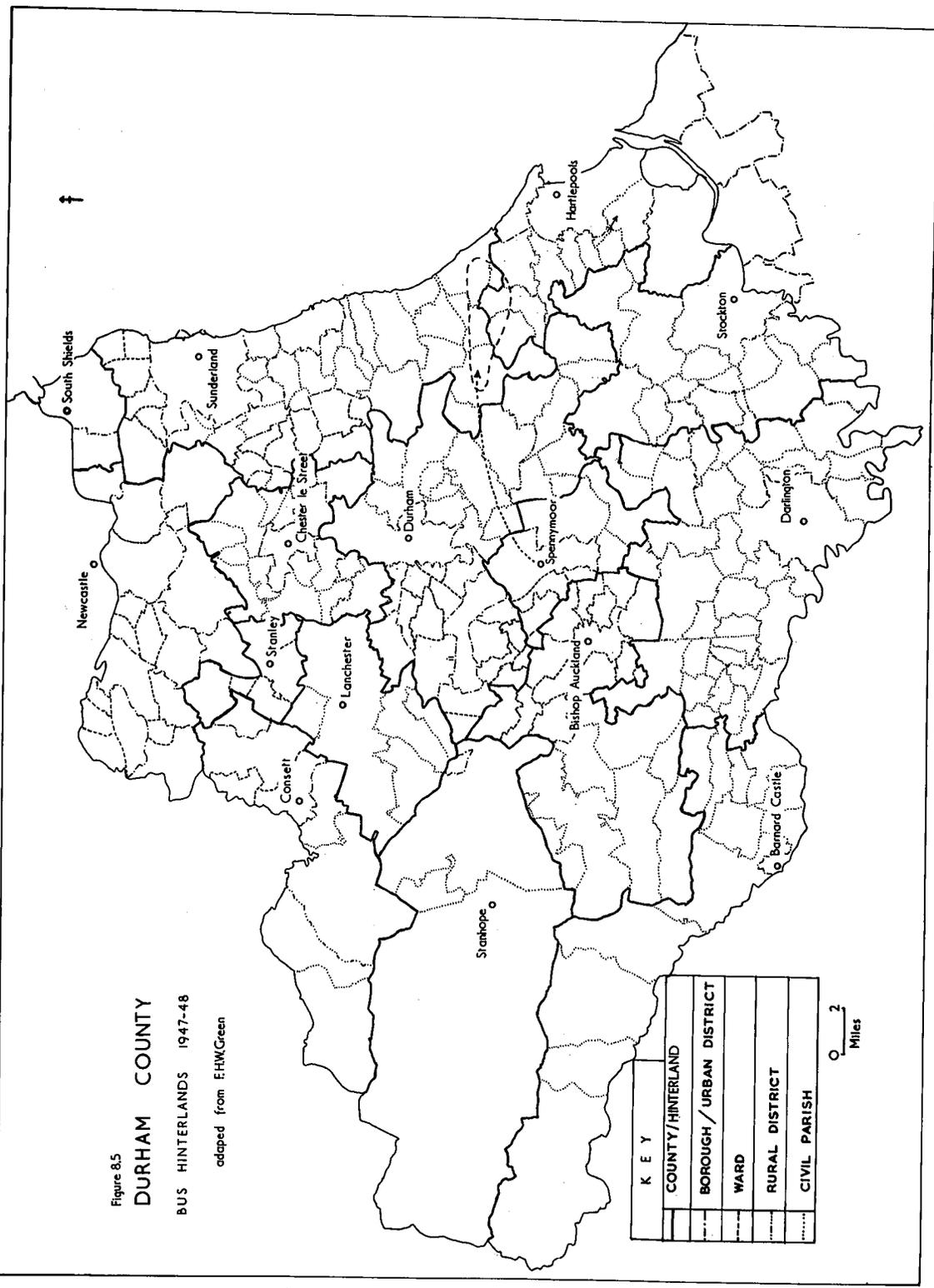
of the services show over 50% attraction to Stanley. Even with cinema and shopping, where provision is inadequate compared with Gateshead and Newcastle, Stanley was still able to compete with these larger centres though on a minority total in these cases. The comparison with Bishop Middleham is clear and the marginal nature of that settlement further demonstrated.

Field of Attraction

In the first chapter a problem was stated. It has led to a search for one element or function by which fields of attraction could be delimited. Mention was made initially of F.H.W. Green and bus hinterlands.¹⁶ Green suggested that they provided the basis of defining urban hinterlands - or umlands in the context of this study. Figure 8.5. shows an attempt to superimpose Green's bus hinterlands on the population units used for this study. Certain problems arise at once. Gateshead is in an obvious omission from the map, especially when places such as Lanchester and Stanley appear as centres. A number of centres appear that have not appeared in the elements of this study e.g. Bowes, Lanchester, Stanhope and several are given centre status and have only one mention in the elements already studied e.g. Chester-le-Street, Spennymoor.

The bus service of 1947-8 provide an interesting case of specific umlands which are comparable with elements already studied. Their network creates its own problems with its own solutions. From the analysis of the elements of this study thus far the author would content that the search for a single element to provide a pattern of specific umlands acceptable for all services is a

Figure 8.5
DURHAM COUNTY
 BUS HINTERLANDS 1947-48
 adapted from F.H.W.Green



K E Y	
[Solid line]	COUNTY/HINTERLAND
[Dashed line]	BOROUGH / URBAN DISTRICT
[Dotted line]	WARD
[Dash-dot line]	RURAL DISTRICT
[Thin solid line]	CIVIL PARISH

0 2 Miles

search for a 'will-of-the-wisp'. The evidence suggests rather that the umlands vary according to the number of centres involved and their varying power of attraction. Even if elements of the same apparent level of service are considered, just one difference in the distribution of centres or slight variations in the distribution of powers of attraction can result in different patterns of umlands. Specific umlands must be treated as a continuum which is highly variable rather than being hierarchical with each hierarchical level having fixed specific umlands.

There do appear to be core areas for town regions which are the areas usually defined as a town's umland.

Both Hartlepool and Sunderland show such core areas but their value must be questioned. For people planning ophthalmology or professional football, what value is the core area of Sunderland (see fig. 8.1)? Its population is far too small to give a reasonable figure upon which to base predictions or calculate any possible present use of facilities. The margin to the core of Sunderland has a population of 669,664 people on the basis of the elements studied. This is nearly three times the population of the core area, which is the specific umland for the technical college. Even Hartlepool with its core population of 99,030 people has a marginal population outside its core which rises to 56,021 and Hartlepool is an insular centre.

This raises the question of threshold values.¹⁷ The hospital service illustrates this and it has already been suggested that the general surgery units at Easington and Stanley are not viable units.¹⁸ They lack sufficient population to justify their existence locally.

We know how many people are required within an umland to provide one patient a year, and this is the interaction index. What is needed is to know how many patients a year justify the existence of a general surgery unit. The interaction index for ophthalmology, for regional technical colleges, for driving tests are different to the general surgery index. Hence their threshold values will differ. The possible link between interaction index, umland population and the calculation of threshold values will be examined in part two of this thesis.

A further complication of this problem has been suggested. There is evidence to indicate that a centre has a particular power of attraction - number of technical college courses, number of hospital beds - partly dependent upon its own internal demand.¹⁹ This is satisfied first and what is left over provides the power of attraction outside the centre to compete with other centres for an umland. This explains Sunderland having so many hospital beds in comparison with Durham City for example, or driving test examiners compared with Hartlepoons and yet, while apparently being such a powerful centre, having a comparatively limited umland.

The Distance Factor

The description and analysis of the coal mining journey to work has been omitted so far in this summary of the elements. With 84 collieries in that analysis the network of centres was very dense and the type of analysis and description applied to other elements was not entirely appropriate. It was simplified into man-power areas which did give a network of centres more akin to

the other elements.

The two main points from the coal mining analysis can be summarised as follows. Firstly it demonstrated the influence of the distance factor with the rapid fall-off of interaction beyond about six miles. Secondly it showed the influence of historical factors in modifying the present patterns of journey to work. The former type of analysis can be applied to the other elements and plots made of the rate of change in interaction by ring sector distances. Figures 8.6-9 show such plots for Sunderland and four of its elements. A fall-off point occurs after an almost linear relationship from the centre itself. The position of the fall-off point varies with the level of service considered. The technical college and driving test elements shows a fall-off at about six miles, paralleling the coal mine journey to work.²⁰ The technical college graph (fig. 8.6) shows a secondary fall-off at about twelve miles. When one remembers that this set of data includes all courses, local, area and regional, then the second fall-off point may be the break in a high level function compared with the low level function courses 'break at about six miles.'²¹

The football club shows a fall-off from twelve miles and ophthalmology has a very gentle slope with a fall-off at about eighteen miles. The fall-off point shows some relationship to the level of service, local services have an effective range of about six miles while the higher level regional services have an effective range of between ten and twenty miles. That this range is an average figure is demonstrated by the shape of umlands. In different directions the effective range of a service can vary.

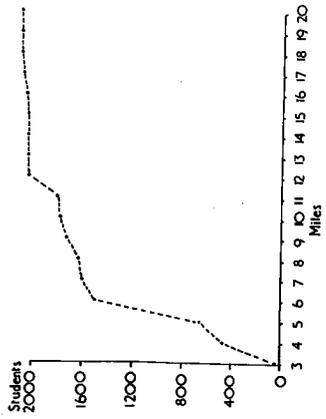


Figure 8.6 SUNDERLAND TECHNICAL COLLEGE STUDENTS by MILE UNITS from SUNDERLAND

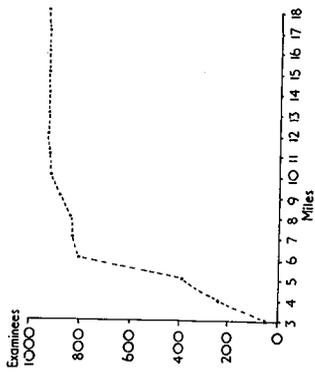


Figure 8.7 SUNDERLAND DRIVING TEST EXAMINEES by MILE UNITS from SUNDERLAND

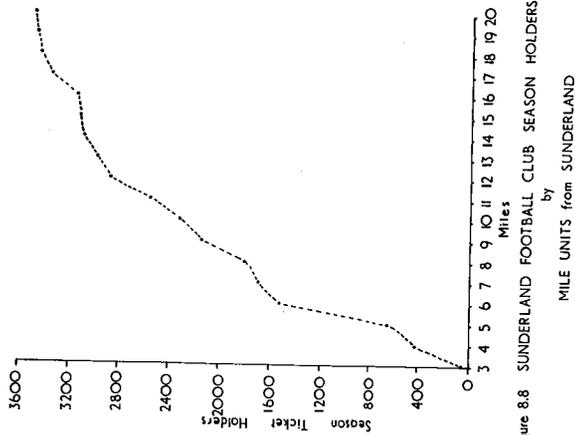


Figure 8.8 SUNDERLAND FOOTBALL CLUB SEASON HOLDERS by MILE UNITS from SUNDERLAND

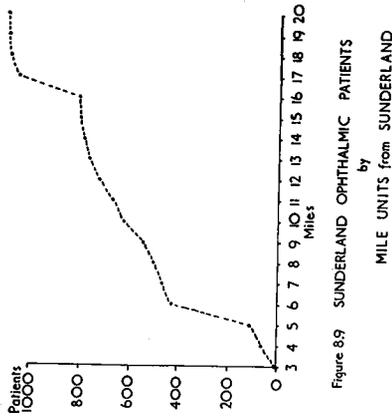


Figure 8.9 SUNDERLAND OPHTHALMIC PATIENTS by MILE UNITS from SUNDERLAND

Again Sunderland provides an obvious case. Eastwards from Sunderland is the North Sea. To the north South Shields provides effective competition at local level within five miles of the centre of Sunderland (see table 8.2). Southwards Hartlepool provides the effective competition in some elements at a distance of seventeen miles from Sunderland. Sectoring is effective in fact. This will influence the rate of fall-off and so the slope of cumulative interaction in any direction. Figures 8.6-9 are really the average rate of change of interaction by distance for their respective elements from Sunderland. As such they may provide a useful concept in any attempt to generalise about town regions, but have limitations in terms of locating actual umlands on the ground.

One final point is worth noting. The distances involved are very short. Most studies of movement for work, shopping, or use of various services have been concerned with centres at tens of miles apart. Durham as a geographical area presents a network of closely located centres. Hence results obtained from this study may not be applicable elsewhere because of the short distance measures involved which are usually within a ten miles radius and rarely more than twenty miles.

Conclusions

Part one of this study has been concerned with the description of real situations in the distribution patterns of specific umlands. An analysis of this empirical data leads to the conclusion that a set of variables are operating throughout the data. These are the power of attraction of a centre, the population of the centre

itself, the network of the centres, the population distribution and the level of the service being provided. A statistical relationship has been established within individual elements between total interaction with a centre, the population of the specific umland and interaction within the specific umland.

These conclusions need to be put into some general system. It might well be argued that they are unique in time and space. Here Green's map of bus hinterlands in 1947-8 is interesting (see fig. 8.5). Given the effects of his network of centres, some towns such as Darlington, Hartlepoons, South Shields and Sunderland had umlands very similar to those just analysed some fifteen years later. Further, the elements studied are diverse and have no links. The Regional Hospital Board is unaware of the workings of the technical colleges, and the Northern Traffic Commissioners have no contact with the professional football clubs. Hence the fact that within the same landscape area such diverse activities show some common ground encourages an attempt to formulate a general system.

The uniqueness in space can only be answered by comparative studies. If a general system is established for county Durham and other workers have shown a similar system to be working elsewhere, uniqueness in space will have been disproved. While this will not be attempted in any detail, it will certainly be considered in part two.

References

1. See Chapter 2, page 33.

2. This survey was made possible because of the help of Geography students at Bede College. The author gratefully acknowledges their assistance.
3. This is well shown by reference to the specific umland maps of Chapters 2 to 7.
4. See Chapter 5, page 133 and Chapter 7, page 196.
5. See Chapter 7 page 196.
6. Personal Communications with the Clerk to the Northern Traffic Commissioners.
7. See discussion of this point in Chapter 4, pages 74.
8. See table 2.5 page 37.
9. The index of 2.6 is used to adjust from a four month very active period to the whole twelve months of 1966. This follows the Sunderland example.
10. See Chapter 3, pages 50.
11. See Chapter 4, pages 93-4.
12. The specific umland maps of each chapter illustrate this point.
13. A sample frame was obtained from the electoral register. Every 10th household was visited. No replies and refusals reduced the sample to 8%. This is an acceptable statistical number.
14. Number of replies in each column varies because some households had not used some of the services listed. The shopping total is high because it combines three items.

15. Watson, T., 'A Study of the urban field of Stanley', unpublished thesis submitted for the Teachers Certificate Examination of the Durham University Institute of Education, 1967.
16. Green E.H.W. op. cit.
17. This item has never been fully defined in Central Place Theory. The analysis of the elements appears to the author to make possible a precise definition of threshold values, to be attempted in part two.
18. See Chapter 5, pages 115-6.
19. See Chapter 7, page 199.
20. See Chapter 6, page 144.
21. For similar features in shopping see:
Thorpe and Nader, 'Customer Movement and Shopping'
Centre Structure: a study of a central place system in
Northern Durham', Regional Studies, Vol. 1., Oxford 1967.

PART TWO

9. CENTRAL PLACE THEORY AND SOCIAL PHYSICS

Introduction

The object of part two of this thesis is to discuss a model which may explain the spatial patterns discussed as an empirical analysis in part one. This requires two stages, the recognition of variables which can be built into the model and some understanding of the motivation of the individuals within the population involved in the patterns already outlined.

The variables have in fact already been suggested. The question asked at the beginning of this study was, what are the town regions of County Durham and how do they compare with each other as between different services. To answer this, information was collected about journeys from settlements to centres and about the level of service available at the centres. So by the very nature of the initial exercise data is available about the population at each settlement or population unit involved in using a service and the level of a service at a centre. From maps and population census data¹ it is possible to add to this the total population of a population unit, the geographic distance of a population unit from the centres providing the service and the distances of centres within a particular service from each other. These then are the variables to be built into the model. It will be possible to add data on the varying level of services for some of the elements but as pointed out in chapter eight this is not easy for the whole.

range of data.²

Individual motivation is the concern of psychologists and by the nature of the original question asked, no data were directly collected on this aspect of the patterns. However the question why people do driving tests or go to technical colleges was asked of administrative officials. One example will suffice. Driving tests are taken by people who possess or have access to a vehicle. This may, inter alia, be privately owned or owned by an employer and driven as part of a person's employment. The total population over seventeen years of age is the potential driving test population. A decision is made by some individuals within this total population which results in their applying for and taking a driving test. They now become part of the driving test population or involved population as opposed to the total population.

The next stage is the selection of the test centre. A variety of reasons for a particular choice are possible - a driving school recommendation, the nearest test centre, near to place of employment, a friend's recommendation or a belief that it is easier to pass the test at one centre compared with others.³ One of the basic reasons for this study is to see if people tend to minimise their travelling distances and so give high priority to taking a test at the nearest centre. This is illustrated in table 9.1.

INDIVIDUALS	a	b	c	d	e	f	n
1	✓	✓	✓	✓			
2	✓	✓	✓		✓	✓	
3	✓	✓		✓	✓		
4	✓		✓		✓		
5	✓	✓	✓	✓			
X	L	L	L	A	A	S	

Table 9.1. Theoretical tabulation of factors influencing individual decisions.

Note that line X is a total line with L meaning large total, A average total and S small total.

A number of factors a to n are considered by X number of people. Each individual (1, 2, 3... X) considers only a number of these factors and these are the ones of which he has personal knowledge.⁴ When the total of individuals considering any particular factor is obtained, the factors can be ranked (L, A, S).

Two points follow from this theoretical analysis. The highest ranked factors would give a set of variables which would help to explain the patterns of interaction in space resulting from X number of decisions. It is hoped that the variables listed earlier which are available from the data will be in this grouping and so provide a meaningful statistical analysis. It is clear that any spatial pattern resulting from a decision mechanism outlined in table 9.1 will be of a probabilistic character rather than a deterministic one.

Social Physics

It is now possible to discuss which of the many lines of statistical analysis to adopt. A wealth of literature is now available on this topic and in the end any choice is dependent, inter alia, upon the data available, the resources available, and the time available.⁵ The gravity model, intervening opportunity model and various stochastic models could be used. The gravity model would appear to have limitations in that it is deterministic in terms of behavioural assumptions. Olsson⁶ has shown however that it can be thought of as a simple regression analysis with

$\log \frac{I_{ij}}{P_i P_j}$ as the dependent variable and $\log D_{ij}$ as the independent variable where I_{ij} = interaction between places i and j

P_i and P_j = sizes of places i and j

D_{ij} = distance between i and j

This model can be made into a stochastic model by the addition of other variables which made the behavioural pattern probabilistic. Hence a model can be developed using multiple regression with the general form,

$$Y = a + b_1 X_1 + b_2 X_2 \dots b_n X_n$$

where Y is the dependent variable and is related to the involved population and $X_1 \dots X_n$ are the independent variables of which one is distance.

The variables that can be fed into this model have already been established. However a general theory of a spatial nature is still required within which to establish the relationships of these variables. This must obviously be linked to central place theory and has already been determined in part by the empirical analysis and the use of the interaction index. Here the numbers of people going to a particular centre for a driving test for example, are related to the total population of the population unit from which they originate. Hence a population unit has several interaction indices. With driving tests it has actual values for each of the centres that people used. It has also a similar set of indices for each of the services studied. Using these values it is possible to show that each population unit has a potential interaction index for each centre within a set of given services. The data shows that these indices increase rapidly with distance from a centre and in fact have a logarithmic form.

This means that a social physics model such as that outlined by Stewart and Warntz, fits the data.⁷ The basis of this theoretical form is derived from physics. A magnet has a power of attraction which creates a magnetic field around it. A series of magnets of varying power have magnetic fields around them each capable of attracting a magnetic body. This gives a set of scalar values similar to the interaction indices. In practice, in physics, a magnetic body will move according to the law of moments to a particular magnet. This movement gives a new value, a vector value. The actual interactions observed in the data are forms of vector values. However, if the magnetic body is replaced by a population unit then a modification of the physics analogue becomes necessary.

A population unit has a number of individuals who will form the involved population of a particular service. Whereas in physics all the 'involved population' i.e. the magnetic body, would move to one magnet, in social physics the involved population divides into small groups and moves to various centres. Instead of a deterministic situation, a probabilistic spatial pattern results. Further this stochastic system allows for an element of randomness to enter the spatial pattern and for a potential interaction to occur at a great distance i.e. the individual who never does the expected.⁸

In the examination of driving tests, it has already been noted that urban fields can extend well beyond the specific unlands. Further, occasional interactions are recorded which are with unexpectedly distant places.⁹ At Newcastle the interaction index is 92 i.e. for every 92 people present in the population unit, there

was one person involved in driving tests during the period of study. At Carlisle the index was 35,556 some 58 miles by road from Newcastle. Assuming a logarithmic rate of change both in interaction index and distance, the London area at a distance of about 300 miles would need a population unit of several millions to give one interaction. This in fact happens. Greater London with some eight million people in 1961 forms a population unit which shows two interactions with Newcastle.¹⁰ This principle can be extended to the whole world to show potential interactions, although actual interactions have a random element. i.e. not every population unit postulated need interact at any particular moment in time.

This theoretical explanation also helps in understanding some observations made in general surgery. There was evidence of patients from foreign countries in that data.¹¹ They were ignored as being statistically insignificant at the time but the theory of social physics as outlined does provide an explanation of this apparent anomaly.

The dependent variable of the analysis is therefore the logarithm of the interaction index. This is related to the total population of a population unit and the number of people within that population unit who go to a particular centre for a particular service. This can be expressed in the form $\log \frac{P_i}{I_{ij}}$ where P_i is the total population of a population unit i and I_{ij} is the observed interaction of a population unit i with a centre j in a particular service.¹²

Base Units

The original data was collected with settlement locations for each interaction. An initial set of units based upon built up areas resulted. When the population of each census area was added to the data, agglomeration was necessary. Some settlements were crossed by the census area boundaries and the settlements of the two census areas were combined. On this basis population units were built up.

When the concept of the interaction index was applied to this grid of units, a further problem arose. This is implied in the discussion above concerning potential interaction at a distance. In all cases the lowest interaction index occurs either at the centre or in a nearby population unit. From here the index is likely to increase outwards.¹³ At Darlington for example the driving test interaction index for the town itself is 78. Just west of Darlington are several small parishes which form potential population units. The interaction index here (around Piercebridge) is about 90. As several of the parishes have a population of less than 90, they have a potential interaction of less than one person (see table 9.2). While this is acceptable in theory, in practice it is impossible. The population unit must have a population greater than the interaction index.

PARISH	POPULATION	INTERACTION.	PARISH	POPULATION	INTERACTION
Archdeacon Newton	65	-	Low Coniscliffe	321	1
Denton	79	-	Piercebridge	157	10
High Coniscliffe	266	2	Summerhouse	86	-
Houghton le Side	59	-	Walworth	182	1
Killerby	55	-	Total	1270	14

Table 9.2. Parishes within the population unit of Piercebridge, driving test data.

Agglomeration resulted in the Piercebridge population unit of 1270 and hence one large enough to measure realistically the relationships between population and movement. Even so, within the grid of parishes that make up this population unit the distribution of the involved population is uneven (see figure 9.1). It is densest by the river side (southern edge) and shows an apparent random interaction in the north.¹⁴ This is also the pattern of the population distribution over the area.

In fact if population units are simply based upon administrative units without agglomeration, the resulting distribution of interactions is simply a population density pattern. The administrative units with large populations show interactions while the units with small populations show single or no interactions.

Also the greater the distance from a centre, the larger must be the population base of the population unit (see fig. 9.2). If the population is less than the interaction index, a zero interaction in one unit will be balanced by actual interaction in another. Again the Piercebridge example illustrates this. Here is the basis of the principle of continuity mentioned in part one. If each population unit does increase in population size outwards from a centre, then a town such as London is large enough in terms of population at a distance of 300 miles to be a viable population unit for town region services studied in this thesis in County Durham. It will also be continuous with other large population units lying between it and north eastern England.

From this it follows that each centre for each service ideally requires a separate grid of population units. Their population size



Figure 9.1 AGGLOMERATED PARISHES OF THE
PIERCEBRIDGE POPULATION UNIT
WITH DRIVING TEST INTERACTIONS

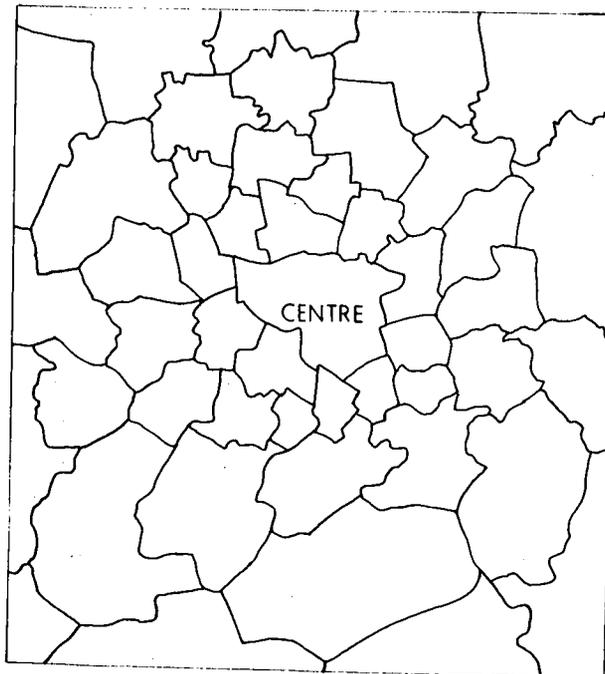


Figure 9.2 THEORETICAL PATTERN OF POPULATION UNITS
FOR A CENTRE
Note this is based upon part of south west Durham and
and assumes an even population distribution

should increase outwards from the centre to give a pattern of continuous interaction, in theory, over the world. This amounts to a map transformation with the intervening population by distance from a centre being the criterion for deciding the spatial size of units.¹⁵ However this study is limited to County Durham and as a result the distances involved are fairly short with few journeys over 20 miles. Thus it is possible to provide a grid of population units which are sufficiently large in terms of total population to give fairly continuous interaction with a centre, spatially, and yet provide a dense enough network or grid of units to give precision to spatial analysis.

Specific umlands and urban field effects

It was established in part one of this study that the shape of specific umlands depended upon the location of competing centres and the population distribution. To study this in the present context three examples have been chosen (figures 9.3-5). Within driving tests, Gateshead has an elliptically shaped umland with the centre at the north eastern end of the long axis. Darlington as a driving test centre has an almost circular umland. These provide a geometrical contrast within one service. Sunderland's ophthalmology is the third example used because it has a complete umland boundary and is at a higher hierarchical level of service compared with driving tests.

From figures 9.3-5 it is possible to see what is happening in terms of the interaction index both within specific umlands and outside them. No matter what the shape of the specific umland or

K E Y	
	Umland boundary
	Population unit boundary
	Interaction index

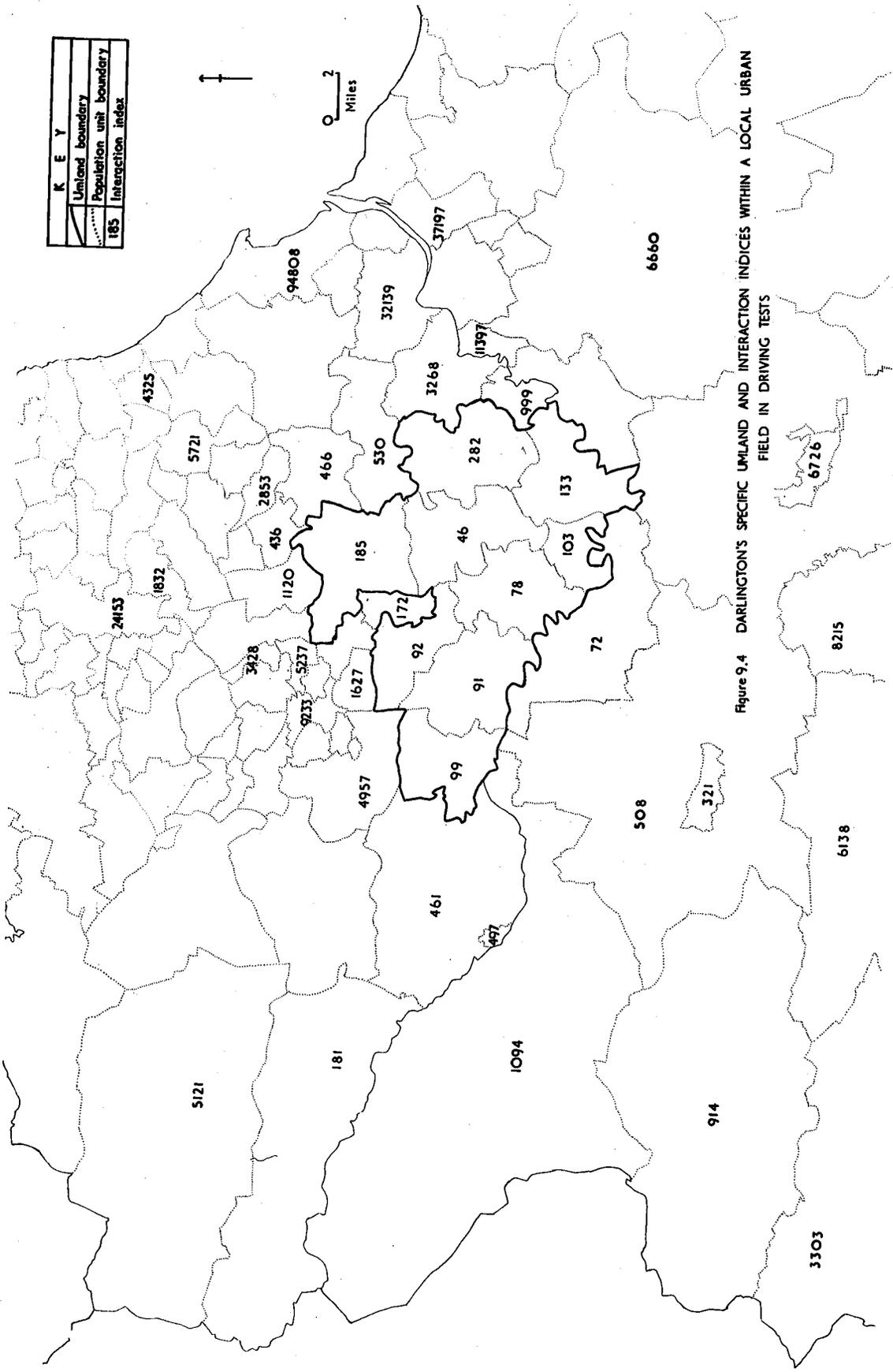
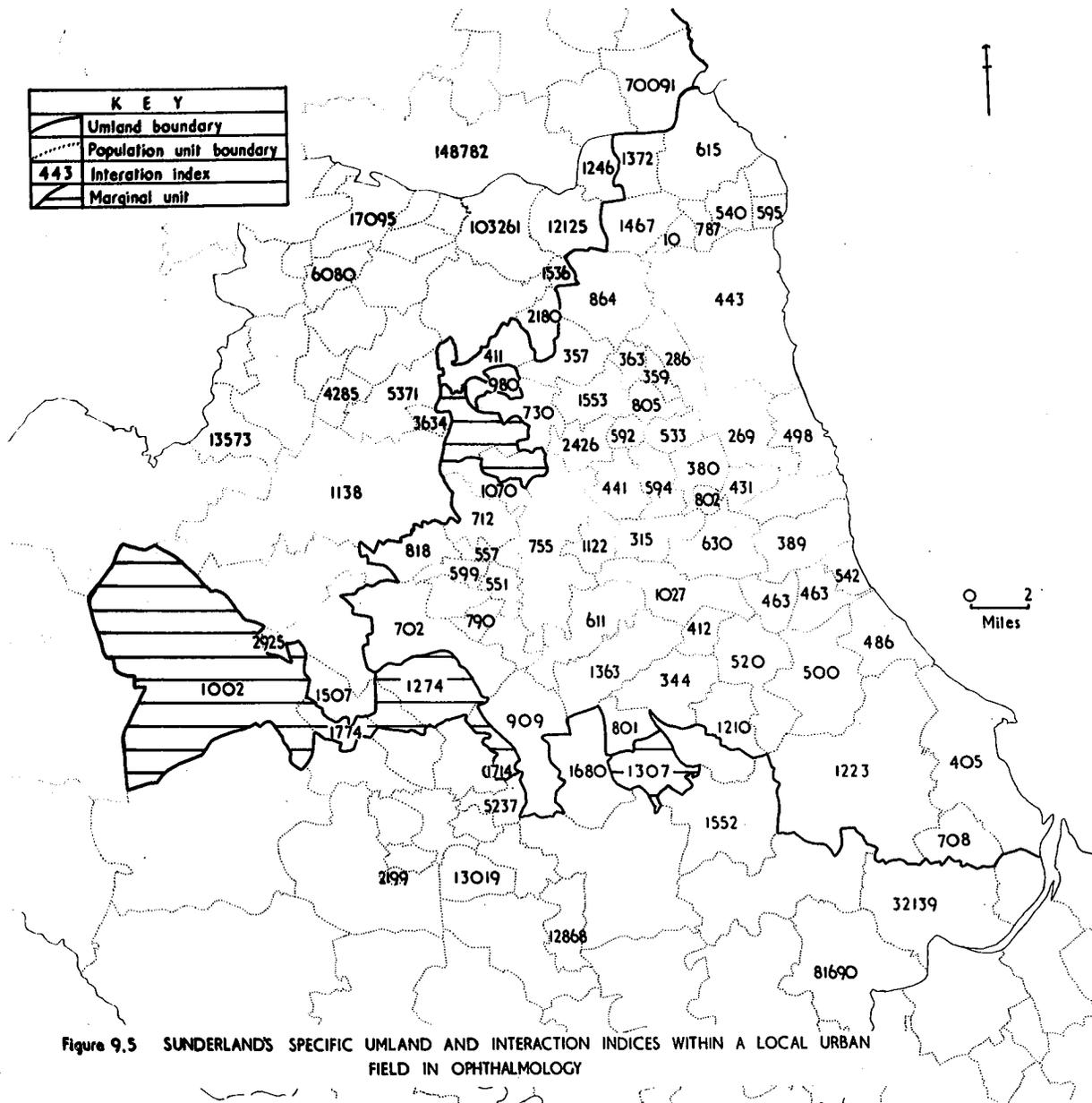


Figure 9.4 DARLINGTON'S SPECIFIC UMLAND AND INTERACTION INDICES WITHIN A LOCAL URBAN FIELD IN DRIVING TESTS



level of service is, the indices change markedly between the specific umland the area beyond it. This has been commented on before when a rapid rate of change in any one direction from a centre has been noted at the margin.¹⁶ This is further demonstrated in figures 9.6-8 where the interaction indices have been graphed against distance using a y axis of log ten. A horizontal line can be drawn across the graphs separating the specific umland indices from the non-umland indices. The ophthalmic graph (fig. 9.8) shows a zone rather than a clear line between umland and non-umland indices. That is to say, the competition between centres or the size of the population units, is not sufficient to give a clear specific umland boundary. A margin as previously defined is to be expected and does in fact appear (see figure 3.1). This graph quantified the transition zone already noted on this map. With the more local (low level) services, boundaries are more clear-cut and the transition zone is sufficiently narrow rarely to appear on the maps cf. figures 4.1, 5.3, 7.1.

The driving test examples have a critical interaction index value at about 300-350. That for ophthalmology is between 1,000-2,000. But below these critical values, i.e. within the specific umlands, the interaction index appears to vary in a random manner. What appears to happen is that the people of a particular area use a particular centre but within certain limits the extent to which the service of that centre is used follows a probabilistic pattern with distance being of little consequence. The scatter of points below the critical value/zone on figures 9.6-8 is random and is only limited by the greatest distance that can be measured from the

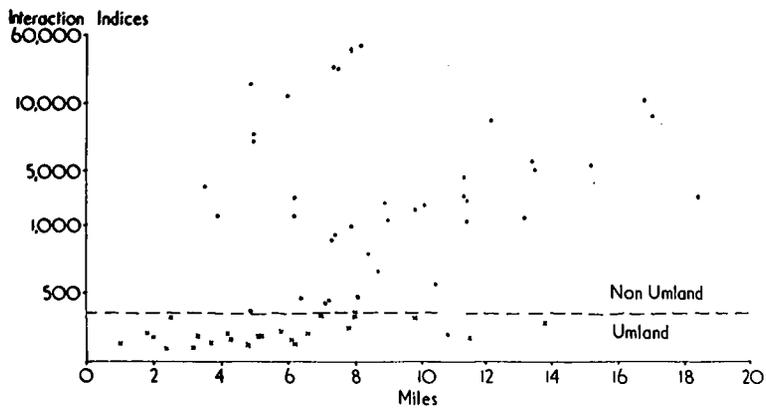


Figure 9.6 GRAPH OF INTERACTION INDICES FOR DRIVING TESTS AT GATESHEAD

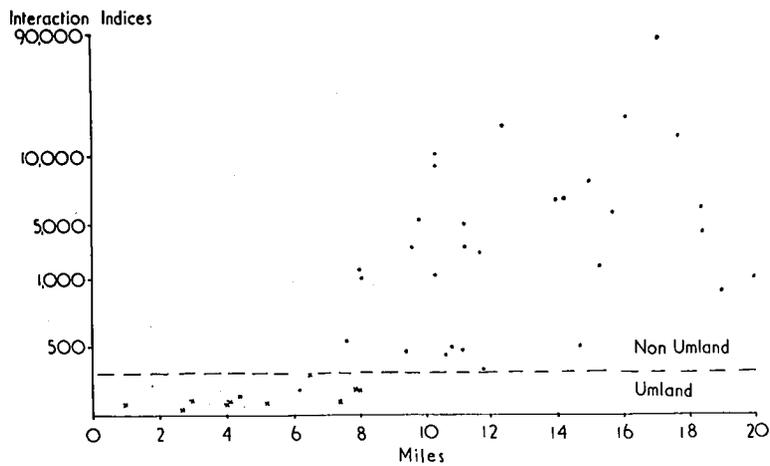


Figure 9.7 GRAPH OF INTERACTION INDICES FOR DRIVING TESTS AT DARLINGTON

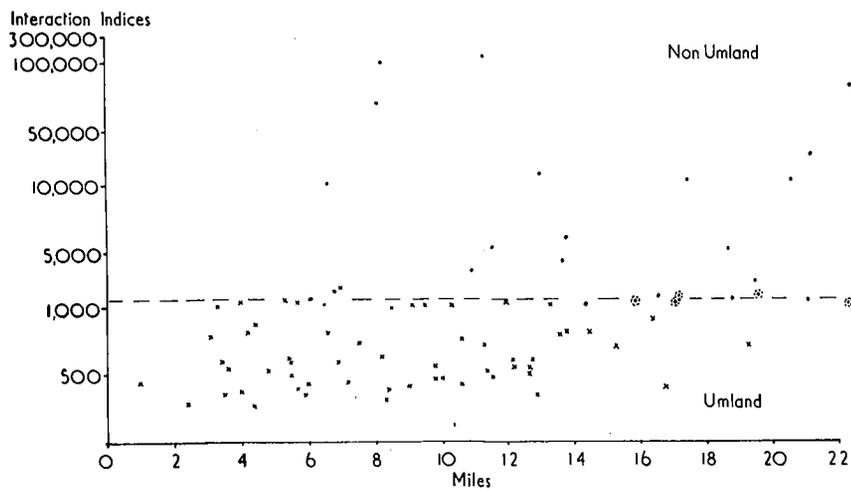


Figure 9.8 GRAPH OF INTERACTION INDICES FOR OPHTHALMOLOGY AT SUNDERLAND

service centre to the specific umland boundary i.e. the geometry of the specific umland.

Within the limits of 20 miles, this is also true to a certain extent of the interaction indices outside the specific umland. They are generally absent from near the y axis and the higher values tend to be distant from both axes. If the graph for Darlington is studied (fig. 9.7) linearity is in fact evident. The fan-shaped Sunderland ophthalmic umland the the elliptical Gateshead driving test umland with their service centres off geometrical centre, show less linearity than Darlington. Linearity on this scale is a result of the geometry of the specific umland rather than distance working evenly across a field of attraction. This can be tested statistically. A regression of Darlington driving test data for the log of interaction indices against distance gave a correlation coefficient of 0.7 which is statistically significant at the 99.9% level. A similar regression for Gateshead gave a correlation coefficient of 0.4 and this was also statistically significant though now at the 99% level.

Two levels of generalisation appear possible. On the scale of the whole field of attraction, there is a tendency for the power of attraction of a centre to decline with distance. On the scale of the specific umland area, a random distribution of interaction indices occurs within the limits of a critical value which is associated with the level of service being studied.¹⁷

In terms of social physics this all agrees with theory. The probabilistic nature of human interaction is shown within the specific umlands. If the pattern had been regular, then a deterministic

behavioural pattern would have been implicit and a simple gravity model would work. Instead the situation is more complex. Two further points are worth noting. Within the specific umlands, continuity generally exists i.e. every population unit interacts with the centre being studied. On close examination, the ophthalmology data reveals three out of 57 units within the specific umland lacking interaction. All three have populations of about 2,000 which is about the upper limit of the critical value. The average specific umland interaction index is 711 (see table 9.3) and the three units are surrounded by population units with interaction indices below the average i.e. more interactions than normal. Hence in terms of social physics theory the non-interacting units are marginal on the basis of population and the need agglomerating to remove the change factor of no interaction because of population size. With driving tests the critical value is well below the population base of the population units and continuity exists almost without exception.

CENTRE	SERVICE	UMLAND	NON-UMLAND
Sunderland	Ophthalmology	711	21,775
Darlington	Driving tests	118	8,413
Gateshead	Driving tests	209	£ 6,835

Table 9.3. Average Interaction Indices for selected centres and services, County Durham.

Secondly it may be possible to explain the apparently random distribution in terms of varying population characteristics. With car ownership, it might be argued that socio-economic class gives

variation in ownership rates. In football there is certainly a difference as between the sexes with males dominating as season ticket holders. At socio-economic level, the football clubs claim a cross section. Possibilities such as these have been mentioned in part one but not fully developed. However these possibilities must not be entirely forgotten and should be tested in future work.¹⁸

The urban fields shows discontinuity immediately beyond the specific umland boundary. The interaction indices rise rapidly into the thousands compared with those of below one thousand in the specific umlands. This is true of driving tests as well as ophthalmology even though the driving test critical factor is 300 to 350. While there is an initial scatter of interacting population units near the specific umland boundary, a rapid change occurs to isolated units and finally to isolated remote areas. For driving tests these remote areas are not on the maps.¹⁹ Again the social physics hypothesis is sub-stantiated in that if population units were large enough continuity from the centres would be maintained, the base population needed for interaction increasing rapidly once the specific umland is left. Where ophthalmic data was collected completely and not limited to northern England a few patients with addresses outside the north were recorded, hence agreeing with the theoretical pattern. An example of complete ophthalmic data is available for Carlisle and is given in table 9.4.

In a few cases specific urban fields were established without specific umlands. Examples occurred in the hospital service and here could be related to historic factors. In such cases, the

field of attraction shows similar principles working.

Location	Interactions
Carlisle C.B.	194
Cumberland and Westmorland	275
Scotland	132
Northumberland	4
Other areas	3

Table 9.4. Carlisle ophthalmic patients by areas of origin 1965/66.

Figure 9.9 shows Easington general surgery urban field and figure 9.10 is a graph of the same data. A continuous almost circular urban field exists where interaction indices are below 700. Above this value the urban field shows discontinuity with a rapid change to isolated units. Blyth has one interaction with Easington beyond the mapped area. Hence the analysis already made is apparently valid for the state where a specific umland is not achieved. The circular nature of the field of attraction in the area of continuity and the marked linearity of the graph plots should be noted. The latter have a correlation coefficient of 0.6 for log of interaction index against distance with a statistical significance at the level of 99%. The choice for patients here is between the adequate but limited local facilities and the more distant, more numerous and more specialised facilities of Hartlepoons and Sunderland for general surgery. With the unusual conditions of competition, the limited area involved (four miles radius of continuity) and the limited population involved, a gravity principle seems to work. The tendency for circular fields of attraction with service centres of low hierarchical value has been commented upon

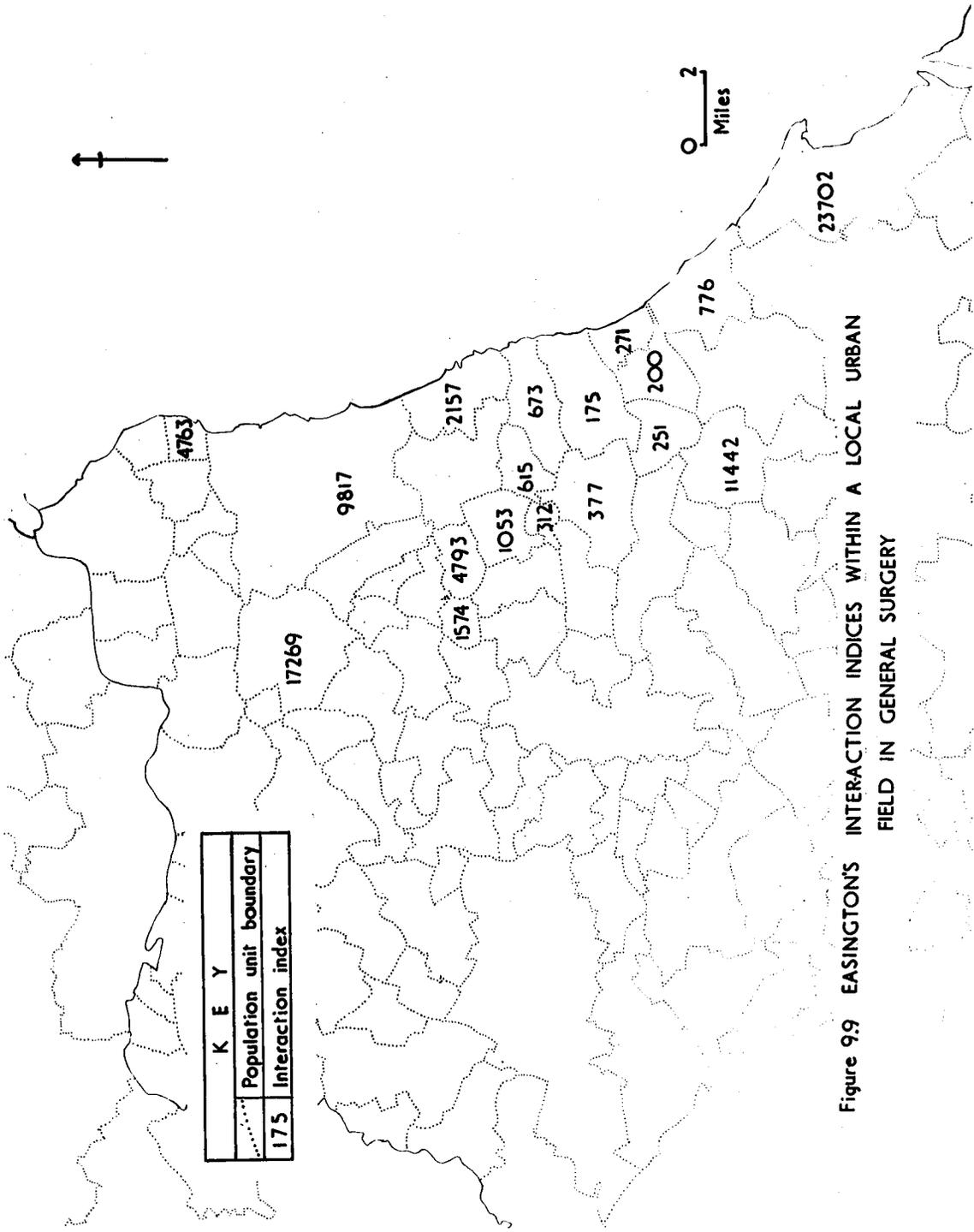


Figure 9.9 EASINGTON'S INTERACTION INDICES WITHIN A LOCAL URBAN FIELD IN GENERAL SURGERY

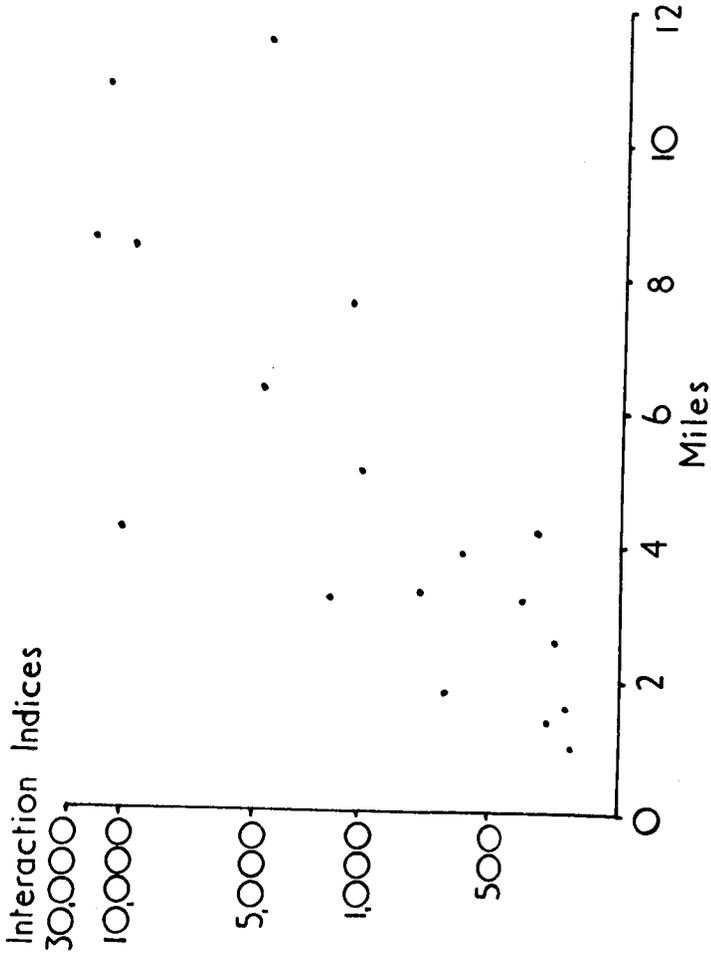


Figure 9.10 GRAPH OF INTERACTION INDICES FOR
GENERAL SURGERY AT EASINGTON

several times before.

The examples have been chosen to illustrate extreme cases and what is true of them as extremes is true of the whole range of data in general. They show that the interaction index is a means of ignoring the population distribution. It shows the potential population required within a population unit to give an interaction. The distribution of population affects the location and spatial size of a population unit, but once this is decided, the index is a result of factors other than population distribution. A relationship between total interaction and specific umland population or interactions was established in part one. This becomes important when considering the question of urban fields. The specific umland is definable by means of fairly easily drawn boundaries but this is not true of the urban field. The social physics hypothesis states, in fact, that the urban field is potentially the whole world and certainly the whole of Britain. The data supports this contention. How does one define an urban field unless it is the whole of Britain, or the specific umland to which it is statistically correlated, or by some purely arbitrary means?

The concept of range would appear to provide a possible answer. Range varies with each hierarchical level and implies an effective limit (i.e. economic) of a service.²⁰ The range of regional technical colleges is greater than local technical colleges, for example. An examination of figure 4.1 and 4.8 shows this to be true. However to state an actual number of units (e.g. miles) for this is difficult. Bishop Auckland is only a local technical college but it has a specific umland extending into Weardale and draws students from that area at a distance of about 25 miles. At regional level

Newcastle serves this area and again the range is about 25 miles. Sunderland as a regional technical college has a specific umland (as opposed to margin) with a maximum range of only 14 miles.

The problem here is the problem examined in this section. The geometry of the specific umlands varies and so range can vary. In the case of Bishop Auckland an elliptical specific umland extends into a rural area with a lack of competition from other colleges. The result is a high range value for the college. Sunderland has a coastal location and is unable, as a regional technical college, to compete in western County Durham with Newcastle which is situated further inland. So its range value is relatively low.

Given a regular geometrical pattern of specific umlands and fields of attraction of the hexagonal pattern postulated by Christaller, then range is a viable concept to which meaningful values can be ascribed. Given the varied geometry of specific umlands in County Durham and adjoining areas as studied in this thesis, it is difficult to give a set of constant workable values to range.²¹

One is therefore drawn to the conclusion that the concept of the specific umland is the major operational unit which can be clearly defined. It can be defined in terms of the interaction index, given a knowledge of critical values, or in terms of competition with other service centres and the collection of data to establish boundaries as in this study. Given a knowledge of specific umlands a viable tool exists for manipulation of data to make future forecasts, or to relocate centres, or to introduce or reduce the number of centres in a service.²²

Distance and competition

Throughout this thesis distance has been measured as geographic distance. To do this all places must be reduced to a point. In fact, using the National Grid co-ordinates, kilometre squares can be used as units and a six figure grid reference for the south west corner of the kilometre square used to represent the whole square. This has been done and so distances are not absolute but are + one kilometre i.e. about 1000 yards. This can be justified in that only the settlement was recorded for each person and a more precise measurement was not needed to study town regions. The grid reference used for a population unit refers either to the kilometre square in which the greater part of a rural settlement occurs or to that containing the median point of population distribution in a large built-up area.

When people choose a centre for a service they tend to think of the particular town where the service is provided rather than a particular street in that town. The choice made is between Newcastle and Sunderland and not between a particular street in Newcastle and a particular street in Sunderland. Hence services have been measured from town centres. In most cases kilometre square covering the town centre also covers the actual location of the building providing the service. Where more than one building is involved, a median point was calculated and this again tended to occur in the town centre kilometre square. It is on this basis that the computer was instructed to calculate distance in the application of the model. For graph work distances have been measured to the nearest tenth of a mile.

The use of geographic distance can be challenged. Work by many authorities on transportation surveys suggests that time-distance is more significant than geographic distance.²³ This assumes a road network of varying quality and a congestion factor that makes it possible for people to travel from A to B by a long route in less time than the most direct route. In County Durham distances separating centres are short. Middlesborough to Newcastle is 36 miles by road so that the bulk of journeys to either centre will be less than 20 miles. Rivers focus traffic onto certain bridging points of the Tyne, Wear and Tees and so provide few alternative routes for the longer journeys. There is a case for arguing that at such short distances in County Durham the time-distance factor will vary very little from the geographic distance.²⁴

Two other points must be made here. Some 200,000 individual journeys form the basic data of this study. To have obtained information from each individual of his routes and actual times travelled was hardly possible. Further time-distance, congestion factor, quality of highways all vary in time themselves. Geographic distance is normally constant in time and as a result it would be possible to repeat this study of services in County Durham at a later date using a distance factor that had remained constant in time. But the distances involved in this study are not just straightforward geographic distances. It has already been shown that specific unland geometry responds to the network of centres. Hence although Washington is nearer to Sunderland and Gateshead than Chester-le-Street, yet most patients for general surgery go to Chester-le-Street. Harraton is nearer to Gateshead and Sunderland,

and about the same distance from Durham as it is from Hebburn, yet it is in the Hebburn specific unland for technical colleges. People travel not to the nearest geographic centre but to the nearest geographic centre with most opportunities still available for them in relation to all other nearest neighbour centres. Two variables are operating, direct geographic distance of unit to centres and the geographic distances separating the centres.

The point has already been shown in part one of this thesis several times and one example will suffice here. Harraton has four technical colleges within easy reach of it, Durham, Gateshead, Hebburn and Sunderland. These are its nearest neighbour centres. Assuming a simple gravity model, people living in the population unit with a technical college in it have easiest access to that college i.e. least competition from other people. People living in population units adjoining the centre population unit have next easiest access and so on outwards. Obviously at some point a population unit is 'next accessible' to two technical colleges at the same stage. The people will tend to go to the college with the least population at that stage because it potentially presents the least friction from other people to entry. Hence the population unit can be allocated to the college with the least population at this stage.

This process has been simulated for the Harraton example and its four nearest neighbour technical colleges (see fig. 9.11). The result in terms of population is shown in table 9.5. When Harraton is reached all four colleges are in theory equally accessible. As Hebburn has the least population at this stage, Harraton comes within

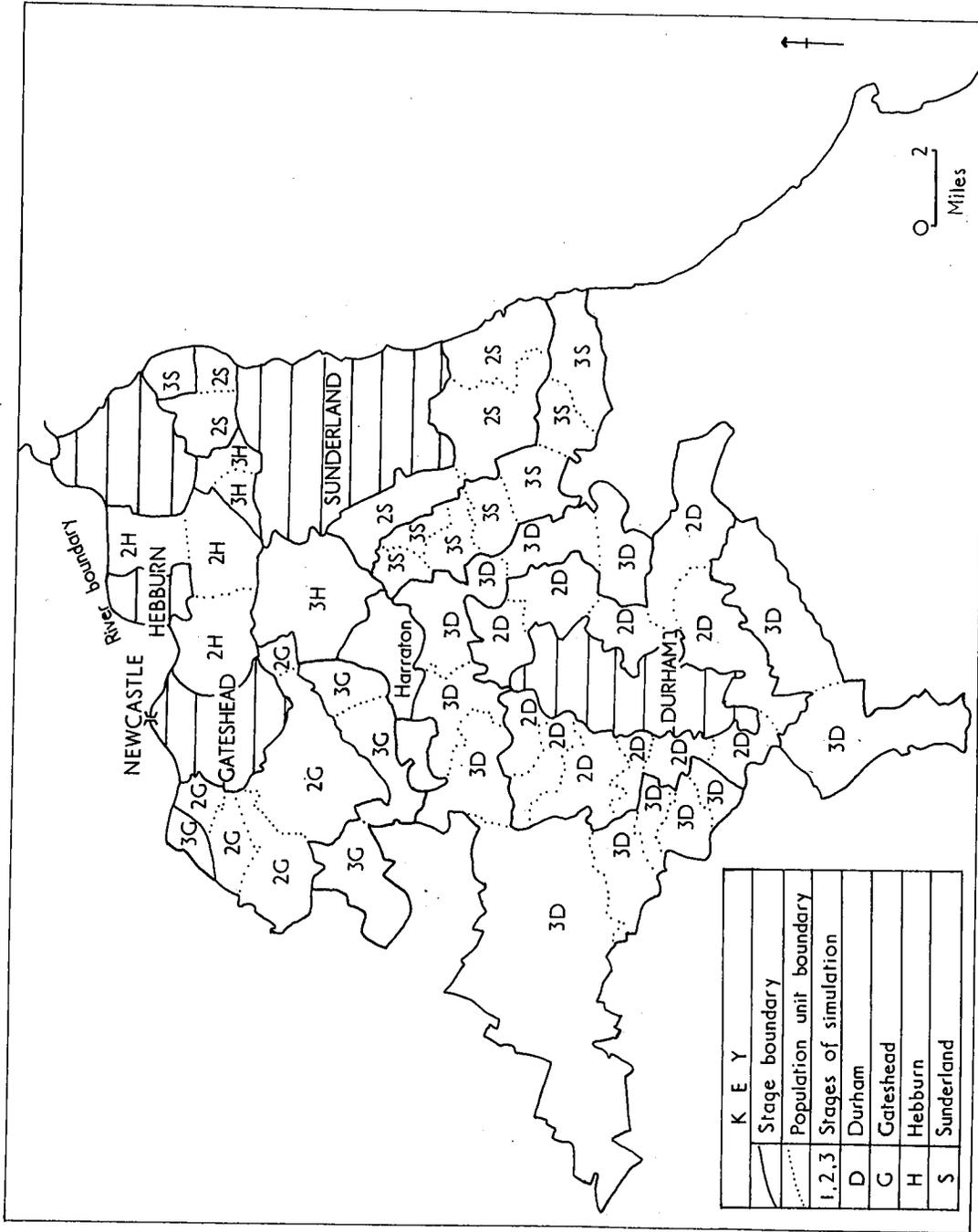


Figure 9.11 MAP OF SIMULATION TO SHOW HARRATON WITHIN HEBBURN
TECHNICAL COLLEGE SPECIFIC UMLAND

Hebburn's specific umland. This is only just true though, as Durham has only slightly more population. In reality this actually happens with 22 students going to Hebburn, 21 to Durham, 17 to Sunderland and 13 to Gateshead. The simulation exercise does reproduce a real situation.

Technical College	Durham	Gateshead	Hebburn	Sunderland
1. Centre population	24,153	103,261	24,927	215,968
*2. Immediately adjoining population	32,215	25,493	71,053	31,943
Total	56,368	128,754	95,980	247,911
*3. Next adjoining population	74,098	21,461	24,974	43,442
Total	130,466	150,215	120,954	291,353

* N.B. Stages 2 and 3 are defined in the text.

Table 9.5. Population distance zones for four technical colleges being nearest neighbours to the Harraton population unit.

This process shows what is meant by population distance. It is dependent upon geographic distance of a population unit to the nearest neighbour centres and upon the intervening population around centres at that distance. This is related to the geographic distances separating the centres. It must also be related to the hierarchical position of the centres; for at stage four, of the above Harraton simulation, Harraton is absorbed into Hebburn's specific umland and the umland is completed. But the other three technical colleges go through several more stages before their umlands are completed. While this all results from the geographic distances of population units from centres, from the hierarchical level of the centres, from the spacing of the centres and the population

distribution over the whole area, the use of interaction index, geographic distances of population units from centres and geographic distances of centres from centres appear to be the three variables which can represent the whole process. This point will be returned to in the statistical model application section.²⁵

A basic assumption about population units that interact with centres is that the distances between them have a statistically normal distribution over the range of measured data. Because most measurements in miles are less than 20 miles in distance the statistical form of the distribution is difficult to assess. In kilometre units the range is greater and so the statistical form can be tested more easily. Certainly there is evidence to suggest distance has a skew distribution and needs transformation. This would agree with other studies of central place data.²⁶ The computer application of the model should resolve this question.

Another question that affects distance is how do settlements become centres? In the context of this thesis most of this type of decision is purely administrative. Hospitals, technical colleges or driving test centres are established by an administrative decision.²⁷ Technical colleges of the Durham County council illustrates this.²⁸ The county boroughs had technical colleges in existence in the 1940's. Durham County council then planned to establish its own technical colleges. They were to be based upon well-developed evening institutes, but it was an administrative decision that brought the colleges into existence in place of particular evening institutes.

Unlike most recent central place studies which are based upon retail trade functions, there is an element of inelasticity in the

services studied in this thesis. Hence it is the population that adjusts to the supply that is provided at the centres. The simulation of Harraton above illustrates this. This would also be a factor in the irregular spacing of centres. The concept of 'population distance' or 'number of intervening people' is not new.²⁹ In terms of the administrative structure that establishes centres and the short distances involved in journeying to the centres in north east England, it is a viable concept. The variable population distribution presents a non-isotropic surface which needs transformation. Geographic distance is therefore modified here by competition between centres spaced at irregular intervals. The population distance is viewed essentially from a centre outwards in all directions and its value changes as competition is met from neighbouring centres. For example, Durham in the middle of the lowland part of the county has competition mainly from Wyneside to the north and Teesside to the south. Hence its population distance is geographically more restricted north-south than it is east-west. As a result Chester-le-Street, five miles north of Durham and Cornsay, eight miles west of Durham, are both about the same population distance from Durham. Most of Durham's specific umlands are elliptical in form in terms of geographic distance but if measured by population distance, the specific umland shapes would be transformed into a more circular form.

The possibility of centred regions occurs when the location of centres takes place administratively. At several points in part one of this thesis this was considered. The evidence shows that while centred regions were potentially possible and administratively

desirable, they did not occur in fact.³⁰ This was partly because there was a lack of administrative machinery to enforce catchment areas. The result is specific urban fields which may be more limited than in a normal supply-demand situation, but which do extend beyond specific unlands. League football shows a more normal supply-demand situation and is thus a little different from regional technical colleges or ophthalmology. Again a social physics situation appears to be operating.

The hierarchy-continuum problem.

The presence or lack of a hierarchy can be tested from the technical college data. While some of this data is incomplete, this would only affect the occurrence of the top level of any hierarchy.³¹ The administrators recognise three types of technical college forming a hierarchy in terms of the academic level of work attempted in each type of college. These are local, area and regional colleges. Figure 9.12 shows the thirteen technical colleges of the study area in rank order. Two steps are clearly evident at about 4,400 students and 2,600 students. Also the first college in rank order is completely isolated from the rest. Hence three groupings do occur on this graph and the theoretical hierarchy can be seen to work in practice.

When it is remembered that in the technical colleges the data was collected in toto without any attempt to recognise differences in the academic levels of the courses available, the result is even more significant. It has already been shown that Sunderland technical college operates at all three levels of the hierarchy while Easington operates only at the lowest level.³² If a continuum really did exist it would show within this data.

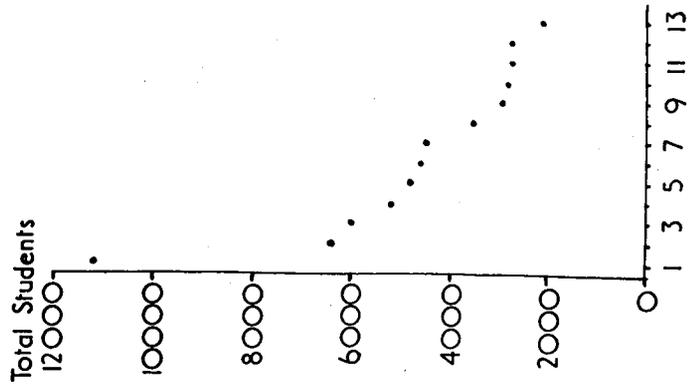


Figure 9.12 STUDY AREA TECHNICAL COLLEGES IN RANK ORDER OF TOTAL STUDENTS

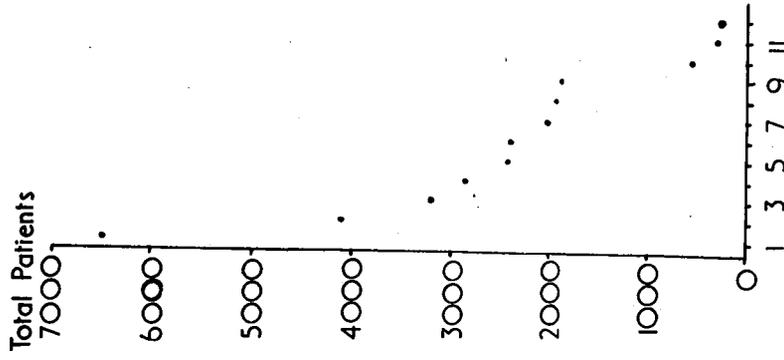


Figure 9.13 COUNTY DURHAM GENERAL SURGERY HOSPITALS IN RANK ORDER OF TOTAL PATIENTS

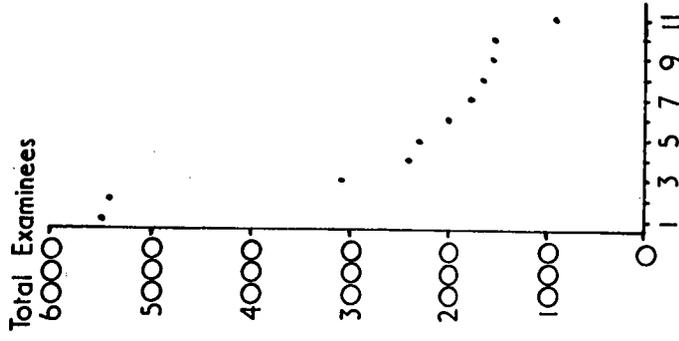


Figure 9.14 STUDY AREA DRIVING TEST CENTRES IN RANK ORDER OF TOTAL EXAMINEES

The hospital data was collected assuming a hierarchy. It is a well established fact that morbidity rates vary from specialty to specialty and from region to region.³³ The likely number of cases to be treated in general surgery units for a given period is far greater than the cases needing ophthalmic treatment for the same period. In north east England in 1965-6, 229 beds were needed for ophthalmic cases. At about the same time 1131 beds were needed in general surgery for the smaller area of County Durham. Given this hierarchy, one can examine more closely what happens with a particular hierarchical level such as general surgery.

Figure 9.13 shows the hospitals with general surgery units in rank order. The first ranked centre is isolated, there is a step at about 2,000-3,000 patients and another step at about 300 patients. Three stages appear discernible within the hierarchical level. The bottom step consists of Chester-le-Street, Easington and Stanley hospitals. Two of these lack specific umlands and Chester-le-Street only just achieves one. Hence they are hospitals which are untypical of general surgery units and are likely to cease existence soon. This leaves the first ranked hospital in isolation. This is Sunderland; a hospital centre it operates at a variety of levels including ophthalmology. Its high ranking and apparent separation may result from its many functions influencing its lower level functions e.g. general surgery, so that these have a high provision value within their hierarchical level.

If this is so then a detailed study of a hierarchical level should show the influences in its ranking order of the total services and functioning of a centre. The greater the services

provided, the higher the ranking order of that centre within any one hierarchical level. An indication of the range of services of a centre is its total population.³⁴ Driving tests provide a service within which there is no hierarchy. Figure 9.14 shows driving test centres in ranked order and two centres do form a separate group while the lowest ranked centres also appear separate. The population size ranking order is in good agreement with the total examinees ranking order (see figure 9.15). The major exception is Darlington which has a small number of examinees compared with its total population.

Hence within a hierarchical level it would appear that centres are ranked by their population size and this reflects their hierarchical position as towns in a central place system. Figure 9.15 shows this across most of the data. As one comes down the service ranking order, population differences in ranking order decrease i.e. become statistically less significant. As a result the scatter graph becomes more irregular, but the basic relationship is still visible. This has been tested by means of Spearman's Rank Correlation Coefficient and the significance of this coefficient established by means of the Student's 't' test. Table 9.6 shows the results and confirms the visual impression of the graphs.

A basic assumption of figure 9.15 (and any population ranking list) is that the services provided serve only the town itself. But the service is provided for a town and its region. Hence any irregularities in the slopes on figure 9.15 may result from large or small specific umlands. This point was dealt with in some detail in chapter seven when considering Bishop Auckland.³⁵ The above

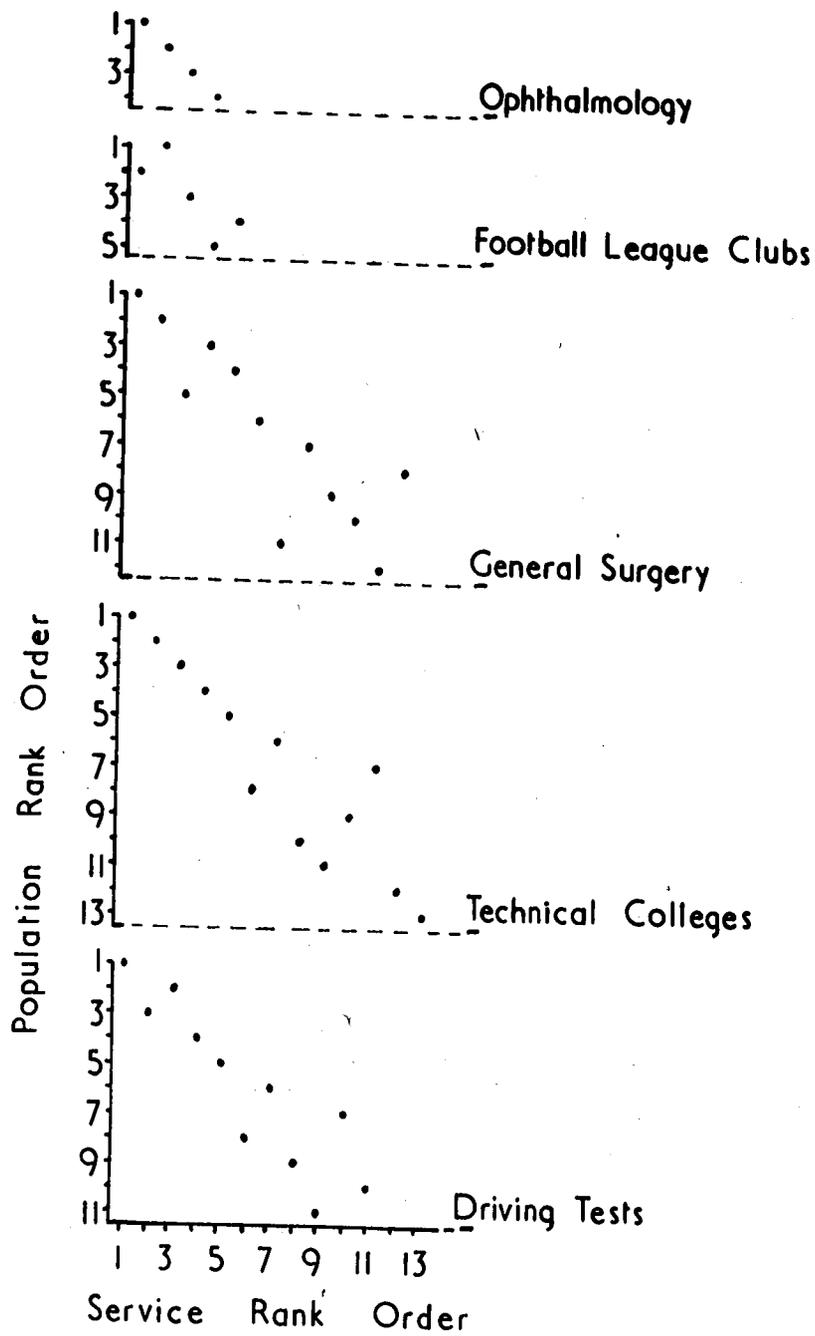


Figure 9.15 SERVICE CENTRES BY POPULATION AND SERVICE RANKING ORDERS

SERVICE	RANK CORRELATION COEFFICIENT	n	STUDENT'S 't' TEST CONFIDENCE LEVEL.
Ophthalmology	1	4	100%
Football League Clubs	0.8	5	99%
General Surgery	0.86	12	99.9%
Technical Colleges	0.9	13	99.9%
Driving Tests	0.91	11	99.9%

Table 9.6. Results of statistical tests on service ranking and centre population ranking of various services.

analysis of two variables will show anomalies because at least three variables are working - town population size; specific unland population size and the provision of the service.

The level of provision of a service reflects overall demand. For example 1,131 beds will serve the overall demand of County Durham for general surgery. This is based upon morbidity rates. The number of beds in a particular centre is the supply. This is decided administratively. Population then adjusts to the supply and distributes itself to the centres according to population distance. Each bed, driving test examiner and technical college course represents a specific number of opportunities. Hence the decisions on supply affect the potential number of patients, examinees or students at each centre. The graphs of these are therefore likely to show a continuum with the possibility of the larger population centres standing out as having greater supply (opportunities) by virtue of size. And this happens in reality.

It follows therefore that the hierarchical order of a centre in a central place system affects all the services it provides. In north east England, Newcastle forms the regional capital (first

order) and Middlesbrough and Sunderland the sub-regional centres (second order).³⁶ At these places a low level service such as driving tests, general surgery or recreational technical college courses will operate at a high level of provision within this service compared with other centres having the same service but which are third or lower order places in the central place system. Figure 9.15 shows this operating.

This can be illustrated by professional league football. This was treated in chapter two as a hierarchical level³⁷ and figure 2.5 shows the ranking of clubs within each division in terms of total attendance and final position. It was shown that there was overlap between divisions to give a continuum, and the ranking lists by divisions can be statistically tested (see table 9.7). This shows high correlations with the gradual decline in reliability down the ranking lists, as shown in figure 9.15. Within north east England a sample of five of these clubs is found. Three, Middlesbrough, Newcastle and Sunderland, appear in the upper part of this hierarchical level and are first or second order centres in the central place system of north east England. Two, Darlington and Hartlepool, appear in the lower half of this hierarchical level and are third or lower order centres in the local central place system.

DIVISION	RANK CORRELATION COEFFICIENT	n	STUDENT'S 't' TEST CONFIDENCE LEVEL
FIRST	0.62	22	99%
SECOND	0.75	22	99.9%
THIRD	0.61	24	99%
FOURTH	0.55	24	95%

Table 9.7. Results of statistical tests on attendance and final division position in League Football 1962-3.

Several conclusions follow from this analysis. The data collected provides evidence of the existence of hierarchies within services. The hierarchical levels show a continuum within a level. Any breaks in this continuum may be explained in terms of uneconomic service centres (clustering at the base of the slope) or a skew distribution of population size of centres (isolation at the top of the slope). Any centre with a high order placing in the central place system will have its low level services operating with a higher provision than similar services at a lower order centre. This may be expressed in another way. The amount of provision of a particular service will depend upon, within the limits of the hierarchical level of that service, the order of a centre within the central place system. Some of the criticisms of the hierarchical order of services may arise from confusion between the amount of provision within a hierarchical level (a continuum) and the differentiation of services to give the basis for establishing hierarchical levels. Hence there is a hierarchy of technical colleges but within area colleges (a hierarchical level) there is a continuum (amount of provision of courses).

The Model Tested

On the basis of the analysis so far a model was established. The starting point is a population unit and the number of people going from that unit to a centre for a particular service. To eliminate the influence of population distribution, this movement was expressed in the form of an index, the interaction index, which states the number of people living in the population unit who were needed to provide one actual interaction. A computer matrix was built up of

these with the distance of each unit from a given centre being summed against its interaction index. The size of the centre was represented by the number of driving test examiners, the football league index or the number of hospital beds and the influence of surrounding centres was allowed for by their distance from the centre being considered, being held as constants for the summation. Each centre was treated this way in turn.

Hence interaction indices are being tested against distance from a centre, the size of that centre and the distance of that centre from all other centres considered in that service (see figure 9.16).

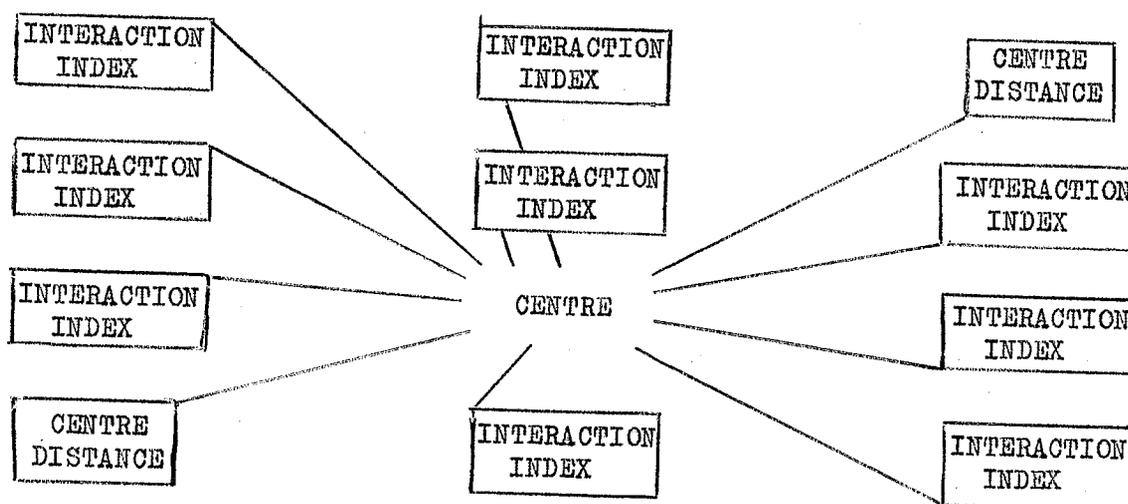


Figure 9.16. Diagram of one stage of model matrix.

Further before the statistical model can be tested, two requirements must be met. All data must have a normal distribution and all functions must have a clear definition. These are inter-related and can be discussed function by function.

It has already been established that the dependent variable, the interaction index, needs transformation into logarithms. It can be

expressed as $\log \frac{P_i}{I_{ij}}$ where P_i is the total population of unit i and I_{ij} is the interaction of unit i with centre j for a given service.

The distance variable was measured by the computer from the national grid references for all units i and centres j giving a geographical distance in kilometres.³⁸ This was done in stages by taking each j^{th} centre and calculating distances to each i^{th} unit that interacted with that centre. A sample of this data was tested statistically and found to have a skew distribution. Hence all distances were transformed logarithmically and a normal distribution achieved. The distance variable can be defined as d_{ij} where d is the geographic distance in kilometres from unit i to centre j . As centres interact with themselves, a constant of one unit was added to all distances to avoid a zero value when transforming into logarithms.

The amount of provision of a service within a hierarchical level requires service by service consideration. Because of the incomplete nature of the technical college data and the built in hierarchy within the data, this service has not been tested against the model. The hospital data was complete for each hospital, the hierarchical levels isolated and bed totals for each centre in each hierarchical level known. Hence the independent variable of hierarchical provision for ophthalmology and general surgery is the number of beds for that service at centre j . From figure 9.13 it is evident that the hierarchical levels have a skew distribution and this was normalised by transformation into logarithms. Driving test data is similar with the driving test examiners as the hierarchical provision which also required normalising by transformation into logarithms.

The football data has been considered as a hierarchical level and the calculations associated with table 9.7 justify this. In chapter two a hierarchical level provision factor was calculated (see table 2.5) but the statistical validity of this for testing the model must be doubted. There is a great statistical gap between the three second division clubs and the two fourth division clubs for which table 2.5 does not adequately allow. Since figure 2.5. shows that this hierarchical level is skew, then any values used must be transformed into logarithms. As it has been already shown that the club's division of the football league and its success or failure in the previous season are significant, the system adopted for hierarchical provision was to rank all football league clubs in order from the bottom of division four to the top of division one. The result for the five clubs concerned is shown in table 9.8.

CLUB	'h' VALUE	CLUB	'h' VALUE
Darlington	13	Newcastle	64
Hartlepoons	1	Sunderland	68
Middlesbrough	67		

Table 9.8. Hierarchical provision values for North East Football league clubs, based upon 1962-3 season.

The coal mining data presented a number of problems in terms of statistical testing of the model. The definition of hierarchy provision has not been attempted at any stage. Further, the quantity of data in terms of units i and j to be calculated would be prohibitive for the computers available for testing the model. As the other data

available was sufficient to test the model, the coal mining data was omitted at this stage.

It should be noted that four sets of data were used to test the model. Two of them (general surgery and driving tests) may be considered as low order functions or services. The other two (football league clubs and ophthalmology) are high order functions or services.

The final function in the model to be considered is the network of centres. Again distances were calculated as geographic distances in kilometres, by means of the national grid references.

INDEPENDENT VARIABLE	99½99% CONFIDENCE LEVEL		5% SIGNIFICANCE LEVEL	
	REGRESSION COEF.	t STATISTIC	REGRESSION COEF.	t STATISTIC
Constant	-	-	2.08	13.23
1. Distance	0.82	6.57	0.80	6.49
2. Darlington	-7.59	0.14	-	-
3. Middlesbrough	-4.41	0.14	-	-
4. Newcastle	-2.41	0.12	-	-
5. Sunderland	-4.51	0.14	-	-
6. Hierarchy	14.01	0.15	-	-
Multiple Correlation Coefficient -			0.39	
Degrees of freedom			238	
			242	

At 5% Significance level

$$\log \frac{P_i}{I_{ij}} = 2.08 + 0.80 \log d_{ij}$$

$$\text{Interaction Index } ij = 10^{2.08} d_{ij}^{0.80}$$

Table 9.9. Model results for ophthalmology.

INDEPENDENT VARIABLE	99.99% CONFIDENCE LEVEL		5% SIGNIFICANCE LEVEL	
	REGRESSION COEF.	t STATISTIC	REGRESSION COEF.	t STATISTIC
Constant	-	-	2.01	10.10
1. Distance	1.18	12.27	1.18	12.28
3. Darlington	6.46	1.31	-0.21	2.73
4. Hartlepoons	18.96	1.29	-	-
5. Middlesbrough	-5.49	1.21	-	-
6. Newcastle	0.84	2.35	-	-
7. Sunderland	-1.52	0.94	0.23	5.28
8. Hierarchy	-15.99	1.30	-0.26	2.58
Multiple Correlation Coefficient	-		0.68	
Degrees of freedom	327		329	

At 5% Significance level

$$\log \frac{P_i}{I_{ij}} = 2.01 + 1.18 \log d_{ij} - 0.21 \log C_3 + 0.23 \log C_7 - 0.26 \log h_j$$

$$\text{Interaction Index } ij = 10^{2.01} d_{ij}^{1.18} C_3^{-0.21} C_7^{0.23} h_j^{-0.26}$$

Table 9.10. Model results for league football.

They were transformed logarithmically as distances have been shown to have a skewed distribution. As these distances were calculated as a matrix (A) to avoid the zero value of centre C_j measured from itself, a constant of one unit was added to all distances. The matrix A is made up of rows in the form C_{ij} added together where C_{ij} is the geographic distance between C_i and all other centres C_j , and itself, plus one unit.

The model tested is of the form

$$\log \frac{P_i}{I_{ij}} = K_1 + K_2 \log d_{ij} + K_3 \log H_j + K_i \log A$$

where K_i is the constant for the i th row of the matrix A and all

other functions are as already defined.

The results are best described service by service. Ophthalmology shows the lowest level of statistical explanation with a multiple correlation coefficient³⁹ of 0.39 (see table 9.9). At the 99.99% confidence level all the variables of the model are forced into the multiple regression analysis and so no constant appears and the statistical level of explanation is considered to be perfect. At the 5% significance level the computer selects the independent variables which has contributed most to the results obtained. This is shown by the t statistic, any variable having a t statistic of over 1.98 being highly significant.⁴⁰

At the 5% level the computer selects distance of interacting units with a constant as remaining significant for ophthalmology within the model with a 39% level of explanation. This suggests that with high level services, competition is resolved into a question of distance. The choice for patients as between hospitals is limited and they go to the nearest centre. The distance variable has an exponent value of 0.80 which gives a very gentle slope to the regression line and this itself suggests limited effective competition.

With professional football the multiple correlation coefficient is 0.63 (see table 9.10). This is a marked increase in the level of statistical explanation. At the 5% significance level, distance, the hierarchical provision values and the centres of Sunderland and Darlington within the settlement network are important. Sunderland is particularly important here probably because half of the data available is for this centre within this service. With a 63% level

of explanation, this suggests that the ophthalmology independent variables need a better definition. However the competition factor is stronger in football. The distant exponent is now 1.18 giving a steeper slope than ophthalmology. As a basic assumption of the model is competition between centres, then as competition increases by more centres being involved, it is more likely to give a higher level of explanation statistically.

General surgery with a multiple correlation coefficient of 0.74 has the best fit of any of the data (see table 9.11). Again distance, a constant and the hierarchical provision values are shown as significant at the 5% level. Two of the centre network appear important - Darlington and South Shields. Competition within the area is now much greater. There are thirteen centres operating, an exponent value of 2.55 for distance and the two centres that are significant are on the margin of the bounded area.

Being a competition model, equilibrium is likely to be achieved within the area of study, but near the margins competition will increase with centres outside the bounded area. Hence disequilibrium results near the border of the bounded area. Both Darlington and South Shields are centres near the border of the bounded area and so are in disequilibrium compared with other centres within the system. Hence they appear as statistically significant within the model.

INDEPENDENT VARIABLE	99.99% CONFIDENCE LEVEL		5% SIGNIFICANCE LEVEL	
	REGRESSION COEF.	t STATISTIC	REGRESSION COEF.	t STATISTIC
Constant	-	-	2.15	6.57
1. Distance	2.54	22.5	2.55	23.27
3. Stanley	0.14	0.57	-	-
4. Stockton	0.16	0.99	-	-
5. Bishop Auckland	0.20	2.66	-	-
6. Sunderland	0.21	0.99	-	-
7. Shotley Bridge	0.25	3.05	-	-
8. Chester-le- Street	-0.16	0.78	-	-
9. Darlington	0.40	3.84	0.21	2.73
10. South Shields	-0.08	0.83	-0.31	3.31
11. Durham	0.04	0.41	-	-
12. Easington	0.16	0.44	-	-
13. Gateshead	-0.04	0.34	-	-
14. Hartlepoons	0.12	1.23	-	-
15. Sedgefield	-0.10	0.12	-	-
16. Hierarchy	-0.79	1.83	-0.89	8.63
Multiple Correlation Coefficient	-		0.74	
Degrees of freedom	454		464	

At 5% Significance level

$$\log \frac{P_i}{I_{ij}} = 2.15 + 2.55 \log d_{ij} + 0.21 \log C_9 - 0.31 \log C_{10} - 0.89 \log h_j$$

$$\text{Interaction Index } ij = 10^{2.15} d_{ij}^{2.55} C_9^{0.21} C_{10}^{-0.31} h_j^{-0.89}$$

Table 9.11. Model results for general surgery.

INDEPENDENT VARIABLE	99.99% CONFIDENCE LEVEL		5% SIGNIFICANCE LEVEL	
	REGRESSION COEF.	t STATISTIC	REGRESSION COEF.	t STATISTIC
Constant	-	-	1.11	3.9
1. Distance	1.64	14.05	1.53	14.66
2. Bishop Auckland	0.02	0.30	-	-
4. Darlington	-0.10	1.29	-0.18	2.38
5. Durham	0.03	0.48	-	-
6. Gateshead	0.39	5.99	0.25	4.08
7. Hartlepoons	0.39	2.61	-	-
8. Hexham	0.14	2.68	-	-
9. Middlesbrough	-0.05	0.87	-	-
10. Newcastle	-0.18	1.49	-	-
11. Northallerton	0.38	6.24	0.23	3.25
12. South Shields	-0.26	3.00	-0.33	4.06
13. Sunderland	-0.11	1.32	-	-
14. Hierarchy	0.00	0.00	-	-
Multiple Correlation Coefficient	-		0.54	
Degrees of freedom	553		559	

At 5% Significance level.

$$\log \frac{P_i}{I_{ij}} = 1.11 + 1.53 \log d_{ij} - 0.18 \log C_4 + 0.25 \log C_6 + 0.23 \log C_{11} - 0.33 \log C_{12}$$

$$\text{Interaction Index } ij = 10^{1.11} d_{ij}^{1.53} C_4^{-0.18} C_6^{0.25} C_{11}^{0.23} C_{12}^{-0.33}$$

Table 9.12. Model results for driving tests

The final set of data is for driving tests (see table 9.12).

This shows a multiple correlation coefficient of 0.54. Compared with general surgery this result is disappointing. At the 5% significance level distance, a constant and the centres of Darlington

Gateshead, Northallerton and South Shields are significant. Again centres near the margin of the bounded area become important. But what fails to be in the analysis even at the 99.99% confidence level is the hierarchical provision value. This is the number of driving test examiners. The 54% statistical explanation compared with general surgery's 74% may be because of this.

Obviously with a distance exponent of 1.53 the level of competition is not as great as with general surgery. However professional football with a distance exponent of 1.18 has a multiple correlation coefficient of 0.63. The failure of hierarchical provision value to be statistically significant must account for the comparatively low multiple correlation coefficient compared with the other sets of data. The whole numbers used for driving test examiners with their small numerical range is not statistically subtle enough. It is known that examiners did work between centres and had leave at periods during the four months of study.⁴¹ A better hierarchical provision value might be related to the number of hours examiners are available per week in toto at each centre. An improvement in this part of the model would improve the statistical level of explanation and slightly alter all the exponents of the other independent variables.

Overall the results for the model are encouraging. Distance is clearly the main variable influencing the pattern of interaction indices, thus supporting the suggestions made at the beginning of this chapter. In terms of the total variables influencing decisions as set out in theory in table 9.1, distance is a major variable. When carefully chosen, the hierarchical provision values are also shown to be significant in explaining the distributions. The centre network

has been disaggregated by the model testing at the 5% significance level. Geographically this is unsound. The centres must be considered as a complete network and are meaningless in part. This statement requires a general discussion.

A basic assumption of the model is that there is a state of equilibrium. In reality this tends to mean that supply is always less than demand so that all the opportunities provided are taken up. Only in league football would this not be completely true. The opportunities provided by a fourth division club as compared with a second division club are difficult to measure and so to know if they were all taken up. But in general the systems studied are in balance as between opportunities available and opportunities taken up. The model examines the distribution of interaction indices. As such these have been shown to be a continuous function in space as is suggested by social physics. If this is so, any bounded area of study must exclude some units interacting with centres within the bounded area. This is more likely to be true of centres near the boundary than those within the core of the bounded area. The disaggregation of the centre network by the model in testing shows this. Centres near the boundary lack equilibrium, distort the overall pattern and so appear statistically significant, e.g. Darlington.

Similarly if physical barriers such as rivers or seas prohibit movement then the result is a non-circular specific umland and this in turn must distort the nearby centres' potential for circular specific umlands. Put in terms of human movement, people move according to the principle of least effort and the competition basis of the model assumes this.⁴² When physical barriers exist then the

equilibrium is achieved only by distorting the normal pattern of the least effort principle by some people taking longer journeys than expected. South Shields is an example of this and Gateshead is another example with the added functional barrier of Newcastle just across the river.

The testing of the model in terms of the centre network has shown the above to be true.

It must be admitted however that the centre network was introduced into the model to explain the irregular geometrical pattern overall of specific umlands. This it has only partly done. This aspect of the model will be worth future study to decide if the rows C_{ij} function by addition (as tested here) or by multiplication, to see if a distance and a mass value such as the hierarchical provision value are needed or if this variable as a whole is only applicable to the analysis of a single centre in relation to other centres and not to the overall situation, as tested here. What the model actually shows may be illustrated diagrammatically (see figures 9.17-18) for the two extreme examples.

INTERACTION	{ Constant }	CENTRES (Nil)
INDEX	{ Distance }	

Figure 9.17. Diagram of model results for Ophthalmology - $R^2 0.39$

INTERACTION	{ Constant }	Gateshead	→	South Shields
INDEX	{ Distance }	CENTRES	←	
	{ Hierarchical provision }	Darlington	←	Marginal centres are significant

Figure 9.18. Diagram of model results for General Surgery - $R^2 0.74$

The change in the exponent value for the distance variable deserves separate comment. Central place studies have discussed this exponent in terms of Reilly's Law.⁴³ In chapter six evidence was discussed of the coal miners leaving the industry at a rate proportional to the distance they had to travel.⁴⁴ This was seen as a continuous function with the general form of d^{-a} . Values for 'a' are available from testing the model for four sets of data. They vary in order as between the order of hierarchical levels and the number of centres in the network (see table 9.13).

SERVICE	EXPONENT VALUE	CENTRES IN NETWORK	AREA COVERED
Ophthalmology Units	0.80	4	North East England
Football League Clubs	1.18	5	North East England
Driving Tests Centres	1.53	11	N. Riding, Co. Durham South Northumberland
General Surgery Units	2.55	13	County Durham

Table 9.13. Exponent values for distances for the model

When considering the model it must not be forgotten that the dependent variable is the interaction index. One of the problems in studying the journey pattern of people is the population distribution. It affects all such distribution patterns and is a non-isotropic surface producing local distortions. The interaction index removes this distorting effect and thereby makes isolation of other variables within journey patterns easier.

It is possible to express the model in a mathematical form and rearrange it into the form

$$I_{ij} = \frac{P_i}{10^k d_{ij}^a K_i^b A h_j^c}$$

From the values obtained in testing the model, values can be fitted to all on the right hand side of the equation and so I_{ij} can be calculated. The results would not be as good as for interaction indices for population units. It is also possible to add or remove centres from the network (matrix A) or change the hierarchical provision values h_j and recalculate either interaction indices for population units or, though less successfully, actual interactions with a population unit with centres in a given service.

In comparison with other attempts to measure urban fields or trading areas the results of this model are good.⁴⁵ The hope put forward that distance, hierarchical provision values and the centre network would provide a high level of explanation as defined by table 9.1 has been fulfilled.

References

1. The 1961 Census has been used throughout as it is the most recent complete Census. The 1966 Sample Census shows little significant change for the study area.
2. See Chapter Eight, page 211.
3. Personal communications with the Clerk to the Northern Traffic Commissioners.
4. This is the statement for diffusion type models. It is well illustrated by Hagerstand, T., 'A Monte Carlo approach to diffusion', European Jour. of Sociology, No. 6, 1965; a discussion of this also is found in Olsson G., 'Distance and human interaction', Reg. Sc. Research Inst., 1965.

5. A recent discussion of this topic will be found in Wilson, A.G., 'Models in urban planning', Centre for Environment Studies, W.P.3.
6. Olsson, G., 'Distance and human interaction', *Geografiska Annaler*, 47B, 1965.
7. For an early statement of this theory see Stewart J.A. and Warntz, W., 'Physics of population distribution', *Journ. of Reg. Sc.*, Vol.1, No. 1, 1958.
8. See Szumeluk K., 'Central place theory I and II', Working Papers 2 and 9, Centre for Environmental Studies, London.
9. The following data shows the extra-North East England driving test interactions:-
NEWCASTLE - Cambridge 1, Carlisle 2, London 1, Madaley (Salop) 1, Rotherham 1, Ruislip (Middx.) 1.
SOUTH SHIELDS - Ashford (Middx.) 1, Glasgow 1, Herne Bay 1, London 1, Manchester 1, Rotherham 1, Sandback (Ches.) 1.
10. See reference 9 above.
11. See chapter Five, page 118.
12. It should be noted that this is different to the dependent variable used by Olsson G., *op. cit.*
13. This is a statement of the distance - decay syndrome expressed in an inverse form. For examples of distance - decay function see Hagerstrand T., *op. cit.*
14. This problem is discussed in its general setting by Szumeluk K., *op. cit.*
15. The questions of quadrant size and map transformation are discussed, for example in Haggett P., 'Locational analysis in human

geography', (Arnold, London) 1965.

16. For example see Chapter Two, page 28 ; Chapter Three, page 47 ; Chapter Four, page 90.
17. This suggests that within the bounded area with its grid of cells a Monte Carlo technique would simulate the pattern.
See Hagerstand T., op. cit., and Haggett P., op. cit.
18. A theoretical and recent discussion of this point is Szumeluk K., W.P.9. op. cit.
19. The unmapped interactions are:-
DARLINGTON - Brecon County 1, Corby 1, Lancashire 1, Portsmouth 1, Renfrewshire 1, Stainmore 1.
GATESHEAD - Alnwick 1, Ashington 1, Edinburgh 1, Leeds 1.
20. A study of the concept of range as set out by Christaller, shows it to be a vague generality. Rather range was imposed upon functions once a hierarchical hexagonal nesting system was established. See Christaller W., 'Central places in southern Germany', (New Jersey), 1968 (translated by Baskin C.W.).
21. A recent discussion of this problem is found in Thorpe D., 'The study of shops and shoppers', unpublished paper read to the Urban Studies group of the Institute of British Geographers, 1967.
22. Two recent studies using the competitive specific umland approach are Cox, K.R., 'The application of linear programming to geographic problems', Tijdschrift voor Economische en Sociale Geografie No. 6, 1965, and Rimmer P.J., 'Inferred hinterlands: an example of New Zealand seaports', Geography Vol.52. Nov.1967.

23. See Teesside Report and Survey (personal communication with Deputy Director); also Lewis, Parry J. and Trail A.L., 'The assessment of shopping potential and the demand for shops'. Town Planning Review, Jan. 1968.
24. This point is borne out by the work of Lowry I.S., 'Model of Metropolis', (Rand Corporation), 1964.
25. See page 254.
26. For example Lieberman and Schwirian, 'Banking in inter-city relations', Jour. of Reg. Sc. Vol. 4, No. 2, 1962; Zipf. G.K., 'Human behaviour and the principle of least effort', (Cambridge, U.S.A.) 1949.
27. Personal communication with the authorities concerned, op. cit.
28. See 'Scheme of Further Education', (Durham County Council), 1951.
29. See discussion in Olsson G., 'Distance and Human Interaction', op. cit.
30. See the early part of Chapter Four, pages 63-66.
31. In particular see table 4.6., pages 84.
32. See pages 75 and 83.
33. Several surveys sponsored by the Nuffield Provincial Hospital Trust shown this e.g. Airth and Newell op. cit.
34. While this is an imperfect measure, it does appear to be a reasonable one. See Thorpe D., op. cit.
35. See page 199.
36. Some ideas on a possible central place system in North East England occur in Fullerton B., 'The pattern of service industries in North East England', Newcastle upon Tyne, 1960.
37. See page 21.
38. This has recently become fairly standard practice. See, 'Report of the models working party', N.E.D.O. London, 1969.

39. The model was tested using an ICL 1900 Statistical Analysis standard programme. The multiple correlation coefficient produced is defined as:-

$$R^2 = \frac{\sum (y_i - \bar{y})^2 - \sum e_i^2}{\sum (y_i - \bar{y})^2}$$

where y_i is the original observations

\bar{y} is the means of the variables

e is the error sum of squares

40. Personal communication with A. McNay, Statistician to the Newcastle Regional Hospital Board.
41. Personal communication with the Clerk to the Northern Traffic Commissioners.
42. See Zipf. G.K. op. cit.
43. See Olsson G., op. cit.
44. See page 149.
45. For example, Olsson and Persson, 'The spacing of central places in Sweden', Papers and Proc. Reg. Sc. Ass., Vol.12.1964.

CHAPTER TEN - CONCLUSIONS

The study of central place theory has shown two main trends in recent years. The general functional discussion of the theory has frequently been narrowed to the retailing element.¹ Also empirical studies have been replaced by theoretical discussions of the behavioural basis of the theory.² By logic and statistical analysis a variety of statistical models have been built and criticised. The present study uses a broader range of functions and an empirical approach to the theory. Using maps, graphs and tabulations, variables have been isolated assuming a competition basis. The failure of centred regions to appear in the analysis shows that the competition basis assumed by the use of specific unlands was correct.

Central place theory postulates hierarchies which result in a central place system within which can be recognised certain orders of centres.³ The evidence presented here supports the existence of functional hierarchies and results in an ordering of centres into a central place system. This does require some qualification though compared with the theoretical statement. Threshold values do appear but the nesting of centres into a hexagonal system with specific range values is not apparent. This may be because the population distribution is uneven over the area of study. Christaller based his study on an area with a rural economy. County Durham has sparsely populated moorland to the west, an urbanised population in the north and a rural population in the south interspersed with the Darlington, Hartlepoons and Teesside urban agglomerations. This population distribution was bound to modify a theoretical pattern

established in an area with an even population distribution and a homogeneous economic base in agriculture.

Is this the only modification though? Does the distribution of population simply distort the hexagonal network and therefore the range factors?

The hexagonal pattern for the nesting of centres according to their central place order, assumes a simple gravity model with deterministic behavioural patterns over an area of homogeneous population distribution.⁴ Central place theory also assumes that a given function occurs at a given level in the ordering of central places and at all other centres of a lower ordering.⁵

To overcome the population distribution problem the concept of the interaction index has been used. This gives an apparently even population distribution by considering the population base required to produce unit interaction within a population unit. The result is an almost random distribution of interactions levels within a specific unland within certain hierarchical limits. The deterministic gravity model is not proven. However if a probabilistic gravity model is ~~not~~ accepted as is implicit in a competition model, then this has been shown to work. While the principle of least effort appears to provide a reasonable working behavioural system it can not provide a complete answer.⁶

This is linked to the problem of functional hierarchies or functional continuums. When research is based upon provision at a centre for a tributary area or field of attraction hierarchies are found to exist. However if people are interviewed the data from this source results in a continuum of functions.⁷ This apparent

conflict may be in defining function as opposed to level of provision, or it may be numerical. The continuum may result from too small a sample. The data of this study shows that on small population base units, random distributions exist. Once agglomeration reaches a sufficient level, zero values are lost, and a probabilistic gravity model operates. Base units of at least 1000 people have been necessary and even these were not always adequate.

Hence the step function producing hierarchies may require a large quantity of data before it appears. This study has a large quantity of data and supports the existence of hierarchies.

Granted the existence of hierarchies, some comment is possible on the concepts of range, or threshold values and of the nesting of central places into hexagonal patterns. Already doubt has been cast on the concept of range and the hexagonal pattern is not evident on the maps produced. The interaction indices within a specific umland certainly vary in value as between the services of different hierarchical groups. In fact any comment upon these concepts requires an examination of specific umlands as defined within this study. This study has shown that the operational unit is the specific umland and this is set in a competitive landscape. Its slope and extent is a result of the competition with centres of the same functional service and their distances from itself (matrix A of the model), the hierarchical level of the function (whether it is of a low, high or other level) and the provision for that function at that centre e.g. number of beds for a general surgery unit, which itself will be related to the already established central place order of the centre being studied.

This system may be thought of as originating out of a lower level order of centres.⁸ The landscape consists initially of a series of points which are at the lowest level of settlement development or ordering of centres. Into this network of points it is decided to introduce a function of the next level of a hierarchy. The hierarchy imposes a limit on the number of points which could be selected for establishing this function. If the initial landscape has 100 points of the lowest order of centres, then the next order of centres network might consist of about 20 points. Thus some 20 of the initial points will be selected for establishing the new function. The selection may be an administrative decision or a matter of pure chance and is probably best expressed in terms of a Monte Carlo technique applied to the landscape.⁹ Two facts need stressing. By this approach the chance of the selected points forming a hexagonal pattern is fairly remote. The work of Dacey on point pattern analysis formulates this chance more precisely.¹⁰ Also that the number of points selected is about 20 and is not necessarily exactly 20. That is that the hierarchy imposes broad limits.

This second point can be illustrated from the data. Three high level functions can be recognised within the data, regional technical colleges, ophthalmology and league football. They have a basic network pattern of three centres consisting of Middlesbrough, Newcastle and Sunderland. This is the complete system for regional technical colleges but ophthalmology adds Darlington to this network and league football adds both Darlington and Hartlepool. The hierarchy sets limits in this case of between 3 and 5 centres, to be selected from the next lowest order of centres.

The centres having been chosen the next step is the provision of the service at each centre. This has been shown to form a continuum and varies with the central place ordering of the centre. This is generally referred to as its centrality and the total population forms one possible way of measuring centrality.¹¹ Given the above ophthalmic network of four centres, the centrality values suggest that the number of actual beds provided will be lowest at Darlington and highest at Newcastle. This happens in reality (see table 3.4). The beds provided might well be called the continuum value to distinguish them from the hierarchical level ophthalmology which also has a value.

Once the centre network is established with a provision of beds, the population involved will adjust itself to using the centre which is nearest to it in terms of population distance. The geographical distance involved in travel from unit i to centres j is modified by the provision i.e. the opportunities of that function, at the centres j and the distribution of population around the centres i.e. competition from people living nearer to any given centre for the use of the opportunities available. This is a restatement of the statistical model already tested. This will achieve an equilibrium with all opportunities being used e.g. each ophthalmic bed will over a period of time result in about the same number of interactions. Generally supply will be about or just below the needs of demand. Any surplus of provision made initially will go out of use whereas any excess demand will result in increased provision.

As a result of this at any one moment in time the centre network may show centres which are low in the continuum or otherwise

anomalous. The former may be centres in decline because of over provision either for example of total beds or of total hospital centres. Hence Easington, Stanley and Chester-le-Street are such a group in general surgery. Another anomaly may arise with expanding demand and the need to increase provision or select a new centre to be added to the hierarchical level. Such is Middlesbrough in driving tests and the discussion of Stockton as a new centre.

This outline suggests a flexible system within which central place theory provides limits to the operation of hierarchical functions. A hexagonal nesting of centres would not result, range would vary according to the number of centres established within a hierarchical level and the threshold value is related to the level of interaction associated with one unit of a function - a driving test examiner's hours, a technical college course, a hospital general surgery bed.

The specific umland results, then, from the level of provision of its centre and the competition from surrounding centres. The interaction index critical value is the relationship during a specific period of time of unit provision for the population of the specific umland. Given a bounded area with a known population specific umlands can be located and interaction calculated when the centre points, the provision at each centre and the interaction index critical value are known. The total provision of the function over the bounded area will be the total population divided by the upper limit of the interaction index for specific umlands of that function. This will have to be calculated empirically for a given area and based on trends.

Having lost the rigidity of the initial statement of central

place theory, the Loschian variation on central place functions follows. Christaller envisaged that all high order centres would have the same group of functions and all the functions of all lower order centres.¹² Losch modified this when he discussed the K value of the hexagonal system. He suggested that a high order centre might lack some of the total functions because of its position within varying K value systems.¹³ In view of the above analysis a logical extension of this is that any centre of a given order in a central place system may have some functions of a higher hierarchical order and may lack some functions of a lower hierarchical order. A difference is seen here between centrality with its ordering of centres and the actual functions performed by any given centres within a recognised level or order of centres. Centrality is seen as being based upon a bundle of functions. The actual functions in any particular bundle may vary even within the same centrality group. However, should a high level function appear within a lower order centre, the provision of that function at that centre will have a low continuum value (or hierarchical provision as defined in the statistical model). Similarly a high level order of centre will have a high continuum value for its low level services.

This point is illustrated in figures 9.12-15. It is also illustrated by the maps of Sunderland and Hartlepoons (fig. 8.1 and 9.3) and their specific umlands. Sunderland is a higher order of central place than Hartlepoons. Both have league football clubs although Hartlepoons is not of an order of central places to apparently justify this. The provision of this function varies between these two centres and is least at Hartlepoons. Both have general

surgery units which is a low level function for Sunderland. The provision for general surgery is greater at Sunderland than at Hartlepoons as a result.

Central place theory is now seen as a set of limits within which a central place system with its hierarchical structure may operate. The whole may be seen as a logical extension of the Loschian modifications of a central place system in terms of modern probabilistic theory.

Some comment is needed on the techniques used within this study. The whole of part one is a traditional type study in geography of a central place system. By means of maps, graphs and tabulations a competitive landscape is analysed. Variables are isolated and a description of the landscape in terms of those variables is attempted. The result is a meaningful interpretation of the landscape.¹⁴

Part two has taken this description a stage further. By the use of statistical techniques which in this case is mainly by a multiple regression analysis, the variables already recognised are tested to see how much they explain the pattern being analysed. The description is being quantified and also the inadequacy of the description is expressed. For a perfect description of the landscape when quantified by statistics a multiple regression coefficient of one will result. Because geography is dealing with human beings and is not deterministic, perfect description or correlation is not expected.

One must question therefore is anything has been gained by quantifying when by definition the exercise can not be perfect. The answer to this must vary according to one's acceptance of the purpose

of geography. If analysis and description are academic exercises justifiable in their own rights, the use by geographers of techniques in which they are dependent upon statisticians may be considered unwarranted. If however analysis should be pursued and tested as far as resources and techniques will permit, the recent growth of statistical techniques should be used if possible.

The gain from the use of these sophisticated techniques is mainly at the level of explaining human action. We are all individuals with different psychics which are influenced by experience of life and this will result in a wide variety of human response. However, at the aggregate level, human beings lose their individuality and tend to show groupings and this has formed the basis for the development of psychology as a science. Similarly in human geography at the aggregate level, man operates in a fairly uniform manner resulting in patterns of movement within the physical landscape - be it of rivers, mountains, roads or buildings - which are capable of scientific analysis. The theory of probability provides the means by which to analyse this human landscape and it is applied through statistical techniques.

Geography is essentially a dynamic subject. The landscape, both physical and human, changes in time. To measure it precisely aids interpretation in time and hence aids the understanding of the dynamic factors. Quantification is a great help here in that the minor changes of variables one to another become more susceptible to analysis when the variables have numerical values. Further, trends can now be established and their forward projection in time is possible.

Hence one can justify the application of statistical techniques to the data of this study on the grounds that they help to further the analysis and refine it, they provide a yardstick to test the conclusions, they provide a theoretical basis for a behavioural explanation of the distributions and they provide the basis for an analysis in time with projections into the future as a possibility.

The total result is an analysis of a human geography landscape which makes it possible to interpret patterns of movement in terms of a behavioural system by a set of variables. The results have the limitations that they occur in north east England at a certain moment in time and for a limited range of functions. However when they are compared with research and the results elsewhere they do fit into the ongoing discussion of central place theory. It has been the object of this thesis to provide empirical evidence to modify that theory and bring it closer to reality.

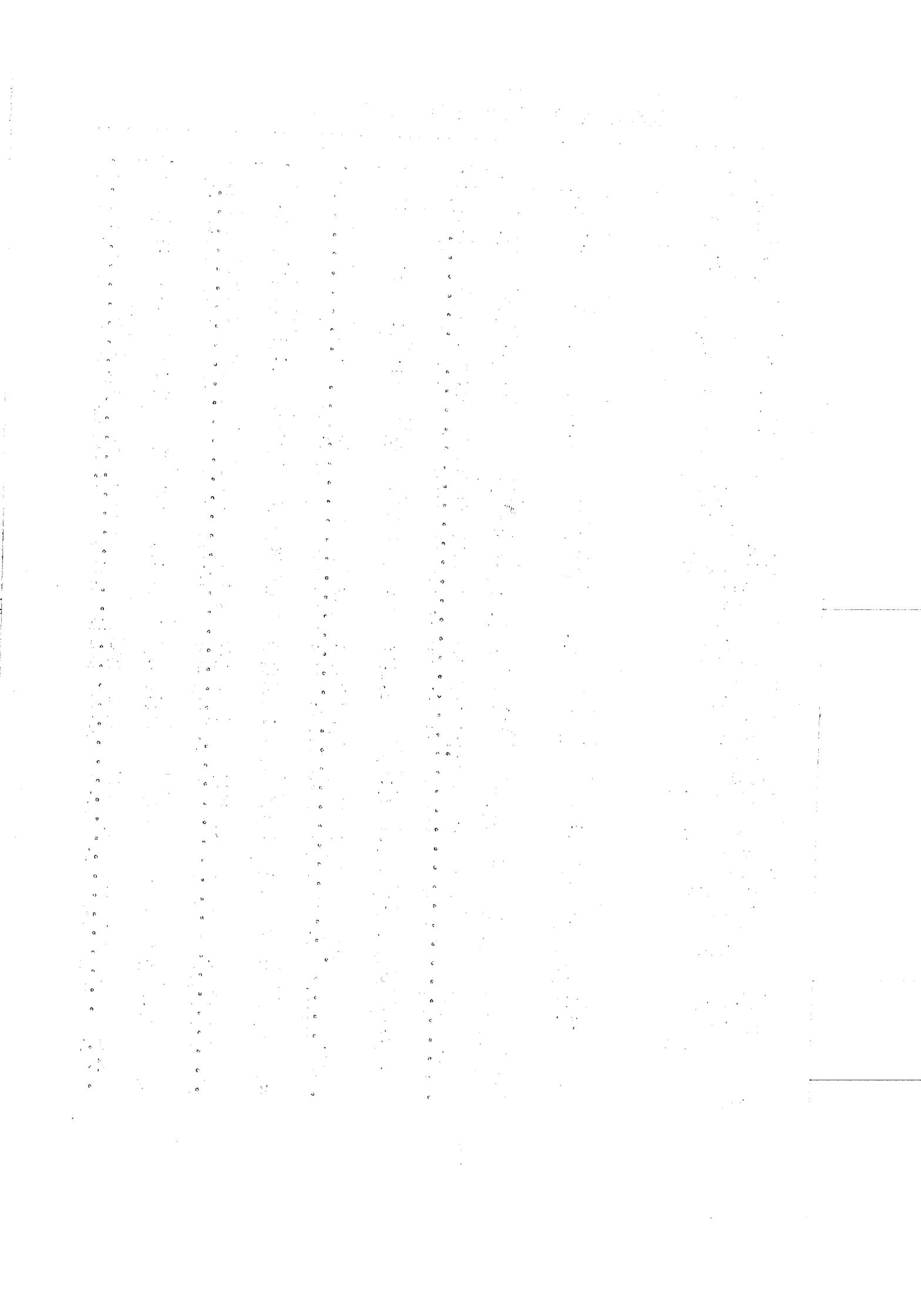
References

1. See Szumeluk, 'Central place theory, I and II', Working Papers 2 and 9, Centre for Environmental Studies, London.
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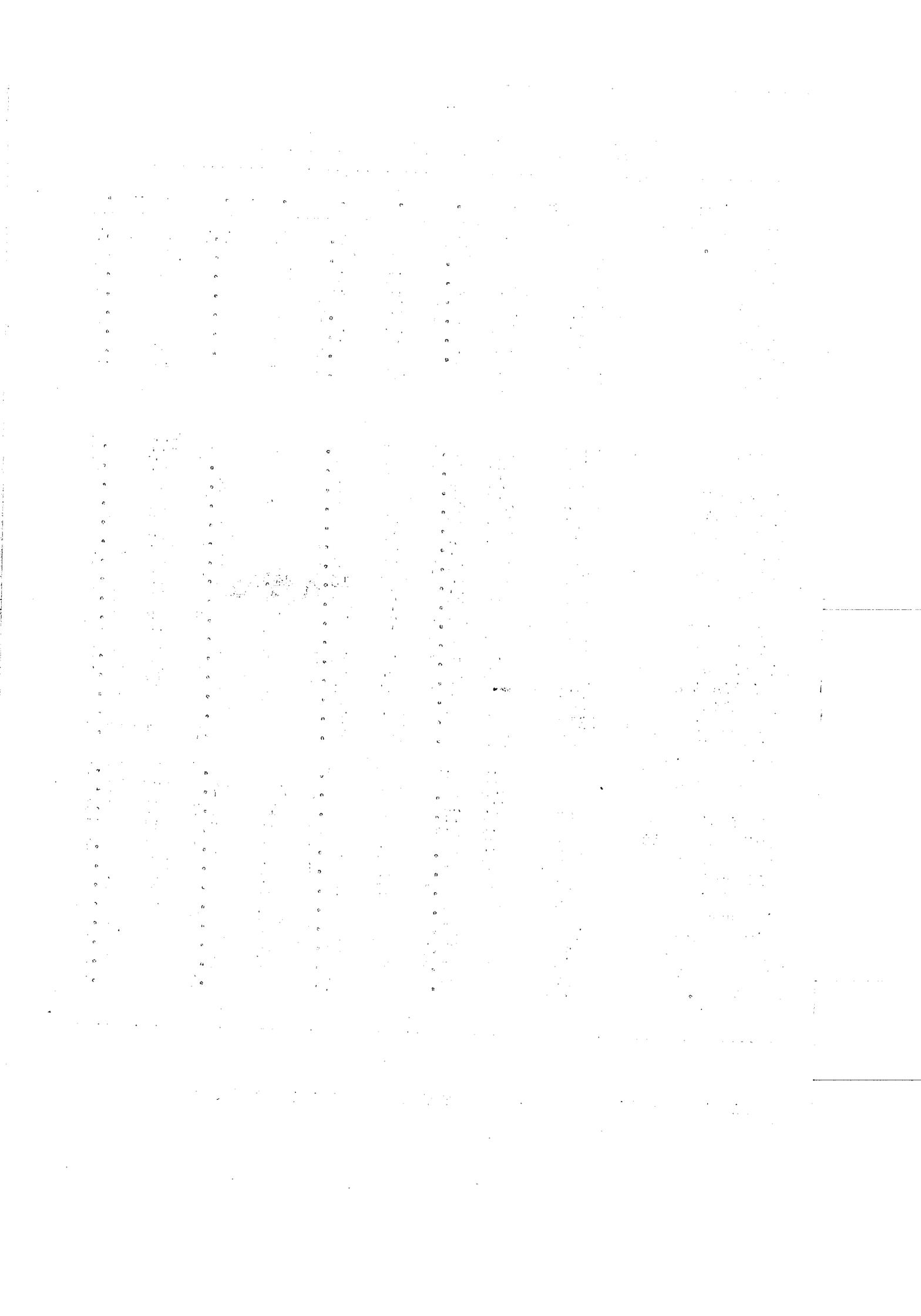
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mile concentric circle zones from pit head - 1964

MILE ZONES													
4.1 - 5.0	5.1 - 6.0	6.1 - 7.0	7.1 - 8.0	8.1 - 9.0	9.1 - 10.0	10.1+							
9	0.6	4	0.3	6	0.4	1	Nil	1	Nil	Nil	Nil		
1	1.5	1	1.5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
58	12.3	2	0.4	3	0.6	2	0.4	Nil	Nil	Nil	Nil		
57	6.6	67	7.7	5	0.6	39	4.5	Nil	Nil	Nil	Nil		
17	3.3	12	2.3	2	0.4	2	0.4	2	0.4	1	0.2		
19	1.8	2	0.2	2	0.2	1	0.1	Nil	Nil	Nil	Nil		
7	1.3	8	1.5	9	1.7	Nil	Nil	Nil	Nil	Nil	Nil		
88	8.1	17	1.6	32	3.0	8	0.7	2	0.2	2	0.2		
7	2.8	15	6.1	2	0.8	1	0.4	1	0.4	1	0.4		
39	16.2	5	2.1	3	1.2	21	8.7	Nil	Nil	Nil	Nil		
5	5.4	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
1	0.3	Nil	Nil	1	0.3	Nil	Nil	Nil	Nil	Nil	Nil		
9	1.4	10	1.6	19	3.0	11	1.7	Nil	Nil	Nil	Nil	(1)	0.1
6	1.0	1	0.2	3	0.5	1	0.2	2	0.3	1	0.2	(3)	0.5
7	3.0	9	4.0	1	0.5	Nil	Nil	Nil	Nil	Nil	Nil		
30	5.6	1	0.2	Nil	Nil	17	3.2	2	0.4	Nil	Nil	(2)	0.4
16	4.0	20	4.8	1	0.2	Nil	Nil	Nil	Nil	Nil	Nil		
1	0.3	2	0.7	10	3.5	1	0.3	Nil	Nil	1	0.3	(1)	0.3
63	9.1	2	0.3	17	2.4	3	0.4	Nil	Nil	1	0.1		
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	2	1.5	Nil	Nil		
1	0.5	1	0.5	2	1.0	Nil	Nil	Nil	Nil	Nil	Nil		
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	(1)	2.7
3	0.6	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	3	0.6		
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	1	1.0	(1)	1.0
2	0.9	9	3.8	Nil	Nil	Nil	Nil	Nil	Nil	2	0.9	(2)	0.9
24	6.0	28	7.0	22	5.5	1	0.2	Nil	Nil	Nil	Nil		
12	2.2	Nil	Nil	Nil	Nil	1	0.2	4	0.7	Nil	Nil		
2	0.2	3	0.3	Nil	Nil	Nil	Nil	3	0.3	Nil	Nil	(1)	0.1
81	2.7	15	0.5	2	0.1	1	Nil	17	0.6	Nil	Nil	(4)	0.1
15	0.6	3	0.1	3	0.1	53	2.0	1	Nil	1	Nil	(2)	0.1
7	0.6	2	0.2	3	0.3	Nil	Nil	Nil	Nil	4	0.4		
26	2.8	29	3.1	16	1.7	3	0.2	1	0.1	Nil	Nil		
5	0.3	161	8.5	8	0.4	1	0.1	3	0.2	Nil	Nil	(3)	0.2
2	0.3	Nil	Nil	Nil	Nil	2	0.3	1	0.1	Nil	Nil	(2)	0.3
7	2.3	2	0.6	3	1.0	Nil	Nil	1	0.3	Nil	Nil		
4	0.7	2	0.3	1	0.2	1	0.2	Nil	Nil	Nil	Nil	(1)	0.2
5	0.4	1	0.1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	(1)	0.1
6	0.4	13	0.9	Nil	Nil	1	0.1	Nil	Nil	Nil	Nil	(1)	0.1
Nil	Nil	3	0.6	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
2	1.9	Nil	Nil	1	1.0	1	1.0	Nil	Nil	Nil	Nil		
73	5.6	22	1.7	Nil	Nil	Nil	Nil	1	0.1	2	0.1	(12)	0.9
11	1.8	1	0.1	3	0.5	2	0.3	Nil	Nil	Nil	Nil		
198	11.6	4	0.2	2	0.1	4	0.2	Nil	Nil	2	0.1	(1)	0.1
30	4.1	7	1.0	1	1.0	1	0.1	Nil	Nil	Nil	Nil		
320	18.9	21	1.3	7	0.4	Nil	Nil	2	0.1	Nil	Nil	(31)	1.8
25	1.3	101	5.4	3	0.2	9	0.5	Nil	Nil	Nil	Nil	(42)	2.2
3	0.1	22	1.0	6	0.3	49	2.3	107	5.0	18	0.9	(26)	1.2
8	0.1	4	0.2	23	1.1	Nil	Nil	Nil	Nil	1	0.1		



mile concentric circle zones from pit head - 1964

MILE ZONES												
4.1	5.0	5.1	6.0	6.1	7.0	7.1	8.0	8.1	9.0	9.1	10.0	10.1+
26	3.5	8	1.1	2	0.3	Nil	Nil	4	0.5	22	2.9	(7) 0.9
16	1.5	2	0.2	3	0.3	2	0.2	Nil	Nil	1	0.1	(3) 0.3
2	0.2	1	0.1	Nil	Nil	1	0.1	1	0.1	Nil	Nil	(4) 0.4
Nil	Nil	Nil	Nil	134	7.0	134	7.0	30	1.6	2	0.1	(374) 19.6
98	10.2	5	0.5	Nil	Nil	1	0.1	1	0.1	Nil	Nil	(3) 0.3
14	1.3	2	0.2	1	0.1	Nil	Nil	Nil	Nil	Nil	Nil	(2) 0.2
10	0.9	1	0.1	Nil	Nil	3	0.3	Nil	Nil	Nil	Nil	(2) 0.2
8	0.8	Nil	Nil	1	0.1	Nil	Nil	Nil	Nil	Nil	Nil	Centre: of S. Shields is 1½ miles from pit head.
23	1.6	37	2.6	2	0.2	2	0.2	3	0.2	Nil	Nil	(83) 5.9
67	11.5	15	2.6	2	0.3	3	0.5	12	2.1	Nil	Nil	(19) 3.3
97	6.6	12	0.8	8	0.5	1	0.1	Nil	Nil	1	0.1	(17) 1.1
47	3.8	7	0.6	Nil	Nil	1	0.1	Nil	Nil	Nil	Nil	(2) 0.2
10	1.0	13	1.4	Nil	Nil	1	0.1	1	0.1	3	0.3	(3) 0.3
42	3.7	17	1.5	12	1.1	4	0.3	1	0.1	Nil	Nil	(1) 0.1
21	5.1	25	6.1	13	3.1	9	2.2	6	1.6	3	0.7	(1) 0.2
1	0.1	13	1.5	1	0.1	5	0.6	Nil	Nil	1	0.1	
17	2.0	3	0.4	15	1.7	Nil	Nil	1	0.1	1	0.1	(2) 0.2
6	6.3	1	1.1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
53	13.8	8	2.1	3	0.8	29	7.5	8	2.1	3	0.8	(12) 3.1
3	0.7	15	3.3	2	0.5	Nil	Nil	1	0.2	Nil	Nil	(1) 0.2
42	10.9	6	1.7	10	2.6	4	1.0	4	1.0	Nil	Nil	
46	3.5	10	0.7	6	0.4	Nil	Nil	1	0.1	Nil	Nil	(2) 0.2
28	2.3	3	0.2	22	1.8	Nil	Nil	Nil	Nil	Nil	Nil	(5) 0.4
4	4.7	5	5.8	23	26.8	1	1.1	Nil	Nil	1	1.1	
44	2.7	93	5.8	3	0.2	3	0.2	Nil	Nil	Nil	Nil	(6) 0.4
1	0.4	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
17	28.4	5	8.3	18	30.0	3	5.0	Nil	Nil	Nil	Nil	
3	1.3	3	1.3	3	1.3	Nil	Nil	Nil	Nil	Nil	Nil	(1) 0.5
2	0.6	2	0.6	1	0.3	Nil	Nil	Nil	Nil	Nil	Nil	
4	2.9	Nil	Nil	3	2.1	Nil	Nil	Nil	Nil	Nil	Nil	
212	16.5	7	0.6	61	4.7	19	1.6	39	3.0	45	3.5	(12) 0.9
2	0.3	11	1.5	18	2.5	3	0.4	10	1.4	6	0.8	(11) 1.5
15	5.5	25	9.2	3	1.1	5	1.8	1	0.4	1	0.4	(2) 0.7
4	1.2	12	3.7	10	3.0	Nil	Nil	3	0.9	4	1.2	
3	0.6	1	0.2	Nil	Nil	Nil	Nil	Nil	Nil	1	0.2	

SOME FACTORS INFLUENCING THE MOBILITY
OF COAL MINERS IN COUNTY DURHAM

Memorandum agreed between author and the Durham Divisional Officers, of the National Coal Board in 1965.

1. By 1850 a tradition was established at the larger mines, such as those of the Marquis of Londonderry, for high wages, houses at the pit head and encouragement of son to follow father down the mine. Source: House J.W. "North Eastern England" Research Series No. 1 Geog. Dept., Kings College, Newcastle, 1954, pp. 39-40.
2. Miners form teams underground which work closely together and once established the miners do not like to break up these teams. They help each other; for example, the older men in the team are given the lighter jobs to do. This gives initial stability to manpower.
3. Seniority for underground jobs gives a stable labour force in any one mine. This is upset by closures and seniority is lost on redeployment to another mine.
4. Miners have formed closely-knit social units. If a mine is closed the miner may work in another colliery, but is not too prepared to leave his original home area.
5. If a colliery is closed subsidised transport is sometimes provided to another colliery for redeployed men. Subsidised transport was a war time and post-war innovation subsequently inherited by the National Coal Board. The result is to encourage men to keep to the same home base and to travel daily to another mine.

6. Colliery housing was originally provided at or near the pit head. This was inherited from the original owners. National Coal Board houses are free and if a miner is already established in a colliery house there is little incentive to move. Should the local mine close, and he continues to work at a National Coal Board Colliery, he keeps his rent-free house and probably has the opportunity of subsidised transport to another mine.
7. Colliery houses today (1965) are frequently occupied by concessionaires such as pensioners. The result is a lack of houses near to mines with vacancies. A miner redeployed to a colliery cannot always be offered a local colliery house and so keeps his original house and travels daily to his new mine.
8. New collieries opened since Vesting Day were manned substantially from surrounding collieries and so show high labour mobility. They attracted labour because of short underground travel distances, new amenities, and long term prospects of employment.
9. Divisional policy is continuity of employment for men in the Industry, hence any manpower needs must, wherever possible, be met from redeployment and this will increase mobility patterns.
10. As the labour force is run-down and concentrated into fewer collieries, mobility will increase. The miner in County Durham is becoming a 'commuter' following a pattern already well established in other industries.

MEMORANDUM ON INTERVIEWS WITH TRAINING OFFICERS IN 1966,
WITHIN THE DURHAM DIVISION OF THE NATIONAL COAL BOARD.

Whitburn Colliery

Always a large pit, a village was built alongside it. However soon expanded beyond local labour force and early tradition of drawing labour from South Shields and Sunderland. Once over 2,000 manpower is now declining.

Boldon Colliery

Sunk 1876, starting to draw in 1900. Traditional source of labour has been Boldon, South Shields and Jarrow. This can be linked to 1920's when ship-building closed down and labour in Jarrow - South Shields went down the mines. Pit expanded steadily until recently. Now there is some contraction which means a steady wastage but no transfers in, so traditional pattern of manpower retained.

Harton Colliery

Sunk on the edge of South Shields, has always been able to draw adequate labour resources from the town. Has had little change in manpower demands or source over last 20 years.

Easington Colliery

Opened in early 20th century with large number of colliery houses. Expanded until about 1945 with local based labour. Housing shortage in late 1940's meant that Peterlee was only possible source of houses for young couples. Hence some movement out to Peterlee. Wingate closure (1963) meant some transfers to Easington.

Shotton Colliery

Opened at end of 19th century, it has had checkered career. Several closures but miners simply unemployed until pit opened again. Hence local labour force. When Haswell closed, miners went to Shotton as it was worked by the same company. Fair number of colliery houses, but 1940's attracted young couples to Peterlee with housing shortage then.

Horden Colliery

Initially local labour with colliery houses. A large colliery so able to absorb Wingate Closures. Has part of West Hartlepool group carrying through from Blackhall and link to Peterlee with housing shortage of the late 1940's.

Blackhall Colliery

Initially local labour with colliery houses. An attractive mine because working conditions are good with thick seams. When Hesledon closed, miners went to Blackhall as it was worked by same company at one time. Conditions drew Wingate transfers and there is a link to West Hartlepool. Some 200 like to live in West Hartlepool with its amenities and work at Blackhall. Link to Peterlee with housing shortage in the late 1940's.

Westoe Colliery

An old colliery, it had few colliery houses but being in South Shields there was plenty of local labour. 1954 had manpower of about 600, virtually all local. Expansion then started, to reach a maximum in 1966. Manpower increased by transfers from closures such as Chester-le-Street and Gateshead.

Morrison Busty Colliery

Essentially a static pit with manpower steady and drawn from Annfield Plain, Stanley and New Kyo and Dipton. With recent drift away from coal mining there are transfers in from closures to maintain manpower.

Greenside Colliery

Pre-1939 this was a show pit. As a result the mine has been worked-out fairly quickly. Peak reached in 1959 with over 800 manpower. Now in steady decline. 1955-56 about 50% of labour from Greenside. 1955-56 Chopwell closed and miners transferred to Greenside. Addison (1963), Stargate (1964) and Emma closed and labour sent to Greenside.

Beamish Mary Colliery

Initial manpower from Stanley area at around 500-600. Steady expansion from 1955 till 1965 to about 700 with working of Brockwell seam and mechanisation. Build-up of manpower for this achieved by transfers from nearby closures from Pelton Fell, South Pelaw and Chester Moor.

Barcus Close Colliery

Originally manned from Rowlands Gill and Highfield. With the local drift away from mining, wastage has been made good by transfers from local pit closures.

Marley Hill Colliery

Sunk in an area of small dispersed settlements. Had few initial colliery houses and drew labour from the already established mining settlements. As this was a large pit, its manpower came from a broad

area from the start. Plenty of good work here attracted labour. Kept labour because of seniority ratings.

Byermoor Colliery

Originally manned from Byermoor, Burnopfield and Hobson. Manpower has been stable at about 400 for some ten years. Some drifting away of miners who have been replaced by transfers. When High Marley Hill drift closed, miners went to Byermoor for example.

Blackburn Fell Colliery

Really a second working for Marley Hill now. Men in fact use Marley Hill shaft. So pattern from pit head here is misleading. Pony putting found here. This is piece work and men can earn good money, but they don't stick the job for long. Hence there is a high turn-over of labour which diversified journey pattern.

Brusselton Colliery

Owned by a Crook Company, it was not really developed until nationalisation. Labour drawn originally from Shildon, Bishop Auckland and West Auckland. Manpower remained fairly steady till 1964. The pit has steeply dipping beds and walking is exhausting along roadways. This has helped to give a turn-over of labour with wastage being made good by transfers.

Before 1948 there was a bus service from Witton Park. More recently men have been transferred from Cockfield and New Shildon. Several small pits - Ramshaw, Princes Street, Esperley, Ramage - closed and miners went to Shildon and this gave miners from Woodland, Copley, Butterknowle, Evenwood. These have now been transferred from Shildon with its run-down, to Brusselton. 1949 this pit was

opened by N.C.B. Hence manning from other pits.

Staindrop Field House Colliery

A drift mine opened in 1951. Original manpower built up from Evenwood and West Auckland. Has remained fairly steady with manpower wastage made up by transfers. Crook workings e.g. Roddymoor, closed, Cockfield workings e.g. Gages Arms closed (1958) and transferred to Staindrop. A result of Divisional policy of internal transfers rather than new labour being taken on.

West Auckland Colliery

Opened in 1955 it was manned from the Bishop Auckland and Etherley areas. Etherley Dene was closing when West Auckland was being opened. About the same time men were transferred in from the declining Crook area.

Washington F Colliery

Originally colliery houses around pit with local labour. The houses have been pulled down and replaced by Council houses. 1939 manpower was built up slowly and Gateshead closures meant some men trying Washington and staying. Hence link to Gateshead established. Transfers in continued from then onwards. Partly a build-up of manpower, partly lack of local manpower or resistance of local labour ("my son isn't going down the mine"). Hence some broadening of manpower source but still mainly local.

Usworth Colliery

Usworth and Washington traditionally linked and a good supply of labour available. Plenty of local housing. Pit has steadily built up its manpower and had a good reputation in the 1940's. This drew

labour from Felling and Gateshead. Although offered local houses, these men prefer living in Felling/Gateshead with their better amenities. Recent link with Sunderland with new housing on Washington side of Sunderland and good bus service. Much use of own transport by miners - scooters and bicycles.

Ravensworth Ann Colliery

Once had a colliery village at Team Valley. Basis of a stable manpower with strong family links to pit. 1960 the village was pulled down and people moved to Birtley. Also links to Gateshead. Some transfers of men in, but not many.

Wardley Colliery

Originally drew labour from local colliery village. 1950-54 saw period of expansion with opening of local drift. Extra manpower attracted from outside for this - Gateshead, Hebburn, Jarrow and South Shields. In 1960's with pit closures, men were drafted into Wardley to give broadening of manpower source. 1964 sees decline. Plenty of local industry and men now attracted away to other jobs.

Metal Bridge Colliery

A drift mine started 'in the middle of a field' in 1954. Built up manpower initially but in 1960's there was a run-down for re-development. This accounts for unusual pattern shown.

Mainsforth Colliery

Started drawing coal about 1906. Colliery houses built on the spot (Ferryhill Station) for miners. Also miners from the older mining settlement of Bishop Middleham attracted from the beginning. About 1918-1920 the Spennymoor iron works closed. Local pits all

small and lacked jobs, so workers had to look east to the expanding pits such as Dean and Chapter and Mainsforth for jobs. Jowett provided a bus service linking Spennymoor-Chilton-Fishburn. (Whitworth Park probably closed in 1920's).

The Carlton Iron Co. owned both Mainsforth and East Howle. When the East Howle pit was burnt down (1910-12) the miners were transferred to Mainsforth, and did not go to Dean and Chapter.

Pit continued to expand until 1950. Hence when small pits at Croxdale and Tudhoe closed, some of the miners went to Mainsforth. Reached peak manpower of 2500 in 1950.

Chilton pit was linked to Dean and Chapter in 1956 and this gave redundancies. Redundancies at Thristlington in 1961 and more at Chilton in 1962 gave more transfers.

Adventure Colliery

Another of the Lord Joyce pits, it has family ties. Has good quality coal but small labour force. As with other pits with small labour force, shows diverse source. With the smaller numbers, influence of men marrying out of the village may show through more strongly.

Hawthorn Colliery

Simply a service shaft for Elemore, Eppleton and Murton pits. Has no working faces, was sunk recently and has labour force drawn from the group of pits. It provides a point for lifting coals near to underground faces.

Lumley Colliery

Really a group of small pits owned by Lord Joyce. There were 8 Lumleys and Mary and George pits. Group policy to be self-contained. Own workshops, locomotives, forestry for pits and No.3 pit (closed 1926) was highly mechanised by standards of its time. Hence bred a family tradition.

Mines originally opened around Great Lumley than newer ones opened towards Fencehouses. As a result Fencehouses grew as a settlement. West Rainton and Leamside were Joyce Pits and so interchange of labour with there. With continued expansion Burnmoor became part of group area.

1930's show change. People looking for work and so prepared to travel. Hence labour taken on from such places as Chester-le-Street and Sunderland. Managers moving round brought in their own labour from pits they had previously worked in. Hence general broadening of labour source.

Now closed.

Deaf Hill Colliery

Was part of a group - Wingate, Trimdons, Station Town - which was owned by one company. When Wingate closed some men went to Deaf Hill because it was once the same company working it, but remained in Wingate for housing. Plenty of colliery houses and a tight community spirit encouraged this.

Contraction started in 1945 with men transferring to Blackhall again continued to live in Trimdons with transport provided to Blackhall. Hence diverse labour because of slow contraction,

contraction not being selective to any particular settlement in labour force.

Bowburn Colliery

Shaft sunk in 1906. Colliery houses provided on the spot. Also a post-war council estate built. Expanded slowly until 1960

Coxhoe colliery closed and colliery houses transferred to Bowburn with miners transferred as well. Plenty of good money to be earned at Bowburn and so attracted miners from surrounding smaller pits. Also marriage to girls living just outside Bowburn partly accounts for broad local pattern. True of Durham, Tursdale, Sherburn.

Cheesey provided a bus service through from Brandon and Jowett from Spennymoor from a very early date.

Sherburn Hill Colliery

Draws traditionally from Sherburn Hill, Sherburn, Durham, Carrville, Pittington, Littleton, Shadforth and Ludworth. Transport provided over this area. Shows similarity to Sherburn Coop area. Family links seem important here. Sons marry into outside villages to give this pattern over an area of fairly small settlements. Colliery houses available at Sherburn Hill and Littleton. Travel has always been easy over area.

Hendon Hold Colliery

Originally there were three small collieries within $\frac{1}{2}$ miles radius. Now combined in one which is over 100 years old. Originally manned from Grange Villa and West Pelton. Rebuilt as a paying mine by working the Tilly seam. Hence enlarged pit drew labour from areas of closure round about Sacriston, Chester Moor, Chester-le-Street and Stanley.

SETTLEMENTS PROVIDING AT LEAST 5% OF A COLLIERY'S MANPOWER

<u>Colliery</u>	<u>Settlements (distance by miles in brackets)</u>
Thornley	Thornley (0.2), Wheatley Hill (0.7), Ludworth (1.2).
Sherburn Hill	Sherburn (1.1), Sherburn Hill (0.2), Durham (3.9), Carrville (2.1), Pittington (1.2), Littleton (0.6),
Blackhall	Blackhall (0.4), Peterlee (2.3), Hesleden (1.5), Hartlepool (5.4).
Wheatley Hill	Wheatley Hill (0.5), Thornley (1.3), Wingate (1.3), Shotton Colliery (1.2).
Eppleton	Hetton (0.6), Houghton (1.5), Easington Lane (1.5)
Houghton	Houghton (0.3).
Adventure	West Rainton (0.3), Houghton (2.4), Fence Houses (2.0), East Rainton (1.3), Pittington (1.6).
Hawthorn	Murton (0.9), Hetton (2.5), South Hetton (0.8), Easington Lane (1.6).
Elemore	Easington Lane (0.5), Hetton (1.4).
Silksworth	Silksworth (0.6), Sunderland (2.3).
Fishburn	Fishburn (0.3), Trimdon (1.4), Ferryhill (4.4), Chilton (4.7).
Trimdon Grange	Trimdon (1.1), Trimdon Grange (0.3), Trimdon Station (0.9), Wingate (2.5).
Bearpark	Bearpark (0.2), Ushaw Moor (0.9), New Brancepeth (1.5), Esh Winning (3.4), Durham (2.1).
Langley Park	Langley Park (0.3), Witton Gilbert (1.5), Esh Winning (2.5).
Chopwell	Chopwell (0.5)

Greenside	Greenside (0.1), High Spen (1.5), Rowlands Gill (2.6), Highfield (2.1), Ryton (1.7), Chopwell (2.7).
Hamsterley	Hamsterley (0.1), Highfield (2.5), Chopwell (1.1), Blackhall Mill (0.4), High Spen (2.4), Consett (3.4), Ebchester (1.1), Rowlands Gill (2.9).
Handon Hold	Pelton (1.3), W. Pelton (0.4), High Hold (0.2), Chester-le-Street (2.5), Stanley (2.5), Grange Villa (0.3).
Eden	Leadgate (0.7), Consett (1.8), Dipton (1.7).
Barcus Close	Burnopfield (0.9), Rowlands Gill (0.4), Highfield (1.1), Chopwell (3.0).
Clara Vale	Ryton (1.4), Winlotion (3.3), Blaydon (3.5), Prudhoe (1.3), Clara Vale (0.1), Crawcrook (0.8), Greenside (1.8).
Sacriston	Sacriston (0.7), Witton Gilbert (1.3), Edmondsley (0.7), Chester-le-Street (3.0).
Craghead	Craghead (0.2), Stanley (1.7).
Emma	Blaydon (2.4), Ryton (0.6), Prudhoe (2.9), Rowlands Gill (3.4).
Burnopfield	Dipton (1.8), Burnopfield (0.5), Tantobie (0.9), Hobson (0.1).
Dean & Chapter	Ferryhill (0.5), Spennymoor (1.7), Coundon (3.3), Chilton (2.1), Leeholme (2.8).
Esh Winning	Esh Winning (0.4).
North Tees	Woodland (7.0), Cockfield (4.9), Staindrop (2.6), Evenwood (5.7)
Brandon	Brandon (1.6), Meadowfield (2.0) New Brancepeth (1.0).

Mainsforth Ferryhill (1.0), Spennymoor (3.4), West Cornforth (1.6),
Chilton (1.7).

Staindrop Crook (6.9), Evenwood (1.2), Cockfield (3.0),
West Auckland (1.3), Bishop Auckland (3.7).

Bowburn Bowburn (0.2), Coxhoe (1.6), Durham (3.2),
Sherburn (2.9), West Cornforth (2.6).

New Shildon Shildon (0.7), Bishop Auckland (2.7).

Tudhoe Park Spennymoor (1.5), Tudhoe (0.2), Croxdale (0.8),
Middlestone Moor (2.3), Ferryhill (2.4).

Whitworth Park Spennymoor (0.5), Middlestone Moor (2.3),
Byers Green (1.7).

Metal Bridge Spennymoor (2.2), Ferryhill (1.5), West Cornforth (1.7),
East Howle (0.7), Croxdale (1.8), Chilton (3.3).

Vane Tempest Seaham (0.5), Sunderland (4.6), Ryhope (1.7).

Dawdon Seaham (0.9).

Thrislington West Cornforth (0.2), Spennymoor (3.4), Coxhoe (1.5),
Ferryhill (1.5).

Brusselton Shildon (1.6), West Auckland (1.7) Bishop
Auckland (2.5), Cockfield (5.0), St. Helen's
Auckland (1.5), Evenwood (3.2).

Kimbleworth Kimbleworth (0.2), Nettlesworth (0.6), Durham (3.0),
Witton Gilbert (1.6), Pity Me (0.9), Sacriston (1.2).

Herrington Herrington (0.4), Shiney Row (1.2), Houghton (2.2),
Penshaw (1.0), Sunderland (4.1).

Harraton Fatfield (1.1), Penshaw (2.3), Birtley (2.0),
Chester-le-Street (1.9), Shiney Row (2.3),

Wearmouth Sunderland (0.8).

Murton Murton (0.4).
 Kibblesworth Gateshead (3.0), Birtley (1.7), Kibblesworth (0.2).
 Ravensworth Park Birtley (2.4), Gateshead (1.8), Chester-le-
 Street (5.2).
 Ravensworth Ann Birtley (1.0), Gateshead (2.0), Chester-le-
 Street (4.1), C
 Medomsley Consett (1.8), Medomsley (0.5), Leadgate (1.5),
 Allendale Cottages (1.0).
 Beamish Mary Stanley (1.0), Beamish (1.1).
 Washington F. Washington (0.2), Gateshead (4.0).
 Glebe Washington (0.5), Gateshead (5.0), Penshaw (1.9).
 Usworth Washington (0.7), Gateshead (4.4).
 Boldon Boldon Colliery (0.2), South Shields (3.0).
 Ryhope Ryhope (0.6), Sunderland (2.2), Silksworth (1.7),
 Harton. South Shields (1.5).
 Deaf Hill Trimdon (0.3), Wingate (1.4), Station Town (1.5),
 Trimdon (1.8).
 Shotton Shotton Colliery (0.4), Haswell (1.8), Peterlee (1.8).
 Easington Easington Colliery (0.5), Peterlee (1.8).
 Horden Horden (0.5), Peterlee (1.2).
 Seaham Seaham (0.2).
 Lumley Fence Houses (0.7), Great Lumley (1.2),
 Houghton (2.2).
 Wardley F. Felling (2.0), Gateshead (3.5), Hebburn (2.5).
 Hylton Sunderland (2.0), Castletown (0.4).
 Whitburn Whitburn (0.8), South Shields (3.0),
 Sunderland (4.0).

Derwent Blackhall Mill (1.4), Consett (2.5), Medomsley (0.5),
Leadgate (1.5), Westwood (1.2).

West Auckland West Auckland (0.3), Witton Park (2.0), Bishop
Auckland (2.2), Cockfield (3.8), Evenwood (2.0),
St. Helen's Auckland (0.4), Etherley (1.4),
Crook (5.5).

Brancepeth Willington (0.8), Crook (2.5), Oakenshaw (0.8).

Watergate Winlaton (3.0), Whickham (1.3), Swalwell (1.8).
Gateshead (2.4).

Lambton D. Fencehouses (0.5), Houghton-le-Spring (1.7),
Chilton Moor (1.0), New Lambton (0.1).

South Hetton South Hetton (0.2), Haswell (1.4), Hetton (2.3)
Easington Lane (1.3).