Problems in the management for recreation of Waldridge Fell, an area of lowland heath: an ecological study.

Leslie Ellison

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Waldridge Fell is one of the last vestiges of lowland heath in central County Durham and it is of particular scientific interest because of its wide variety of acidophilous heath communities.

Some 2000 years of extensive human pressure had created an open heath landscape from former forested lowlands but changes in farming practice made severe inroads into the heath in the nineteenth century. The greatest threat to the vegetation of Waldridge Fell, however, came with the demands of car-borne recreationists for informal leisure space in the 1960's and early 1970's.

In 1975 the County Council began a positive management programme. This thesis records the results of monitoring the first two years of this programme.

Exclusion of the motor vehicle has led to revegetation of most of the heavily damaged track surfaces by species adapted to a moderately heavy intensity of pedestrian wear. Limitation of access to the Fell, however, has certain inherent dangers.

Evaluation of the landscape of the Fell has identified four zones which visitors may seek out as future 'leisure goals'. The purposeful nature of the existing paths in giving access to these goals may 'freeze' the use of the Fell within the narrow confines of the present track system. Energy expenditure tests confirm that much of the remaining heath is inpenetrable by normal recreationists. The removal of beneficial trampling could lead to a closure of the heath landscape unless a new policy of management is instituted.

Problems in the Management for Recreation of Waldridge Fell, an Area of Lowland Heath : an Ecological Study.

by

Leslie Ellison B.A. (Birmingham)

Thesis submitted for the degree of M.Sc
in the University of Durham.

The content of this thesis, apart from any acknowledged references to published works, is entirely the product of my own research.

It has not previously been submitted in whole or in part for any other degree or diploma.

Leslie Ellison

April 1978 Leslie Ellison

Waldridge Fell from the South: Autumn

"If we are not careful to preserve a considerable area of heath as a memorial, then I do not doubt that our descendants will censure us for our short-sightedness and lack of feeling"

Raunkiaer (1913)

Plate 1 Ref: 10-F

Photographed 1st November 1975

Problems in the Management for Recreation of Waldridge Fell, an Area of Lowland Heath : an Ecological Study.

Contents

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Note on nomenclature

The scientific names in the text are based on Clapham, Tutin and Warburg 'Flora of the British Isles' 2nd Edition (1962) and the common names, where used, are those given by McClintock and Fitter (Collins guide, 1974).

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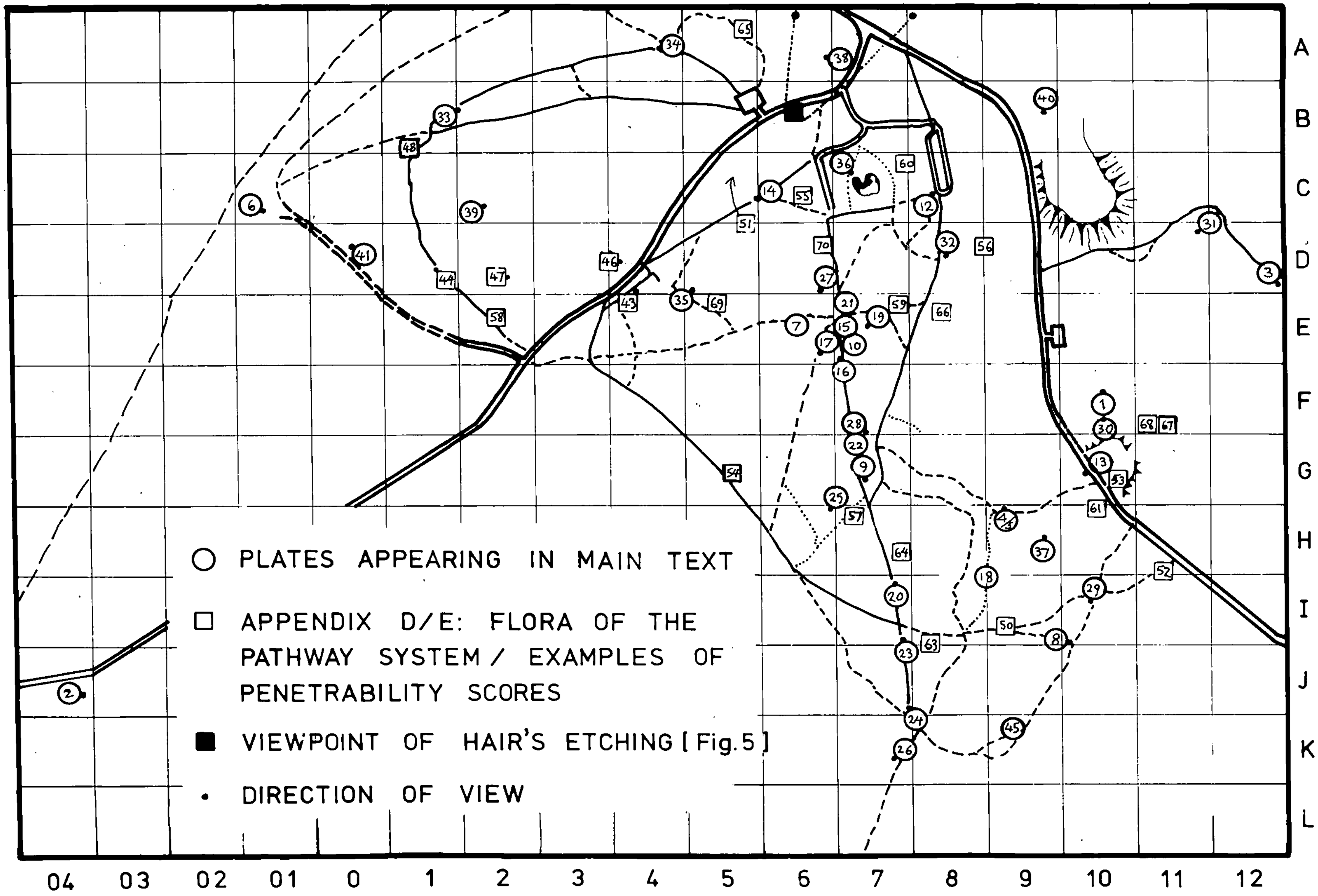
LOCATION OF THE FEATURES ILLUSTRATED IN THE TEXT



INTRODUCTION

Waldridge Fell is an area of lowland heath occupying a cuesta of sandstone in the productive Coal Measures of County Durham. It lies between 2.5 km and 3.5 km south west of the centre of Chester-le-Street and has an areal extent of some 115 hectares. From a height of 129m above O.D. on the rim of a gently sloping plateau, which still seems to retain a thin wash of glacial drift, the land drops steeply northward down to a polluted stream, the Cong Burn. Southward, it drops gently for a distance of some 1,100 metres until the steep valley sides of the South Burn are reached; here the local summit levels are approximately 90 metres above O.D. and the flat valley floor some 15 metres lower down.

The South Burn follows a roughly south west to north east course en route for its confluence with the River Wear just south of Chester-le-Street, so the main upland of Waldridge Fell is roughly wedge-shaped in appearance with its apex in the deeply dissected and varied terrain of the South Burn area..... a configuration which will later be seen to have a considerable influence on the ecology of that area.

A large almost rectangular and fairly flat area has been down-faulted on the eastern side of this wedge of upland; and here water, that seeps readily through the coarse sandstone of the upland, emerges. This waterlogged area is known as Wanister Bog.

Examination of Figure 1 and the stereo plates demonstrates that the Wanister Bog area provides the greatest contrast in relief of the area. Along the scarp that runs approximately north - south from Waldridge Colliery village to the crest of Nettlesworth Hill above the South Burn, are some of the steepest gradients of the Fell. A pit spoil heap in the north-east conforms to, although it accentuates, the relief of the eastern part of the Fell.

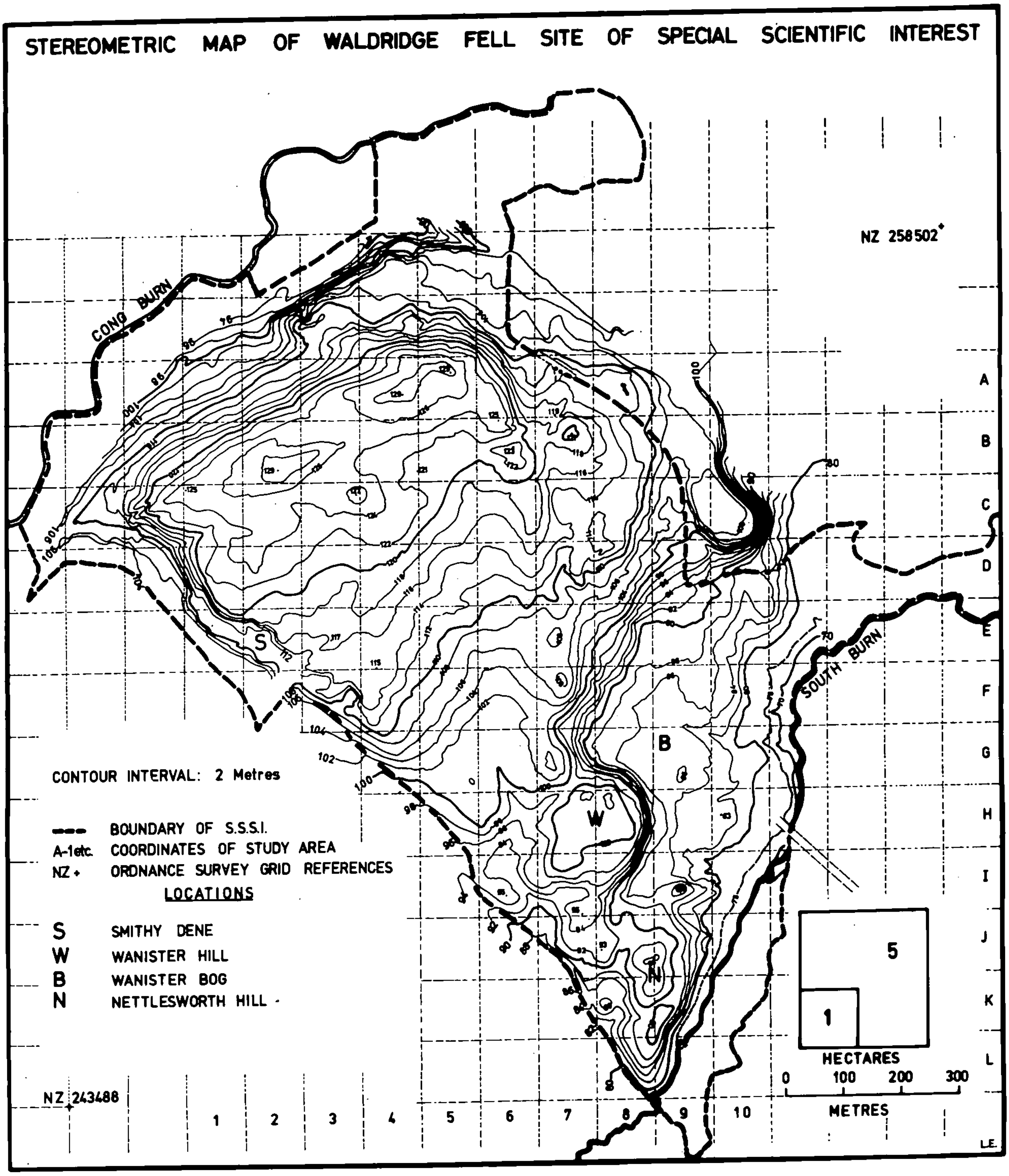

STEREOMETRIC MAP OF WALDRIDGE FELL SITE OF SPECIAL SCIENTIFIC INTEREST
NZ 258502+
CONG BURN
SOUTH BURN
S
W
B
N
CONTOUR INTERVAL: 2 Metres
BOUNDARY OF S.S.S.I.
A-1etc. COORDINATES OF STUDY AREA
NZ + ORDNANCE SURVEY GRID REFERENCES
LOCATIONS
S SMITHY DENE
W WANISTER HILL
B WANISTER BOG
N NETTLESWORTH HILL
A
B
C
D
E
F
G
H
I
J
K
L
1
2
3
4
5
6
7
8
9
10
NZ 243488
5
1
HECTARES
0 100 200 300
METRES
L.E.

Fig. 1

Shallow coal seams outcrop in the northern part of the Fell and these have been worked for nearly two centuries so that some parts of the Fell have, locally, a very rugged relief particularly where "graben" faulting has recently taken place (see Plate 7). The spoil round some of the oldest pits has weathered and been colonised by heath to form small islands some two metres or so above the rest of the dip slope. Local slumping has also created small hollows. Apart from vigorous run-off along bare surfaces during rainstorms, no surface drainage can be noted on the upland parts of the Fell away from the South Burn.

In this varied terrain, a wide variety of heath, marsh and woodland habitats exist and the area has attracted the attention of many researchers.

Jeffreys (1916) made a careful study of the dry heath, grassland and wet heath associations of the Fell and in particular he studied water supply as an ecological factor and the toxic effects of bracken litter on other heath species; his photograph of the sharp frontier, that existed in 1916, between the bracken and wet grassland below Wanister Hill, is used by Tansley (1939) to demonstrate one of the main characteristics of Pteridietum.

Bridgewater (1970) examined this same frontier in his as yet unpublished work on the British Heath Formations and Wheeler (1975) examined the alder and birch woodlands of the South Burn Valley. In particular the South Burn woods appear to be a refuge for species elsewhere supressed by the 'improvements' of man. In addition, variables of water supply from seepage, surface flow and stagnation of precipitation, make the damper parts of the woodland an area of peculiar diversity.

Bellamy (1970) concentrated his studies on the woodlands of the lowland areas of Waldridge Fell - dismissing the more open land above as "a matrix of overburned, ravaged heathland". There is no doubt that birch-oak forest would be dominant over most of the Fell were it not for the activities of man and it is significant that bracken is dominant over large areas of the upland and indeed, dominated the whole Fell in 1916; Tansley is at pains to point out that it is primarily a woodland plant with altitudinal limits corresponding to those of forests. The whole site is of considerable educational value and has been defined as a Site of Special Scientific Interest.

With the decline in the fortunes of the Coal Industry Waldridge was scheduled as one of the Category 'D' villages and with the closure of the mine in 1967, the Waldridge Lane School on Chester Moor became redundant and was equipped as a Field Studies Centre. A nature trail was laid out in the South Burn woodlands; and the woodlands, with their long history of protection from the activities of man, and the upper Fell with its longer history of trampling, burning and interference by man, assumed different roles within the S.S.S.I.

The disappearance of the old mine cottages on the northern part of the Fell, in the late 1950's,coincided with an increased affluence of the public. New industries came to Sunderland, the Team Valley and along the Great North Road - e.g.at Spennymoor and Newton Aycliffe. Although the North East was never to be as affluent as the rest of England, diversification of industry and the need for greater mobility was creating a population with a high number of car-owning households. Informal open air activities involving the family as a unit and necessitating the car for transport had, by the middle 1960's become a feature of the weekend leisure pattern throughout the whole of urban Britain.

Areas of open countryside close to the major urban centres came under pressure - and for 85,000 car owning families (1) South of the Tyne, Waldridge Fell was the largest expanse of "countryside" with a natural appearance over which visitors could walk, or even drive cars over, in their immediate hinterland. Fortunately for the ecology

(1) See Appendix B4

of the heath, few of the 85,000 families knew of the existence of the Fell. Even so visitor pressure had become such that by the early 1970's there was a growing erosion problem on its trackway system and a danger to the more vulnerable habitats. This led to the Environment Committee of the County Planning Department (1) taking over the management of the S.S.S.I. in November 1974, and ultimately to the beginning, a year later, of the public works that were to profoundly alter the amenity of the Fell.

At the beginning of 1975 a plan was drawn up for the Fell with the following objectives:

(i) The Fell should be maintained as a site of Special Scientific Interest.
(ii) The open moorland landscape should be preserved.
(iii) The derelict and damaged areas should be restored.
(iv) Recreational facilities should be provided for the quiet enjoyment of the Fell by the general public.
(v) Appropriate educational use of the Fell should be permitted and assisted.
(vi) Use of the Fell should be limited so that the scientific interest and landscape might be maintained and its recreational and educational resources protected.

Implicit, therefore was the concept of 'zoning' for recreational activities could prove incompatible with scientific study - damage by car-based picnickers has been referred to above and will be discussed in Chapter I. Indeed some of the objectives might only be realised at the expense of others.......... the open nature of the moorland, for example, has been achieved as a result of extensive distribution of human pressure; and concentration of activities into the northern part of the Fell might

(1) See Appendix F.

accelerate the 'closing' of the moorland in the south. The conservation of scientific areas might thus only be achieved at the expense of visual quality, one of the main 'leisure' resources.

The need for monitoring the effects of the positive management of the Fell by the County Council was manifest by the winter of 1975/76. This study was begun early in 1976 with such a monitoring role as its main objective.

Aims

The study aims to concentrate on three main areas:

(i) The ecology of the main trampled areas; looking for significant short-term changes during the first two years of the management and the factors influencing such changes.

(ii) An assessment of Landscape Quality and the estimation of efficiency of the existing network of communications in linking "leisure nodes".

(iii) A Quantification of terrain penetrability as an indicator of the constraints on future pedestrian routes.

It will be demonstrated that open areas of the Fell are indeed the most popular and to fully understand how an area of "overburned, ravaged heathland" could become a cherished piece of landscape for several hundred motoring families, it is necessary to examine first the way in which recreation has become a major land-use parameter and how "landscape" has become a natural resource.

CHAPTER 1

LANDSCAPE AS A RESOURCE

> "It is important to stress the point that in (the North East) we cannot evaluate beauty and the scientific interest of flora until we have the social conditions for all those who live there to enjoy it".[1]

> "These new car parks are ruining the Fell for us locals - why else should public money be wasted on providing tarmac surfaces if it isn't for outsiders to come and use?" [2].

One of the problems faced by the North East has been the close juxtaposition of areas of scenic beauty to large, often dirty, industrial complexes. It has often been difficult to reconcile the wishes of an informed minority seeking to conserve a particular environment with the demands of an urban majority for a more pleasant home environment and better living conditions. The Cow Green dispute was lost by conservationists because it was difficult to weigh the intangible benefits of rare plant congregations not yet fully researched, against the obvious benefits to the unemployment situation in South Durham from an expanding I.C.I. In a cost-conscious society, needless extra expense tends to be questioned. Clearly for the Durham County Council to be able to attempt to divert pressure from the Southern end of the Waldridge S.S.S.I. which they were administering for educational purposes, by building amenities elsewhere as "honeypots", a climate of opinion must have been created which made it (i) financially possible, and (ii) socially justifiable.

The next chapter will demonostrate how Waldridge Fell came to be an island of semi-natural vegetation in the midst of a sea of ploughed land but the present area of study is concerned with the development of pressures on commonland by recreationists in the last twenty years.

(1) Ted Leadbitter (Labour M.P. for The Hartlepools) on 'Cow Green' issue, 28.7.66, see Gregory R. (1975) p.183.

(2) Anonymous respondent to visitor survey : Waldridge; 30.8.76.

For decades, commoners had been failing to exert their traditional rights of pasture and once this happens, as the Royal Commission on Common Land pointed out, "there are probably no rights at all worth exercising OTHER THAN OF TAKING 'AIR AND EXERCISE' which anybody can do in fact (if not in law)".(1)

There has been a long history of pressure on common grazing land for recreation, Hoskins (2) quotes Statute 35 (Elizabeth 1) which denied inclosure for agriculture of commons within three miles of London, so that city dwellers had open space for recreation.......... a very early forerunner of the country park idea.

Thorpe (1949) also showed how village greens, formerly common 'safe' pastures within or at the edge of settlements had, much earlier than the twentieth century, achieved mainly an amenity and recreational value. In 1845 the General Inclosure Act (3) suggested that sections of common land could be inclosed "for the purpose of exercise and recreation for the inhabitants of the neighbourhood" (although these commons would be close to urban centres and enclosure would be for their protection from building development as <u>urban</u> parks rather than as enclosed 'islands' in farmland)........ the idea of Amenity Commons had been launched.

By 1878 Epping Forest (2,500 hectares) could be purchased by the Corporation and City of London as a public open space. At the same time, of course, huge tracts of wilderness were being developed as National Parks in the United States - and protective measures of this nature were to be slow to arrive in Europe - despite there being little wilderness to conserve by the end of the 19th Century. Raunkiaer's plea for some tracts of heath to be conserved "as a memorial" (4)

(1) Cmmd 462 (Royal Commission on Common Land) H.M. Govt. (1958) para. 74

(2) Cmmd 462, H.M. Govt. (1958) p.157

(3) Ibid

(4) Raunkiaer (1913), p.305.

suggests that he could not envisage wholesale protection in a Denmark hell-bent on agricultural reclamation and afforestation in 1913.

Urban dwellers in England and Wales had by virtue of the Law of Property Act, 1925 (Section 193) rights of public access to all commons which lay "wholly or partly in an urban district" but the Royal Commission on Common Land (1958) recommended that all common land should be open to the public as of right(1) (subject to certain conditions). This recommendation was not incorporated in a subsequent Act but the significance of leisure as a major land use was clearly manifest by 1958. Further foreshadowing of the 'Country Park' idea came in another recommendation: "the local authority should be able to undertake a scheme for management and 'improvement' to enhance public enjoyment still further" - e.g. by constructing car parks and providing public lavatories and passing by-laws to prevent nuisances such as the leaving of litter, "lighting of fires and driving cars on the common". (2)

Certainly by the late 1950's the problems brought to open heathlands by a more mobile population were causing concern. The incidence of heath fires in Chester-le-Street district alone reflects the effects of a mid-city population being rehoused on the urban fringe(3); although legislation of long standing was available without need for new laws, in the case of firing of the heath(4), the penalties were in need of revision.

The early 1960's saw an increase of leisure visitors to the open tracts of countryside and the problems of over use of camp grounds, mountain tracks, excessive burning, trampling and other forms of damage began to occupy researchers. By 1965 sufficient research into the effects of leisure visitors had been done for a more careful review of the situation to be made.

(1) Cmmd 462, H.M. Govt. (1958) para. 317
(2) Cmmd 462, H.M. Govt. (1958) paras. 319 and 329
(3) See Appendix B3.
(4) See Appendix A3.

Bracey (1970) writing at this time pointed out the vulnerability of the countryside to pressures from townspeople using cars for access and stated: "The urban outpouring of people and vehicles....... cannot be stemmed; it can and must be effectively directed and channelled to areas where country environments are not destroyed by the sheer weight of numbers."(1) Thus the conference of the Royal Society of Arts Study Group 6 (1965) on the subject of "Outdoor Recreation, Active and Passive", was an important one.

Its terms of reference were:

(i) To review existing and prospective demands on land for outdoor recreation of all kinds.

(ii) To consider existing and prospective facilities, resources and space available for meeting the demands.

(iii) To review the problems of multi-purpose use and zoning in the light of recent studies.

It saw a need to reconcile the urgency of providing for forty million urban dwellers access to and facilities in the countryside with the need to conserve that countryside for future generations. In paragraph 23, four broad categories of recreational resources were identified:

(a) Intensive areas - where the facilities for active leisure rather than the site itself needed to be considered.

(b) General recreation areas - where sites in general use for agriculture, forestry or water conservation would provide for other leisure pursuits (e.g. Derwent reservoir: sailing, fishing).

(c) High Quality Environment Areas - defined as "areas where conservation of the landscape and natural features will be paramount..... facilities for recreation should be limited to the enjoyment of nature".

(d) Historic buildings and sites.

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(1) Bracey (1970) p. 276

Of these (c) most aptly describes Waldridge Fell although how the quality of environment could be measured had not been fully thought out; later in this thesis the developments in landscape evaluation between 1967 and 1973 will be considered.

Paragraph 29 of the Paper stresses the conservation aspect with the statement "In managing any area of the countryside for recreation, the primary objective should be the retention or creation of a varied natural environment" (with planners seemingly raised to the status of Gods). Recreation was clearly seen as a land use and certain recommendations were strongly urged(1):

(1) Responsibility of Local Authorities for outdoor recreation should be redefined.

(2) Planning authorities should define areas for recreational development as part of their development plans.

(3) "A Body with suitable powers and with wide geographical limits (a reconstituted National Parks Commission)..... would ensure the provision of facilities for open-air pursuits.... both inside and outside National Parks, offering financial support where necessary."(2)

(4) Percentage grants for developing facilities in the countryside wherever they are required rather than the prevailing system of block grants to local authorities.

(5) Control of car access to footpaths and green lanes.

Finally it advocated "that planning authorities be required to prepare proposals for outdoor recreation areas to be included in development plans. Such proposals would be binding upon the local planning authorities who would be responsible for their implementation. Government grants should be made available to assist the implementation of approved proposals.... the time has come when recreation should be given a fairer share of the physical resources of the country".

(1) R.S.A. (1965) Paras. 46-52

(2) R.S.A. (1965) Para. 48

With the publication of the Government White Paper "Leisure in the Countryside" in 1966, most of the R.S.A. recommendations were accepted as Government policy and the idea of Country Parks came to the fore.(1) It was acknowledged that car ownership would continue to grow...... in 1966 less than 45% of families were owners..... but Country Parks should be accessible to all town dwellers. It was implicit therefore that they would be in sections of countryside reasonably close to towns and served by existing public transport routes. By provision of car parks and toilets on commons (by special procedures designed to "extinguish" common rights in the small appropriated areas), commons could also function as Country Parks without their status being altered.

In 1966, the Ministry of Housing and Local Government had three policy objectives for Country Parks.

"(1) To make it easier for town-dwellers to enjoy their leisure in the open, without travelling too far and adding congestion to roads.

(2) They would ease the pressure on the more remote and solitary places.

(3) They would reduce the risk of damage to the countryside - aesthetic as well as physical - which often comes about when people simply settle down for an hour or a day......"(2)

Implicit in these objectives is that the chosen site will be subjected to increased public pressure, resulting in the damage to its aesthetic qualities and the increased physical damage that would have been directed elsewhere. Zetter (1971) examined these negative reasons for the Country Park concept and posed the questions (1) has traffic congestion been reduced on the roads? (2) have more vulnerable areas been protected? for if they had not the purpose of the Country Park

(1) Cmmd 2928; H.M. Govt. (1966), paras 18-26

(2) Cmmd 2928; H.M. Govt. (1966), para 18

had not been fulfilled. The most important function of a Country Park is seen by Zetter as the achievement of a balance between conservation and recreation; the most important aspect of the associated legislation: the ability of the local authority to secure grant aid of up to 50% of expenses from central sources.

By 1968 the Country Park was defined, for the purposes of the Countryside Act, as being:

> "in country surroundings, not necessarily beauty spots, where people can go to relax and enjoy themselves. They are primarily intended to meet the demand resulting from increased leisure and mobility of large numbers of the population living in cities and urban areas and looking for a change of environment within easy reach. The location of the parks in relation to urban areas and alternative recreational facilities is of prime importance".

After 1968, legislation having been provided to give access to the countryside, the main concern was diverted to the internal communication system within the countryside. The Footpaths Committee (1) reported in 1968: "It is now generally accepted, and much of the evidence before us confirms, that the majority of footpaths today have a recreational purpose in sharp contrast to the utilitarian purpose which gave rise to many of them". The long history of land ownership and restrictions to access however had often produced circuitous paths in the countryside; and Gosling(2) saw "much of the value and charm of footpaths lies in their waywardness", implying that recreationists prefer indirect routes to particular goals. The newly constituted Countryside Commission therefore began to take a very active interest in footpaths in the countryside. Huxley (1970) saw ALL paths within the countryside to have a purpose......" 'waywardness' may be a characteristic we enjoy once it is imposed by an existing trail - but paths are not unaccountable",(3) i.e. some factor, physical or legal, has forced the path to

(1) Sir Arthur Gosling (1968) para 8

(2) Ibid. para. 3

(3) Huxley (1970) "Footpaths in the Countryside", p.25

deviate at some time and: "given a hypothetical flat and uniform surface, the majority of people will travel the shortest distance from origin to objective".⁽¹⁾

As research into footpath creation forms the basis of the later part of this thesis, no further reference will be made to the recreational ecology research, referred to by Huxley, at this stage but it is clear that other lines of research were being followed during the late 1960's into the purpose of recreationists. Some of the most interesting aspects of behaviour of recreationists centred on the motivation for travel and the nature of the countryside sought out by different strata of society.

Wager (1967) had already indicated that large grassy areas were favoured (preferably these should have some expanses of water close by) and that level heathland was low on the priority scale. Distance people were prepared to travel to recreational sites varied with attractiveness but the majority of visitors travelled less than 20 miles. The Countryside Act assumption that urban dwellers wanted a "change of environment within easy reach" seems to be based largely on Wager's work.

Later research appears to confirm the assumption. Board <u>et al.</u> (1969) found 30 miles across open countryside was the maximum day trip to lesser known beauty spots on Dartmoor. The thirty miles, of course, enclosed the urban centres of Exeter, Torbay and Plymouth that form a ring round the Moor.

The Peak Park planning board (1974) also found that 30 miles was an outer limit of the main catchment area of chosen sites and a similar study of the New Forest by Peters of Hatfield Polytechnic⁽²⁾ in 1970 found 15-30 miles radius enclosed the catchment area of most trippers.

(1) Huxley (1970) "Footpaths In The Countryside", p.25

(2) See Zetter (1971)

But in most cases quoted above a circular tour was preferred by the majority of motorists, i.e. the sites chosen by the researchers rarely formed the sole destination - or the planned destination of trippers - and this is reflected in the shortness of the stays at most open-country sites...... and a high turnover rate in clientele.

Waldridge Fell is not well-known as a beauty spot outside of the immediate locality, a visitor survey (1) showed less than 10% of the visitors were first-time 'chance' arrivals but 97% (28 out of 29) of the respondents who already knew of its existence claimed it to be the specific objective of their trip. All visitors to the site claim to be regular visitors or intend to become regular visitors, and there is no doubt that pedestrian pressure will increase even if the County Council do not resort to publicity. The compactness of Waldridge Fell creates one of its principal problems. Wager (1967) points out that the mobile urban dweller sees the countryside as an extension of his own garden and the car as convenient a base for home comforts as his house; he indulges in the activity known as "day camping". From this base camp, which takes some time to organise, expeditions are mounted. Normally these are of short duration particularly when the "day camp" is set up some distance from home. The day tripper has probably four options open to him in informal recreation situations in the open country:

(i) picnicking

(ii) play or "taking in the view" passively close to 'base camp'

(iii) walking for pleasure over short distances

(iv) driving for pleasure.

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(1) See below Chapter V.

Once the site is close to the urban centre one of the major components of the day - the pleasure of driving through, and viewing, the changing rural scene - is lost. On rough terrain like Waldridge Fell the options are limited to picnicking and sitting close to the car, or exploring the pathway system. So high and windswept are the main car parks on the Fell that the option is often reduced still further, to option (iii), walking. On Waldridge Fell it is possible to walk almost the whole trackway system, at a leisurely pace of 4 k.p.h. within one hour.

It would seem that from now on effective management of semi-natural open space situated close to urban centres will depend less on a knowledge of ecology and more on the behavioural psychology of users of open heath environments.

Because the conditions that have conspired to produce the present heath environment are rarely those that operate today, considerable "engineering" may be necessary merely to maintain a superficial resemblance to the commons and heaths of pre-Countryside Act days.

So that an understanding of the present landscape can be gained, it is appropriate to look at the vegetational history of Waldridge Fell.

Boundaries of the Fell : 1

Nettlesworth Field : an area enclosed at an early date and forming the western boundary of Waldridge Fell

"By far the most conspicuous element in the new landscape were the small, hedged fields".

(Hoskins (1970) p.187)

Nettlesworth field was won from the waste in the Middle Ages and has been in continuous cultivation ever since. A small stream accepts the drainage from the land drains that were laid after 18th century and early 19th century improvements, and this together with the hedges, planted about 180 years ago with reorganisation of the farmlands, form a barrier to access to Waldridge Fell from the west. The surviving squarish 18th century enclosures show clearly in the middle distance. Gorse occupies the disturbed ground of the former Nettlesworth 'A' pit (in operation between 1840 and 1894).

Plate 2 Ref : 04-J
Photographed 26th May 1977

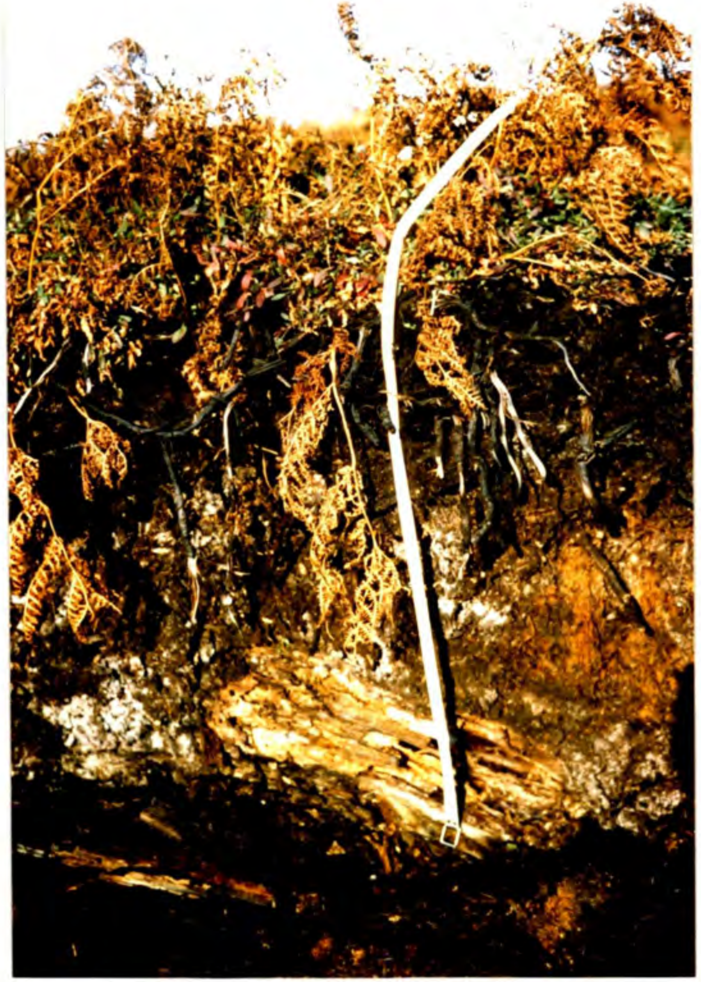
Boundaries of the Fell : II

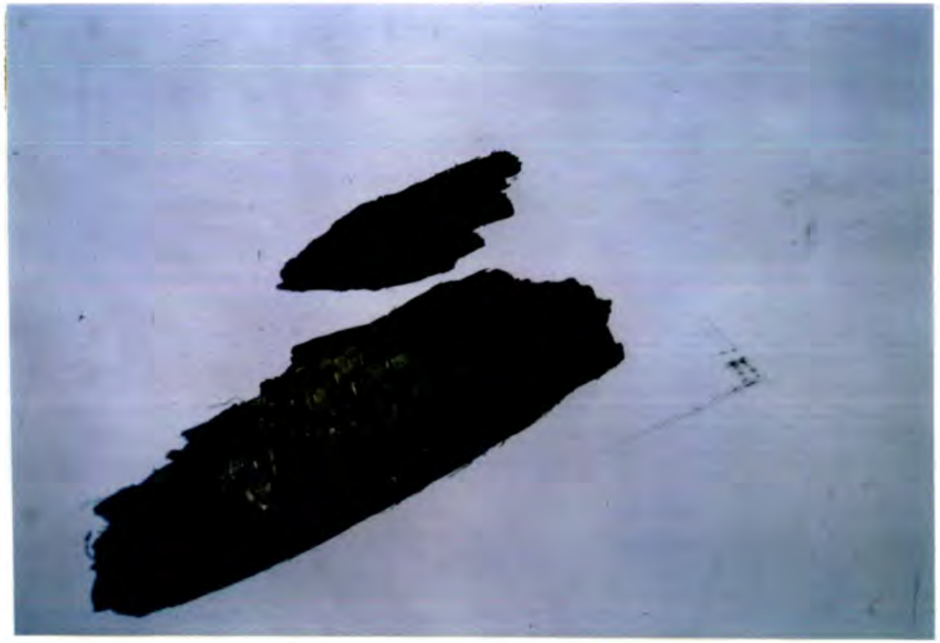
Ancient trackway following the perimeter fence of Waldridge fields

> "A narrow lane, quite unfit for wheeled traffic winds around the end of the ridge....... it is in fact the north-eastern boundary...... and it runs like a rampart-walk cut half-way up the side of a high, steep bank".
>
> (Hoskins (1970) p.67)

Displacement of soil to this depth could not have been effected solely by herded cattle and other trampling agents, although elsewhere along the central track of the Fell shallow hollow-ways have been created where paths have followed the same route for long periods of time. This photograph shows what is probably the double 'wall' between Chester-le-Street fields and the lord's waste of which Waldridge Fell is the last vestige. It is probable that Waldridge derives its name from these two elements (boundary wall and cultivation'rigs).

Plate 3 Ref : 12-D
Photographed 26th May 1977





Plates 4 & 5. Ref: 9-H

Photographed November 1975.

4. Section through the drying peat of Wanister Bog showing birch layer at 68-70 cms

Removal of approximately 1 metre of the organic layer has led to a local lowering of the water table and this has permitted the establishment of bracken - formerly restricted to the well-drained slopes of Wanister Hill.

5. 'Fossil' birch dating from Sub-Atlantic phase of peat development of c. 400 B.C. (Pollen Zone VIIb/VIII)

Anaerobic conditions until recent digging, had kept this tree layer in a remarkable state of preservation.

Smithy Dene drift mine : a temporary scar on the landscape

Drift mines, by virtue of their direct access to the coal seams via gently sloping adits, tend to have fewer surface installations than deep shafts. The early 19th century pits could conceivably have resembled this mine. Small in size with no pretensions of permanence, the most lasting feature of the small mine was the shale spoil heap that grew outwards from the shaft entrance - often to no more than the height of a pack horse or chaldron wagon rim. Most of the small hills referred to in Jeffreys (1916) are pit hills of less than 2 m. altitude above the surrounding Fell.

Plate 6 Ref : 01-C

Photographed 30th March 1977.

Recent pit fall near the central track

Local subsidence, where old coal workings are close to the surface, results in very irregular terrain. Steep sided deep holes such as this provide sharp contrasts in habitat. The surface at the rim becomes desiccated with the lowering of the water table, and the shady hollow may be colonised by damp-loving species as it has been here with rosebay willow herb (Epilobium angustifolium). The many pitfalls in this area may cause the ancient east-west track to be abandoned in this section and also encourage the spread of gorse.

Plate 7 Ref : 6-E
Photographed 31st May 1977

The effects of concentrated human tread near the South Burn.

Concentrated tread has produced a deeply rutted surface over 20 cm. below the surrounding heath surface - here dominated by bilberry (Vaccinium myrtillus). The accumulated 'mor' peat of centuries has been completely removed and the mineral sub-soil is not likely to regenerate for some years.... particularly, since the surface becomes a watercourse after heavy rain. The poor quality of the surface has promoted the heath to the right as a main pathway and already substrate damage is occurring there. The reduction in traffic on the older path will probably allow the gorse to grow outward more easily and this in turn will reinforce the movement of the path: a 'braided' pathway will result similar to, but not so regularly spaced as Plate 9. Evidence that the gorse is already diverting tread can be seen in the breaking down of the path rim in the foreground as people transfer their line of intent to the higher level.

Plate 8 Ref: 10-I
Photographed 31st May 1977

Recent vehicular and human trampling forming a vegetation frontier near Wanister Hill

It is probable that track-laying vehicles created the broad, deeply rutted surface of this track during World War II. Human tread is largely responsible for the slightly less-worn area occupying the right-central area, where three species of grasses (Agrostis tenuis, Nardus stricta and Festuca ovina) are well adapted to withstand tread. Further braiding is taking place as walkers seek a more comfortable surface through the light bilberry on the left. The dense heather on the right acts as a deterrent to transgression on that side.

Bilberry is often part of a burn sub-sere where heather and bilberry are co-dominant, especially on steep slopes (Tansley, p.752) and it appears that the wide track has here acted as a fire break.

Plate 9 Ref: 7-G
Photographed 31st May, 1977

The effects of heavy vehicles on coarse sandy soils : I

Inhibition of growth of bilberry by vehicles

Unlike the two previous sites there is no narrow fringing grassland belt where the bilberry is stunted by intermittent tread, here the effect of regular motor traffic before 1976 was to create a sharp divide. Removal of the surface soil and 'mor' has created conditions where regeneration by heath species is unlikely for decades. To assist regeneration of grasses on the path surface, some remedial action by the managers of the heath will be necessary to halt further erosion by sub-aerial agents.

Plate 10 Ref : 7-E
Photographed February 1976

The effects of heavy vehicles on coarse sandy soils : II

The effects on heavy vehicle tyres on coarse loose sand : compaction and disturbance.

The most significant influence on soils that have been at rest for centuries is erosion but on coarse sandy soils vibratory action can

(a) compact soils...... and this increases the apparent wetness of the surface through the reduction in pore space in the soil itself;

(b) disturb ground upwards through the refraction of the 'bulb' of pressure upwards by more consolidated surfaces below.

These broken surfaces are much more vulnerable to erosion than other parts of the surface and they are more prone to invasion by drought resistant adventitious species.

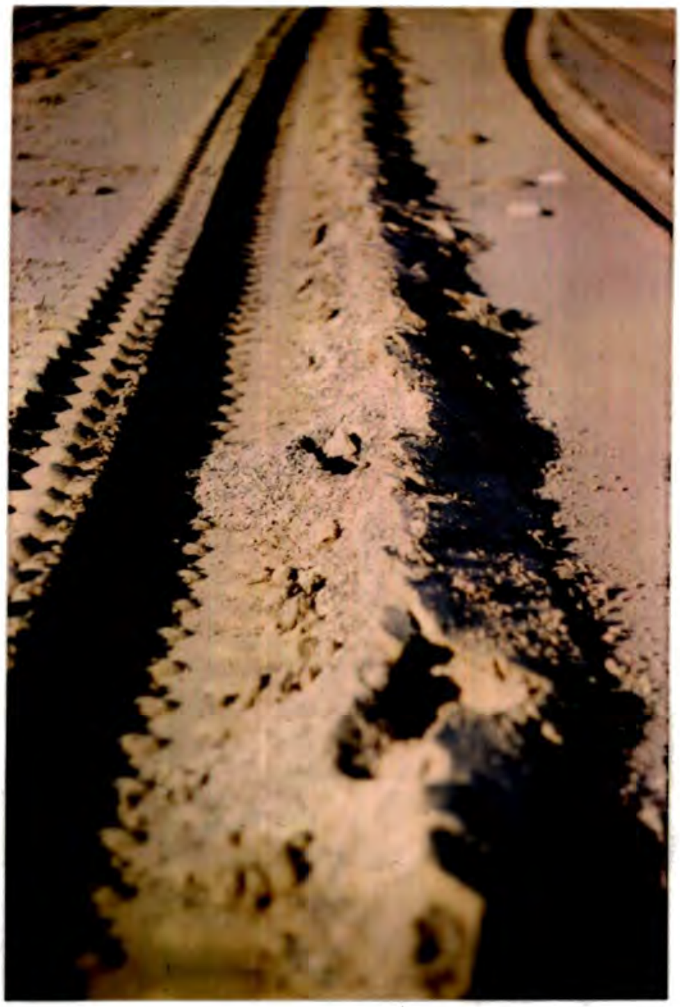


Plate 11 Beach at Crimdon, Co.Durham
Photographed October 1976

Remedial action by Durham County Council: William Street car park in 1977.

> "The point is not that tarmacadam is objectionable in all situations, but that where its use is unavoidable an important element of countryside has been lost".
>
> (Huxley (1970) p. 27)

This car park was laid out in January 1976 on the then overgrown remains of colliery housing, demolished some thirty years earlier. Before 'improvement' the area was part of a species rich grassland with calcicoles on soils containing lime mortar rubble and Agrostis tenuis dominating the remainder of the small plateau shown on this photograph. The shrub belt forms a convenient screen, cutting out the view of the colliery housing lying below the north eastern corner of the Fell.

Plate 12 Ref: 8-C
Photographed 24th May 1977

CHAPTER II

THE ECOLOGICAL HISTORY OF WALDRIDGE FELL

> "Commons often form islands of semi-natural vegetation in the midst of a sea of ploughed land. They have naturally become refuges for many rare or interesting plants or types of vegetation........ and are thus of great interest.......... and have been notified to Planning Authorities as Sites of Special Scientific Interest".(1)

The 115 hectares of heathland at Waldridge Fell are only a very small remnant of the lowland heath that formerly extended over the low sandstone hills that form the dominant landform between the river Wear and river Derwent. The characteristic vegetation is Calluna vulgaris but this is in competition with Nardus grassland and Pteridium aquilimum and, increasingly, with trees and shrubs now that grazing is curtailed.

In many respects the lowland heath, developed on siliceous 'podsols' resembles the moors that develop on the dried-out peats of upland blanket bogs where it was long held that the Callunetum was an arrested sere, and that locally harsh climate factors prevented the development of climatic climax forest of birch-pine or even oak. In lowland areas, Tansley (1939) suggests that the long history of man's activities since Mesolithic times must have prevented the development of forest. Eyre (1968) also acknowledges the anthropogenic factor and persists in stressing that many heaths are a sub-climax of birch-oak or pine forest. Gimingham (1972) criticises this inconsistency - lowland heaths are a prime example of Biotic Plagioclimax vegetation; i.e. replacement vegetation stabilised by the pasturing and other activities initiated by man.

Rarely do the heaths have such a long history of continuous treelessness as many writers have implied. When Raunkiaer made his plea

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(1) Cmmd 462, H.M. Govt. (1958) para. 74

for retention of "considerable" areas of heath as a "memorial" to the traditional Jutland landscape,(1) he was at pains to point out that "little would be gained by the retention of small areas of heath lying amidst plantations and fields. In the course of time they would become covered by a vegetation dominated by trees". Presumably his recommended "considerable area" would still be grazed extensively and therefore lightly, whereas small areas could not economically compete with the improved lands surrounding them - and thus fall into neglect. When Raunkiaer wrote his paper, however, he probably felt that his heathlands dated back at least to Neolithic times. Iversen(2) has demonstrated from Pollen analysis that the great rise in <u>Calluna</u> and <u>Pteridium</u> pollen and the sudden decline in forest species in Jutland, date from 740 A.D.

As it happens over 1,000 years of heathland dominance is a very long time when we consider the relative youth of the present lowland heaths of northern England. These appear to have been created by forest clearance in the twelfth century or even later (see Fig. 2). Place name evidence is particularly revealing - for the vast majority of settlements in the northern part of County Durham show woodland to be the significant element in their names, with the emphasis on forest clearing.(3) Furthermore, the nature of the cleared vegetation is given - broom, holly, 'old stumps', thorn and nettles; all imply secondary growth so the clearings were effected in land that had already been won from forest and regenerated, only to be recolonised by man in the Middle Ages. Only one area of virgin 'climatic climax' forest appears to have been encountered: Ash trees west of Durham City (e.g. "Esh"). Durham itself was probably sited on an abandoned cultivation site.(4)

(1) Raunkiaer (1913), p.305, see Plate 1
(2) Quoted in Gimingham (1972), p. 22
(3) See Appendix A (1).
(4) Raine (1828) contains a translation of the monks' description of the vegetation of the meander loop in 995; the majority of species named imply secondary growth (Briar, bramble, quickthorn).

Population pressure in northern England was never severe; Tinsley (1975) claims that the eastern slopes of the Pennines before c. 500 B.C. would be clothed with open woodland of birch, pine and hazel - with oak occupying the valleys; and her pollen profiles for Nidderdale show little influence of man before c. 2000 B.C. Small peaks appear in the Graminae and Ericaceous pollen profiles and associated grains of Plantago lanceolata and Rumex acetosella (the latter is held to be part of a burn subsere) are characteristic of close grazed turf, but Tinsley feels that these indicate intermittent summer pasturage rather than continuous occupance. About 1730 B.C. (base of Pollen Zone VII (Godwin)) came the first major clearances - with the greatest inroads made into Betula, the pollen grains of which show a marked decline. Probably because this species occupied the lighter soils and it formed a lighter forest cover, Betula was more readily cleared than the Alnus which occupied the damp valleys of northern England.

Betula sp. were, in fact, the dominant arboreal species of the fringes of the County Durham uplands from Boreal times (Pollen Zone VI b). Godfree (1975) found tree layers with the perserved twigs of Betula in Teesdale peats at various depths below the surface. Raistrick and Blackburn (1931) had observed at 68 cm., tree layers in the peat on Framwellgate Moor, close to Waldridge, and Kershaw (1967) also found Betula remains at 68 cms depth (corresponding to Pollen Zone VII (sub-boreal climate) at Cranberry Bog, Beamish, a site at the same altitude only 4 km from Waldridge (see Fig. 2). Plates 4 and 5 show a tree-layer in the drying peat of Wanister Bog - again this is at 68 cms and should be compared with the Kershaw profile.(1)

Engulfing of trees by peat on the fringes of sump-like hollows like Wanister Bog and Cranberry Bog point to climatic change with a

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(1) See Appendix A (4)

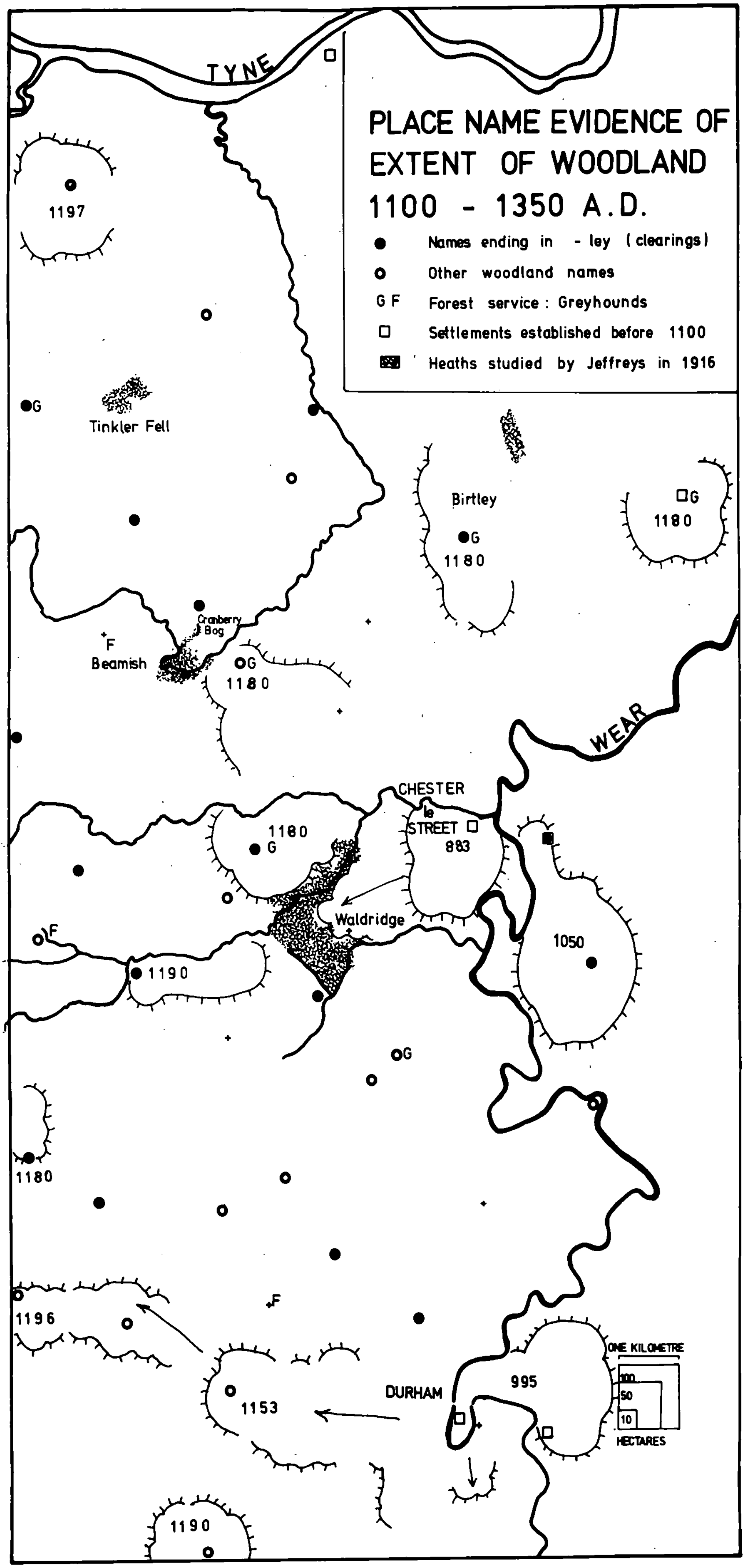
TYNE
PLACE NAME EVIDENCE OF EXTENT OF WOODLAND 1100 - 1350 A.D.
● Names ending in - ley (clearings)
o Other woodland names
G F Forest service : Greyhounds
☐ Settlements established before 1100
▨ Heaths studied by Jeffreys in 1916
1197
G
Tinkler Fell
Birtley
G
1180
G
1180
Cranberry Bog
F
Beamish
G
1180
WEAR
CHESTER le STREET
883
1180
G
Waldridge
F
1190
1050
G
1180
F
1196
1153
DURHAM
995
ONE KILOMETRE
100
50
10
HECTARES
1190

Fig. 2

greatly increased humidity but, apart from on ill-drained surfaces and on high exposed moors, such conditions should have encouraged tree growth.

Perhaps as much an influence on the submergence of the tree layers was the clearance of the upper slopes of Waldridge Fell, Beamish Fell, etc., which led to a less efficient recycling of ground water formerly "drained" by evapo-transpiration from the trees. Indeed much water is held within the tree itself and when it is replaced by annual plants or deciduous grasses like Molinia caerulea water is more rapidly returned to the atmosphere or made available for sub-surface percolation. The clearing of the plateau sandstones would contribute greatly to the flow of water into the peripheral bogs and the rapid growth of peat. Tinsley established, by radio-carbon dating, a date of 340 ± 100 B.C. for the tree layer at 70 cms at Skell Ghyll and this is compatible with the estimated date of c.400 B.C. for Beamish. From this early Iron Age date to about the time of the Norse invasions the practice of clearing the woodlands by burning and the maintenance of a mainly ericaceous cover is well brought out by pollen profile analysis. Periodic charcoal layers in the northern peats occur at approximately 10 cms and 22 cms, representing forest clearance in the Middle Ages, and in the Anglian settlement period after periods of forest regeneration(1).

It can be seen therefore that the heath landscape has never been stable for long periods but from about 1350 until 1750 Calluna moorland was probably the dominant landscape feature over most of western Durham except on steep valley sides. Kershaw (1967) shows that these refuges were normally clothed in Alnus-Quercus with Corylus underbush (probably on damper soils and Betula on lighter sands. The pattern is still

(1) Periods of regeneration caused by the withdrawal of the Roman legions in the 4th century and the "Harrying of the North" in the eleventh.

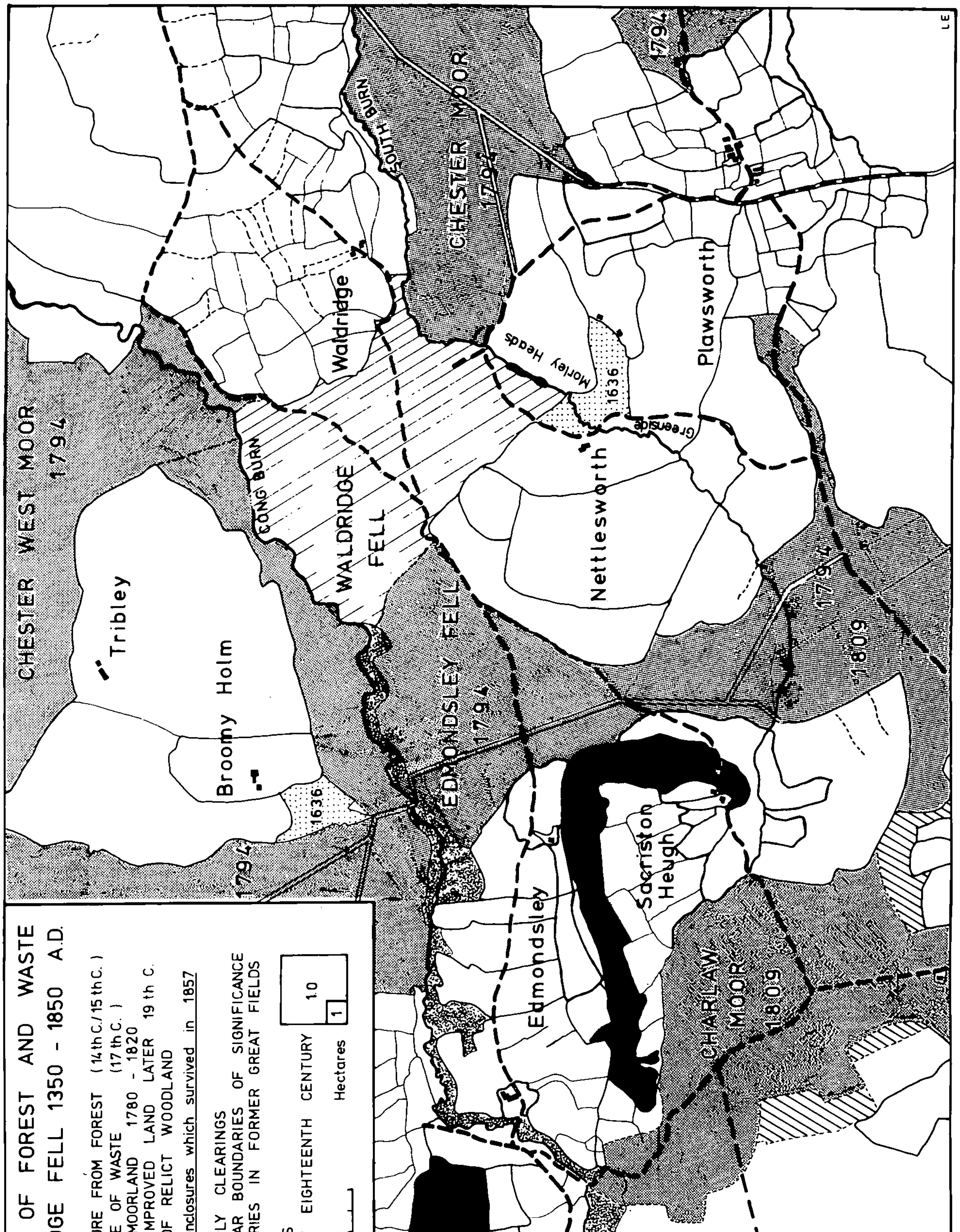
THE ENCLOSURE OF FOREST AND WASTE
ROUND WALDRIDGE FELL 1350 - 1850 A.D.
ANCIENT ENCLOSURE FROM FOREST (14th C./15th C.)
EARLY ENCLOSURE OF WASTE (17th C.)
ENCLOSURE OF MOORLAND 1780 - 1820
EXTENSION OF IMPROVED LAND LATER 19th C.
LARGE AREAS OF RELICT WOODLAND
Hedges within ancient enclosures which survived in 1857
PROBABLE EARLY CLEARINGS
OTHER IRREGULAR BOUNDARIES OF SIGNIFICANCE
PARCEL BOUNDARIES IN FORMER GREAT FIELDS
ANCIENT TRACKS
ROADS: MAINLY EIGHTEENTH CENTURY
One Kilometre
Hectares
10
1
CHESTER WEST MOOR
1794
Tribley
Broomy Holm
1636
1794
CONG BURN
WALDRIDGE
FELL
Waldridge
SOUTH BURN
CHESTER MOOR
1794
1794
Morley Heads
1636
Greenside
Nettlesworth
Plawsworth
EDMONDSLEY FELL
1794
1794
1809
Edmondsley
Sacriston
Heugh
CHARLAW
MOOR
1809
Langley
LE

Fig. 3

similar today in the South Burn woods of Waldridge Fell (Wheeler (1975) and Bellamy (1970)).

The value of the Cranberry Bog diagram lies in its completeness and therefore it can act as a basic reference for vegetational development in this part of the British Isles. It gives ample positive evidence that heath vegetation is a result of clearance and grazing which has suppressed the development of birch-oak forest. However complete the 'Cranberry' profile, the uppermost 10 cms are much disturbed by root action (cf. plate 4) so that we must turn to documentary evidence for changes since the Middle Ages.

The 1647 Parliamentary Survey of Chester-le-Street (Surtees 1972) indicates that there were no woods in the Manor - implying that no stands of mature timber were available; the South Burn woods would be considered worthless scrub - in any case they were part of Waldridge Fell and the Bishop had no economic interest in that area; local freeholders, copyholders and tenants had too many traditional rights.

Little inroad was made into the Lord's waste from the fifteenth to seventeenth centuries except for two small parcels, one to the north of the Cong Burn, another close to Nettlesworth Hill.(1)

<u>Figure 3</u> shows how the pattern of extensive heath round Waldridge Fell was drastically reduced in the late 18th and early 19th centuries as a result of Private Acts of Parliament. At the same time vast areas of the Pennines, Cheviots and Highlands of Scotland were being similarly improved (2) at the expense of rural depopulation. In Durham, however, the lowland heaths diminished in size at the same time as a general rise in population; and the remaining vestiges of heath were subjected to increased pressure by Copyholders and Freemen of the contiguous parishes

(1) Surtees (1972)

(2) See Prebble (1963)

for grazing.(1) In the 1830's the stocking ratio was particularly high: as many as 320 animals, the equivalent of more than three sheep per hectare were recorded.

Overgrazing to this degree would result in a diminution of ericaceous species and an increase of grasses - Gimingham (1949) has demonstrated that on drier soils Erica cinerea would assume greater competitiveness on the heath as sheep selected the younger shoots of Calluna vulgaris but both give way to grasses with excessive grazing. Nicholson et alii (1970) point out that Nardus stricta is poor in nutritive value and it tends to be left by sheep and cattle, except for during a very short period of its growth cycle - thus heavy overgrazing would produce a dominance of Nardus grassland (as in plate 38).

Nicholson et alii were also to demonstrate the reponse to heavy clipping (of the kind produced by human trampling) in which Nardus actually proved less competitive than other heath grasses - especially Agrostis sp. and Festuca ovina and this point will be returned to later in the thesis.

It is unlikely that the levels of overstocking recorded for the 1830's were maintained for long and the pattern of management from 1800-1850 would aim for a patchwork of uneven aged Calluna with burning frequent enough to keep most of it at the 'building' phase (i.e when it is between 6-15 years old). Elliott (1953) states "systematic burning in short cycles results in almost pure heather stands" and good practice in the 19th century was to maintain the Callunetum in a youthful stage of growth. Regular burning ensured that no old woody growth developed. If old heath burns high temperatures are generated and the Callunetum can be replaced by Pteridietum (see Plate 19) or a

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(1) Darling M/S (1830) Appendix B1.

burn-subsere is begun where Vaccinium myrtillus is temporarily more important. Both Pteridium and Vaccinium myrtillus have deep roots which rarely are affected by burning. Some grasses are also encouraged by heather burning, including Deschampsia flexuosa and Agrostis tenuis (the latter being normally intolerant of the deep shade and the former although tolerant of shade is made more competitive after the removal of the heather canopy).

A second pressure was being exerted on the Fell from the beginning of the nineteenth century. Stimulated by the Napoleonic wars, local militia and horse yeomanry troops were established. Because most of the commons were no longer an essential part of the agricultural pattern after the Great Enclosures, and because the national emergency dictated it - and the Lord of the Manor encouraged it - common land became the logical place for the pursuit of training schedules. The Baker M/S (1826) show how the Durham Yeomanry regularly had 140 troopers training between 1819-1826. The training circuit was mainly set out on the level northern plateau of Waldridge Fell where dry coarse sands would quickly lose their organic layer with such intensity of wear. Conversely low lying sections (e.g. between Tinkler Row and the Hylton pit, Fig. 4) would become deep quagmires, later to develop wet Nardetum or Juncus bog. Two gallops extended deep into the Southern Fell.

Perring (1967)(1) studied the effects of very heavy trampling by horses on the Newmarket Heath, and found that constant use and dampness together conspire to produce strong grassland communities. The "Lambton" training circuit still stands out clearly on the aerial photograph despite its ceasing to be used since c. 1876. This is not so much because compaction of the soil has persisted, it cannot, nor because a mineral based soil was exposed along the track (in places organic-based marsh has developed) but the strong grassland communities

(1) See Duffey (1967) "The Biotic Effects of Public Pressure....."

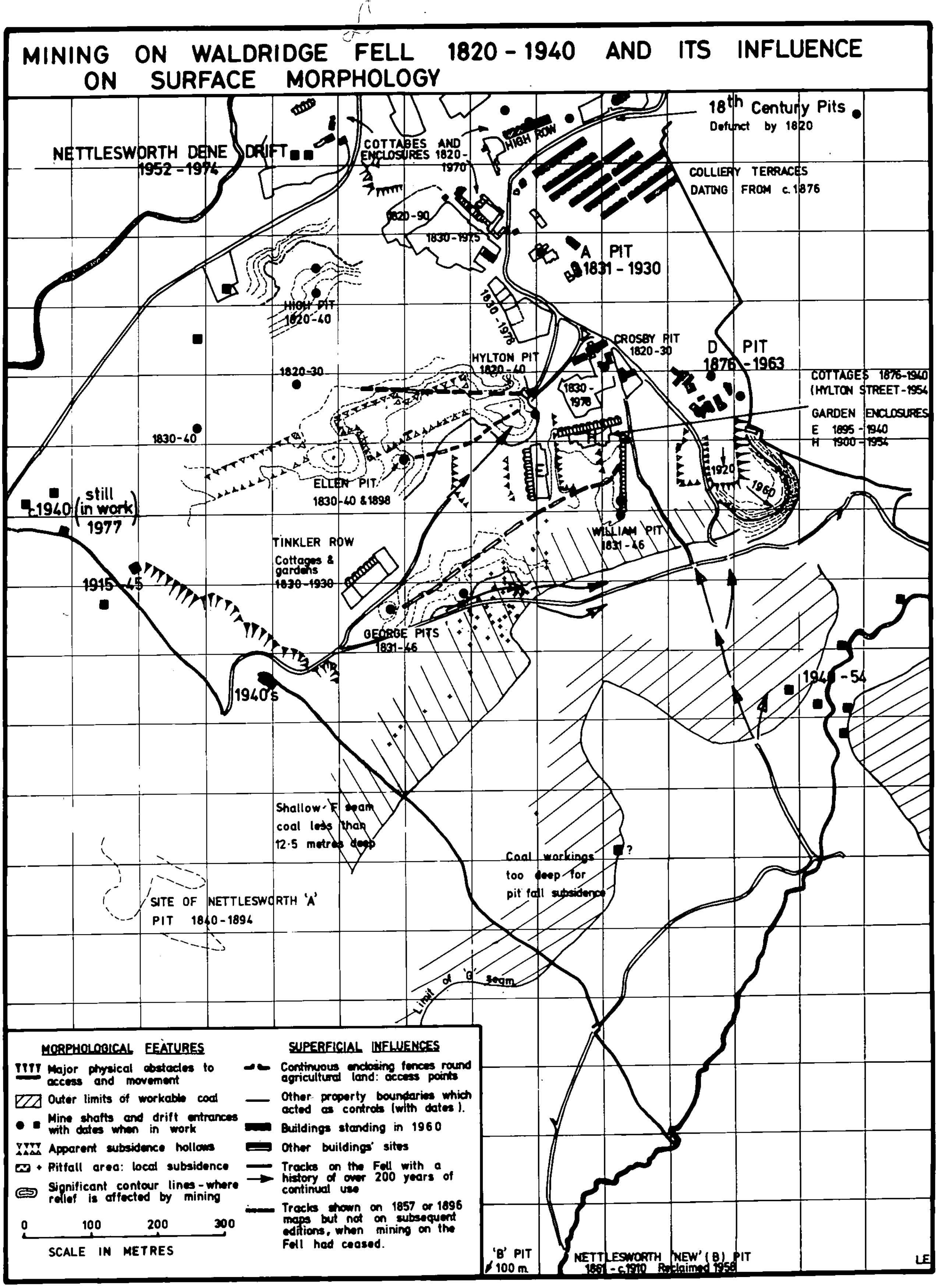
MINING ON WALDRIDGE FELL 1820 - 1940 AND ITS INFLUENCE ON SURFACE MORPHOLOGY
NETTLESWORTH DENE DRIFT 1952 - 1974
COTTAGES AND ENCLOSURES 1820 - 1970
HIGH ROW
18th Century Pits Defunct by 1820
COLLIERY TERRACES DATING FROM c.1876
1820-90
1830-1975
A PIT 1831 - 1930
HIGH PIT 1820-40
1830-1976
CROSBY PIT 1820-30
D PIT 1876 - 1963
HYLTON PIT 1820-40
COTTAGES 1876-1940 (HYLTON STREET-1954
GARDEN ENCLOSURES E 1895 - 1940 H 1900 - 1954
1820-30
1830-1976
1830-40
ELLEN PIT 1830-40 &1898
1920
1960
c.1940 (still in work) 1977
TINKLER ROW Cottages & gardens 1830-1930
WILLIAM PIT 1831-46
1915-45
GEORGE PITS 1831-46
1940's
1946-54
Shallow 'F' seam coal less than 12·5 metres deep
Coal workings too deep for pit fall subsidence
SITE OF NETTLESWORTH 'A' PIT 1840-1894
Limit of 'G' seam
MORPHOLOGICAL FEATURES
Major physical obstacles to access and movement
Outer limits of workable coal
Mine shafts and drift entrances with dates when in work
Apparent subsidence hollows
Pitfall area: local subsidence
Significant contour lines - where relief is affected by mining
0 100 200 300
SCALE IN METRES
SUPERFICIAL INFLUENCES
Continuous enclosing fences round agricultural land: access points
Other property boundaries which acted as controls (with dates).
Buildings standing in 1960
Other buildings' sites
Tracks on the Fell with a history of over 200 years of continual use
Tracks shown on 1857 or 1896 maps but not on subsequent editions, when mining on the Fell had ceased.
'B' PIT 100 m.
NETTLESWORTH 'NEW' (B) PIT 1861 - c.1910 Reclaimed 1958
LE

Fig. 4

have been kept distinct by continued grazing and intermittent wear in a heath that has become more and more senescent on either side of the circuit.

The military training would have been a major influence on the vegetation of the trackways in the north and centre of the Fell from c. 1820 until 1870. Soon after 1870 military reforms instituted by Lord Cardwell led to the disbanding of what were in fact private armies.

A third factor was operating, again in the northern part of the Fell, and again mainly between 1820 and 1870. This was the mining for coal. At first the pits were small, localised and short lived and the main effect of mining (and quarrying in Smithy Dene) was to create disturbed ground rather than main areas of trampling. Gorse (Ulex europaeus) and Bramble (Rubus fruticosus) are both slow spreading shrubs; seen by Tansley(1) as "the first stage of the seral development of woody vegetation" because of the shelter its spiny branches give to colonising trees, gorse seems to be spread readily by birds to disturbed ground. Roadside embankments, the 'D' pit spoil bank, Smithy Dene quarries - all established towards the end of the nineteenth century, had been colonised by gorse by 1916 and were inpenetrable by 1976. Pitfalls that have developed in the last 30 years over shallow workings of the 'D' pit (see Figure 4) have already been colonised by gorse- the correlation between ground disturbance and gorse seems definite(2). Prolonged human trampling near the miners' cottages on the Fell was to produce a grass-heath of Agrostis-Festuca association but the pit heaps with their high shale content form distinctive islands of woody growth in the heath.

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(1) Tansley (1939), p.506

(2) See plates 15 and 2

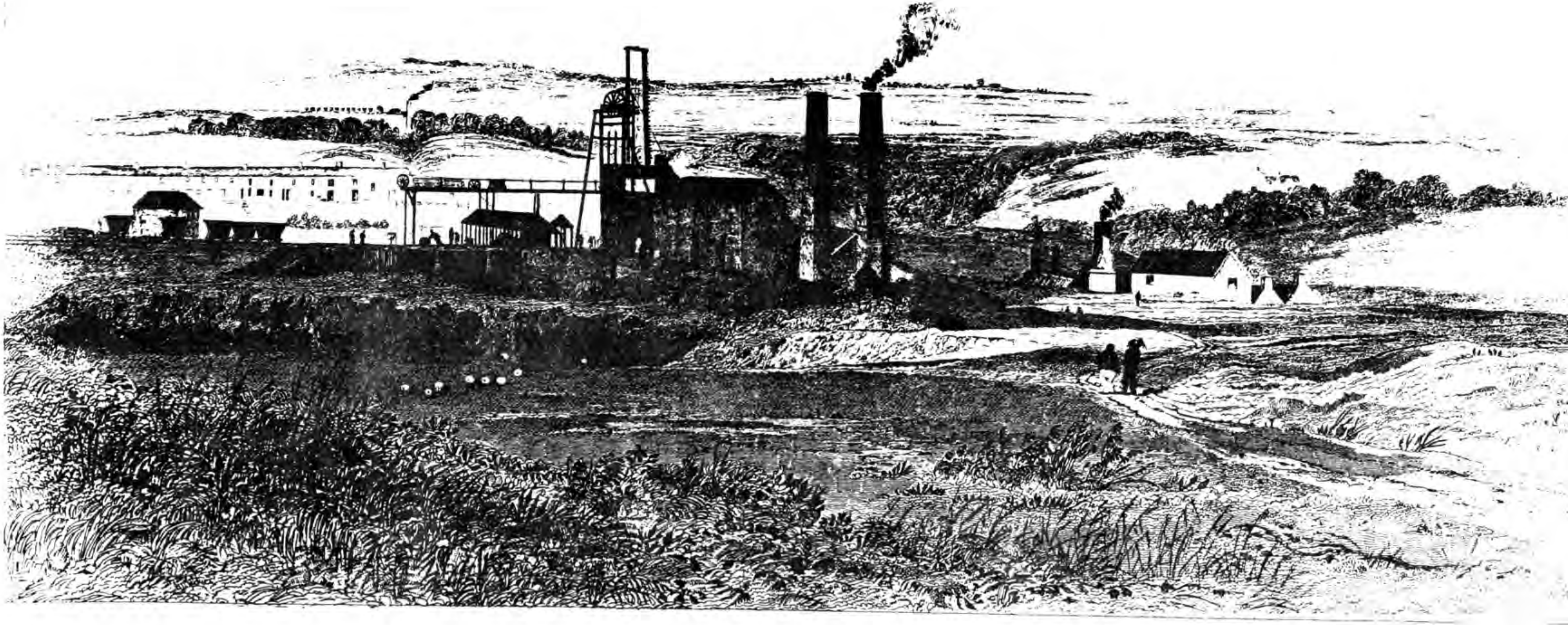


Fig. 5

WALDRIDGE COLLIERY.

MAIN AREAS OF TRAMPLING PRESSURE ON WALDRIDGE FELL DURING THE PERIOD 1794 TO 1920

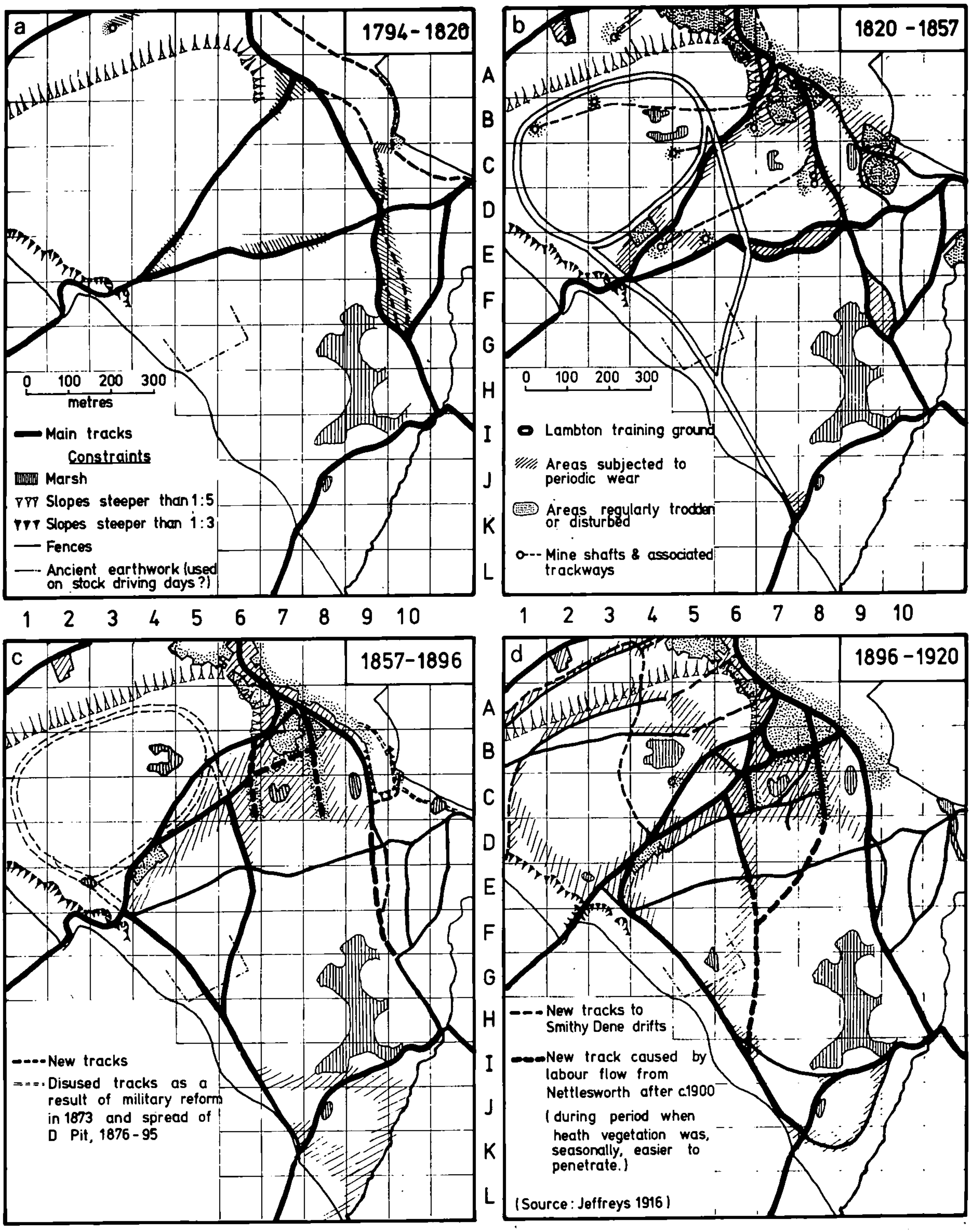


Fig. 6 a-d

VEHICULAR PRESSURE ON WALDRIDGE FELL 1939-1975 AND THE EFFECT OF 180 YEARS' TRAMPLING ON THE ECOLOGY

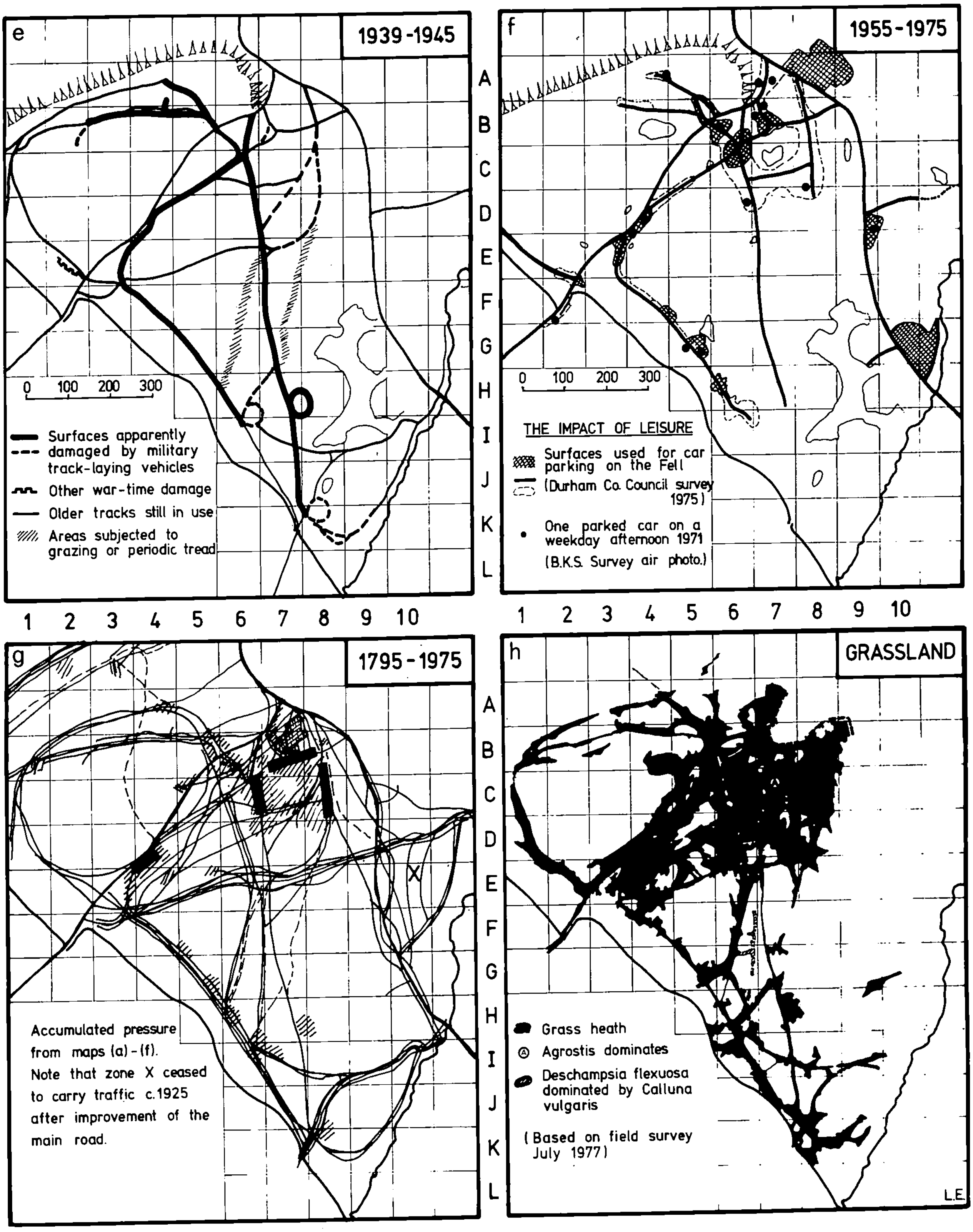


Fig. 6 e-h

THE VEGETATION OF WALDRIDGE FELL IN 1917

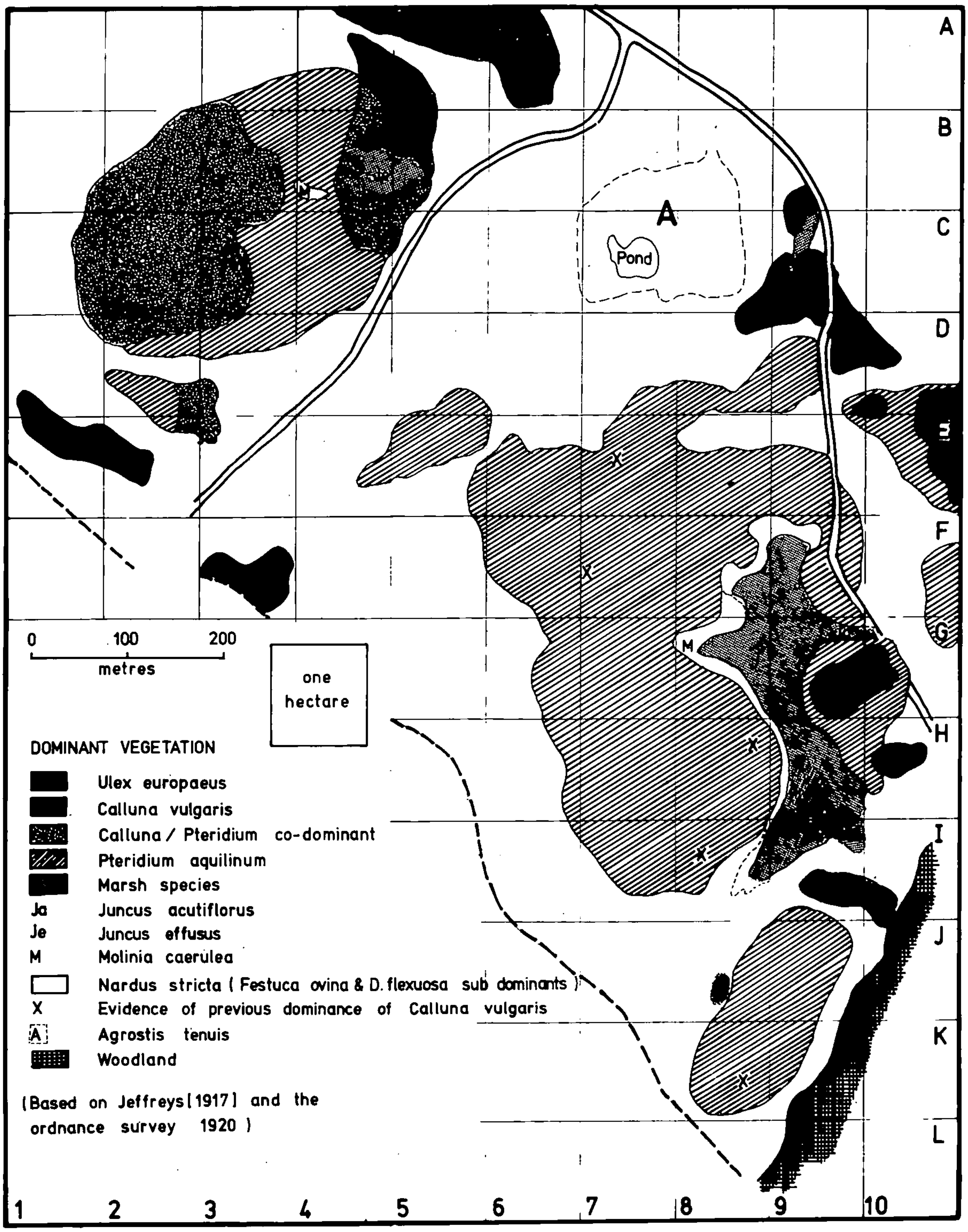


Fig. 7

THE VEGETATION OF WALDRIDGE FELL IN 1977

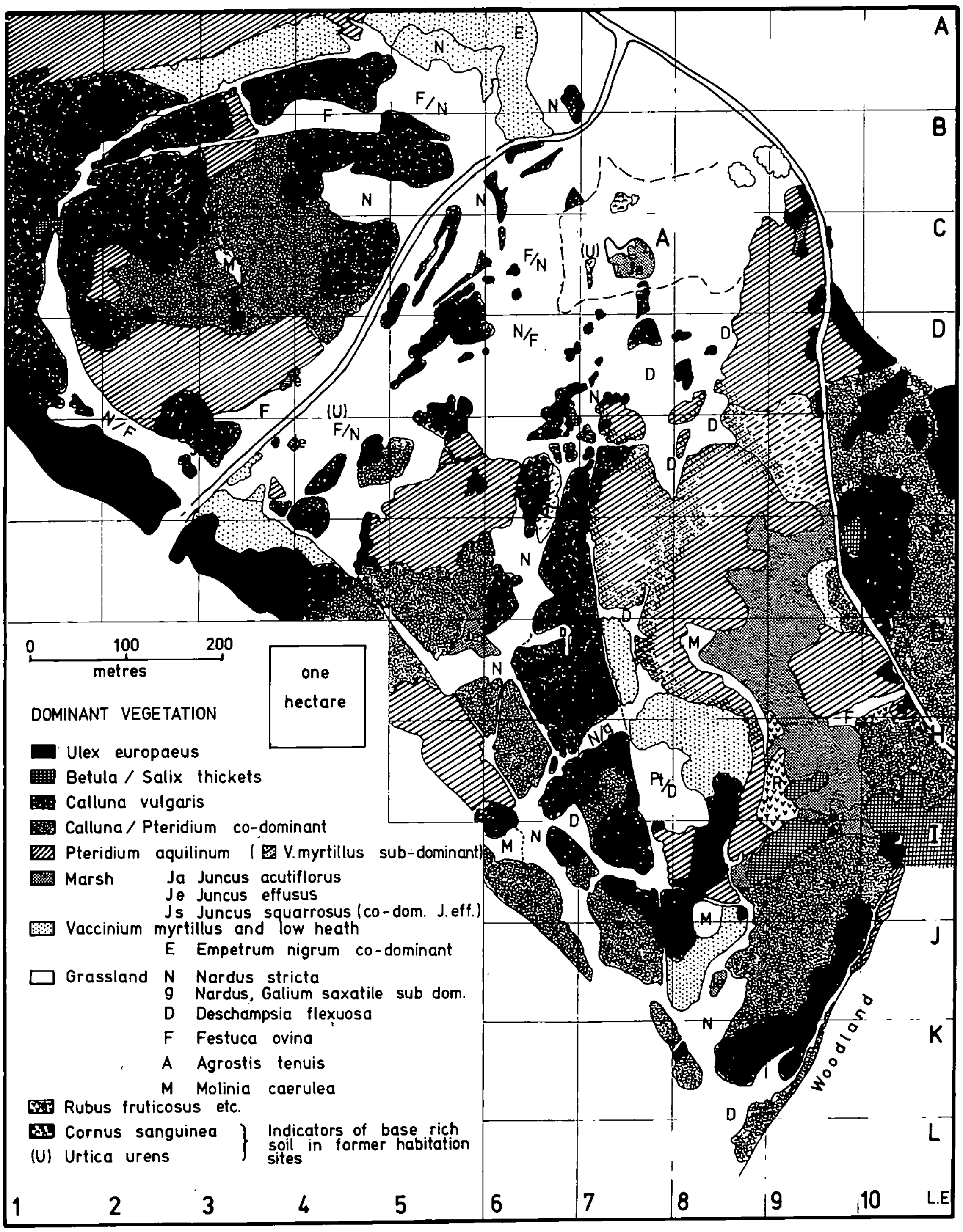
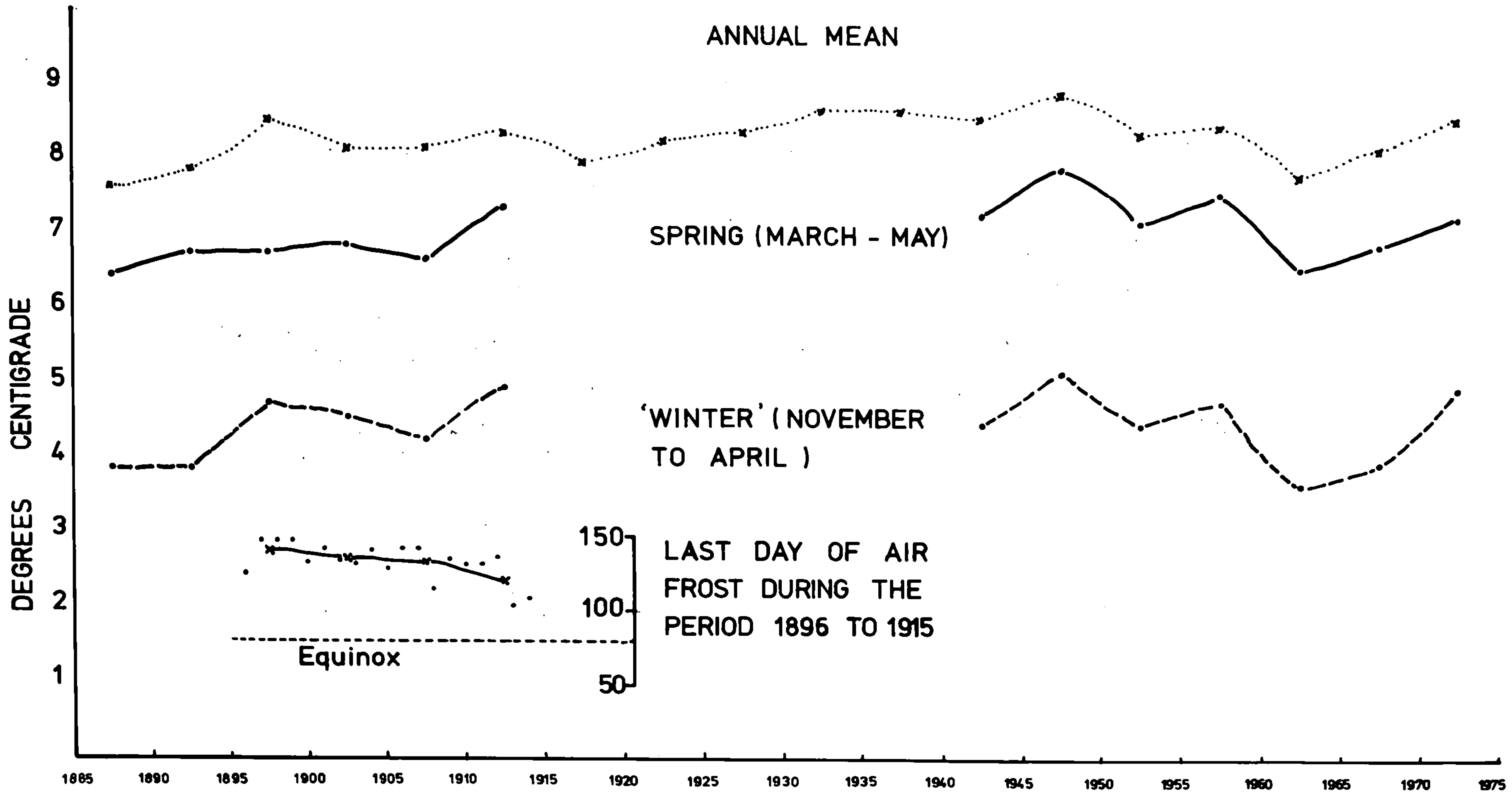


Fig. 8

Fig. 9

WINTER AND SPRING TEMPERATURES: CENTRAL DURHAM

FIVE YEARLY MEAN MID TEMPERATURES, BASED ON DURHAM UNIVERSITY OBSERVATORY RECORDS



Meanwhile the effects of enclosing the land round Waldridge Fell was to be seen in a concentration of trans-Fell tracks into specific routes.(1) Plate 3 shows what appears to be a heavily eroded track in the eastern part of the Fell but it is more likely that the hollow-way in question is a property boundary. Traffic in the 19th century was probably light.

Figure 5 shows how the main track in 1840 between Edmondsley and Waldridge Mine was still mainly grass-covered while the surrounding area also appears to be under grass. Only the crest of the steep scarp on the left is covered with what appears to be coarse heath of Calluna - Pteridium and possibly Rubus species.

The set of maps forming Fig. 6 demonstrate the trampling history of Waldridge Fell and to some extent they explain the factors that have led to the present distribution of grassland.

Soon after 1870, perhaps even before that date, the grazing of the Fell declined. Competition from the sheep grazing lands of the Southern Hemisphere hit farming hard and the boom in mining was providing a more rewarding occupation for many in the area. By 1916 Jeffreys was to note "no grazing" on the Fell of significance beyond the damage to some gorse near Tinkler Row by a "few" goats, and the grazing of two or three horses.

The stage was set for a rapid expansion over the better drained Nardetum by Pteridium aquilinum and the increasing 'legginess' of unmanaged Calluna vulgaris - which by 1960 would be reaching a very degenerate state, vulnerable to periodic fires and open to colonisation by Pteridium spores and Betula seedlings. Watt (1947 and 1955) has shown that bracken has a cyclical growth pattern - which may explain the change in bracken distribution between 1917 and 1977 (see Figs. 7 and 8) but also that bracken can dominate and supress heather, particularly

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(1) See plate 2

if mild springs give its vigorous growth impetus. "Severe winter or spring frost would act differentially in favour of Calluna and severe grazing or fire in favour of bracken".(1) Fig. 9 shows that from 1895-1915 conditions were particularly favourable to the growth of bracken at a time when the heather was at its least vigorous stage of its growth cycle.

Apart from the creation of a new north-south trackway during World War II when, according to the Royal Commission report (1958) "Waldridge Fell was used as a training area for tracked vehicles during the war"(2) the Fell was subjected to less and less trampling pressure between 1920 and 1954 when the last colliery houses on the Fell were demolished.

The landscape therefore assumed a semi-natural appearance. Severe winters of the 1940's probably encouraged the re-assertion of Calluna on the plateau and on the dip slope behind Wanister scarp (see Fig.1 and overlays) formerly dominated by Pteridium. Adventitious seeding of trees and gorse added, in thirty years, a more varied texture to the surface; Calluna invaded the Nardus-Festuca grassland south of the Edmondsley Road and the species rich Agrostis grassland closed over the lime-mortar rubble of the decayed cottage footings above the pond in the north east. The water table dropped in Wanister Bog as a result of peat cutting by more mobile leisure gardeners and trees began to colonise the south and south east of the Fell and from their refuge near the South Burn.

In 1916, Jeffreys identified water-supply as a main ecological factor on the Fell. By 1966 man as a trampling animal had become as significant a factor and the system of informal paths or intermittently used tracks had become etched deep into the surface in places - receiving often in one day, by the end of the 1960's the wear the local population might have inflicted in a normal year before 1920.

(1) Watt (1955), p. 490

(2) Cmmd 462 H.M. Govt. (1958)

The landscape of the Fell now contained within it a peculiarly distinctive ecological factor: the footpath network. The vegetation of Waldridge Fell is its most distinctive landscape feature but the vegetation of the footpath network has become at the same time a distinctive part of that landscape; and the paths themselves major factors in promoting ecological change.

Remedial action by Durham County Council: Closure of the track across the southern end of Wanister Bog

Plate 13a Ref: 10-G
Photographed March 1976

Plate 13b
Photographed October 1976

A deep ditch with upthrown earth barrier was put across this moderately used track during the winter of 1975/76. Primarily to exclude vehicles, it proved an obstacle to the less energetic pedestrians for, so high is the water table in this part of the Fell, the ditch filled with water and remained difficult to cross long into the summer drought of 1976. As can be seen from the second photograph, regeneration was rapid. The surface largely retains its organic cover and this has favoured the return of Deschampsia flexuosa and Vaccinium myrtillus. On a drier section, Rubus fruticosus was invading the centre of the track through sucker penetration in 1977. All of these species are intolerant of trampling. The most rapid revegetation of the bare surfaces was by the grass species Festuca ovina and (in wetter areas) Nardus stricta. The 'disturbed' mound was clothed in broad-leaved grasses (Dactylis glomerata, Lolium perenne) and adventitious 'weeds'. This was one of only two sections of the pathway system where Agrostis tenuis was not observed in the transects.

Physical influences on the ecology of pathway surfaces : I water content

Track surface damage and regeneration on the 'Tinkler Row' track at Site 'T_3'

Plate 14 a Ref: 6-C
Photographed February 1976

Plate 14b Ref: 6-C
Photographed June 1977

The wetter areas of the trackway system suffer the greatest localised terrain damage through rutting and displacement. In waterlogged areas, pore space is occupied by water so that compression of soil can not take place without upward displacement of water and the accompanying transport of finer particles to the surface. This produces a smear of fine material over the surface vegetation that has not been damaged by bruising. The resultant loss of light may severely inhibit growth. Recovery after damage, conversely, is more rapid than on dry areas provided the damaging pressure is reduced - as it has been on this track since the construction of earth barriers. The track was formerly used by motorists seeking informal parking sites on the grassland lying to the south of the Edmondsley Road; now even walkers use the track infrequently.

Track surface damage at the low-lying intersection on the busiest stretch of the 'Ellen Street' track.

The main routes, tracks 'E' and 'C', actually skirt the wettest depression but there is usually a high water table and standing water on the surface from September to May and after heavy rain in summer. The hollow is occupied by Nardus stricta, with Juncus effusus and Juncus squarrosus but lack of organic material on the main track surface, together with heavy tread, seems to have restricted revegetation to Poa annua on fine sediment and Agrostis tenuis on coarse material deposited at the foot of the eroded slope. There is no evidence to suggest regeneration would not be rapid at the intersection if tread was reduced. The grey colouring on the track surface in the foreground is caused by the outcropping of thin seams of coal associated with the 'F' seam (a similar layer can be seen below the turf on plate 7) and the damp hollow is either caused by hand winning of coal in the 1940's or by slumping associated with shallow subterranean workings. The gorse on the slope marks the edges of pitfalls (see Figure 4).

Plate 15 Ref : 7-E

Photographed 16th October 1976

Physical influences on the vegetation of track surfaces: II Climate

a.

b.

c.

d.

Plates 17 a-d Ref: 6-E

a : Photographed August 1976

b : Photographed October 1976

c : Photographed December 1976

d : Photographed February 1976

Seasonal differences in a grassland recently colonised by bracken (winter of 1976/77).

In addition to a curtailment of growth by frost, the fronds of Pteridium aquilinum are vulnerable during winter to strong winds and compression of falls of snow. The deciduous nature of the plant is well brought out by this sequence of photographs. Where the Pteridietum is light it offers only seasonal inhibition to movement by pedestrians; but a dense cover of fronds may lead to an accumulation of a deep litter and an impenetrable stubble – below which little can grow.

A series of moist warm summers and mild winters would conspire to promote a dominance of bracken; dry summers in 1976 and 1977 together with a cold spring in 1977 have limited its spread in this exposed part of the Fell.

PHYSICAL INFLUENCES ON SURFACE VEGETATION I : WATER SUPPLY

The vegetation of a mineral soil surface subjected to heavy trampling and prolonged drought.

Plate 16a (Ref 7-F)
Photographed 5th September 1976

Plate 16b
Photographed 16th October 1976

The soil in this section comprises very coarse sand with additional larger fragments of weathered sandstone. It is freely draining, occupying a slope of $4^{o} - 6^{o}$.

Little localised rutting has taken place, but the general removal of the organic layer means that it rapidly dries out in the warmer summer months.

The first picture shows the parched condition of the grasses on the track surface after a severe summer drought and the second shows their quick response after heavy autumn rains. Water deficits during the main growing season may be here just as inhibiting to regeneration of cover as low temperatures in winter and spring.

Agrostis tenuis seems the best equipped grass to colonise the coarse dry material of the heavily trampled surface.

In effect this track has a desert microclimate with high insolation by day, rapid loss by radiation by night and rapid water run-off. Main growth may be restricted to the cool mornings and evenings during the warmest times of the year when humidity tends to be higher. Deep rooted ericaceous species would normally colonise the sandy soil, create shade and drop leaves to form a 'mor' peat, but the trampling pressure tends to exclude them.

Bracken at the 'crozier' stage of its growth cycle

This photograph shows a frond of bracken uncurling from the crozier-shaped loop that the spring sunshine had encouraged to push up from the deep litter on Wanister Hill.

Young bracken is very vulnerable to frost but where litter is deep the croziers are effectively protected until the main frost danger has passed. In a cool year, however, the insulating layer also excludes early warmth: the result is the bracken produces less cover. Elsewhere on the Fell spring of 1977 was late; most fronds appeared some 30-35 days later than this one, which had advantage of southerly aspect on a steep slope and protection from cold winds. At this stage too, the crozier is prone to trampling damage for its succulent young shoot is very brittle.

Plate 18 Ref : 8-I
Photographed 20th May 1977

Colonisation of heath by bracken after fire

Plate 19 a Ref : 7-E
Photographed 5th July 1977

Plates 19 a & b Ref: 7-E

a: Photographed July 5th, 1977

b: Photographed September 5th, 1977

"Bracken rhizomes, owing to their depth below the surface, are rarely injured by fire and they may easily occupy the ground before the moor plants have regenerated". (Tansley (1939) p.503.

During the drought of summer 1977 the area shown as being dominated by Calluna Vulgaris on Fig.8, was set alight and most of the Calluna was damaged. The warmth of the summer, and the raising of the ground temperature by the fire have promoted a vigorous growth of Pteridium aquilinum. Vaccinium myrtillus, with its rhizomes some 5-8 cms below the surface, has also survived the fire and it is likely that the co-dominants of area 7-E will be Pteridium aquilinum and Vaccinium myrtillus, for several years. The area is somewhat exposed to strong winds, however, and the number of seeds surviving from the heavy yield of 1976 should result in a reassertion of Calluna in time.

Plate 19 b Ref: 7-E
Photographed 5th September 1977

Physical influences on the vegetation of track surfaces : II

The effects of gradient on pathway condition: gully erosion, deltaic deposition and braiding caused by lateral spread of human tread.

Vehicles have been responsible for cutting deep ruts, particularly with the increased traction exerted near the crest of the slope. The ruts have become local water courses and headward erosion has led to the channels becoming deepened - and accompanying slope retreat has led to an overall lowering of the level of the pathway surface through removal of "interfluves". Degradation of the upper slope has been accompanied by aggradation of the slope foot by deltaic deposition. Colonisation of such surfaces is best effected by annual growth of plants when the deposits are more stable during the drier part of the year (June to October). Early flowering species such as Poa annua can gain an early foothold in the spring and this grass is dominant on the fine sediment in the foreground.

The uneven surface has encouraged pedestrian transgression on to the right-hand slope and already two new tracks are showing signs of wear. The bracken is clearly more easily penetrated in the early part of the year, because of its deciduous nature, than the dense heather on the left.

Plate 20 Ref: 7-I
Photographed 16th October 1976

Agrostis tenuis colonising coarse deltaic material at the foot of steep slope.

Gully erosion removes considerable areas of the bare pathway surface on the steep slope of the 'Ellen Street' track. Periodically tussocks of vegetation slump into the channel and grasses spread vegetatively from these, but generally the steep slopes and rapid run-off during rainstorms keep the surface devoid of vegetation. During periods of heavy rainfall or after sudden thaws of snow, the small torrents can transport heavy particles but these are dumped at the foot of the slope where the velocity of the current is reduced. A coarse delta, so formed, has been colonised by Agrostis tenuis round its dry edges. Water percolates through the centre of the delta and finer particles tend to become trapped in the interstices and here Poa annua shows as the bright green flush on the right hand margin. Perennial heath will find difficulty in gaining a hold on such an unstable surface.

Plate 21 Ref : 7-E
Photographed September 1977

Physical influences on the vegetation : III : Gradient

Fine alluvial deposits in former car-rut with differential colonisation by Poa annua and Agrostis Tenuis.

Overdeepening of the track surface on what is otherwise a well drained terrace ("contour track") has locally reduced the velocity of the surface drainage. Fine alluvium has choked the channel and its recent drying out has instituted the beginning of a seral succession with algae causing the green shade in the foreground. Vegetative invasion by Poa annua is taking place on the lower right-hand margin where fine material has been trapped within the heath grasses at a point where water has slopped over the down-slope edge of the track. The upper shoulder of the rut is much coarser and drier and the dominant grass is Agrostis tenuis.

Plate 22 Ref : 7-G

Photographed 16th October 1976

CHAPTER III

THE PHYSIOGRAPHY OF TRAMPLED AREAS

It is now appropriate that the main areas of public pressure, that existed at the time of designation of Waldridge Fell as a Country Park, be indentified. It has already been demonstrated that on Waldridge Fell it has been the human factor that has been paramount for the last hundred years and that wherever human tread has been concentrated, the coarser heath species have been replaced by grassland (Fig. 6 g/h).

There are two principal types of area dominated by grass species:

(1) Broad areas of Grass Heath - extensively trampled in the past and now seemingly capable of carrying higher traffic than they are experiencing at present.

(2) Intensively trodden paths through heath - which may be becoming more and more inpenetrable, where suppression of the dominant species has resulted in narrow ribbons of grass which appeared, in 1975, to be subjected to increasingly excessive trampling.

GRASS HEATH

In the more extensively trampled areas, dry "grass heath" has developed and within this, sub divisions can be discerned which reflect a function between degree of pressure, wetness of the soil, organic content and perhaps soil acidity and texture. In undisturbed wetter areas rich in organic material, Nardus stricta dominates and the tussocky habit of this plant and its dense rhizomes (well illustrated in Plate 50), which persist after the deciduous leaf fall, reduce the number of other species in the area; these may be further reduced by selective grazing. Large tussocks of the grass form (see Plates 38 and 51) and this discourages human entry to the area so that areas under Nardetum carry the lowest density of human tread within the grassland belt, and already Calluna vulgaris is reasserting itself together with adventitious specimens of Betula and Crataegus particularly in the part of the grass heath north of the Tinkler Row track (see middle distance of Plate 35).

Deschampsia flexuosa is one of the species that is compatible with Nardus and this occupies the drier parts of the grassland belt wherever organic content of the topsoil is high. The drier nature of the terrain makes the Deschampsia grassland vulnerable to attack by the spread of Pteridium aquilinum.

Wherever human pressure has been so high that the organic 'peaty' layer is thin, dry grass heath of Agrostis-Festuca composition develops. The ground is less tussocky and the grassland is species-rich (see Chapter IV, tables 7-8).

The density of the footpath network shown on Figure 13, both the major and minor paths, is thus a cause and an effect of variations in the grass heath distribution. The likelihood is that the greatest density of minor footpaths and the greatest erosional pressure on trackway systems is going to occur where areas of grass heath are located and that the remainder of the heath will tend to be subjected to a lower level of trampling than is necessary to maintain the open nature of the landscape - i.e. there will be an absence of what Burden and Randerson (1972) refer to as "beneficial trampling". Clearly the presence of an intricate network of minor paths distributes human tread more evenly throughout the area and induces beneficial trampling.

INTENSIVELY TRODDEN PATHS

Outside the main grass heath belt there are areas of intensive tread. Man is a social animal and yet at the same time a reasoning one, he is more likely to follow the track made by previous pedestrians than to blaze a new trail through virgin terrain, provided that the track leads in approximately the direction he wishes to go. In this behaviour man, as a track-making creature, is following the well known 'economic' principle of least effort as well as making the assumption that all paths have a purpose.

Bates (1950) demonstrated how man reinforces chance deviations in route by the habit of following already trodden terrain; although the almost imperceptible effect of hard or soft terrain, or minor changes of slope or vegetation texture could not be discounted for the continuance of waywardness. Subsequent users of the track will seek to straighten out unnecessary deviations; Huxley (1970) points out "unless a pathway satisfies most users' wants....... people will walk off it" - (a feature well demonstrated by Plates 8 and 20). This point about the purpose of paths will be returned to in the chapter on terrain evaluation, but the significant fact here is that the paths which appear the most <u>purposeful</u> receive the greatest use: Plate 25 shows the result of one main path being superseded by a more direct north-south route, carved through dense <u>Calluna vulgaris</u> during World War Two.

Where several primary routes converge, the greatest erosion is likely, as people transfer their allegiance from track to track; and areas between major intersections are most vulnerable to damage. The fire-damaged heath shown on Plate 19 is an example of such a vulnerable location between two primary routes, this time the human influence going beyond the area over which he tramples. The peculiar configuration of Waldridge Fell is such that at the apex of the triangular shape of the upland, where three of the principal tracks converge, lies the most significant part of the S.S.S.I. The area assumes a more inviting appearance as a result of the sudden release from the claustrophobic restrictions of the dense heath of the southern part of the Fell but the peaty soil and steeper slopes of Nettlesworth

Hill above the South Burn are more vulnerable to erosion and indeed processes could be initiated that prove to be irreversible.

A STUDY OF THE PHYSIOGRAPHY OF THE INTENSIVELY TRODDEN PATHS

EXTENT OF TERRAIN DAMAGE

The amount of traffic that a path carries is most directly reflected in the amount of terrain damage, both in lateral spread of the track surface and damage exerted vertically into the substrate. It was therefore possible to identify which parts of the Fell carried the most traffic during the late 1960's and the beginning of the 1970's by examination of the stereo pairs of air photographs (see Plates 71 a & b).

Bellamy and Radforth (1971) measured terrain damage by vehicles in the Tundra using both air photographs and ground survey and expressed their semi subjective observations on a parallel scale of vegetation damage and soil structural change. A similar scale was devised for field use in this investigation but it proved adaptable to aero-photograph interpretation. It is given below in the field context. The Bellamy/Radforth scores were expressed on two eight point scales and it is notable that only when traffic is intense do the scales prove congruent; that is, when light traffic crosses wet or waterlogged ground there is a greater tendency for the substrate to be damaged than the living mat of vegetation - but driest sites suffer a loss of vegetation before the soil structure shows signs of damage. For this survey, it proved convenient to assess the two criteria on five point scales, and the sum of the two scores was used to give a "pathway wear" score.

TABLE 1

SCORING SYSTEM USED FOR ASSESSING TERRAIN DAMAGE

(i) Lateral damage

Total width of transect with non vegetated surface(1)

Over 2 metres	= 5	
1.05 to 2 metres	= 4	
0.55 to 1 metre	= 3	(2)
0.25 to 0.5 metre	= 2	
Slight to 0.25 metre	= 1	
Vegetation cover continuous	= 0	

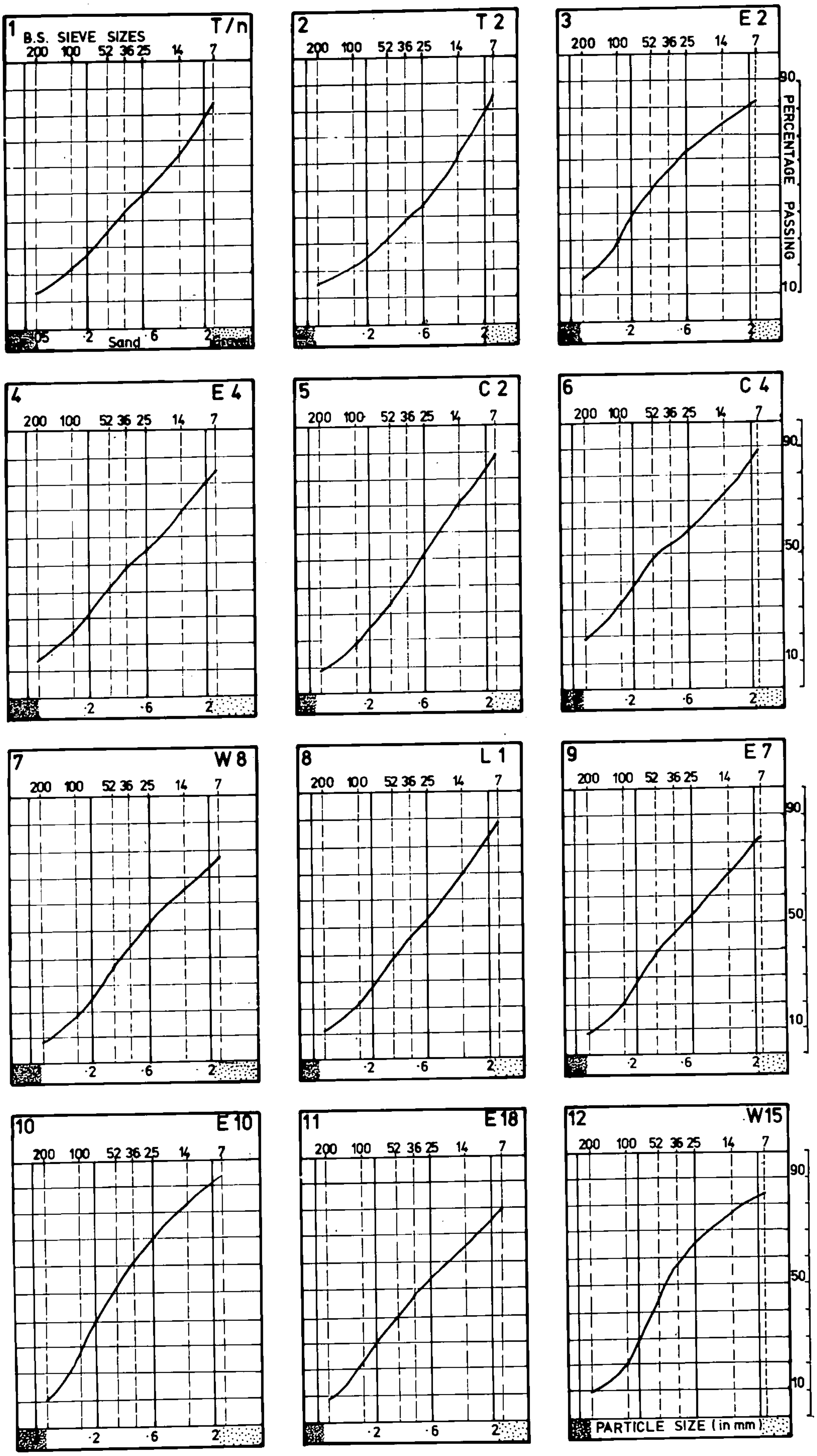
(ii) Vertical damage into secondary terrain

Deeply rutted (12 cm+), organic layer removed full width of track ('Wide' path only)	= 5
Multiple ruts, deep, "braided" with organic layer removed in more than two parts of section	= 4
Ruts present (organic layer removed in continuous longitudinal belts) only shallow organic layer elsewhere on surface.	= 3
No continuous ruts (irregular, pitted surface some damage to organic layer	= 2
Turf and rootlets show below base of bruised vegetation	= 1
Complete turf	= 0

1. The term non-vegetated surface is used in preference to 'bare' earth. On peaty soils within the Callunetum, apparently bare surfaces were noted to be bonded by a mesh of the alga Zygogonium ericetorum; the top of the peaty layer in dry conditions resonating quite markedly as the under peat shrank with water loss. It is difficult to estimate when the regeneration process has actually begun, particularly when the ground is waterlogged in the early spring.

2. Huxley (1970) points out that the standing human usually occupies no less than 25 cms lateral section and that walking action extends the influence of the foot across approximately 40 cms of path. A narrow but heavily used pedestrian path can therefore achieve a score of 3 on this scale; similarly, vertical displacement of its terrain can achieve a score of 3 on the 'vertical' scale. This scoring is significant in correlation made between pathway erosion and other, physical, criteria later in this chapter.

FIGURE 10. PARTICLE SIZE DISTRIBUTION OF THE SOILS OF WALDRIDGE FELL



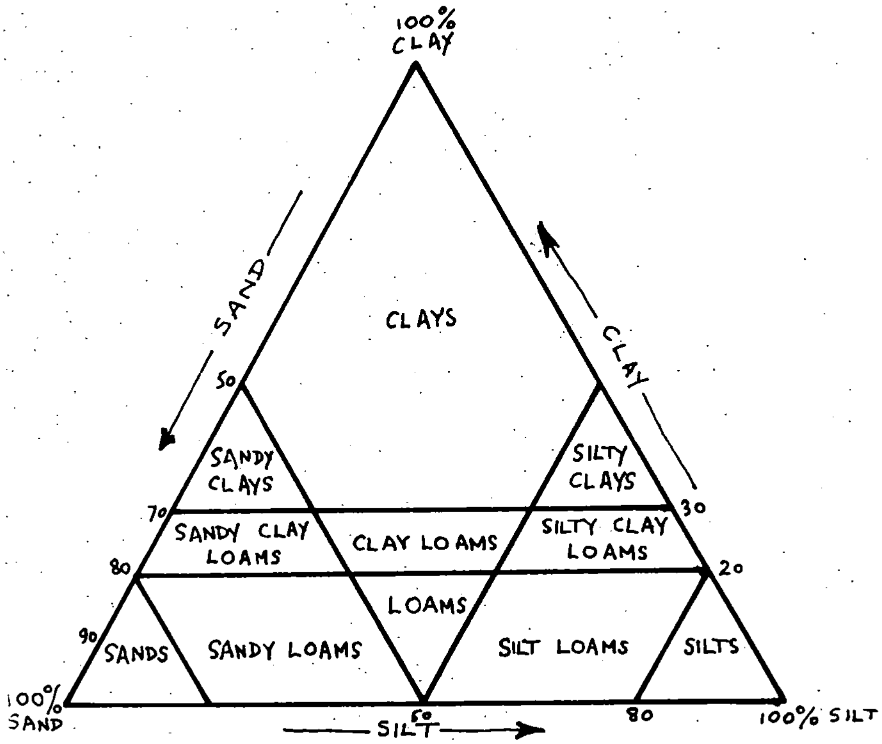


Figure 11 A SOIL CLASSIFICATION BY TEXTURE
U.S. BUREAU OF SOILS SYSTEM

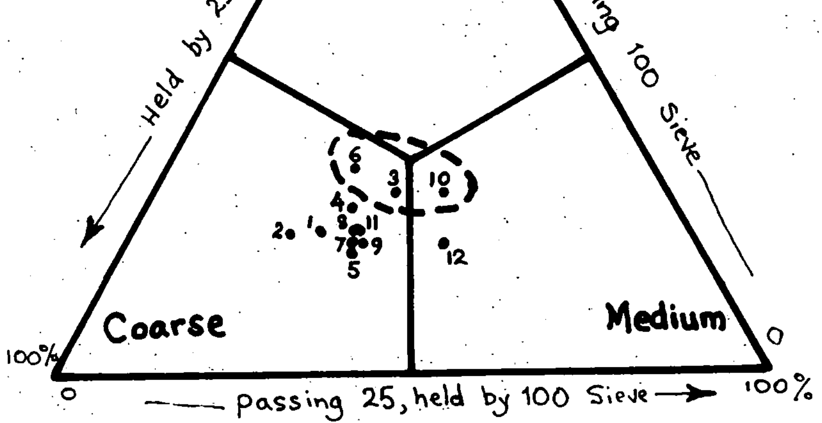


Figure 11 B RECLASSIFICATION OF SANDY SOILS
OF WALDRIDGE FELL

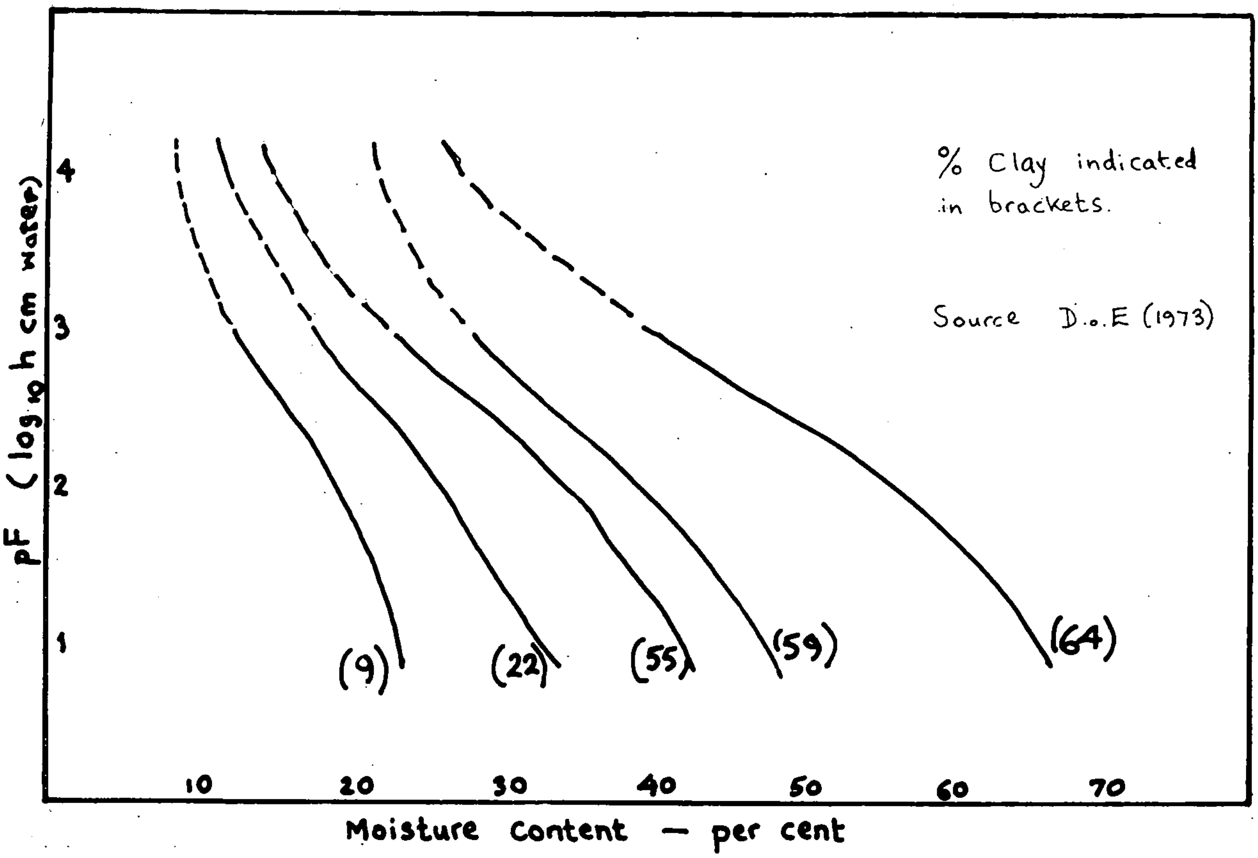


FIG. 12 A. COMPARISON OF SOIL MOISTURE SUCTION (DRYING) CURVES FOR FIVE SOILS WITH DIFFERENT CLAY CONTENT

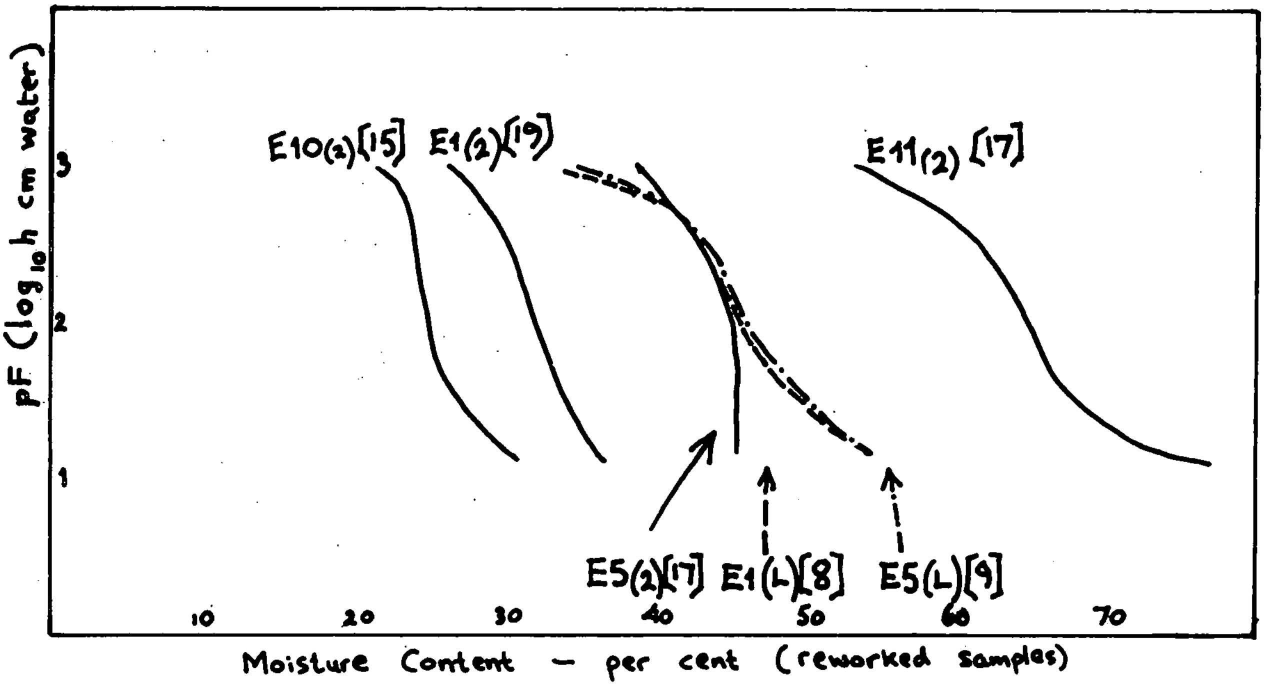


FIG. 12 B DRYING CURVES FOR SOILS WITH VARYING PROPORTIONS OF 'FINES'

PATHWAYS: CLASSIFIED BY PROMINENCE ON AERIAL PHOTOGRAPH 1971

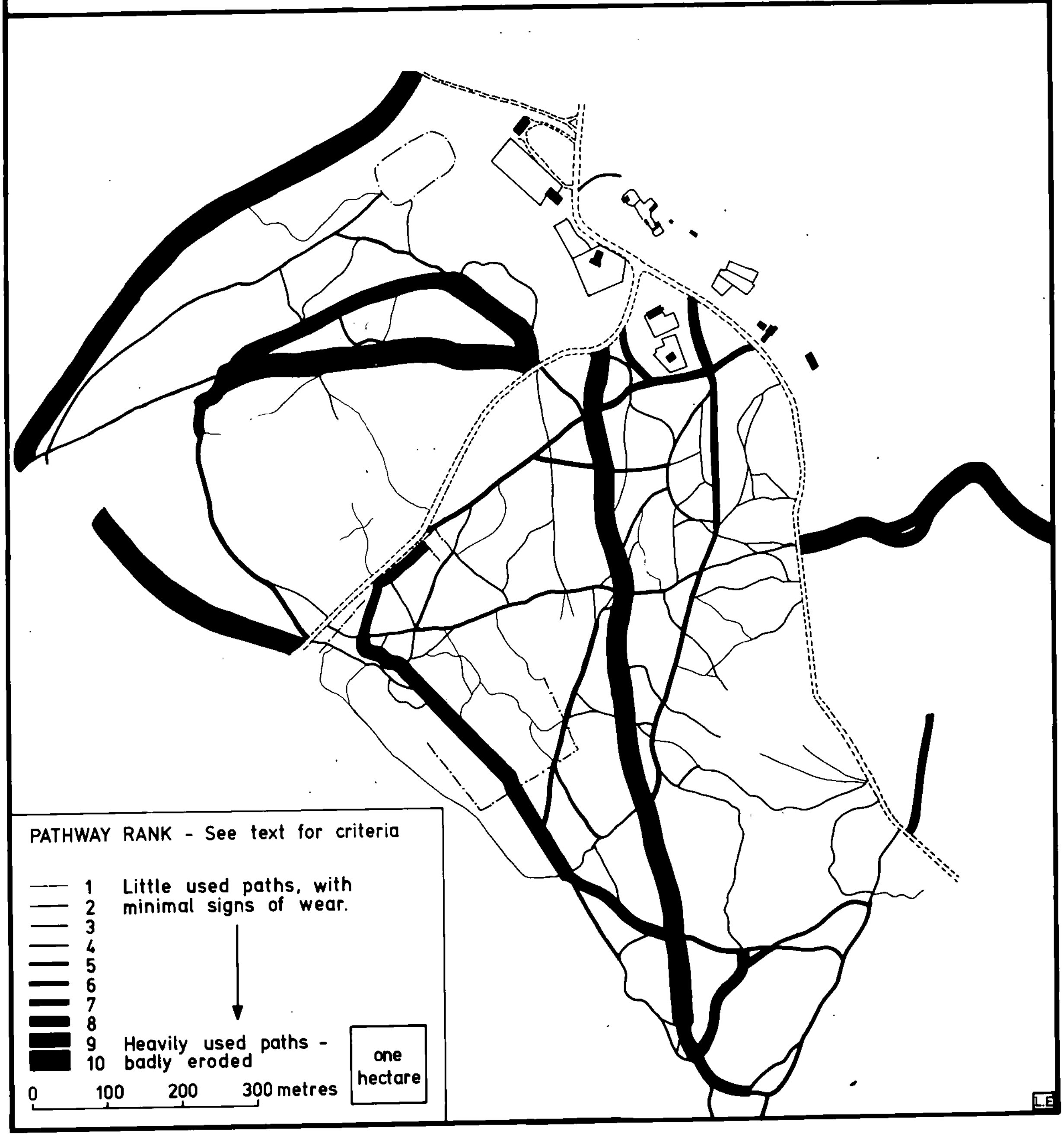


Fig. 13

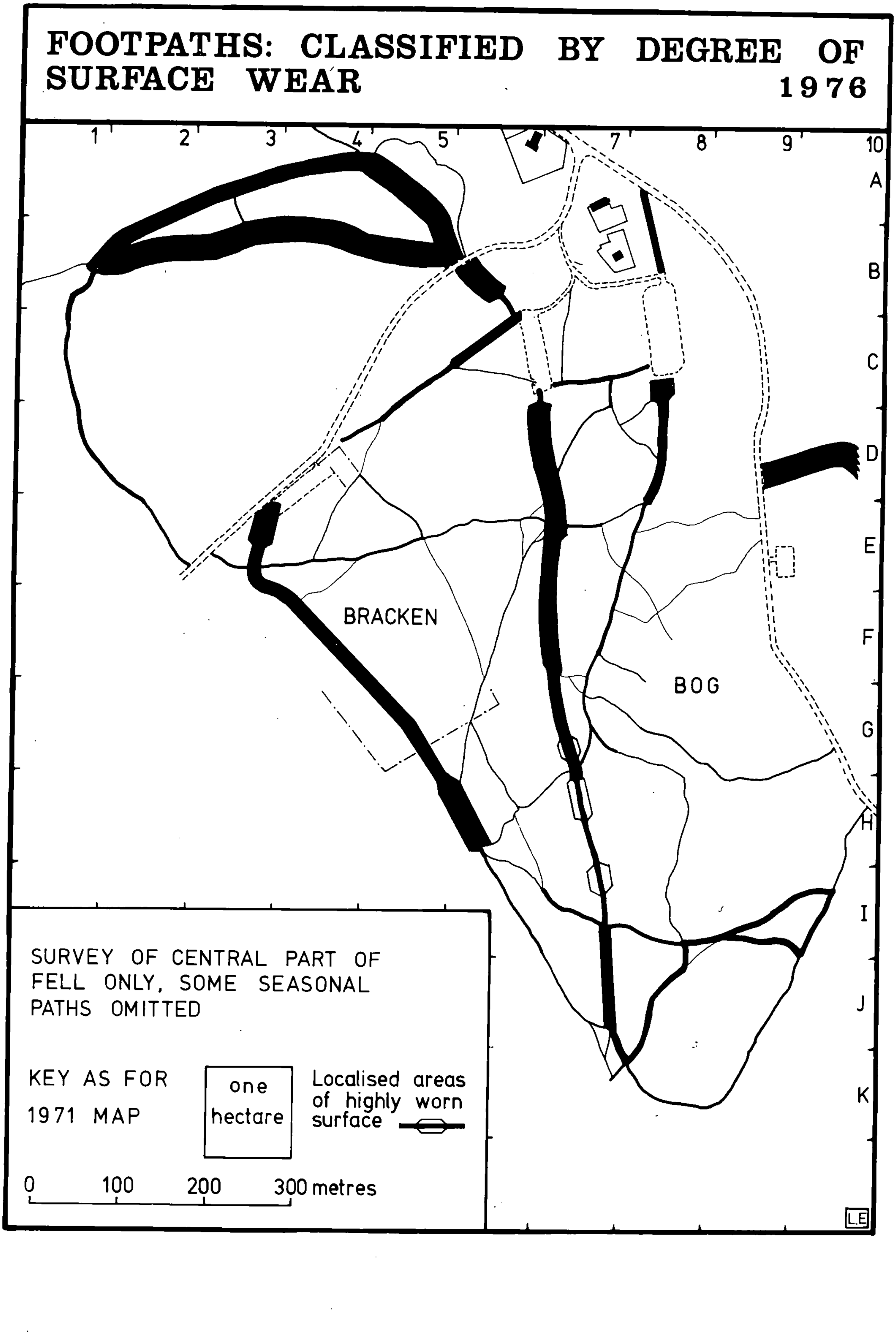

FOOTPATHS: CLASSIFIED BY DEGREE OF SURFACE WEAR
1976
1
2
3
4
5
7
8
9
10
A
B
C
D
E
F
G
H
I
J
K
BRACKEN
BOG
SURVEY OF CENTRAL PART OF FELL ONLY, SOME SEASONAL PATHS OMITTED
KEY AS FOR 1971 MAP
one hectare
Localised areas of highly worn surface
0
100
200
300 metres
L.E

Fig. 14

Figure 13 shows the results of applying this scale to photogrammetrical interpretation of stereo air photographs. The assistance of a skilled photo interpreter was available, to determine altitudinal changes based on measurement of planimetric displacement and to operate plotting equipment, in the production of the contour map of the S.S.S.I. (Figs. 1 and 29); the same methods are applicable to measure depth of pathway displacement as differences of altitude on a slope; the dimension of altitude is shown as being proportional to the ratio of ground height to flying height and also directly proportional to the radial distance of a point from the plumb point image. Once experience has been gained in recognising the appearance of certain vertical displacements then other points can be placed in 'relative' order.

The degree of surface wear was established for the paths at approximately fifteen metre intervals and a mean score achieved for each section of path between main intersections.

The aerophoto has limitations which in this case can be listed:

(i) It was not possible to determine extent of organic cover, only depth of displacement.

(ii) It was not always possible to determine whether vegetation had been completely removed.

(iii) The criterion of depth of displacement led to certain paths, now defunct but still showing as scars on the ground, being included in the hierarchy when they now receive little or no traffic - particularly notable was the eastern continuation of path 'C' beyond the William Street track.

The main routes of Figure 13 were then plotted on a base map (scale 1:2,500) and the scoring system was used in the field. The field survey identified areas of moderate to severe erosion (having a combined score of 6 or more) as being the primary routes of the "car recreation" era and showed a strong positive correlation between those areas used for informal car parking (see Fig. 6f) and the most heavily eroded paths (Fig. 14).

In areas where vehicle pressure and pedestrian pressure together had produced severe erosion, it was expected that significant regeneration would take place after the exclusion of motor vehicles. In those areas where the moderate to severe erosion was clearly the result of pedestrian pressure alone, regeneration might not take place, but if it did it would reflect a change in the distribution of visitors on the pathway system after the creation of the diversionary car parks.

It was realised that certain physical properties might be operating differentially within the Fell which would create a 'noise' factor in the study of regeneration of 'bare' surfaces as a result of the diverted trampling. These are examined below.

SOIL COMPACTION

Compaction is the process whereby soil particles are made to pack more closely together, thus increasing the dry density of the soil. The compaction is achieved by forcing small particles into the interstices between coarser particles and thus effectively reducing the pore space (or 'voids'). Compaction thus reduces the ability of the soil to absorb moisture and with any given amount of water precipitated onto a surface, the compacted areas would become waterlogged earlier because of the reduced infiltration possibilities.

Russell (1973) points out the importance of pore space to root penetration. For most temperate grasses, a pore space of 0.2 mm is necessary, thus the higher the proportion of particles in a soil capable of filling such spaces (i.e. passing 100 imperial soil sieve - and called later in this study "Fines") the greater the compaction possibilities and the greater the chance of inhibition of plant growth.

Soils high in clay have the greatest properties of being compacted through trampling pressure and of remaining consolidated under continuous pressure. Most studies of soil compaction are carried out on disturbed soils of ploughed fields or in connection with constructional engineering where the established crumb structure and aereated condition of the soil can be considerably altered by compaction.

Proctor (1933), writing on the construction of earth filled dams stressed the point that moisture content is the most important influence on the degree to which a soil may be compacted; the presence of water at the time of applying the compacting force is crucial...... frictional resistance between the particles is increased by the force of capillarity in dry soils and wherever the small angles of quartz, or the flat sides of clay particles touch, surface tension gives cohesiveness. As water is added this force is reduced and the particles spring apart slightly. As compaction requires the rearrangement of soil particles so that the voids are reduced, clearly trampling done in dry weather, when cohesion is greatest, has less effect than pressure exerted during wet conditions.

In soils containing a low clay fraction compaction is not likely unless considerable vibratory action is exerted. Bayfield (1971b) noted compaction or disturbance of soil profiles to depths of up to one metre in areas used by tracked vehicles near Scottish ski-lifts and Bellamy and Radforth (1971) noted the greatest terrain damage was achieved by vehicles with vibrating tracks rather than pliable rollers. The Department of the Environment (1973) have found that compaction is most satisfactorily obtained, 'satisfactory' that is for traffic purposes, by rollers fitted with 'feet' to ensure maximum vibratory disturbance. The 'animal hoof' action was examined by O'Connor (1956) who identified soil disturbance by cattle under wet conditions as compaction; by Tanner and Mamaril (1959) who found that coarse silty loams with little clay were not significantly affected by cattle trampling; by Edmond (1966) who again noted compaction being less on coarser soils.

There seems to be very little evidence that compaction can be both lasting in its effects nor detrimental to the plant's regrowth. Edmond identified 'puddling' or 'smearing' as the most serious inhibitor of growth and also that under certain circumstances, trampling might produce beneficial compaction by eliminating species preferring coarser grained soils; it has already been suggested that a correlation exists between disturbed ground and Ulex europaeus on Waldridge Fell.

Several researchers have tried to isolate compaction as one of the parameters in devegetation of surfaces but the methods used for measurement have not always proved conclusive. Burden (1969) measured the increasing depression of the ground surface across a lateral profile and was forced to conclude that erosion of the surface layers was more significant than structural change. Randerson (1969) and Mancey (1972) used the methods advocated by the British Standards Institute (1967) involving the extraction of soil cores with a cylindrical extractor, trimming them to a constant length and testing for pore space/moisture content relationships and by testing volume of cores in the field with dry sand; Mancey found the tests inconclusive in a dry heath sandy soil.

O'Connor (1956) and Liddle (1973, 1975) used impact penetrometers to test for soil density at different depths below the surface, it seems, however, that although they did detect penetration resistance at the surface which at first increased with depth then decreased to a state of equilibrium, they were in fact partly measuring cohesion as a result of moisture distribution rather than compaction. Liddle demonstrated rut formation in a dune soil (a notably unstable, disturbed medium) was greatest where vehicles exerted downward pressure after cresting a rise or other small elevation.

Plate 11 shows how wheel action in unconsolidated sands does in fact result in downward compression of loosely packed material; and the concentric waves of pressure from a 'bulb' of pressure below the wheel, linked with shearing stress, can disturb the soil surface upwards - particularly where a crust of wind sorted particles has formed.

Clearly then, wheel action and the action of feet exert pressures vertically onto the soil capable of displacing particles. The evidence that this pressure can be lasting, therefore detrimental to plant regeneration, is slight. Burden and Randerson (1972) were forced to conclude that the physical effects of bruising and the smearing of plants by fine material (reducing photosynthesis) were more significant in vegetational changes than the effects of soil properties. O'Connor (1956) had concluded that "compactness of soil was not serious enough to affect plant growth". Witsell and Hobbs (1965) felt that they had demonstrated the effects of compaction on a growing crop but the compacted condition improved rapidly in the field, especially where frosts were experienced in winter. An earlier research (Gupta (1933)) had detected little or no effect by denser soils on the growing crop - whereas smaller root systems developed in denser soils they appeared to more completely exploit the soil nutrients. Gupta concluded that diminished aeration affected growth less than <u>soil texture</u>.

For this investigation therefore it was decided that tests for soil compaction would be withheld until tests for soil particle size and water holding properties had been carried out. In view of these tests, now to be described, compaction of the soil was in fact discounted as a factor likely to inhibit the regeneration of pathways on Waldridge Fell.

SOIL PARTICLE SIZE

Soil samples were taken from a wide variety of locations close to the pathway sections selected for the study of regeneration. It was decided that transects would be laid across paths only in that section of the Fell lying between the Edmondsley Road, the Chester Moor Road and Nettlesworth Hill (See Appendix C, Fig. 25), for the following reasons:-

(i) Visibility across the terrain was good for any census work required.

(ii) The area contained almost all the paths likely to be affected by the redeployment of wear.

Vegetation transects were to be on a systematic sampling basis, with an interval of 30 metres between each station (see Chaper IV). So that an idea of the environmental soil composition could be gained, pits were dug through the 'mor' peat, which was found never to be more than 12 cms in depth in well drained areas, and the surface of the A_1 horizon was cleared of fallen debris before a quantity of soil was removed at 12 to 15 cms depth. The soil was bagged in air tight polythene and sealed. All samples were taken on the same spring day after a period of drought and in wind free conditions before the heat of the day.

It was already known that Jeffreys (1916) had classified the eastern part of the scarp as coarse sand and that he saw a relationship between the distribution of Pteridietum and this soil texture. Fig. 26 shows the extent of the coarse sand according to Jeffreys. One objective of the tests was to determine the true extent of the coarse sands in the study area. It was felt that soil texture could affect the drainage properties (by percolation), or water holding properties of the surface and could also affect the podsolisation process all of which could act as environmental influences on the species performance in different sections of the pathway network. It was also necessary to establish local controls against which soil samples, taken from pathway surfaces, could be compared.

Using a grid system and random numbers, areas of the central Fell were chosen after which a selective decision was made. Twelve pits were dug and they presented a remarkable uniformity of soil profiles.

SOIL PROFILE

A top horizon (A_{00}) was composed of undecomposed humus, slightly thicker in Nardus and Calluna areas than elsewhere, but always between the limits 2-4 cms.

Beneath this was the black peaty organic layer (A_0), almost uniformly 8 cms thick. This contained the fibrous roots of the living vegetation.

This was followed by the A_1 horizon: a thin band of grey sand (1 cm), then 2 - 3 cms stained a purple colour from the 'mor' peat above, before a layer containing fine rootlets, imparting a browny colour, gave way at a depth of 15cms to yellow sand (the B/C horizon). This sand was presumably derived from Coal Measures Sandstone but a thin wash of glacial sand could not be discounted.

MOISTURE CONTENT

Samples were removed from 15 cms depth, placed in sealed polythene bags and taken to the laboratory for testing for moisture content. This was calculated according to British Standard (1967) test No.1A (oven drying method) and is presented in Table 2, column 6.

The dried sample was then placed on a mechanical shaker in a nest of British Standard "Imperial" sieves, according to British Standard (1967) dry sieving test, 7B, which is suitable for fine sands.

Care was taken not to overload sieves, particularly on the finer meshes; a table giving recommended limits is given in the B.S. booklet. Where necessary large samples were divided by riffle sorting. In a humid environment the finer particles in the lowest pan can absorb moisture and it is essential to weigh with speed as well as accuracy.

The cumulative percentage by weight of the total sample passing each sieve is normally presented on a semi-logarithmic chart, although it is also useful to know how much of each sample is retained by each sieve. Table 2 includes this latter information while Fig. 10 presents a visual

Table 2   Data for soil samples 1-12 : Collected 27th April 1976

Sample Number	Vegetation	pH	Initial wt. of sample in gms.	Dry wt.(1) of sample in gms.	% moisture in field sample	% of weight retained on sieves as listed(2)							Wt. passing 200 sieve classed as 'Fines' (3)
						7	14	25	36	52	100	200	
1.	Nardus	5.5	899.5	754.0	19.3	15.7	19.6	15.7	5.7	6.4	14.4	9.1	13.0
2.	Calluna/ Vaccinium	6.0	1033.7	786.5	31.4	14.8	21.6	19.3	6.3	5.9	10.8	6.0	15.0
3.	Ulex	6.0	661.2	567.5	16.4	17.5	8.3	10.9	6.7	8.5	19.7	12.0	16.2
4.	Agrostis/ Poa	6.7	914.2	737.6	24.0	15.7	15.1	14.7	6.0	7.2	16.5	10.6	14.2
5.	Calluna	5.5	*180.9	144.9	25.5	12.3	17.0	18.9	10.0	7.9	15.3	10.4	8.3
6.	Deschampsia flexuosa/ Calluna	5.7	922.0	756.7	21.8	11.2	15.8	14.1	5.1	6.0	15.4	13.7	18.6
7.	Calluna/ Pteridium	6.0	677.7	564.5	20.1	22.9	12.1	12.8	8.1	7.0	17.4	11.6	8.1
8.	Pteridium/ Calluna	5.3	857.3	643.7	33.2	11.8	18.3	16.8	6.7	8.0	16.3	10.9	11.1
9.	Calluna	5.7	669.5	541.7	23.6	18.8	13.3	14.6	6.6	8.7	18.0	11.6	8.3
10.	Pteridium	5.5	685.8	554.9	23.6	5.8	11.6	13.9	7.2	9.8	24.3	16.9	10.8
11.	Vaccinium/ Ulex	6.0	804.6	636.1	26.5	20.1	13.5	12.8	6.4	7.0	18.1	13.3	8.6
12.	Betula/ Vaccinium	5.5	1078.0	914.6	17.9	16.1	7.2	12.5	7.0	10.9	26.4	10.4	9.5

(1) Large quantities were riffle sorted and results combined (300 gm. maximum for sandy soil

(2) Sieve pans were only available in 'imperial' meshes, stated in mesh per inch.

(3) Clay and silt particles both pass through the '200' sieve (75 micron)

* Second sample.

record of the physical composition of the samples.

It is clear from Fig. 10 that the soils of Waldridge Fell show very little variety. Those soils which apparently contain a markedly larger amount of fine material probably contain no more Clay particles because later tests showed that the 'finer' soils did not necessarily evince any greater water holding properties than some of the coarser soils.

Table 3, below, gives the names of different sized particles and the B.S. sieve which retains them.

Table 3 : Particle-size scale (British Standards Institution) nomenclature

Particle name	B.S. Sieve No.	Nearest continental sieve (microns)	Size of smallest particle mm.
Gravel & Stone	7	2,500	2.0
Coarse sand	25	600	0.6
Medium sand	72*	200	0.2
Fine sand	200	75	0.06
Coarse silt	Passes 200	Passes 75	0.02
Medium silt	-	-	0.006
Fine silt	-	-	0.002
Clay	-	-	< 0.002

* Note : Sieve 100 used for Waldridge Fell survey.

Despite the tiny size of some of the silt particles they are still multi-faceted quartz particles (often nearly spherical due to attrition) and their properties of water holding are similar to sands. Clay particles have a further property besides their small size which ensures that they retain more water: they are lamellar and thus clay soils have a larger internal surface area than a comparable weight of silt - so that they can hold more water by the property of capillarity. It is this power to hold more water that gives them greater cohesion during drought conditions...... a point to be discussed further under the headings 'Smearing' and 'Suction' later in this Chapter.

Dry sieving can only isolate particles above a size of 75 microns and even some of the material passing this size is classified as fine sand; a soil composed almost entirely of fine sand would have greater cohesive properties in dry weather, because of the larger number of interfaces, compared with coarser sands, but it would still defy compaction and it would still drain freely and encourage podsolisation. Passing the '200' sieve are all the silts as well as the clays and these can only be further classified by use of pipette or hydrometer. These latter tests were not applied to the Waldridge survey because generally less than 10% of the total material passed the '200' sieve.

During sieving, certain amounts of the finest clay particles will adhere to coarser materials and be retained higher in the nest of sieves and the full test requires that materials from sieve 36 down should be retested by flotation methods. Because of the small proportion of fine material isolated, this was not done. Beaumont (1967) examined the drift soils of eastern Durham and found that over 70% of the material passed the '200' sieve. He experienced difficulty in isolating the clay content from the silt but found it to be less half of the fine material (about 30% of the total sample).

The results of the mechanical sorting were then subjected to further examination.

Table 4 isolates some of the information presented in an earlier table of data.

Table 4 : Classification of soils of Waldridge Fell by particle size

Sample and Location	Silt/Clay % passing 200	Fine sand passing 100	Coarse Sand	
			Above 25	Above 52
1 T/N	13	22	51	63
2 T 2	15	21	56	68
3 E 2	16	28	37	52
4 E 4	14	25	46	59
5 C 2	8	19	49	66
6 C 4	19	32	41	52
7 W 8	8	20	48	63
8 L 1	11	22	47	62
9 E 7	8	20	47	62
10 E 10	11	28	31	48
11 E 18	9	22	47	60
12 W 15	10	20	36	54

The soils of the whole study area can clearly be identified as sand (according to the U.S. Bureau of Soils system desribed in Dept. of Environment (1973) when soils containing more than 80% of particles larger than 0.05 mm are so classified - see Fig. 11a.

CLASSIFICATION OF SOILS

Triangular coordination was used to further classify these samples and the results of the exercise are shown on Fig. 11b. It is interesting to note that samples 1 and 2 which on Table 3 stand out as containing a significant amount of silty material (and no doubt were excluded by Jeffreys from the "coarse sand" category on this count) also have the largest proportion of coarse sand particles. Most of the sandy soils of the study area appear to be in the medium to coarse category.

There was no correlation between surface morphology and the points with the highest proportion of fine or medium particles.

SOIL ACIDITY AND PARTICLE SIZE

One of the effects of the coarseness of the soil on plant associations could be the rate at which leaching is encouraged by percolation of water through coarser sands. The soil samples were therefore tested for pH value by colorimeter method : B.S. (1967) test 10 (B).

Table 5 shows the ranking of the samples on the basis of coarseness of soil and pH reading. The correlation statistic $r_s = 1 - \frac{6\Sigma D^2}{N\,(N^2-1)}$ was applied and $r_s = +0.122$ indicates that on soils of this type <u>soil acidity is not affected by minor variations in soil texture</u>. Indeed the marginally positive correlation is contrary to expectations.

Table 5 : Correlation between pH and soil coarseness

Sample	pH rank	Coarse rank
1	9.5	2
2	3.5	1
3	3.5	10
4	1	8
5	9.5	3
6	6.5	9
7	3.5	4
8	12	6
9	6.5	6
10	9.5	11.5
11	3.5	6
12	9.5	11.5

$r_s = +0.122$

Much more significant influences on soil acidity are observable on the Fell. The presence of certain heath plants alone can influence the acidity of the soil beneath them: <u>Ulex europaeus</u> has been demonstrated by Grubb (1971) to exert an acidifying influence on chalk, a mineral notable for its richness in bases. On Waldridge Fell lime mortar from demolished 19th century cottages has introduced bases favouring calcicoles, and it is likely that salts were introduced onto the grassland by car wheels in the winter months before January 1976.

Where fine particles have been deposited on track surfaces as a result of changes in gradient, vegetational differences are observable (see Plates 21 and 22) but the presence of moisture at these places seems to be more significant than the slightly higher pH values obtained from the surface deposits.

PARTICLE SIZE AND SOIL MOISTURE CONTENT

The samples of soil were taken on the Fell after a long period without rain (18.5.76) so that any differences in wetness of the surface and of moisture content of the soil samples would be a result of a complex relationship between permeability of the soil and the height of the water table. That terrain damage and recovery is influenced by water content of the soil has been shown; how far this is influenced by particle size is now considered.

SOIL SUCTION

Water falling onto the soil under natural conditions soaks into the ground until it reaches an impermeable layer below, when all interstices between particles become saturated and the water table is formed. There are on Waldridge Fell, several places where the water table is close to the surface and it is not possible to establish a causal relationship between soil particle size and pathway condition in such localities (see Plates 14 and 15).

Above the water table moisture can be held in the soil in four ways:-

(i) As part of the crystal structure of soils - not removeable at temperatures below 110°C therefore an integral part of the soil solids.

(ii) Adsorbed on the surface of soil and dependent partly on the relative humidity of the surrounding air and partly on the amount of surface of soil particles involved.

(iii) Water held between points of contact of particles by surface tension.

(iv) Water held by capillarity in the pores between particles.

The greater the number of points of contact (as in clay soils) and the smaller the size of pore space, the greater is the possibility of held water. The force which counteracts the movement of water towards the water table is known as <u>SUCTION</u>; it is expressed on a logarithmic scale (pF) representing the pressure of n cm of water at log 10.

Fig. 12a shows how a soil, low in clay particles at the normal atmospheric pressure of pF 3, is capable of holding less water than a clayey soil. Conversely, a clay soil with the same amount of soil moisture as a sandy soil will exert a higher suction and its particles therefore will be more cohesive.

It was felt that areas subjected to increased human pressure could experience attrition as a result of the forces exerted by the human foot - a twisting action on level ground (Harper, Warlow and Clark, 1961). Such an action could break up the medium sized particles and produce more fine particles particularly during drought conditions, when friction was greatest. In subsequent periods of wet weather rain splash would redistribute these particles over the surface and effectively seal it.

TEST FOR SMEARING

Using a auger with a detachable sampling tube, cores were removed from pathway surfaces in heavily trampled sections in the centre of the path

Samples were taken from the top 2 cms, from the 2-4 cm level and from 4-6 cms below the surface and from at least five points within each study transect. Some selection of sites was necessary so that surfaces 'protected' by large obstacles (e.g. a projecting stone) or obviously recently affected by sub-aerial erosion (e.g. on the top of a gully bank, liable to subsidence) were not sampled.

It was hoped that the proportion of finer material (passing 100 sieve) would demonstrate (i) diminishing effects of attrition/smearing with depth and also (ii) differences between path surface and local soil beneath the undisturbed heath. It was also intended to test (iii) whether smearing was greater in wet sections of the heath pathway system than on dry surfaces.

Because of the limited laboratory time available (1) and the precision needed when weighing small samples, only seven sites could be processed for surface (0-2 cm) conditions. Inconsistencies in the proportions of fines with depth were obvious after only three samples had been sorted, and objective (i) was abandoned: clearly a greater depth than the top 6 cms should have been sampled. (Dutt (1948) noted puddling effects through the top 15 cms and Lutz (1943) treated the whole of the top 10 cms as homogeneous).

The method used was the Dry Sieving method described earlier (B.S. Test 7B) and results are tabulated below in Table 6: full data is presented in Appendix C3.

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(1) Each sample represents 5 twelve-minute periods of mechanical shaking and appropriate weighing time. Appendix C3 represents the analysis of over 80 specimens.

Table 6 **Effects of trampling on particle size**

Surfaces are arranged in descending order of terrain damage as demonstrated by Fig. 15 (extent of bare surfaces).

Site	Vegetation	Surface Condition	'Local' % fines (L)	Top 2cm of path % fines (P)	Gradient of surface in degrees	% change $\frac{P - L}{L}$
E 5	Juncus spp.	Wet	24	41	0	71
E 1	Nardus stricta	Dry	23	38	1	65
T 3	Juncus spp.	Wet	22	34	0	55
T 2	Calluna/ Vaccinium myrtillus	Dry	21	33	3	57
E 7	Calluna	Dry	27	28	4	4
E 10	Vaccinium myrtillus/ Pteridium	Dry	35	35	4	4
C 4	Calluna/ Deschampsia flexuosa	Dry	32	38	1	19

Comment

(i) A significant increase in the amount of smearing by fine particles is evident in all the heavily trampled areas of the northern part of the Fell.

(ii) The effect of removal of fines by surface water flow in the southern part of the Ellen Street samples (where the gradient reaches a critical angle for surface flow) cannot be ignored.

Lutz (1943) found similar increases in silt proportions in a sandy soil; and the reduction of infiltration rate due to the smeared surface was seen to be detrimental to growth of trees with feeder roots below the 'compacted' surface. Lutz did not examine the effect on plants with roots utilising the top 2 cms.

An experiment was set up to test whether an increase in the proportion of fine particles increased water holding properties. The suction (drying) curves are presented as Fig. 12b.

The soil suction plate apparatus method of determining soil suction only operates for values of pF 0–3 but it was hoped that the drying curves produced would bring out the water holding properties of the samples. The method and the apparatus are fully described in Road Research Technical Paper (1952) and it is not important to describe the method here. It needs certain criteria for its successful use however:

(i) Care must be taken to ensure that the apparatus is undisturbed during operation; although due care was taken, it is not certain that vibration did not disturb the airtight joints.

(ii) At low pF readings the apparatus is susceptible to sudden changes in atmospheric pressure and temperature variations, and during some of the time the North East consistently experienced the highest daytime temperatures for decades. When samples E 5 (2) and E 11 (2) were being processed, there was a sudden change from anticyclonic conditions to the passage of several weak depressions – accompanied by a rise in the column of mercury in the manometer of about 4 cms.

(iii) Each test extends over a period of approximately ten days, so that several weeks elapse before any errors in procedure can be detected. In this case the failure to add exactly the same amount of water to the reworked sample almost certainly rendered the samples E11 and E10 abortive.

In Fig. 12b the figures in brackets after the sample number refer to the percentage of fine particles in the sample. It is by no means certain that the figures represent the same commodity: sand or silt. However, in the one example where the pathway surface sample contained considerably more fine particles than the one from its immediate off-path control pit and where the initial humidity of the specimens was comparable, there is some viability of the results.

E.5 is a 'wet' site (see Plate 15); heavy trampling most certainly forces finer particles to the surface (suspended in the water forced to the surface by disturbance). Five samples taken from the top 2 cms of the surface gave a mean percentage of "fines" of 17 whereas the untrampled soil immediately off the path, but at the base of the peaty layer, had almost half the quantity of fine material, at 9%.

The drying curves for the two samples confirm that although the sample low in fine particles began with a higher moisture content, its capacity to hold moisture was lower than the "trampled" specimen, high in fine particles. Specimen E 1 (L), with identical percentage of fine particles (9%) and drawn from the same geological region of the Fell was fortunately brought to the same degree of initial moisture content as specimen E 5 (L); the behaviour of its drying curve appears to confirm the experiment.

RESULTS

There is some evidence, not fully supported by experiment, that heavy trampling does alter the surface texture of a path so that it contains more fine particles. While there is a living mat of vegetation these fine particles will coat the plant and inhibit its growth. The greater water holding properties of the surface appear to compensate for its more cohesive nature and smaller pore space as a medium for plant regeneration. Had the smearing been effected on a soil with a high clay content the subsequent baking during drought might have created a surface slow to regenerate. The bulk of the surface fines on Waldridge Fell are silt particles however, and this seems to be a good rooting medium particularly for grasses and certain 'weed' species.

THE INFLUENCE OF SLOPE

Over most of the Fell, gradients are gentle; pathways over the main plateau section between Ellen Street car park and the col to the north of Wanister Hill descend from 120 metres above O.D. to 100 metres in a horizontal distance of approximately 500 metres, an average gradient of 1 in 27 (or approximately 2^{o}). The track does not drop uniformly however, and there are a series of short sharp descents and sections that are almost level; both types of terrain affect drainage properties and erosion potential.

MacGregor (1957) points out that artificial drainage is necessary on surfaces with slopes of less than $\frac{1}{2}^{o}$ and at 11^{o} run-off is fast and potentially destructive. 11^{o} slopes are also difficult to negotiate by vehicles without the increased traction necessitated by use of low gears. MacGregor recognised ten critical degrees of slope, expressed against physical conditions, and these could be used as indicators of slope severity on a pathway network; scores for terrain damage could be correlated against these.

The system is summarised below.

Table 7 Ten critical degrees of steepness

Slope in degrees	Comments	Description	Score
$>30^{\circ}$	At 30° scree becomes unstable, soils thin. At 40° terracettes and slumping are marked, hands needed to negotiate climb, continuous turf cover seldom found.	Excessively steep	10
$25-30^{\circ}$	Water run-off fast; gullies quickly formed. Paths forced to zig-zag to negotiate (toe-in needed for ascent).	Very steep	9
$18-24^{\circ}$	'One-in-three' or steeper, dangerously steep for motor vehicles, walking requires effort, run-off torrential.	Steep	8
$11-17^{\circ}$	Limit of cultivation, run-off potentially destructive, walking requires effort.	Fairly steep	7
$6-10^{\circ}$	Slight effort when walking, drainage rapid, negotiable by cars with low gears operating.	Moderate slope	6
$3-5^{\circ}$	Negotiable by cars with ease, run-off brisk (good drainage).	Gentle slope	5
$2-3^{\circ}$	No noticeable effort required by walker, run-off fairly fast.	Very gentle slope.	4
$1-2^{\circ}$	Noticeable run-off; fine particles can be carried.	Negligible slope	3
$\frac{1}{2}-1^{\circ}$	Streams have no velocity and carrying power.	Imperceptible slope.	2
$<\frac{1}{2}^{\circ}$	Artificial drainage needed, deposition takes place.	Level	1

Notes

(1) The first figure is the critical angle in each case.

(2) Slopes steeper than 25° are not likely to carry direct paths so that the steepness scale for paths, of 1 to 8, is narrower than the scale for "erosion" of path surfaces. Some adjustment of the index is necessary therefore at the upper end of the scale.

In the field the angle of gradient was taken at every point that had been given a 'terrain' score, using a Suunto clinometer attached to a bipod (so placed that it 'averaged' minor undulations on the surface). The paired scores (gradient and terrain damage) were subjected to a Pearson product moment correlation and the low positive correlation

$$r = 0.25 \quad (N = 46)$$

was found not to be significant when converted to a t score using the statistic

$$t = r\sqrt{\frac{N - 2}{1 - r^2}}$$

Clearly certain steep slopes had their degree of terrain damage exacerbated by the increased gully erosion and increased vertical pressure of downhill tread, but the badly eroded slopes were no more dominant a feature than the heavily trampled paths closest to the northern access points to the Fell, where slopes were gentle. Provided that gullies are filled in and the destructive erosion halted on slopes greater than 8°, there is no doubt that vegetation could stabilise such surfaces (see Plate 24 a/b of a slope of 6°).

SOIL COHESION

A test for resistance to wear as a result of 'compaction' using a Proctor needle penetrometer as an alternative to the impact penetrometer described by Liddle (1973 et seq.) was discontinued when it became obvious that day by day changes in cohesion could occur as a result of precipitation.

Essentially, during drought conditions, sections of the path still retaining a proportion of humus were capable of retaining more moisture than bare sandy surfaces and therefore of offering less resistance to the penetrometer. As Tansley (1939) points out, "the water content of the soil of the Callunetum is usually a function of its humus content, since clay and silt fractions are generally negligible".

DESCRIPTION OF EXPERIMENT

With a needle of surface area .05 sq. inches attached to a spring-loaded plunger, the stem of which was calibrated to read in pounds, forces of between 1-200 lbs per sq. inch could be exerted on the surface until the plunger penetrated to a line above the needle point. In controlled experiments penetration resistance is calculated from the force required to drive a suitably sized needle into the soil at a rate of $\frac{1}{2}$ in./sec to a depth of 3 ins.

Consistently across the whole 'mor' peat layer at the edge of a wide range of samples, a force of 52 lbs per sq. in. was required to depress the surface $\frac{1}{2}$ inch. Disturbed margins of ruts required less pressure, often less than 36 lbs per sq. inch; centres of track surfaces with humus present and with grasses rather than heather, required on average 80 lb per sq. inch but bare dry surfaces composed of fine mineral soil (stone free) gave resistances of 186-200+ lbs per sq. inch.

Some indication of the vulnerability of peaty surfaces as opposed to soils higher in mineral content to erosional pressure might be gained from such tests. The main assumption being once a path has been worn bare no further damage can be effected during dry weather or when drainage is good during wet weather.

CONCLUSIONS

The factors considered in this chapter indicate that both physical factors as well as human factors contribute to the destruction of the vegetation in pressurised areas. But rarely do physical properties of the soil continue to operate once the human pressure is removed or reduced. Physical conditions on a wider scale, such as low lying areas where water appears at the surface, still continue to éffect plant associations.

There is no reason to suppose that regeneration could not take place on all the surfaces being monitored by this survey. Certain species are clearly better equipped to withstand sustained light pressure and it is now appropriate to study the regeneration process on those areas most likely to be used by recreationists on Waldridge Fell.

The four zones of pressure on broad tracks.

In heavily used tracks subjected to intermittent vehicular use four main zones of pressure can be discerned.

(i) The deeply eroded ruts where destructive pressure is exerted both on cover and terrain.

(ii) The intervening plateau which has lost some of its organic cover by

  (a) early transgression by vehicles before main ruts were established,

  (b) slope recession due to weathering or tread

  (c) general wear by pedestrians.

(iii) Central pressure zone - the area subjected to maximum pedestrian use once vehicles are denied access to the track.

(iv) 'Shoulder' zone on the outer sides of rut where pedestrians were obliged to trample off the track during the passage of motor vehicles, or during periods of heavy pedestrian pressure.

On this photograph the track is a 'recent' one cut through a stand of dense Callunetum. Zone (iv) is not continuous because the heather and deep ruts have constricted the usable surface to the centre of the 'plateau'. Regrading of the surface in this section of track would probably aid the spread of an even turf similar to plate 24.

Plate 23. Ref : 7-J

Photographed 5th September 1976

Regeneration of surface with a low organic content

Plate 24a Ref: 8-K

Photographed 5th September 1976

Plate 24b Ref: 8-K

Photographed 16th October 1976

This section of the 'Ellen Street' track, like the transect featured in plate 16, lost its 'mor' peat layer some thirty years ago and suffers from drought more acutely than the deeper, organic soils surrounding it. The grasses however are quick to respond to prolonged rainfall. The effects of human trampling are lower in this more southerly section of the Fell and, because few vehicles drove across this turf, a track with a more uniform grade of surface has developed here than anywhere else on the Fell except track "L" (see plate 17).

Broad tracks without ruts allow pressure to be more evenly distributed laterally across the surface and intolerant species such as bracken, bilberry and heather are kept at bay until visitor numbers decline or when new goals are aimed at and paths are made redundant.

Regeneration of surface with high organic content:

This track appears to have been created sometime between 1896 and 1920. In places the whole surface has been closed up by Calluna vulgaris which has now reached an advanced degenerate stage of its cycle. Evidence points to its being abandoned in the 1940's when the more direct north-south 'Ellen Street' route was created by track-laying vehicles. No ruts can be discerned below the Calluna and because the track was first trampled during a period of dominance by **Pteridium aquilinum** it is probable it was broad and little substrate damage inflicted. Deschampsia flexuosa, intolerant of severe trampling but adapted to competing with the bracken and heather forms dark green cushions along the line of the path. Observation elsewhere showed that Deschampsia flexuosa is less successful on mineral soils than on organic soils.

Plate 25. Ref : 6-G
Photographed 21st May 1977

Nettlesworth Gate

The gate and stile, dating from the late eighteenth century enclosures but regularly maintained until the beginning of the twentieth century, show that Waldridge Fell had still a trackway across the heathland from the enclosed fields throughout the nineteenth century. The gate was still used for the exercise of common grazing rights for some time after the 1794 Act and for vehicular access perhaps during the 1940's. Absence of ruts and the completeness of the grass cover shows how the route is of only minor importance now. Only about half a dozen inhabitants of Nettlesworth cross the Nettlesworth field track to enter the Fell and few of the visitors to the northern car parks ever cross the boundary fence.

With the removal of the eighteenth century hedgerows, the middle distance has reverted to its pre-enclosure landscape.......... if not to its former cultivation patterns.

Plate 26 Ref : 7-K

Photographed 31st May 1977

CHAPTER IV

QUANTITATIVE STUDIES OF THE VEGETATION ON WALDRIDGE FELL

As a necessary basis for the study of regeneration on heavily used surfaces on Waldridge Fell, it was decided to study the plant associations of the grass heath lying south of the Edmondsley Road. The species present in this sector of the Fell at the turn of the century were noted by Jeffreys (1916) and they would have had to be compatible with extensive but heavy tread, comparable with that exerted during a normal summer today. Not only was a large part of the grass heath surrounded by miners' houses, but the village school, with over one hundred pupils in the 1890's,(1) was on the northern edge of the grass heath and in addition there were goats and fowls freely roaming the area. No 'mor' peat remains in the section of grass heath marked 'A' on Figs. 7 and 8 and thus its soil properties have much in common with the heavily eroded track surfaces elsewhere on the Fell. If a consistency of species present could be seen between the 1916 survey and a survey carried out in 1977 then a model might exist for the successful management of the Fell tracks.

Meanwhile it was necessary to study the regeneration taking place naturally on the track surfaces. Transects were laid out on a systematic sampling basis and belts of surface were carefully mapped for species presence, using $(25\text{ cm})^2$ quadrats. Twenty transects were laid out, but two were across a pathway where equilibrium appears to have been reached - no excessive wear was apparent and seasonal variations in density of Pteridium aquilinum were seen to bear a complex relationship to tread and climatic conditions - so only eighteen transects feature on the regeneration diagrams (Figs. 15 and 18 to 22) and discussion of Pteridium is devoted to a separate section of the chapter. Contiguous

(1) Durham County Records (1962)

to selected transects, wire indicators were placed, so that intensity and distribution of traffic on the paths could be measured; the results of the trample intensity survey are shown on Fig. 16 and subjected to further analysis on Fig. 17.

Although vegetation recovery was only monitored over two seasons (1976 and 1977) a permanent monitoring system could be based on the study transects.

The Grass Heath Association

Areas of grass heath have been shown by Tansley (1939) to be the habitat of a particularly wide range of species. It is inappropriate to give a 'typical' list. Most of the species of the grass heaths have a wide range of tolerance and they would probably succeed in the acid heath were the competition of the more acidophilous species curtailed. It is therefore more appropriate to examine why the dominant heath species are excluded from the mineral rich soils on the grass heaths. The main reason seems to be the absence of a peaty layer of 'mor'.

In particular Tansley points out that Deschampsia flexuosa is likely to be excluded from grass heath when the peat layer is absent or thin.

Nardus stricta seems more vulnerable to trampling than the Agrostis-Festuca species but its reappearance in grass heath after a succession of wet years also shows that it would prefer soils with a high humus content because of their greater water holding properties.

Calluna vulgaris is clearly excluded by trampling, and the exposed raw humus is then quickly dispersed by continuing tread, but it does reinvade the grass heath when trampling declines although Gimingham (1949) shows that it is less competitive on mineral soils.

Both Nardus and Calluna, with their leaves so slow to break down and become part of the soil, can eventually form the peaty layer which seems to be so important to the more acidophilous plants.

Test for species composition of the North Eastern shoulder of Waldridge Fell

A square frame enclosing one tenth of a square metre was dropped every four metres along two traverses of the grass heath on the slopes above the pond (shown on Figs. 7 and 8). Relevés were confined to the heactare 7-C so that the disturbed spoil of the new car park embankments and the rubble from demolished buildings would not affect the results. The hectare 7-C also comprises the largest extent of grass heath containing no former garden enclosures (which were excluded by Jeffreys in his study in 1916).

The method of presentation used below (Table 8) is similar to that used by Raunkiaer in 1913,(1) it also indicates the presence of some of the rarer flowering species which were seen adjacent to or close to the sampling point. Scores were allocated in inverse proportion to the increase in area of the relevé: thus .1m^2 = 1, 1m^2 = .1, 10m^2 = .01. Common species were not so scored because the effect on their valency number would be less than 1. Had this method of scoring, which is semi selective, not been used many more relevés would have had to be taken to ensure a complete species list. Raunkiaer found that 25 relevés were usually sufficient to establish a Formation and that this is so can be seen by comparing lists I and II in Table 8 - where Agrostis tenuis and Festuca rubra appear as co-dominant in both cases.

Table 8. Relevés in the Agrostetum of Waldridge Fell : June 1977

I. East facing slope.

Species	Position on transect					Valency
	1	6	11	16	21	
Agrostis temuis	/////	/.///	/////	/./. /	/////	88.0
Festuca ovina	//.//	/.///	//../	/..//	+////	72.5

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(1) Raunkiaer's method was chosen because it was felt that Jeffreys' frequency table would have been achievedusing similar methods.

Species	Position of transect					Valency
	1	6	11	16	21	
Festuca rubra	///./	/.+//	++.//	/..//	/////	69.2
Galium saxatile	//.//	/.+//	o+..+	...++	.//..	38.1
Plantago lanceolata	o....	+//..	.///.	+//+.	ooo+/	34.0
Dactylis glomerata	o....	+//..	./+//	+//+o	...+.	30.2
Poa pratensis	.+/..	//...	o+///	+/.+.	.+oo/	34.3
Rumex acetosella	./...	..../	/oo./	..o/o	/....	24.2
Cerastium vulgatum	./...	.//..	.../.	../..	/....	24.0
Achillea millefolium	.+...	.....	.../.	+./..	+.o+/	14.1
Hypochoeris radicata	.+...	....o	o+++/	o./++	/....	15.3
Crepis capillaris	.+...	.....	.....	.....	.....	0.5
Anthoxanthum odoratum	../o.	.....	.....	.....	.....	4.1
Capsella bursa pastoris	o....	.....	.....	.....	.....	0.1
Stellaria media	o....	.....	.....	.....	.....	0.1
Lolium perenne	o....	.....	.....	.....	.....	0.1
Agropyron repens	.../.	/....	.....	.....	.....	8.0
Trifolium repens	.....	+//..	.////	./.+.	o.../	33.1
Ranunculus repens	.....	/o...	..//.	../..	.....	16.1
Urtica dioica	.....	+....	.....	oo..+	.....	1.2
Holcus lanatus	.....	.////	//.//	/..+.	.....	36.5
Poa annua	.....	.o...	.o/..	...+.	.....	4.7
Holcus mollis	.....	../..	.../.	./o+.	../..	16.6
Rubus fruticosus	.....	../..	.....	o/...	/....	12.1
Calluna vulgaris	.....	....o	....o	+....	...+.	1.2
Nardus stricta	.....	.....	/....	+....	..+/.	9.0
Pilosella vulgata	.....	.....	/o...	o....	.....	4.2
Rumex acetosa	.....	.....	/....	.+o..	.....	4.6
Cirsium vulgare	.....	.....	..///	oo/.o	.....	16.3
Cirsium arvense	.....	.....	..+..	+....	.....	1.0
Vicia angustifolia	.....	.....	.../o	/+./.	/....	16.6

Species	Position on transect 1	 6	 11	 16	 21	Valency
Leontodon autumnalis	•••••	•••••	•••//	•••//	•••••	16.0
Luzula campestris	•••••	•••••	•••••	/••••	//o•/	16.1
Epilobium angustifolium	•••••	•••••	•••••	o••••	•••••	0.1
Alopecurus pratensis	•••••	•••••	•••••	o••••	•••••	0.1
Trifolium spp.	•••••	•••••	•••••	••+••	•••••	0.5
Campanula rotundifolia	•••••	•••••	•••••	•••••	•/•//	12.0
Galium verum	•••••	•••••	•••••	•••••	•/•••	4.0
Medicago lupulina	•••••	•••••	•••••	•••••	•••/•	4.0
Taraxacum officinale	•••••	•••••	•••••	••••o	••••o	0.2
Lotus corniculatus	•••••	•••••	•••••	•••••	••••o	0.1
Bellis perennis	•••••	•••••	•••••	•••••	••••o	0.1
Conopodium denudatum	o••••	•••••	•••••	•••••	•••••	0.1

/	Located within quadrat ($\frac{1}{10}$ m^2) value	1
+	Located within radius of 56.5 cm from centre of (1 m^2) value quadrat (adjacent)	0.1
o	Visible within 1.8 m radius (10 m^2) (not applied to abundant species)	0.01

Table 8 Relevés in Agrostetum of Waldridge Fell : June 1977

II. West facing slope

Species	1	6	11	16	21	Valency
Agrostis tenuis	/////	/////	///+/	/////	/////	96.5
Festuca rubra	///./	.////	.//..	///..	.////	68.0
Festuca ovina	.+///	/....	/.../	.+../	./+/.	37.5
Galium saxatile	//+o.	../+.	..o..	.//++	.+///	34.7
Poa pratensis	+../.	..+..	+//./	++.++	/....	23.5
Holcus lanatus	+o../	//...	.....	.....	+/...	17.1
Nardus stricta	+//+.	.....	+../.	.....	..../	17.5
Calluna vulgaris	/.o..	.....	.....	.+...	.....	4.6
Cynosurus cristatus	./+..	..o..	../.+	.../.	.....	13.1
Trifolium repens	...//	//+/.	./../	/.+.+	../..	37.5
Plantago lanceolata	...//	/++/.	+.o./	/+/.+	../..	34.6
Lotus corniculatus	...o+	.....	../..	.....	.....	4.6
Achillea millefolium	...+o	//.+.	../../	/+/./	.....	29.6
Luzula campestris	..../	.....	.....	..../	+....	8.5
Dactylis glomerata	....+	.....	.....	.....	.....	0.5
Cerastium vulgatum	....+	//o/.	....+	/....	.....	17.1
Pilosella vulgata	..../	...+.	...+.	o/...	.....	9.1
Holcus mollis	.....	+/+..	.//./	o.//+	/../.	33.6
Medicago lupulina	.....	//...	.....	.....	.....	8.0
Taraxacum officinale	.....	+/...	.....	+.+..	.....	5.5
Bellis perennis	.....	o/...	.....	.....	.....	4.1
Lolium perenne	.....	+....	.....	.....	.....	0.5
Ranunculus repens	.....	.+...	..../	.....	.....	4.5
Rumex acetosa	.....	././.	/....	/.///	..o/.	32.1
Agropyron repens	.....	.+...	.....	.....	.....	0.5
Rumex acetosella	.....	..+./	..o..	o//..	/+...	17.2
Hypochoeris radicata	.....	../+.	.....	+//./	.....	17.0
Crepis capillaris	.....	../..	.....	o....	.....	4.1
Poa annua	.....	.....	/....	/....	.+...	8.5
Anthoxanthum odoratum	.....	.....	/....	.....	../..	8.0
Urtica dioica	.....	.....	./...	.....	+....	4.5
Leontodon autumnalis	.....	.....	.....	/./.+	.....	8.5
Trifolium spp.	.....	.....	.....	+....	.....	0.5

/ Located within quadrat $(\frac{1}{10} m^2)$ value 1

\+ Located within radius of 56.5 cm from centre of quadrat (adjacent) $(1 m^2)$ value 0.1

o Visible within 1.8 m radius $(10 m^2)$ 0.01
(not applied to abundant species)

Thresholds of frequency of species were established both on the basis of valency scores and by examination of the actual occurrence within the traverses. The frequency in 1977 could then be correlated with the frequency observed by Jeffreys in 1916 by comparing scores allocated on a rank basis; thus:

Valency	Frequency	Score
70 +	Co-dominant	1
30-69	Abundant	2
8.3-29	Frequent	3
2.3-8.2	Occasional	4
0.6-2.2	Rare	5
< 0.6	Very rare	6

Table 9 shows that very little change has occurred in the species list of the Agrostis-Festuca heath of Waldridge Fell in sixty years.

A correlation of $r = 0.45$ ($N = 44$) is satisfactory (90% confidence level). The main anomalies between the studies are marked (*) and are discussed below in the table.

TABLE 9 CHANGES IN THE COMPOSITION OF THE AGROSTETUM ON WALDRIDGE FELL 1916 - 1977

Species	Frequency in 1977	Frequency in 1916
Agrostis tenuis	Codominant	Codominant
Festuca rubra	Codominant	Codominant
Festuca ovina	Abundant	Abundant
Galium saxatile	Abundant	Abundant
Plantago lanceolata	Abundant	Occasional
Poa pratensis	Frequent - Locally abundant	Abundant
Trifolium repens	Abundant	Abundant
Achillea millefolium	Frequent	Frequent
Cerastium vulgatum	Frequent	Occasional
Dactylis glomerata	Frequent	Frequent
Holcus lanatus	Frequent	Frequent
Holcus mollis	Frequent	Occasional
Hypochoeris radicata	Frequent	Occasional
Leontodon autumnalis	Frequent	Occasional
Luzula campestris	Frequent	Frequent
Nardus stricta*	Frequent	Apparently Absent (Classed V.r.)
Ranunculus repens	Frequent	Frequent
Rumex acetosa	Frequent	Occasional
Rumex acetosella	Frequent	Occasional
Vicia angustifolia	Local (frequent)	Apparently Absent
Agropyron repens	Occasional	Not listed
Anthoxanthum odoratum	Occasional	Abundant
Campanula rotundifolia*	Occasional	Occasional
Cynosurus cristatus	Occasional	Frequent
Calluna vulgaris*	Occasional	Very Rare
Circium vulgare	Occasional	Occasional
Circium arvense*	Local	Frequent
Crepis capillaris	Occasional	Rare
Lotus corniculatus*	Occasional	Apparently Absent
Medicago lupulina	Occasional	Occasional
Poa annua	Occasional	Occasional
Pilosella vulgata	Occasional	Local
Rubus fruticosus	Occasional	Occasional
Taraxacum officinale*	Occasional	Apparently Absent
Urtica dioica	Occasional	Apparently Absent
Bellis perennis*	Rare	Apparently Absent
Galium verum	Rare	Frequent
Alopecurus pratensis	Very Rare	Not Listed
Capsella bursa-pastoris	Very Rare	Not Listed
Conopodium denudatum*	Very Rare	Occasional
Epilobium angustifolium*	Very Rare	Apparently Absent
Lolium perenne*	Very Rare	Not Listed
Stellaria media*	Very Rare	Occasional
Trifolium Spp.	Very Rare	Rare
Polygala vulgaris	Absent or v.r.	Frequent
Pontentilla erecta*	Absent	Occasional
Pontentilla sterilis	Absent	Frequent
Equisetum arvense	Absent	Rare

r = + 0.452 (N = 44) t = 3.269 (90% Confidence)

Margins of the Grass Heath

At the beginning of the twentieth century the margins of the grass heath must have been very distinct particularly near the miners' cottages and their inter-connecting tracks. Nardus stricta and Calluna vulgaris appear to have been suppressed north of a line joining the extremities of William and Ellen Streets and fences round garden plots would ensure a sharp boundary between their disturbed soil and the Agrostetum above the pond. With the demolition of the miners' cottages in the mid 1950's distinct sub regions have developed as enclaves within the grass heath. Each enclave reflects a different physical characteristic which locally affects the dominance of Agrostis tenuis.

Earth embankments

On the disturbed earth of embankments, recently constructed to prevent vehicular transgression onto the grass heath on the south side of the Ellen Street approach road (Ref. 7-B), the species are limited in number:

Plantago lanceolata	Co-dominant
Lolium perenne	Co-dominant
Stellaria media	Abundant
Capsella bursa pastoris	Abundant

In moist soil below the earth banks, in a continuation of the hollow occupied by the pond, the following species occurred:

Bellis perennis	Locally dominant
Ranunculus repens	Locally dominant
Cirsium arvense	Frequent
Taraxacum officinale	Frequent
Rumex obtusifolius	Frequent

This embankment vegetation seems largely to be derived from seeds buried within the soil scraped from the former garden sites. Studies by Brenchley (1918) have demonstrated that seeds survive long periods of burial in well drained earth, particularly grass seeds. So that until the earth mounds achieve some stability either through compaction by human tread, or gradual settling down and sorting by precipition and frost action, a constant supply of buried garden species seems possible. Jeffreys (1916) had noted the abundance of Stellaria media in the cottage gardens; but an investigation of species in this part of the Fell in 1968, when the house footings were covered by close turf of broad leaved grasses, showed chickweed no longer to be abundant.

Masonry rubble

At the western end of the former Hylton Street (see Fig. 4) parts of the cottages remain. A thicket of Cornus sanguinea and specimens of Sambucus nigra seem to have deflected the activities of levelling machines in the period after the mid 1950's. In the nineteenth century, mortar used for building contained much lime, and high pH values have been obtained for this area. In addition to being base-rich the rubbly soils are either coarse and unstable when dry (a condition favouring adventitious 'weed' species) or of a fine downwashed sediment which tends to remain moist because of shade from the bushes. On the finer soil the association is as follows:

Epilobium angustifolium	Dominant
Tussilago farfara	Locally dominant
Conopodium denudatum	Abundant
Dactylis glomerata	Abundant
Trifolium repens	Locally abundant
Urtica urens	Locally abundant
Agrostis tenuis	Frequent
Festuca rubra	Frequent

Agrostis tenuis grows well on the drier soils but on the base rich areas dominated by the calcicole coltsfoot, the grass appears to be shaded out by the large leaves of that plant.

Pit Spoil

The Hylton pit, occupying hectare 7-B has been defunct for over a century but its shale soil has been long exposed to trampling of an intensive recreational nature because of its proximity (i) to the miners' cottages, (ii) the school and later, (iii) the car parks. It has a limited range of species:

Festuca rubra	Dominates the trampled areas
Rumex acetosella	Locally abundant
Plantago lanceolata	Locally abundant
Lotus corniculatus	Dominates the south facing lower slopes

The northern and west facing slopes of the mound are covered in Calluna vulgaris particularly where the ancient holloway, already abandoned in 1896, creates steep slopes avoided by both animals and humans.

South of the Pond

Although the depression round the pond has had exactly one hundred years of recreational pressure upon it and suffered no erosional damage, the pond itself has acted as a diverting agent. Two informal paths have developed on each side of the pond and these tend to carry the bulk of casual pedestrian traffic; in addition a prominent track links the extremities of the former cottage rows. Thus a trapezium-shaped area between the Nardetum of the Fell and the pond has probably been subjected to much lighter pressure than elsewhere in the Agrostetum.

Calluna vulgaris is locally dominant in this sub-region over an area measuring approximately 10 m x 8 m (shown inside the Agrostis heath boundary on Fig. 9).

Nardus stricta is a co-dominant species in this part of the dry grassland (see relevés 1-4, Table 8,ii).

Comparison of the 1971 air photograph and the extent of the Calluna vulgaris stand in the field (1977) confirms that the spread of the heath into the Agrostetum is vigorous and recent. This area under Calluna vulgaris appears to have doubled in six years and the oldest plants in 1976 were barely at the 'building phase' (Barclay Estrup 1971). Attention is now turned to the significant changes in frequency of species between 1916 and 1977 (Table 9).

(a) Nardus advance

In 1916 Nardus stricta was not observed; it was sighted in approximately 22% of $1m^2$ relevés on the transects made in June 1977. Most of the specimens seen apart from the relevés II i-iv, noted above, were young with the central rhizomes still active. Two years of drought had preceded the survey and the spread of Nardus can therefore not be explained on climatic grounds, nor on the water holding properties of the area - which was a freely draining slope low in humus. Evidence points to the diversion of some of the extensive trampling by the earth embankments built in January 1975.

(b) Calluna advance

Since 1916 Calluna vulgaris has reasserted itself over much of the Fell and it has invaded a large part of the long established Nardus-Festuca grassland near the Edmondsley Road. Its increased frequency in the Agrostetum is therefore to be expected. Its lower incidence than Nardus shows that trampling is still sufficient to suppress most of the Calluna advance except in the 'refuge' areas already referred to above.

(c) Stellaria media decline

Apart from on or near the disturbed soils of new embankments, chickweed has apparently disappeared with the cultivated plots of the miners' cottages. Together with other adventitious species such as Capsella bursa-pastoris and species of thistle, chickweed must be considered an ephemeral part of the Agrostis association.

(d) Potentilla erecta decline

The most significant casualties of the association are Potentilla species: Potentilla erecta and Potentilla sterilis. At the time of the survey the conspicuous yellow flowers of the former were profuse over the grassland areas of Waldridge Fell except in the Agrostis-Festuca area; Potentilla erecta has a wide tolerance of soil moisture conditions and it occurs on both mineral and organic soils over a wide variety of textures. It is shade tolerant and it appears to compete well with vigorous Nardus stricta rhizomes.

La Page (1967) found that Potentilla erecta and Potentilla sterilis together with Polygala vulgaris were three of the few common species to be completely eliminated from meadows subjected to camping activities while Poa spp, Agrostis and Trifolium repens were actually encouraged. It would seem therefore that Potentilla erecta would succumb to over-use of the Agrostis grassland. The spead of Nardus and Calluna however obviates the consideration of this factor.

More important perhaps will have been the effects of the introduction of lime mortar dust to the surface of the Agrostis area and perhaps the import of salts from the roads by vehicle tyres in winter and spring; Potentilla erecta is more vigorous in acid, peaty soils.

The Potentilla erecta Formation

To confirm the calcifuge habit of Potentilla erecta the section of the Fell within the grassland belt lying between the central track and the car park area was traversed (refs. 6-C, D, E). 20 points were chosen randomly and the nearest stand of Potentilla erecta to each point was made the central point in a $\frac{1}{10}$ m^2 quadrat. The species list appears below as Table 10. The acidophilous nature of the plant is well brought out by its association with Nardus and Calluna and its wide tolerance of moisture conditions is implicit in the list of less frequent species, which have differing water requirements.

Table 10. The Potentilla erecta formation in the Nardetum of Waldridge Fell

Species	1	6	11	16	Valency
Potentilla erecta	/////	/////	/////	/////	100.0
Nardus stricta	////.	/////	/.///	/*///	86.0
Calluna vulgaris	/////	///o/	////*	o//*/	82.4
Festuca rubra	/*...	/*../	/..o.	//...	32.2
Festuca ovina	//.**	*/./.	/./**	.//*.	46.0
Epilobium angustifolium	*....	...oo	...o.	.....	1.6
Galium saxatile	*....	...o/	*./..	.....	12.2
Pteridium aquilinum	*....	....o	o....	..../	6.4
Ulex europaeus	o....	....o	o.*..	....*	2.6
Vaccinium myrtillus	o/...	.*...	//...	.....	16.2
Deschampsia flexuosa	./*/*	..*o/	//*.*	.//..	40.2
Agrostis tenuis	.***/	//./*	*.../	/*...	36.0
Juncus spp.	.../*	*o...	....*	//*..	19.2
Holcus mollis	..../	.....	.....	.....	5.0
Betula pubescens	...o.	.....	..o..	.....	0.4
Holcus lanatus	.....	.....	..o..	.....	0.2
Luzula campestris	.....	.....	.....	..../	5.0

It is clear that continued light trampling on soils low in organic content is sufficient to encourage the development of Agrostis-Festuca grassland. Because these grasses are less aggressive than Nardus stricta and their leaves do not form an acid 'mor' humus layer, the variety of species in the Agrostetum is wide.

The benefits to the aesthetics of the landscape and botanic interest of the S.S.S.I. of a spread of Agrostis grassland into the heath would be considerable. Attention is now turned, therefore, to the survey of the intensively trampled pathway surfaces.

The Pathway Survey

The initial state of the surfaces

These have already been summarised on Fig. 14 which shows that although primary routes extend down the full length of the scarp of the Fell, terrain damage falls off from north to south. This is probably a result of a tendency by car drivers to seek parking space within the grass heath (Fig. 6f). Diminishing degrees of wear by motor vehicles with increasing distance is demonstrated clearly by plates 16, 9, 20, 23 and 24 which now should be consulted in that order. From almost total removal of a section of the A_1 horizon over some two and a half metres, to parallel ruts of decreasing width, to only minor localised damage caused by skidding, the effects of car tyres comes out clearly.

The erosive damage of human feet is small compared with the effects of vehicles. Leney (1974) quantified the increasing erosional force of different human activities; she suggested that running increases the overall erosion by 30% over walking and she also quantified the effects of certain animals compared with humans: viz : dogs 50%, horses 200%. The evidence of terrain damage on Waldridge Fell suggests that horses are much more destructive than Leney's estimate suggests and their influence is more permanent. Plate 17d shows the permanent scar left by Yeomanry training on Waldridge Fell where a broad swathe of deeply disturbed terrain crossed the 'mor' peat. It remains a habitat more favourable to bracken and grasses even after 100 years.

Plate 17 also shows that human wear of moderately high frequency makes little impact on the turf compared with vehicular or equestrian wear (see report on track 'L' below). This is probably because the most significant erosive force is that of attrition by horizontal forces. The passage of one car (with its rear wheels crossing approximately the same terrain as its front wheels) makes continuous contact with the ground and clearly affects more terrain than ten or twenty pedestrians and the force applied by each wheel is no less than eight times greater than the force of a human foot; in fact the vehicle probably exerts even greater attritional force because its drive forward is only done by the backward horizontal thrust of wheels on the ground. Humans exert most force downwards; forward movement being effected by muscular action at the knee and hip joints while the body weight is being taken by the ground.

Tracks that have been subjected to both human and vehicular pressure tend to be broad; and clear zones of pressure can be discerned across them (see caption to plate 23). When vehicular pressure is removed the zone boundaries become more blurred and pedestrian pressure tends to be distributed more evenly across the path. Narrow paths produced by smaller daily flows of people tend to have their wear concentrated more in the path centre.

The histograms in column one of Fig. 15, where the observations of the belt transects are presented, show clearly this effect of differential pressure. The most heavily eroded areas are those where tyre tracks were made; a minor peak shows in the centre of all the broad tracks: indicating the zone of maximum pedestrian pressure during the time of vehicular access.

Changes in distribution of pedestrian wear since 1975

To detect changes in distribution of pressure, wire trampleometers were laid down near selected transects using the method described by Bayfield (1971).

A line of nails 10 cm apart with fine copper wire extending vertically for 5 to 10 cms, depending on height of vegetation cover, proved efficient at registering lateral extent of surface use. Frequent readings at the sites also ensured a good indication of relative volume of pressure on different sections of path.(1)

(1) Quickly assessed by counting number of wires depressed. On paths carrying heavy traffic there is a danger of already depressed wires failing to record passage of tread; if the site is visited frequently and indicator wires returned to the vertical position again, this problem is avoided.

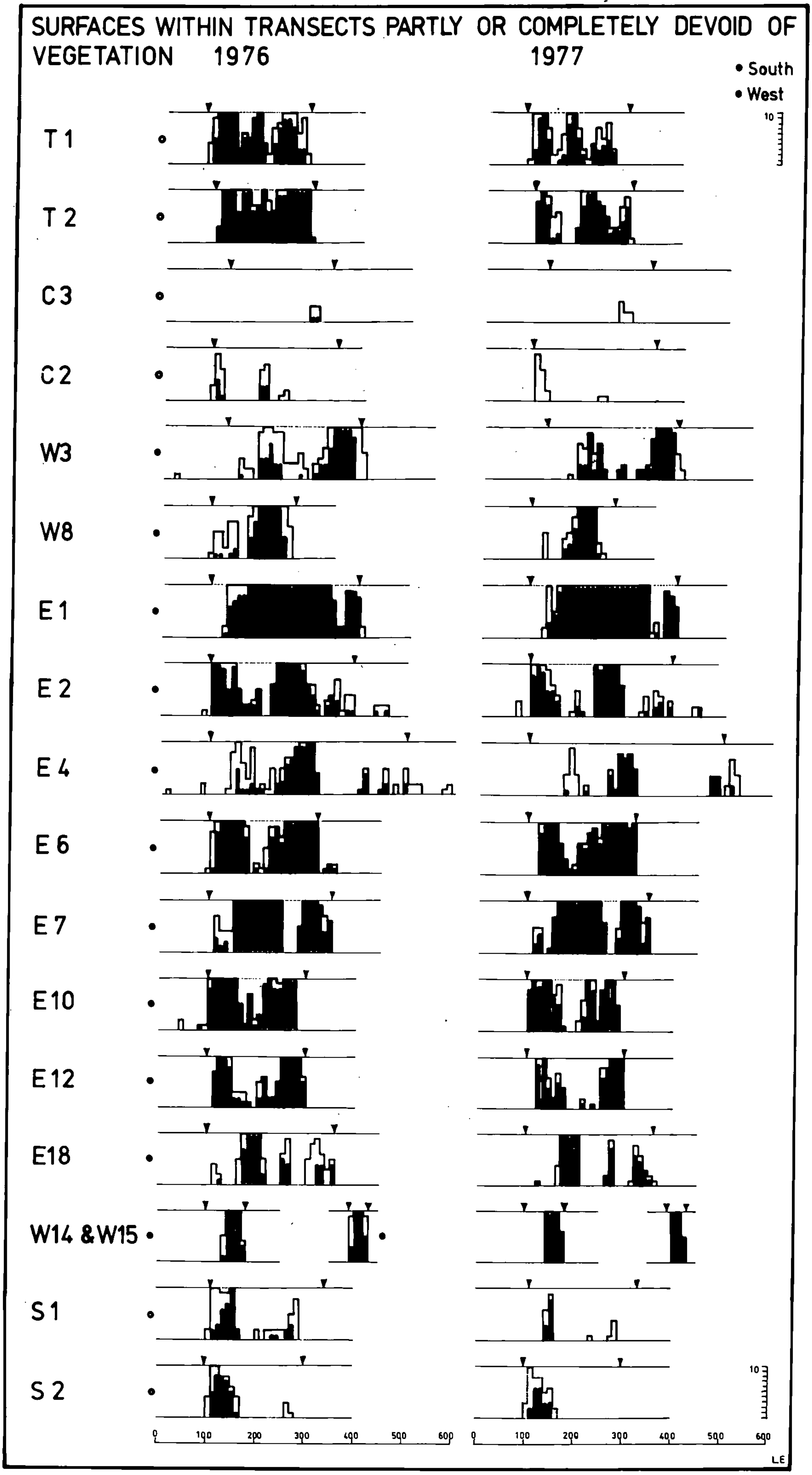
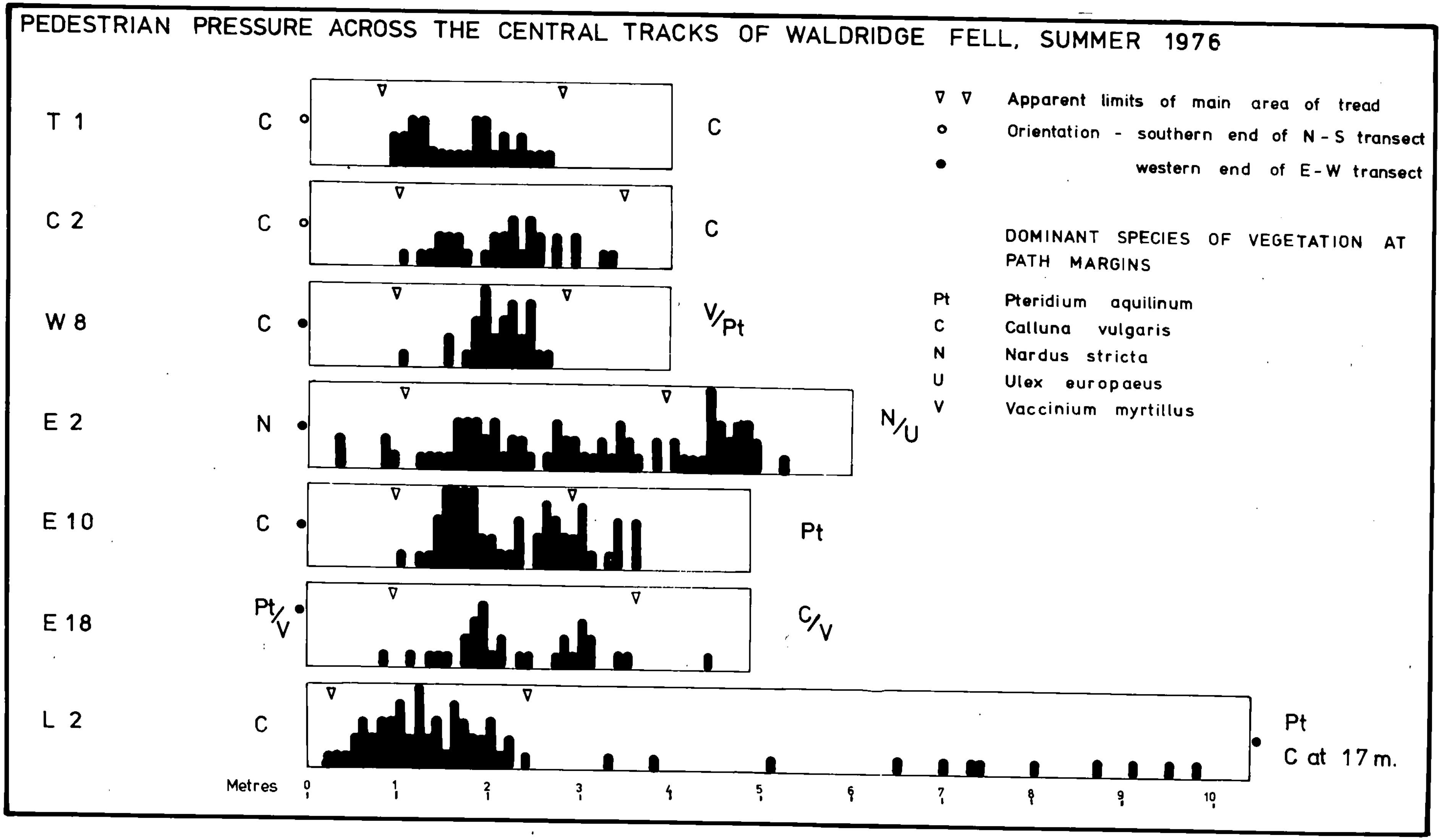

SURFACES WITHIN TRANSECTS PARTLY OR COMPLETELY DEVOID OF VEGETATION
1976
1977
• South
• West
10
T 1
T 2
C 3
C 2
W3
W8
E 1
E 2
E 4
E 6
E 7
E10
E12
E18
W14 & W15
S 1
S 2
10
0
100
200
300
400
500
600
0
100
200
300
400
500
600
LE

Fig. 15

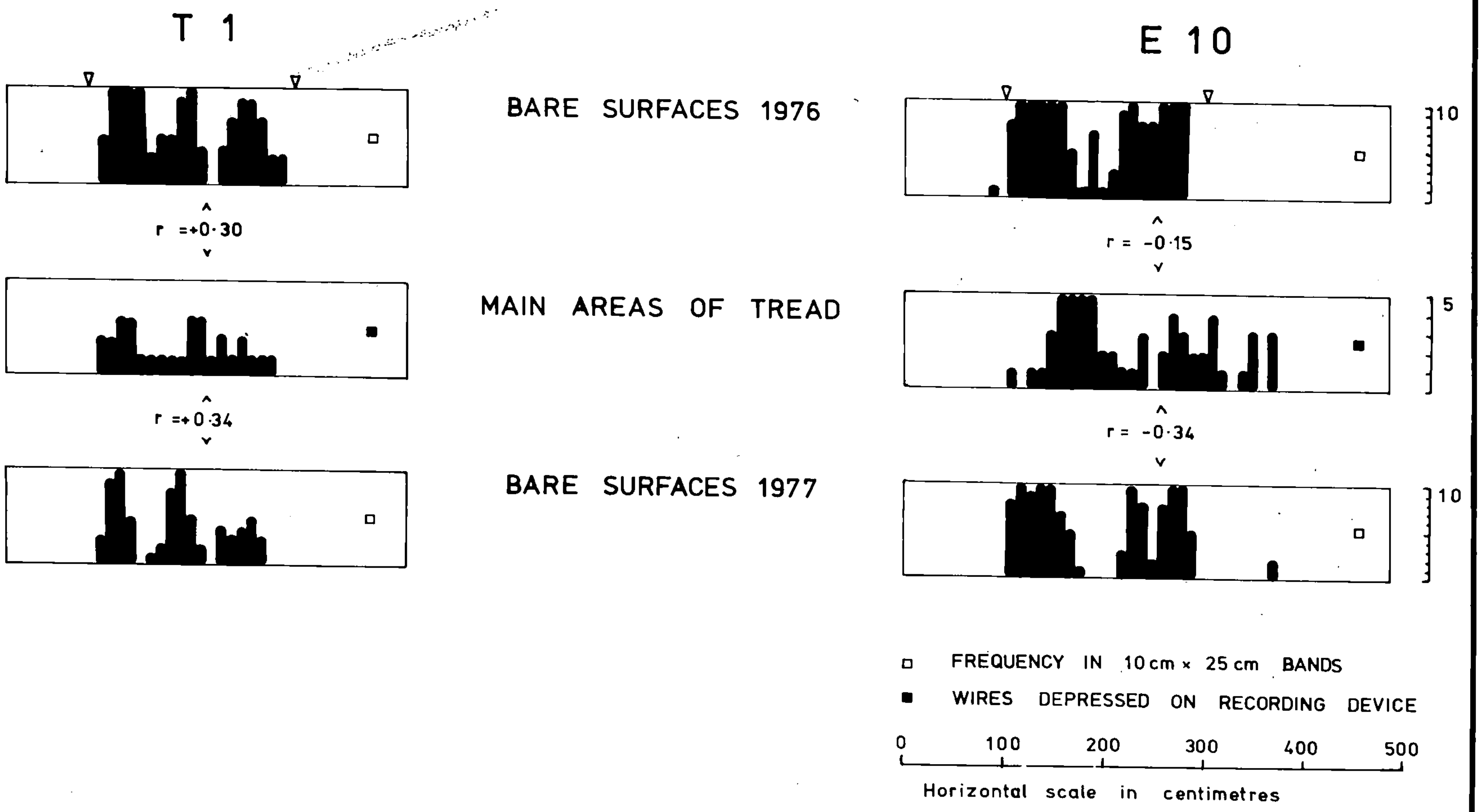
Fig. 16



PEDESTRIAN PRESSURE ACROSS THE CENTRAL TRACKS OF WALDRIDGE FELL, SUMMER 1976

Fig. 17

DISTRIBUTION OF SURFACES WITH NO VEGETATION COVER 1976 & 1977 AND THEIR RELATION TO ZONES OF HEAVIEST TRAMPLING TRANSECTS T.1 & E.10



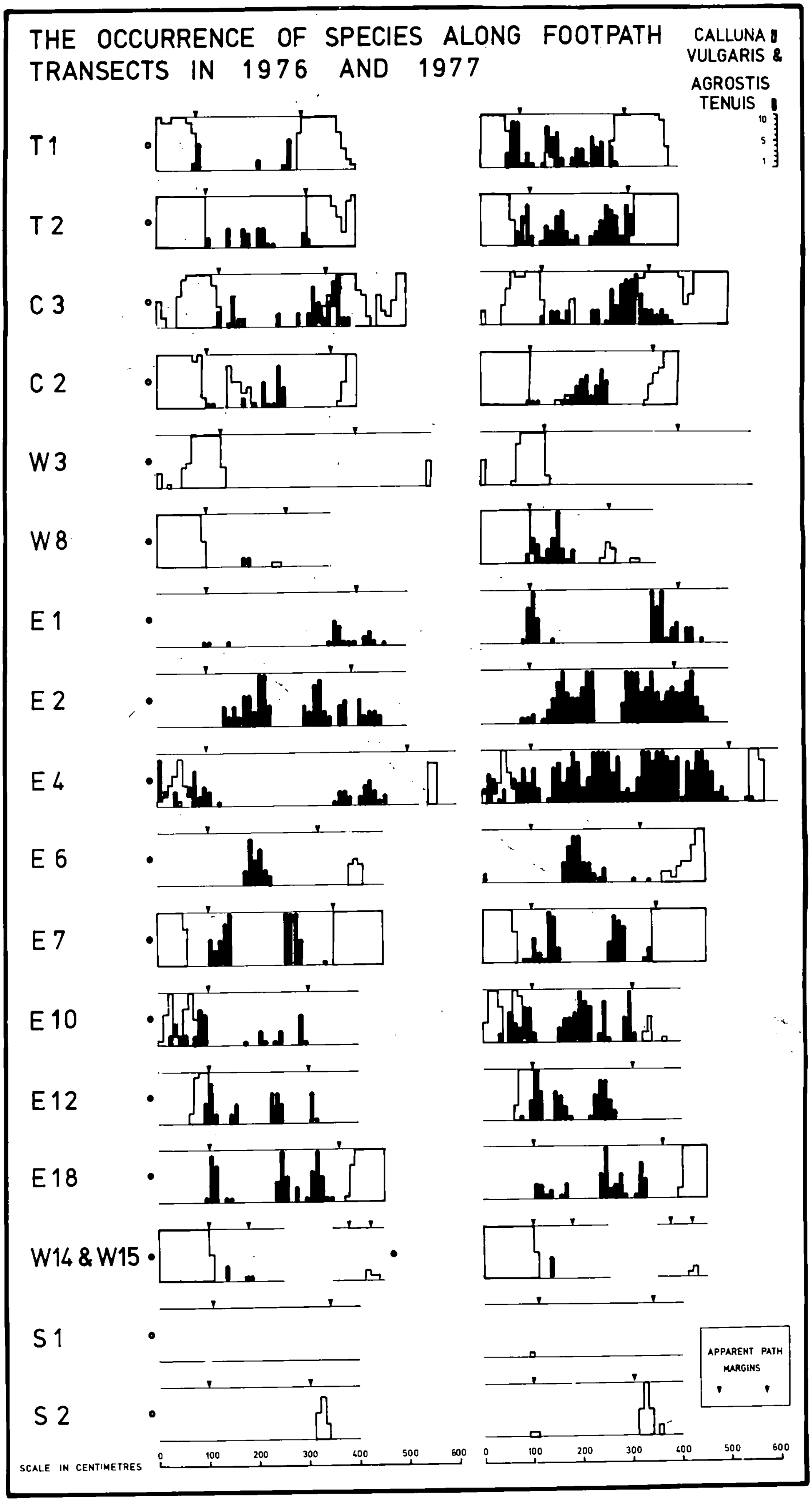

THE OCCURRENCE OF SPECIES ALONG FOOTPATH TRANSECTS IN 1976 AND 1977
CALLUNA VULGARIS &
AGROSTIS TENUIS
10
5
1
T1
T2
C3
C2
W3
W8
E1
E2
E4
E6
E7
E10
E12
E18
W14 & W15
S1
S2
APPARENT PATH MARGINS
SCALE IN CENTIMETRES
0
100
200
300
400
500
600
0
100
200
300
400
500
600

Fig. 18

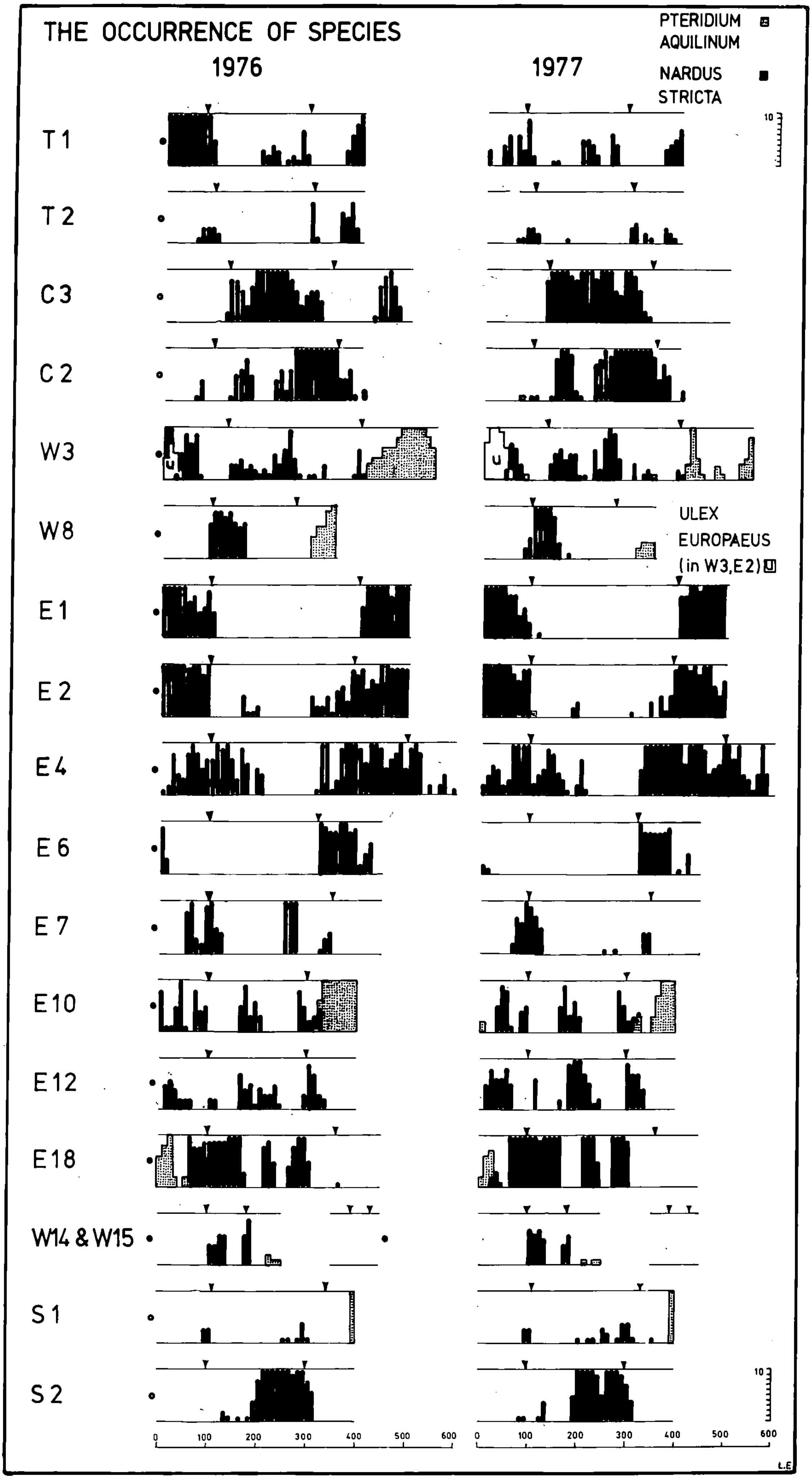

THE OCCURRENCE OF SPECIES
1976
1977
PTERIDIUM AQUILINUM
NARDUS STRICTA
ULEX EUROPAEUS (in W3,E2)
T1
T2
C3
C2
W3
W8
E1
E2
E4
E6
E7
E10
E12
E18
W14 & W15
S1
S2
u
10
0
100
200
300
400
500
600
L.E

Fig. 19

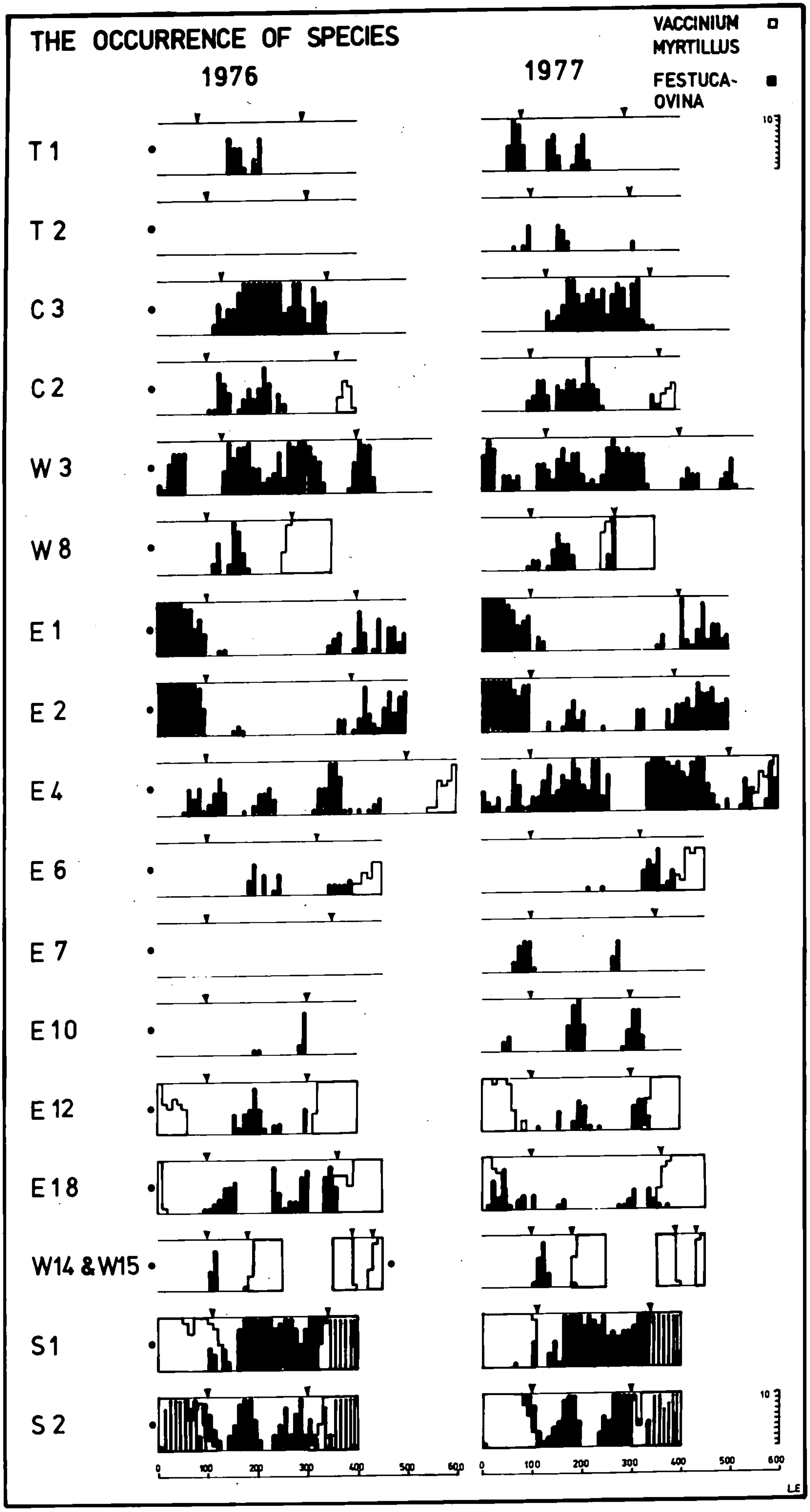

THE OCCURRENCE OF SPECIES
1976
1977
VACCINIUM MYRTILLUS ▫
FESTUCA-OVINA ▪
10
T 1
T 2
C 3
C 2
W 3
W 8
E 1
E 2
E 4
E 6
E 7
E 10
E 12
E 18
W14 & W15
S 1
S 2
0
100
200
300
400
500
600
LE

Fig. 20

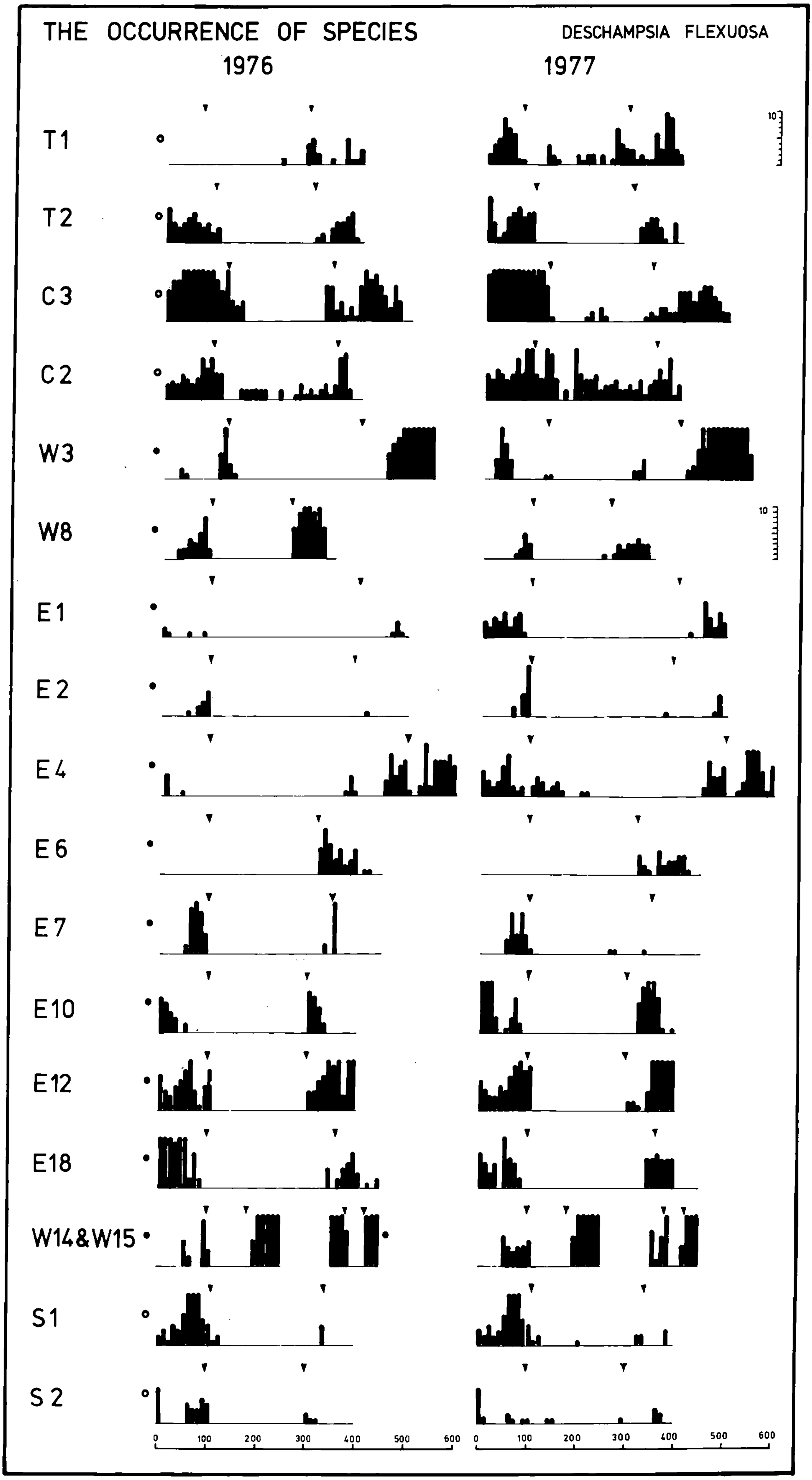
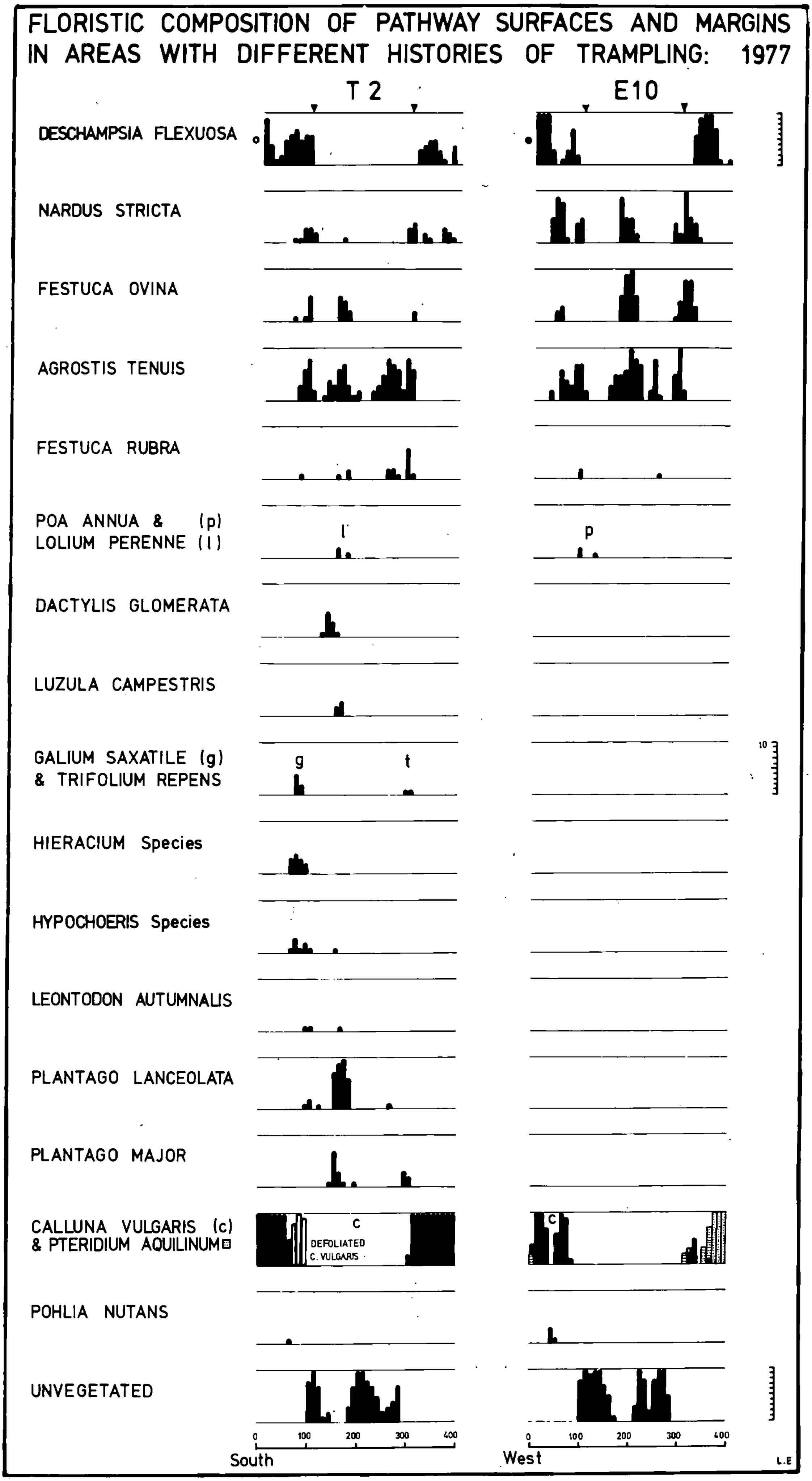

THE OCCURRENCE OF SPECIES
DESCHAMPSIA FLEXUOSA
1976
1977
T1
T2
C3
C2
W3
W8
E1
E2
E4
E6
E7
E10
E12
E18
W14&W15
S1
S2
10
10
0
100
200
300
400
500
600
0
100
200
300
400
500
600

Fig. 21



FLORISTIC COMPOSITION OF PATHWAY SURFACES AND MARGINS IN AREAS WITH DIFFERENT HISTORIES OF TRAMPLING: 1977

Fig. 22

The results are presented on Fig. 16 and the histograms should be examined in conjunction with the following notes and Fig. 15 (extent of bare earth).

Tinkler Row track (T)

The traffic on this track has been considerably reduced. It should be noted that the histogram T1 is the combined score from two separate observations. So light was the traffic on the Spring Bank holiday (1976) when all other readings were taken, that a skylark nesting one metre from the track laid three eggs during the period when over 100 cars per day were visiting the car parks at each end of the track.

In 1975 the Tinkler Row track was used by leisure motorists seeking to find a parking place on the northern grassland of the Fell. Paralleled by the main Edmondsley Road it was never so heavily used by vehicles as the Ellen Street track (E) nor the western Fell track (B) but the amount of traffic it carried was sufficient to create ruts by the end of the season and these show as the extensive 'bare' surfaces on Fig. 15.

The combined trampleometer readings of early summer 1976 show a peak of tread still occurs at the path centre where the ground surface is more even but the heaviest wear is now directed onto the southern side of the track. This side is the one that gives the best views over the undulating landscape of the southern Fell. The effect of the drawing power of a view is reflected in the recovery of less tolerant species (such as Calluna vulgaris in this instance - see Fig. 18) on the none-view side and their deterioration on the 'view' side.

Differential recovery profiles are evident wherever any one side of the path is favoured more than another.

William Street track (W)

This track follows the contours of the Wanister scarp and it occupies a man-made bench caused by downward pressure of pathway users; only the first 200 metres appear to have been used by motorists (note width of eroded surface at W3 compared with W8) and the narrower path thereafter tends to be most heavily trodden near the centre. The most used half of the surface, however, is still the side with views across the valley, to the east. Any recovery of the eroded surface of the path 'W' would either be temporary or be a result of a change in behaviour of the visitors to the Fell. It is more than likely that the apparent regeneration of the section of path at W8 is a result of two very dry years giving the normally vulnerable organically rich soils of this scarp area more cohesion and thus less inhibition of growth by smearing.

Central Track (C)

The breadth of this track reflects its former importance as the main routeway of the region; it never seems to have been used by cars west of the intersection at E6 probably because of dangers of subsidence. (See plate 7). The width of the trackway seems to encourage wide lateral spread of pedestrian traffic and an even turf cover with no one species being dominant.

Ellen Street Track (E)

This track can be studied as three distinct sections.

E18

The trampleometer readings for site E18 were taken for a shorter period of time than the sites E2 and E10 so that although the pattern of wear across the track is clear, the volume of flow is not accurately portrayed. Observation indicated that the most southerly section of track 'E' carried more traffic than the central section at E10 probably a result of the confluence with track 'W' in study area 7-H.

The ruts in this most southerly section are shallow and straight and the track crosses a plateau behind Wanister Hill. The bare surfaces act as a focal point and tread appears to reinforce the pattern established some years ago. The heavily worn areas of 1976 have not recovered because of the continued intensive tread on their bare surfaces. Figs. 16 and 15 (i) and (ii) show E18 to have the most congruent of all the tread/erosion profiles. Species performance of the main heath grasses deviated at this site from performance elsewhere. Nardus stricta was the only species that made gains and it ousted already established Agrostis and Festuca. The assumption must be that the concentration of traffic onto the bare surfaces of this part of the track reduces the pressure on the grassy sections and thus Nardus is responding positively.

E2

In constrast to the situation described above, the eroded surface of the track in the north is rough and stony similar to that shown on plate 16b. In addition the grass heath on either side of the track is a good walking surface because of its close 'cropped' turf, and tread is now concentrated on the pathway margins and noticeable revegetation is being made by the trample resistant grasses Agrostis tenuis and Festuca ovina on the track itself where wear is almost uniformly spread.

E10

Unlike the margins of the track at E2 there is here no grass heath available for lateral transgression and this track is typical of all the broader tracks passing through dense heath - pedestrians select the short cropped turf between bare ruts and they avoid the coarse Calluna vulgaris. Seasonally they use the Deschampsia flexuosa turf that grows beneath Pteridium aquilinum and if there is an early spring the growth of the latter can be severely restricted by removal of the croziers (see report on path L). A short wet period during June, which usually keeps the pedestrian to the drier sandy sections of the path allows the Pteridium to grow to a density that deters transgression for the rest of summer.

Fig. 17 shows the change in traffic distribution. There is no correlation between tread and the bare surfaces of 1975 and, despite continued heavy tread in the central section of the path the overall redistribution of tread means that recovery has been most marked in the central 'pedestrian' plateau. The negative correlation between the bare earth and pedestrian tread means that the surface is now no longer beyond its recreational carrying capacity. The most successful species in the heavily trampled section is Agrostis tenuis (see Fig.22).

Southern route to Wanister Hill (S)

Wire trampleometers placed on this track failed to register any significant walker pressure and no recognisable distribution pattern could be graphed. The track is over wet terrain and the recovery in less than 8 months comes out clearly in Plate 13, and, over the survey period, in Fig. 15.

Like the Wanister scarp track from William Street, this area has a soil rich in organic material; Agrostis tenuis is not apparent in the area and Nardus stricta/Festuca ovina dominate the surface. In drier areas Rubus spp. were active in breaking through the pathway surface. However, despite the early arrival of Festuca spp. (ovina and rubra) and Deschampsia flexuosa, the seral succession in this part of the Fell promises to be:

Zygogonium ericetorum
Pohlia nutans
Vaccinium myrtillus
Calluna vulgaris
Ulex europaeus
Betula-Quercus

Until 1975 this area was subjected to intermittent burning of the *Ulex*, but the reduction of pressure on this area should allow the scrub to develop.

Grass track on Lambton training circuit (L)

Cars had never used this track. The broad stretch of grassland, approximately 17 metres wide, together with established *Pteridium aquilinum* (which does not produce its frond cover until late spring) has moderately heavy tread concentrated on its western edge. During the early part of the year intermittent tread keeps the incidence of bracken fronds low and clearly the vegetation of this area reflects a complex interrelationship between visitor pressure and climatic conditions. There were no bare areas on this track and the high volume of traffic recorded probably represents an atypical maximum achieved on a dry, warm bank holiday. The histogram, Fig. 16 , shows that the concentration of wear is no greater than on track W and the soil is less vulnerable to erosion than on the steep scarp. Observation on other visits confirmed that more regular use, particularly during wet conditions, was made of track W and this explains the more severely damaged condition of the latter.

Results of the restriction of vehicular access to car parks

Study of the distribution of tread and the changes in distribution of denuded sections of pathway surfaces between 1975 and 1977 (autumn) indicates the following:-

(1) Access points to the principal tracks from Ellen Street and William Street will continue to be subjected to heavy wear particularly the latter which is scheduled as the main 'all weather' car park yet it opens out onto the less stable scarp face route. Recovery will take place as the smeared crust produced by vehicular compression

breaks with frost action and leverage by roots of adventitious species. Disc ploughing and reseeding is recommended to speed this process.

(2) All other areas formerly used by cars are revegetating. Wet areas, formerly the most damaged, are revegetating more rapidly than dry stony surfaces which have less chance of promoting growth during the period of greatest heat (and drought). Essentially the growing season in dry areas is restricted to spring and autumn and to the early part of a summer day.

(3) The least change is experienced on sections of track where cars had not been driven and equilibrium had already been established. Unless change in behaviour of visitors takes place, the scarp route W and the direct path E will continue to be heavily used. They should be harrowed and sown with wear resistant species in September, after the main period of tread is over, to eliminate worn sections which otherwise may be slow to recover.

(4) Two tracks have been reduced to minor importance (S and T) one will probably disappear within the degenerating <u>Callunetum</u> of the South Burn area, the other may remain part of the species rich grassland typical of the northern section of the Fell.

The changes are summarised below in Table 11.

Table 11 Changes in denuded area of track surface

	Site No.	Relative Location	No. of 5 cm^2 sections bare		% recovery	Comments
			1975	1977		
Formerly used by cars	W 3	Close to car park	84	85	– 1	Smeared shale
	E 1	↓	237	219	+ 8	–
	E 2		147	108	+ 26	–
	E 4		81	42	+ 48	On deltaic material
	E 6		164	152	+ 7	Wet site
	E 7		160	160	0	Dry stony site
	E 10		140	116	+ 17	–
	E 12		103	80	+ 22	–
	T 1	Remote from car park	123	74	+ 40	Reduced tread
	T 2		163	94	+ 42	
	S 1		37	11	+ 70	
	S 2		34	20	+ 41	
Pedestrian only	W 8	Main N–S route	70	52	+ 26	*
	W 14		34	36	– 5	
	E 18		61	66	– 8	
	C 2	Cross routes	11	1	–	Equilibrium reached
	C 3		2	0	–	
	L 1		No bare earth		–	
	L 2		No bare earth		–	
	W 15	Scarp crest	28	25	+ 10	Minor track

* Track W has had increased pedestrian use. The regeneration on section W 8 may represent a transition stage on a recently shifted pathway. After W 14 the track merges with E (see E 18).

Species performance on the intensively trodden paths and tracks

Definition of study areas

Before the data presented on the species histograms (Figs. 18–22) and, in more detail, in Appendix D can be evaluated it is necessary to define the limits of the survey. Earlier in this chapter reference to paths has been confined to bare earth and heavily eroded track surfaces and there was no need to resort to further clarification; now that discussion will centre on vegetation growing "on paths" or within a metre of the "pathway margins" more precision seems necessary.

The experienced fieldworker is able to use a subjective assessment based on familiar indicative signs to establish the extent of path surfaces:

Bates (1935) states: "The vegetation of the path is usually shorter.... the most outstanding phenomenon is the dark green colour.... maintained throughout the year (but) most conspicuous in winter.".

Jeffreys (1917) was able to quantify the height difference: "Festuca rubra on the path was 15 cms in height and in the Nardetum 75 cms. Agrostis was 5 cms high on the path, and 20-30 cms in the Nardetum. Deschampsia flexuosa grew in the Nardetum but not on the path.". The latter point, incidentally, raises a further definitive point: that of indicator species. "Where a path exists among (plants with stiff stems) it can always be traced by the absence of Calluna, Ulex and Pteris" (Jeffreys,1917). Vaccinium myrtillus must also be added to this list of woody plants - which act as negative indicators.

Huxley (1970) refers to the visual evidence of height and colour: "The green footpath will stand out from the browns, purples and yellows of the surrounding sward" - a point to be returned to under the discussion on landscape aesthetics in the next chapter. He also refers to positive indicators of wear resistant grasses.

Subjective selection of boundaries within transects was made for this survey but it was possible to check the validity of the selection using the wire trampleometer. Wires used for the pathway transects shown on Fig. 16 were straightened and left unexamined for two weeks. The area characterised by a continuous succession of depressed pins was held to be the pathway surface - except where a central 'rough' plateau divided the profile's continuity. After the sampling period the estimated position of the pathway edge was found to be at or within 10 cm of the limits of continuous pin depression in every case but one. Transect E. 10 had an indeterminate boundary on its eastern margin but the presence of bracken stubble was used as a negative indicator, because that strongly growing plant would eventually act as a deterrent to off-path transgression later in the summer. One metre beyond these margins proved to be sufficient to cover any normal transition between the path and the untrampled (1) heath; it also gave an approximate balance between scoring for off-path/on-path frequencies because most paths proved to be two metres wide.

Species scores

Within each $(5\ \text{cm})^2$ section of a $(25\ \text{cm})^2$ quadrat, species were recorded for presence. At first it was intended to use a Braun Blanquet weighting but this proved too difficult to apply in areas of mixed species, and unnecessary in homogeneous stands; the dominance of one species shows on the full data chart by the score of 10 and the absence of any other score including that for bare earth. Frequency of occurrence in the columns of $(5\ \text{cm})^2$ sections every 10 cms across the transect could thus range from 0 - 10.

Readings were taken during the latter part of the winter of 1975/76 and at the end of the main growing season of 1977; although problems of scoring deciduous species ~~was~~ were anticipated in a count made during the dormant period, no such difficulty was encountered.

Bracken stubble was still standing from the autumn and the subsequent clearance of this stubble first by snow and then by strong winds confirmed that it was indeed one year's growth that was being measured.

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(1) The word 'untrampled' in the case of grass heath is to be interpreted loosely.

Results of survey

These are presented in the series of histograms in Figs. 18 - 22 and in Table 12 below. The full data could not be presented visually for each transect in any way that would permit meaningful comparisons, but E.10 is typical of the tracks through the acidophilous heath where *Calluna vulgaris* is in competition with *Pteridium aquilinum* and its data is presented on Fig. 22.

The dry heath of Waldridge Fell is strikingly poor in species; discounting the vulnerable arboreal species (*Quercus robur* and *Betula pubescens* in particular) the list comprises:

Calluna vulgaris	Co dominant
Pteridium aquilinum	Co dominant
Vaccinium myrtillus	Locally sub-dominant
Erica cinerea	Local
Empetrum nigrum	Local
Nardus stricta	
Ulex europaeus	
Deschampsia flexuosa	
Galium saxatile	
Festuca rubra	
Festuca ovina	
Agrostis tenuis	
Pohlia nutans	
Cladonia spp.	

Of these only *Deschampsia flexuosa* seems to be compatible with the coarse heath species and like them it cannot tolerate heavy trampling. Thus, when this species poor heathland is subjected to heavy wear the number of species drops still further.

Apparently only three heath species, all grasses, are capable of surviving on heavily trampled surfaces:

Nardus stricta

Festuca ovina

Agrostis tenuis

Of these Agrostis is the least competitive in normal acid heath. Rogers and King (1972) refer to its preference for the driest, most basic sites - sites also favoured by the even less competitive Festuca rubra - two conditions not readily found on acid 'mor'. One result of the removal of its main competitors is the promotion of vigorous growth in the Agrostis and a complementary growth of the Festucae.

Nardus appears to be less competitive on heavily trampled surfaces than Agrostis. Nicholson et al. (1970) noted its poor performance when subjected to heavy clipping during its main growth season, March to May (note the influence of the Easter and Spring bank holidays in the context of this study). The poorer relative performance of Nardus compared with Agrostis and the Festucae, and even the vulnerable Deschampsia, in the current survey cannot be divorced from other environmental influences, however. The excessively dry summers of 1976 and 1977 have conspired to reduce the effectiveness of Nardus as a coloniser of open habitats as well as allowing Agrostis (and even Deschampsia on transect C.2) to assume co dominance in areas formerly under homogeneous stands of Nardus.

The performance of the main heath species on or near the Fell tracks is summarised in Table 12.

TABLE 12 A Summary of the performance of the main heath species on or within a metre of the main tracks of Waldridge Fell

Species	Number of transects (1976) in which species occurs Maximum possible = 18	Total Score all paths (1976)	Total score all edges (1976)	Total score all paths 1977 - using 1976 limits	Total score all edges (1977)	% change 1976 - 1977	
						Path	Edge
Deschampsia flexuosa	18	157	1059	252	1218	+60	+15
Nardus stricta	17	1090	1021	1142	907	+ 4	-11
Festuca ovina	15	962	577	1044	793	+ 8	+37
Agrostis tenuis	14	455	123	1044	184	+129	+49
Festuca rubra (a)	6	37	27	135	81	+264	+200
Poa annua (b)	6	117	24	56	46	- 52	+ 91
Other grasses (c)	4	12	6	14	12	n.a.	n.a.
Calluna vulgaris (d)	15	41	1134	107	1213	+161	+ 7
Vaccinium myrtillus	10	42	734	38	768	- 9	+ 5
Pteridium aquilinum (e)	6	-	256	2	116	+	(*)
Other woody species (f)	5	-	143	2	176	+	+ 23

Notes

(a) *Festuca rubra* has responded to the dry weather conditions of summers 1976 and 1977. It is still a minor species on the Fell and a few extra appearances show as a high relative increase.

(b) *Poa annua* was observed to prefer the fine silty medium deposited in certain areas of the track system. Drought conditions affect it negatively. The off-track increase was confined to one water recipient hollow.

(c) *Molinia caerulea*, common on wetter parts of the Fell, was not observed near any of the main tracks. Wet places adjacent to tracks were under *Juncus effusus*. Main grass species were: *Dactylis glomerata* *Holcus lanatus*, *Holcus mollis* and *Lolium perenne*.

(d) Heath dominants, heather and bilberry, formed sharp boundaries to most of the transects except E1 and E2. The heather appears to be spreading after profuse seeding in two dry summers; it is also displacing bilberry shoots that appear to have made the first advances on path margins.

(e) *Pteridium aquilinum* received a major setback in the very cold Spring of 1977. This is reflected in the low frond count; root development may be more extensive however and the appearance of fronds on the track surfaces indicates that the reduction is not caused by increased trampling.

(f) *Empetrum nigrum*, (C3), *Ulex europaeus* (E2 and W3), *Rubus fruticosus* (S2) and *Erica cinerea* (E6), were the species of the edges.

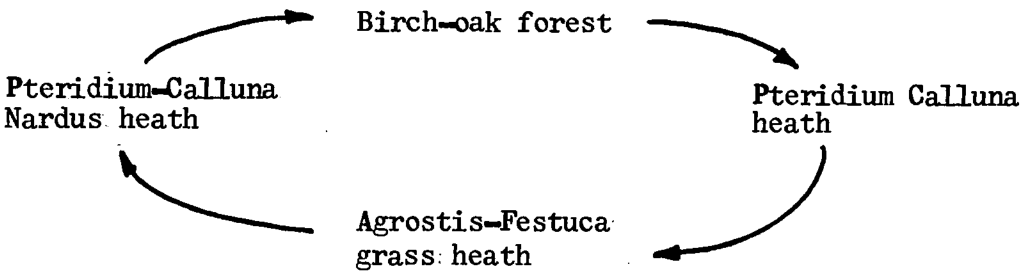
From the evidence of the performance of species there is a tolerance of trampling by the main heath grass species that may serve as a model for management and recovery of the principal trackway surfaces:

Most tolerant ——> Least tolerant	Intolerant
Agrostis tenuis —> Festuca spp. —> Nardus stricta	Deschampsia flexuosa

If the present levels of visitor use continue on the Fell, *Agrostis tenuis* grassland is likely to develop on all the broad tracks. These will become, in fact, extensions of the extensively trodden grass heath of the northern Fell. Deeply scarred surfaces would benefit from levelling and moderate vibratory compaction to prevent erosion. Re-seeding with an *Agrostis/Festuca* mix would assist but not alter the natural process of regeneration.

The evidence of transect T.2 where pressure has been reduced but not terminated, is that the pathway *Agrostetum* will become species-rich. The presence of an abundance of species in the surrounding grass heath near Tinkler Row track has ensured a rapid recovery of that surface (see Fig. 22). Two seasons has seen the establishment, on one 25 cm wide band alone, of no less than 32% of the 44 species recorded in the whole of the long established *Agrostis/Festuca* heath further east. Elsewhere on the surface of the Tinkler Row track additional species were observed.

The patterns observable in this survey confirm the hypothesis that *Agrostis/Festuca* grassland is a 'plateau', created by moderately heavy human pressure, in the cycle:



All the nuances of transition and reversion are observable on Waldridge Fell today. Management problems in the future may be associated more with under use than over use of certain parts of the trackway system, for the attractive landscape of the Fell has been achieved by an extensive trampling by man and beast over many decades. Usually undesirable regeneration can be observed before the process becomes irreversible: the practice of burning heather in short cycles has been employed on rough grazing for centuries and the growth rate of birch and gorse is so slow that changes can be appreciated before dense thickets develop. The almost inpenetrable gorse east of Chester Moor road is a result of neglect.

The most pervasive changes on the Fell, and perhaps the most dramatic because of the "toxic" effect on the ground vegetation beneath the plant, are caused by spread of bracken. The final section of the study of footpath regeneration is devoted to the performance of Pteridium aquilinum in the central part of Waldridge Fell. The uncontrolled spread of this species would have more impact on the landscape quality and recreational amenity of the heathland than any of the other heath dominants.

The Pteridietum of the 'Lambton' track : a case study

The presence of bracken in a heath is not entirely disadvantageous from an aesthetic point of view, particularly in winter when the red brown leaves provide a visual contrast with the funereal colours of the rest of the heath (see Plate 20). In summer however the monotonous green of large stands of bracken are a negative influence on the scenery - well demonstrated by the difference between Plates 17A and 23; bracken is much less dominating in the latter. From the point of view of the walker, bracken is not favoured and the paucity of species makes Pteridietum an area of low interest to visitors interested in natural history. Work by Goldsmith et al. (1970) tends to confirm these observations.

When bracken attains full height it is extremely difficult to penetrate on foot (see Chapter V) and the sharp stubble and thick litter act as a deterrent throughout most of the winter; but for brief seasons, particularly in exposed windswept areas, the terrain can be trodden and it is on the effects of such trampling that the study now concentrates.

Seasonal density of Pteridium aquilinum

Plate 17 traces the effects of climate on a dense stand of Pteridium on Waldridge Fell. Five main stages are passed through: (1) The warmth of summer promotes a rapid growth of petioles which, in the absence of competition by Calluna vulgaris, are close together. The trampling of the area is light except along the eastern edge (see Fig. 16) so bracken has invaded the whole of the broad stretch between the Calluna fronts. The much wetter, organically rich soils at the foot of the slope have not been invaded by the plant and Nardus stricta dominates the extensively trampled area where several minor paths converge. Off-path, Molinia caerulea is frequent in that area. Petioles achieve a height of some 20-30 cms within two weeks of the first appearance of the croziers in the late spring. Once the bracken has reached this height and the fronds have spread out, only the areas kept open by regular trampling can be freely walked through, and over several years the strength of growth from the rhizomes increases.

(2) After the first frost of autumn the petioles become brittle and the fronds die. In sheltered places the stubble still deters trampling pressure but this case study is of a part of the Fell where the effects of bracken vacillate with the seasons. It is during this period that litter is deposited that Jeffreys (1917) found to be so toxic to potential competitor species. Plate 18 shows how deep this litter can be (scale of photograph 1 x 1).

(3) Winter snow, if deep enough, flattens the stems of the bracken to the ground - but generally the snow softens the stems and leaves so that they begin to rot after the thaw. In sheltered places the deep litter acts as a supporting layer so that the broken stems and fronds do not lie on the actual surface and the dry litter does not break up so quickly. This part of the Fell on track (L) is much more exposed; the bracken does not grow to such great heights as elsewhere (see Plate 69) and the effects of snow lie is greater.

(4) The broken and flattened bracken is quickly dispersed by strong winds in the late winter cyclonic disturbances and the grassland is once more relatively open for walkers to extensively trample and the few ponies to graze. Trampling on the woody 'evergreen' Calluna vulgaris suppresses its growth but the deep rhizomes of the Pteridium are not affected by tread until the next stage of growth.

(5) Croziers of the plant are pushed up as soon as the accumulated temperatures of the spring reach a certain level..... this level has not been researched for this study but in the case of path (L) the conditions are reached much later than below Wanister Hill, probably because of the insulating effect of the deep litter in the latter area.

A mild winter followed by an early spring will cause the croziers to push up early and as the brittle fleshy petioles emerge they are vulnerable to trampling. It is at this stage that the timing of heavy trampling pressure becomes critical. Easter and Spring bank holidays are the two periods when heavy trampling pressure is exerted by visitors to the Fell on several consecutive days instead of the normal weekly interval of Sunday only. The bank holidays of early in the year also tend to be times when leisure visitors choose to use the Country Parks close to the urban areas rather than range further afield - or, in the case of coastal urban areas like the Tyne/Wear conurbation to use the beaches on a fine day. In 1976 spring was early and the bank holiday of May was as late as the 31st of the month; thus the period of the crozier stage of bracken on track 'L' coincided with the period of maximum tread.

Table 13 Relationship between trampling intensity and density of Pteridium aquilinum : Track L

Distance in metres across transect

	0	1	2	3	4	5	6	7	8	9	10
Wires down in each 25cm section	1.3.6.7	8.8.7.6	5.2.0.0	1.0.0.0	1.0.0.0	1.0.0.0	0.0.1.3	0.0.0.0	1.0.1.0	1.0.1.1	0.0.*.*
Frond density	2.0.0.0	0.0.0.0	0.1.7.9	3.5.X.6	3.5.X.8	0.4.3.4	2.3.3.0	5.3.4.4.	4.6.0.4	2.2.3.3.	5.6.3.8

X = 10 or more fronds of bracken in 25 cm section

* Not recorded

r = -0.621 t = 5.136 (N = 42)
(confidence 95%)

Frond counts were taken in September 1976 across sections of the Pteridietum shown on Plate 17, mainly to determine whether a front of advance could be identified similar to that described by Watt (1955). Instead of cyclical 'waves' of growth being evident, zones of low frond incidence could be seen in the readings which were not visible in the field because of the lateral spread and interdigitation of the leaves. The correlation between frond incidence and the depression of wires on the trampleometer shown on Table 13, is a high negative one. Although it was inconceivable that each single passage of tread recorded on April 19th could have coincided with the new surge of growth of croziers across the whole of the lightly trampled sward, the likelihood of those several lines of bruised grasses being picked out by subsequent walkers (suggested by Bates' observations of trackmaking; 1950) in the succeeding days of fine weather, is high. Thus the hypothesis is postulated that tracks through bracken are made during a few critical days of the growth period. If no traffic crosses the Pteridietum during the first few days of the appearance of the croziers, they quickly attain a height that diverts pressure to the part of the heath where Pteridium is less dominant i.e. along the Calluna margin or along the edge of a waterlogged or wet region in the case of track 'L'.

Bridgewater (1970) noted that tracks on Waldridge Fell often followed vegetation boundaries, accentuating the difference between species composition on either side; Plates 17d and 28 are but two examples demonstrating that this is indeed the case.

To test the critical temperature hypothesis, controlled trampling tests were made during the spring of 1977. Conditions in the spring of 1977 were far from ideal for the growth of Pteridium in the exposed grassland of track 'L'. Whereas croziers did not appear from beneath the protective litter at the foot of Wanister Hill until the 20th May, almost a month later than they were observed the previous year, no growth was apparent on the 'Lambton' track for another ten days.

Twelve test strips were marked out into the Pteridietum at 2 metre intervals and groups of three strips were subjected to 10, 20 and 50 traverses, at varying speeds and length of pace, at approximately 10 day intervals between the middle of May when no croziers were visible and the beginning of July, when a close cover of fronds was established. The intervening plots were sampled as 'controls' for frond density, together with the trampled strips, at the end of August. Both control plots and test strips showed some local variations in density that occurred through chance.

The results of the frond counts are given in Tables 14 (a) and (b) where % deviations between mean trample scores and the environmental means show that:

(1) The most significant damage to the croziers was effected by trampling applied during the early part of June..... or approximately two weeks after the first croziers appeared. During the first ten days after appearing the new bracken shoots are very easily snapped off.

(2) Light trampling makes little impact on the petioles or foliage of the mature Pteridium during its vigorous growth period although heavy traffic - of a kind hardly experienced on the main footpaths themselves - is still injurious to the plants. It is probable that, whereas at the crozier stage only minor contact is sufficient to snap the brittle new shoot, several direct blows are needed to break the more flexible mature petiole.

Table 14 a Bracken frond density along 25 cm x 10 m belt transects in the Pteridietum near the 'Lambton' track. (Survey date 5.9.77)

Transect identification number : Top set (even Nos.) test strips
Lower set : untrampled controls

	26	28	30	32	34	36	38	40	42	44	46	48	Metres from track 'L'
Number of tramples per strip	10	20	50	10	20	50	10	20	50	10	20	50	
Date of test	31.5.1977			26.5.1977			10.6.1977			5.7.1977			
Fronds per 25cm^2	6	3	6	6	2	9	2	5	2	5	5	2	1
	4	2	3	6	3	6	2	2	0	4	4	2	2
	2	4	6	3	3	4	1	1	0	4	5	2	3
	2	5	2	0	5	4	2	1	1	3	4	2	6
	3	3	1	2	5	1	2	1	0	6	4	1	7
	1	2	0	3	4	5	1	2	1	3	4	1	8
	1	1	0	4	3	6	2	1	1	3	2	2	9

	25	27	29	31	33	35	37	39	41	43	45	47	49	Metres from track 'L'
Fronds per 25 cm^2	7	7	6	6	8	4	9	5	10	12	8	4	5	1
	3	6	3	6	8	4	5	7	13	6	4	7	6	2
	1	2	3	3	2	4	4	6	7	3	5	6	5	3
	4	7	4	4	4	4	4	4	6	3	2	2	3	6
	5	6	5	5	6	3	5	5	4	4	10	3	4	7
	8	7	7	4	5	4	4	4	7	7	4	5	5	8
	6	5	5	6	4	5	4	4	4	5	5	3	4	9

Table 14b The influence of different intensities of trampling on the performance of Pteridium aquilinum at different dates in spring 1977

Date of Experiment	Mean frond count on test strips	Mean frond count on untrampled Pteridietum	% change in frond count of test strips
		10 Tramples	
26 May	3.4	5.1	-32.9
31 May	2.7	5.6	-51.3
10 June	1.7	4.9	-64.7
5 July	4.0	5.3	-24.2
		20 Tramples	
26 May	3.6	4.8	-21.9
31 May	2.9	5.2	-45.3
10 June	1.9	6.1	-69.7
5 July	4.0	4.9	-18.9
		50 Tramples	
26 May	5.0	4.5	+11.0
31 May	2.6	4.8	-46.3
10 June	0.7	6.5	-89.0
5 July	1.7	4.5	-62.0

Conculsions

It should be possible to calculate the accumulated temperatures during early spring from Durham Observatory records and to predict an initial growth period for bracken croziers. Key sites could then be monitored from this predicted growth period (or from the first week of June) and a treatment programme could be insitituted ten days after the main growth of croziers was observed. "Rolling" by two or three traverses of a County Council maintenance vehicle or simple chain harrowing could open up two to three metre wide strips across the main areas of *Pteridietum* and the traffic by summer visitors would probably keep these new paths open. Although the present large areas of *Pteridietum* would be difficult to eliminate in this way, the redeployment of trampling from its present severely restricted routes, could induce beneficial trampling to under-used areas of the Fell; and the breaking up of the large stands of *Pteridium* could not fail to enhance the landscape quality of the Fell.

In any case it is vital that such action be taken, however labour intensive the operation might be; because the vigorous growth of *Pteridium* is capable of advancing at nearly 1 metre a year on a broad front as well as colonising, by spores, degenerate *Callunetum*. Secondly the control of *Pteridium* is essential because of its facility to assume dominance wherever the *Calluna* is subjected to burning (see Plate 19 a/b) and fire is still the most economical way of managing the heath.

It now seems appropriate that the study should turn to the affect that the vegetation has on the quality of the landscape and subsequently to examine whether the present vegetation can influence the future patterns of communication within the Fell.

CHAPTER V

QUALITATIVE STUDIES OF THE LANDSCAPE OF WALDRIDGE FELL

Changes in the vegetation pattern of Waldridge Fell have become more a function of human behaviour and less a function of physical conditions. It is appropriate that a study be made of the demands made on semi-natural or 'wild' areas by leisure visitors; the most significant demand seems to be for scenic diversity or contrast.

Streeter (1971) recognised the fact that although urban visitors to Box Hill usually stayed within a relatively small radius of the car park, the rest of the area constituted a "view" which contrasted with the foreground. Hill top sites clearly provide the greatest scope for passive viewing of a wide horizon.

Wager (1967) found that people prefer to park along a vegetation boundary rather than an arbitrary line of stakes and Huxley (1970) observed that "human pressure tends to be greatest along habitat boundaries". White (1971) also noted the 'edge effect" on people's selection of sites and she saw habitat boundaries to have the aesthetic attraction of variety. Goldsmith (1974) observed that people seek out land-water interfaces or areas presenting contrasts in vegetation.

Goldsmith <u>et al.</u> (1971) used questionnaire maps to find distributions of visitors to the Scilly Isles and to find the motives behind their foci of interest. They found that distribution was related to features of interest or beauty; although certain sheltered sites were favoured for recreation and, because of the importance of coastal phenomena like beaches, "noise" factors were present in the survey but exposed sites were still heavily used if they commanded a pleasant view. Certain areas were seen to be preferred and though Goldsmith recognised the part played by other variables he saw vegetation exerting a strong influence.

Wager (1967) had also found that commons with a wider variety of vegetation were sought out as being "more attractive" but within these attractive areas certain types of vegetation proved more popular for long stays. Both researchers produced a terrain popularity index. Goldsmith attached a weighting factor based on areal extent of the habitats but in Table 15 below, this weighting has not been applied so that a more viable correlation can be made with Wager's work.

Table 15 Ratios of preferences of pedestrians for different vegetation types

	Grassland	Woodland	Pteridietum	Callunetum	Ulicetum
Wager	10 (1)	9.3	2.9 (3)	1.1	.3 (4)
Goldsmith	10	- (2)	3.9	1.8	.9

1. Wager included car park areas
2. There were no significant areas of woodland in the Scilly study.
3. Mostly Pteridium aquilinum dominated heath ("mixed heath" Wager).
4. Classified as 'scrub' in Wager's survey and may include other species such as Betula, Salix, etc.

The broad agreement between the surveys is further endorsed by the findings of the Peak Park Survey (1974) which was on a much larger scale. Here it was possible to observe the foci of traffic flows and the 'market orientation' of vendors of ice cream, caterers in wayside inns and the provision of informal accommodation, to the different scenic zones. Visitors were also asked to rate the landscapes of the region - which being inland and without major contrasts in relief can provide a useful indicator of responses within a heathland area like Waldridge Fell. Although the gradings referred to 'landscape' in the broadest sense, vegetation types were implicit in the description:

'Wooded valleys and dales' were rated the most attractive

Gritstone plateaus with acidophilous heath were rated the least attractive,

with a ratio of 10 to less than 2 expressing a preference for the two types of terrain.

The implications are that visitors to semi-natural or wildscape areas seek variety and contrast. Uniform stands of Callunetum and Ulicetum in an area like Waldridge Fell should continue to be skirted by paths rather than become the foci of routes; and areas of open woodland should continue to exert a strong pulling power, particularly those areas where grass or low heath forms the understorey.

Visitor survey : August bank holiday 1976

To test the demands that visitors would make on the Fell environment, a visitor survey was made. Because of shortage of manpower for issue and collection of questionnaires,(1) and the distance between the car parks, the William Street car park was selected for the survey.

A total of 154 vehicles used the Fell car parks (representing approximately 420 visitors) during the period of the survey, so the response to the questionnaire survey represents a 20% sample.

Questionnaire sheets were accompanied by an information sheet and were either placed in windscreens of parked cars or handed to visitors personally. Identification numbers were written at the top corner of the questionnaire and a separate note was made of the method of distribution and the time of issue. The response rate to the questionnaire was high: 80% were completed and this included three postal responses. There was no difference in the response rate between the personal and indirect methods of issue. The information sheet was seen as a means of securing this cooperation.

(1) See Appendix E.6

A time limit was established for the survey so that skewing of the sample in favour of 'local' visitors could be minimised. The times of 11 a.m. to 4 p.m. arrival time with collecting point closure at 6.30 p.m. allowed for approximately one hour's driving time at the beginning of the day and at least one hour's walking time on the Fell at the end of the day.

The day began dull but warm but after noon it became sunny and cloudless. Although the fine evening attracted many local visitors to the Fell after 6 p.m. - and their tread was monitored in a trampleometer experiment, set up earlier in the day - their response was not sought. Because of the dull start to the day no visitors were excluded by the decision to withhold issue of material until 11 a.m. One car was parked on the Fell approach road at 9 a.m. its owner was furtively removing turf (1) and it is unlikely that he would have become a respondent.

Results of survey

Origin of visitors

This is summarised in Table 16. The whole of the clientele can be classed as local visitors - only one group coming from more than 16 km away and this proved to have residential allegiance. The filtering effect of the urban areas along the south bank of the Tyne can be seen in the lack of visitors from Newcastle etc. (a fact confirmed by County Council surveys and by inspection of the franking on motor taxation certificates on parked cars throughout the year). The development of a large new private housing estate within 2 km of the Fell (White Hill, Chester-le-Street) should reinforce the dominance of Chester-le-Street residents in the visitors in future.

(1) Freemen and copyholders of Chester Deanery had a right of turbary on Waldridge Fell but by-laws now forbid the removal of 'peat' (see Plate 13).

Table 16 Origin of visitors to Waldridge Fell

Direction		Place	Frequency +	Total
	Distant	Consett	C.	1
North and West of the Fell	↑	Jarrow Boldon	J.B.B.‡	3
		Gateshead Washington Birtley	G.G.G. B.B.W.	6
	Near			
Contiguous Settlements		Chester le Street Pelton Holmside Sacriston	C.C.C.C.C.C.C.C.P.H.S	11
	Near	Durham Penshaw Houghton le Spring	D.D.D. P.P.H.H.	7
South and East of the Fell	↓	Sunderland	S.S.S.	3
	Distant	Blackhall (Hartlepool)	B.*	1

* Signifies ex-resident of Waldridge

‡ Signifies ex-resident of Chester le Street

\+ Letter indicates points of origin.

Knowledge of the Fell

90% of the visitors had made a specific decision to visit the Fell and the majority could be classed as FREQUENT visitors during summer months.

Table 17 Frequency of visits of motorists to Waldridge

Type of visitor	Visits per year	% of sample
Regular : at least once a week	50+	35
Frequent: at least once a month	12+	19
Occasional: at least two visits in summer	2+	35
Infrequent*	(1)	11

(*) All the first-time visitors (4) declared their intent to revisit the area frequently; and their reason was always the same: the varied terrain, its atmosphere of solitude yet its ease of access.

Activities and demands

Only two groups (5%) spent the majority of their time in or close to their cars and one of these was a disabled driver in his invalid 'tri-car'.(1) The willingness of the Waldridge visitors to leave the car-parking area and range far from their base is counter to observations by other researchers (e.g. Wager (1967) and Board *et al.* (1972)) and indeed contrary to the expectations of the Durham County Planning Department who hope to divert pressure from the vulnerable southern part of the S.S.S.I. To some extent this is explicable by the presence, within a 3 km journey, of a more accessible, large, riverside grassy parking area which fulfills the needs of "typical" car-borne recreationists.... indeed, on the same bank holiday, the

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(1) The second party, of 4 middle-aged people, spent almost an entire day playing dominoes and whist.

Chester riverside at Lumley bridge held over 500 vehicles and more than 1,500 visitors.

The main trackways are used by all those visitors who leave the car park zone; and observation confirmed that visitors penetrated deep into the Fell along the tracks (see trampleometer recordings, Fig. 16). The majority of visitors claim to leave the main tracks and explore the 'wilder' parts of the Fell. 38% of visitors were dog owners but there was no statistically significant difference between dog-walking visitors and other groups in this departure from the main tracks.(1)

Picnicking occupied over half the personnel (50% of the groups) the majority returning to the parking area and using the Agrostis-Festuca grassland for informal play. Undoubtedly many of these visitors would have driven onto the Fell had parking not been limited by mounds.(2)

The average stay of all groups was 1½ hours, but two modes of one hour and over two hours were apparent and this represents approximately 3 km walking time for every group....... sufficient time to cover the full trackway system in a circular perambulation.

By their comments on the car parks or in their reasons for revisiting the Fell, 62% of visitors were explicit about their recreational needs.

Traditional values

Only 10% signified that they would prefer more sophisticated facilities, most others seemingly regretting the vandalism of improvement.

(1) The season during which the survey was mounted might have contributed to the lure of the wilder areas for non dog-owners: 25% of the respondents claiming to leave the paths declared their interest in berry picking (bilberry and bramble).

(2) 25% of cars on the 1971 air photograph had penetrated deep into the heath and nearly 40% were parked beyond present parking limits (see Fig. 6f).

A majority (60%) indicated their demand for either:

'solitude'
'plenty of space'
'peace' or
'open air'

and a further 30% implied that they did not wish the landscape to change (e.g. the ex-resident who regularly revisits from Hartlepool). 90% of the respondents therefore signified their environmental needs to be those very qualities demonstrated by Wagar (1964)(1) to be most severely affected by crowding, namely:

solitude,
aesthetic enjoyment,
healthy environment,
continuation of tradition,

needs that the Chester riverside does not fulfill.

Recreational carrying capacity

Wagar (1964) suggested that there is a 'recreational carrying capacity' - a level at which recreational use can be applied without destroying the quality that first attracted the recreationist.

On Waldridge Fell the capacity is low; if every parking space were full, the distribution of visitors would average over three per hectare. Due to inpenetrability of some sections of the Fell (see later in this Chapter), heavy concentrations of visitors on most sections of the trackway system would result were it not for a natural "zoning" of activities that has developed.

(a) Picnicking and passive viewing of distant landscapes, on the elevated northern part of the Fell.

(b) Walking and vigorous exploration by children and dog-owners in the central Fell.

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(1) See Appendix E.7.

(c) Bird watching, nature study, quiet recreation in the accidented terrain and varied vegetation of such areas as the South Burn valley.

The part of the Fell close to the Edmondsley road has a high carrying capacity but as most of the visitors to the open landscape of that area also tend to visit other parts of the Fell, a certain amount of what Wagar called "engineering" will be necessary if parts of the Fell are not to be subjected to pressures that would exceed their resources.

Engineering

Examples of ways in which the effects of human pressure can be modified include:

(1) Channeling movements of people and therefore limiting damage to certain areas; e.g. by waymarking of paths to particular objectives or, more simply, by cutting new paths and relying on the social instincts of visitors to follow purposeful routes (see (3) below).

(2) Providing surfaces that withstand tremendous use
The damaging effects of vehicles has been concentrated onto durable car park surfaces on Waldridge Fell.

(3) Providing access to areas that are otherwise unused.
So far this piece of engineering has not been undertaken on Waldridge Fell..... two major new routes are suggested below. (See Fig. 24).

(4) Erecting obstacles to easy movement in order to divert pressure; for example, the embankments along the roadside in area 10G/11H have diverted pressure from the Wanister Bog path (see Plate 13). In this context, it should be recognised that dense thickets of gorse

or bramble, or of bracken from June to September, can prevent access to otherwise desirable zones, therefore on Waldridge Fell certain obstacles are being allowed to develop that are certainly not deliberately engineered. The dangers to the visual quality of the majority of the Fell caused by under-use and subsequent diversion of pressure will be discussed below.

It was felt that an evaluation of the landscape of the Fell might identify zones that could provide alternatives for the leisure visitor. These could be exploited by the managers of the area to ensure a more extensive trampling - which seems essential to the maintenance of the open landscape and the protection of vulnerable sites. 'High quality' areas could be used as seasonal foci to which visitors could be directed so that recovery could take place in areas affected by intensive use.

A simple landscape evaluation exercise was applied in the spring of 1977.

Landscape evaluation

Since the Town and Country Planning Act of 1947, local government bodies have had a statutory duty to evaluate the aesthetic quality of landscapes for their protection or development. The result has been a demand for landscape evaluation techniques that has stimulated experiment and innovation.

Most of the techniques are applicable on a macro scale and range from subjective assessment of overall visual qualities to statistical analysis of components found, by empirical means, to affect people's preferences for an environment. In general, urban industrial phenomena are found to be intrusive and to exert a negative influence on visual quality; dramatic relief and natural vegetation exert positive influences.

The quality of the heath landscape

I. Colour in the landscape: The influence of seasonal change on the colour and texture of part of Waldridge Fell.

a.

b.

c.

d.

Plate 27. Ref: 6-D

a: Photographed 26th May 1977.

b: Photographed 5th September 1976.

c: Photographed 16th October 1976.

d: Photographed 3rd December 1976.

Because of a steep convex slope (featured in plates 15 and 21) this view is not possible from the main car park - where views are restricted further by earth banks. Variety of this nature lures walkers along the pathway system as they seek new panoramas and changes in colour and texture on the Fell. This illustration is a good example of the component "surface cover" on the Tandy scoring system; for, whatever the season, the same quality of tonal variety is observable throughout.

Component: "Surface cover".

The quality of the heath landscape

II. The influence of relief: Panorama of Wanister Hill and the South Burn valley.

Although the central 'Ellen Street' track takes a direct north-south line this view over the Wanister Bog and Wanister Hill cannot be obtained more readily than from this viewpoint - although with more effort a slightly wider view can be gained from the small rounded hill about 50 metres to the north east. The more "wayward" contour path from William Street gives uninterrupted views similar to this, although with less overall range. Part of path 'W' can be seen in the middle of this panorama.

Plate 28 Ref : 7-F
Photographed 31st May 1977.

Component : "Undulation"

The quality of the heath landscape

III. The influence of trees: An "Intimate" view of the South Burn slopes of Nettlesworth Hill.

> "..... the forest boundary is commonly the limit to the view. Only where the land surface is considerably accidented do its forms begin to reveal themselves despite their cover."
>
> (Linton (1968) p. 231)

Linton was criticised for his placing too much emphasis on relief in his evaluation scheme; where forest obscured valley form it resulted in a negative score. Fines (1968) placed most emphasis on views out and trees clearly restrict the view from this area of the Fell. But as a dark green backdrop and with its irregular skyline, this belt of trees accentuates the diversity of the foreground. Trees clearly make a positive contribution to this part of Waldridge Fell, where, incidentally, there is a good linear view, down valley, given depth and perspective by the hillside on one hand and the woodland boundary on the other.

Plate 29 Ref : 10-I
Photographed 10th June 1977 Component : "Trees in mass"

The quality of the heath landscape

The influence of trees : An open view near the Chester Moor road.

This photograph, taken in spring from a position a little higher up than that of plate 1, illustrates the diversity of the eastern section of Waldridge Fell where single trees add variety to what would otherwise be open heathland with fairly uniformly sloping terrain. Most of the woodland regeneration has taken place since 1920, demonstrating the effects on the landscape of reduction in grazing. It will be difficult to manage this area by the economic method of burning, and the area will ultimately lose this open quality.

Plate 30 Ref : 10-G Component: "Trees singly"
Photographed 20th May 1977.

Some examples of landscape evaluation scoring on Waldridge Fell:

Visual regions. The eastern margins

The wooded valley in the middle distance viewed across the red bracken stubble does not yet in early spring make a strong contrast with the scarp of Wanister Hill and 'William Street' area in the distance. However, the view has depth and great variety of texture (see also plate 30). Despite its obvious scenic qualities only one track skirts this terrain and the one car park in the area has no easy means of access to it. Gorse is beginning to dominate the hill tops and there is a danger of the whole area reverting to inpenetrable scrub.

Plate 31 Ref : 12-G (Score +8)
Photographed 20th May 1977 (cf. 10-E)

Visual regions of Waldridge Fell

William Street to Wanister Hill scarp path.

The most significant feature here is the accentuation of the difference between the heath on Wanister Hill and the marsh vegetation below on the flat surface of Wanister Bog by the steep scarp face. Views out are not exceptional but they give depth and interest to the landscape. The variety of vegetation is less than in the eastern margins but this is a popular track with visitors to the area, and much eroded in places.

Plate 32 Ref : 8-D
Photographed 10th June 1977

(Score +6)

Visual regions of Waldridge Fell

The northern slope.

The angle of the slope is such that the rough heath is less of a component in this landscape than narrower stretches of heath elsewhere on the Fell. The altitudinal range is greatest in this part of the Fell although the relief is less prominent than on Wanister Hill. Even the ravages of mining and overburning in this area are mellowing with time and the industry in the background is made less obtrusive both by distance and the woodlands of the Cong Burn Plantation.

Plate 33 Ref : 1-B
Photographed 20th May 1977 (Score +8)

Visual regions of Waldridge Fell

View towards Broomy Holm and the Cong Burn – Humble Burn interfluve.

> "To a townsman any farming landscape out of sight of the town offers the relief of being 'in the country'."
>
> (Linton (1968))

This view over the land won from the waste after the 1794 Enclosure Act offers the contrast between cropland and heath, together with distant views, that has made this another well-used track. The horses, free to roam on the Fell, tend to favour the grazing in this largely bracken-free corner..... much to the concern of many visitors.

Plate 34 Ref : 4-A
Photographed 20th May 1977 (Score +7)

Visual regions of Waldridge Fell

The grass heath between Tinkler Row and Ellen Street.

Consistently trampled and grazed over centuries, this area has developed as an Agrostis-Festuca grassland. Reduction in use has led to its being recolonised by Calluna vulgaris, Nardus stricta and adventitious species such as Epilobium angustifolium with certain 'weeds of cultivation' close to former habitation sites. Occupying a slight trough behind ancient overgrown pit mounds, views are not extensive and the trees are concentrated into a small pocket close to the road. Numerous small damp hollows are probably caused by local subsidence.

Plate 35 Ref : 5-D
Photographed 5th September 1977 (Score +3 to +5)

Visual regions of Waldridge Fell

The view from Ellen Street car park.

The pond occupies a fully enclosed hollow with no surface outlet. Most of the year there is little water in the pond and it is being choked with Juncus species and willow (Salix cinerea).

There had been continuous rain for several weeks after the longest drought on record until just before this photograph was taken. Apart from this one point where distant, but nondescript, views can be obtained, the area has little to commend it but it is still popular with car-borne picnickers.

The relevés for the 'dry-grassland' study were taken in two transects crossing the foreground and the middle distance beyond the pond.

Plate 36 Ref : 7-C
Photographed 16th October 1976

Component : Water
(Score +2)

Visual region of Waldridge Fell

Wanister Bog

The bog is less wet than it was at the beginning of the twentieth century and colonisation of it by trees such as the grey willow (Salix cinerea) and locally, the hawthorn (Crataegus monogyna) indicate that the hydrosere is nearing its later, "carr" stage. Despite the low relief the vegetation includes "single" trees; and views outward to surrounding hills form a more varied environment than in plate 36. The relative inpenetrability of the marsh deters visitor pressure.

Plate 37 : Ref 9-H Score +4

Photographed 20th May 1977

Visual Region of Waldridge Fell

The North Eastern Shoulder

Horses grazing the Nardus-Festuca grassland near Waldridge Colliery village.

> "horses are often highly selective grazers and this results in patches of coarse grassland....."
>
> (Lowday 1977 p.22)

The grassland in the north-facing hollow has here been reduced to very coarse tussocky Nardus stricta by overgrazing by tethered animals. There are very restricted views out and the colliery village with its air of decay detracts from the environmental quality of this part of the Fell.

Plate 38 : Ref- 7A

Score = 0

Photographed February, 1976

The "treeless" heath of the nortern Fell

Plate 39 a Ref: 2-C

Photographed 20th May 1977

Waldridge Fell is at its highest and most exposed in this northern section. It is dominated by Calluna vulgaris at the crest but the lower slopes near the Edmondsley Road, are more sheltered and are under dense **Pteridietum.** The sheltered hollow in the centre of this photograph is also dominated by **Pteridium aquilinum** - which seems to be protected from frost conditions by good air drainage into Smithy Dene (See Fig. 8 and relief overlay). Although not on any through route because of the natural barrier of Smithy Dene, it was the closest part of the Fell to the main centres of mining activity of the 19th and 20th centuries, and the terrain lent itself more readily to continued grazing from 'Edmondsley' than any other part of the Fell; thus it has probably been the most vulnerable part of the heath to accidental fires in addition to its being the area most likely to be 'managed' by burning : a practice which excludes tree cover.

Plate 39 b : Ref 2-C

Photographed 30th August 1977

> "For a fortnight in the year the moorland has its moment of high glory when the heather is in bloom"
> (Linton (1968) p.232)

The relatively treeless and monotonous landscape has few "visual surprises" to offer, with no views out, no variety of colour (except between the bracken and heather), no undulation; it is an area that does not attract walkers away from the perimeter track.

(Score +2)

The Site of Waldridge 'D' Pit

"Dereliction due to Coal mining is, perhaps the most obvious, and most offensive of all dereliction".

Bracey (1970) p.146

Ten years after the closure of the pit it forms a prominent sky-line feature opposite the main 'William Street' car park. It severely depressed landscape evaluation scores in the north east of the Fell. (Score -2).

Plate 40: Ref: 9-B

Photographed June 1977

Component: Human Artifacts

Smithy Dene drift mine from the South East

Although the buildings shown in this photograph are of a 'temporary' nature and much of this untidy appearance could be remedied after mining activities cease, the coal mine is a considerable scar on the landscape of this edge of Waldridge Fell. The large expanse of bare earth and coal spoil will be slow to regenerate. Here the managers of the country park will have to be imaginative when they set out to create a 'natural' environment for the proposed picnic area, which is planned for Smithy Dene.

The site is 'Introverted' - that is, it offers no alternative visual experience other than can be seen between the steep sides of the valley. Introversion makes the decay and dereliction in Smithy Dene seem much more significant than the rubble on the Waldridge 'D' site.

Plate 41 : Ref 01-C

Photographed 31st March 1977

Component: Human Artifacts

(Score -4)

Fines (1968) considered the landscape in totality and the environmental quality of any one point was the rating of its congruence with a predetermined scale based on the mean score of group preferences for a sequence of photographic views. The statistical validity of Fines' work has been questioned by Brancher (1968) and by Linton (1968).

Linton saw landscape quality to be an interaction between landform and land-use and his method has been proved to be applicable to a wide variety of regions (e.g. by Gilg (1974)) but its incompatibility with Fines' results for Sussex was demonstrated by Crofts and Cooke (1974).

Neither of the methods can be used for small-scale application such as was demanded for Waldridge Fell, although a semi-subjective scale of visual regions using a modified Fines approach could be drawn up. The visual regions are presented in Plates 31 to 41.

Thayer (1976) has shown that certain elements can be used as predictors of perceived natural beauty. The general applicability of weightings given by Linton to certain elements, and the positive contribution of certain components of landscape by the more sophisticated C-S-W (1) and 'Manchester' (2) evaluation techniques led to the selection of a component analysis approach for the survey of Waldridge Fell.

The main criticism levelled at the component approach is made by Thornes in a critique contained in Crofts and Cooke (1974); he states: "Nature is greater than the sum of its constituent parts"

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(1) The Coventry-Solihull-Warwickshire Sub-Regional Planning Study Group report 1971 was tested in a different region by Blacksell and Gilg (1975) and proved to be generally applicable except for a need to revise weightings for heathland and a need to extend the range of variables.

(2) The Manchester University Landscape Evaluation Research Project (1976) used similar objectively derived weightings to the C-S-W evaluation technique.

..... and Penning-Rowsell and Searle (1977) found one of the main failings of the 'Manchester' technique was its lack of a complementary analysis of the quality of views, to balance the objective weightings of a diversity of elements of landscape. They compared the 'Manchester' study with the evaluation technique devised by Tandy in 1967 (and subsequently revised in 1971) and found the former harder to apply and to require up to twelve times the manhours of research, and more sophisticated analysis, to achieve broadly similar results.

Tandy (1975) has been more concerned with intra regional differences and more intimate studies of small sites (as befits an architect rather than a planner) but his scheme (1) was devised to provide a more balanced answer to Fines' pioneer work than that devised by Hebblethwaite for Hampshire(2), which did not consider outward views; Tandy's scheme meets most of the requirements of the Waldridge Fell survey.

The six components selected for assessment are the most appropriate for the heathland environment and the added dimension of extra-territorial views appears to exert sufficient weighting in the context of central Durham.

Tandy's method is seen as naive by more than one critic and it has the fault of mixing subjective qualitative assessments with a restricted range of components, of which the quantitative scores can be loosely applied. But it has been demonstrated to be simple to use and more generally applicable than the more elaborate component analysis of the C-S-W and 'Manchester' techniques. It has been used by County Planning departments including West Sussex. Its tendency to equate quality with variety makes it more likely to reflect the preferences of visitors to Waldridge Fell than many other surveys.

(1) Tandy (1971)

(2) See Murray (1967) p. 25

The application of Tandy's evaluation technique

On Waldridge Fell, one hectare may contain a rich variety of terrain. In the escarpment zones and near Nettlesworth Hill great contrasts are apparent within a few metres, particularly in the range of views out of the survey site. A $(100m)^2$ unit was chosen as the unit of survey and in the field an evaluation was made every 50 metres within the site and the mean of the four readings was to be the score.

To balance the danger of subjectivity in scoring by one surveyor and to eliminate the bias that may be exerted by 'training',(1) the survey was carried out using 32 first year students of environmental science drawn from a wide cultural background and from widely differing scenic regions of Britain. Before preparatory discussion of the technique they had not been introduced to the idea of landscape planning and their choice of course allowed a certain degree of confidence to be attached to their response to the quality of the heath environment- it must be remembered that the users of Waldridge Fell appear to have an 'environmentalist' bias. 83 hectare 'cells' were evaluated by at least two students working independently and, because their results were fed into a computer, it was possible to correlate scores of contiguous cells known to be in uniform terrain to establish a 'running mean' if necessary.

Seven components are identified in the Tandy scheme:

(a) Colour and texture of the surface cover

(b) Undulation (degree of relief)

(c) Trees in mass (2)

---

(1) The élitism of the guardians of public property has often been attacked and Penning-Rowsell (1977) points out "many professionals receive little aesthetic training.... there is not reason to believe that the public should have less confidence in their own judgement than they have in those of so-called experts".

(2) Linton tended to give large areas of conifers a negative score because of their impact on the 'natural' environment; and clearly the large scale of trees makes them stand apart from other forms of vegetation.

(d) Single specimens of trees

(e) Water bodies

(f) Human artifacts

(g) Views out

Each of these were to be quantified on a presence/absence basis with a further weighting for components dominating an evaluation point to the exclusion of others; i.e. -

Not present = 0
Some present = 1
Present over all or most of the site = 2

Clearly apart from relief and views, only one other component can be allocated a maximum score of 2 for presence, because the other components are related to surface cover within the site. Tha quantity factor is then multiplied by a quality factor ranging from -2 to +2 through zero. The sum of the scores results in an evaluation score for the site. The theoretical range of scores is from +18 to -18.

In addition to the group survey an evaluation was carried out, using the scoring scheme, by one 'trained' moderator. Intended as a ground check for components (to supplement the aerial photograph), against which errors of data input into the computer (1) could be compared, the moderator's map of environmental quality shows a high positive correlation with the group survey.(2)

Four main areas of scenic diversity are identified by the survey. These are shown on Fig. 23. These areas are likely to become the recreational goals on the Fell.

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(1) ICL/1903A computer from which a map was retrieved using a CIL graph plotter.

(2) See Appendix E.1 and Figs. 27 and 28.

LANDSCAPE DIVERSITY AS DEMONSTRATED BY COMPONENT EVALUATION [Map 1] AND SOME MANAGEMENT PROBLEMS ASSOCIATED WITH REDEPLOYMENT OF CAR PARKING AND TREAD [Map 2]

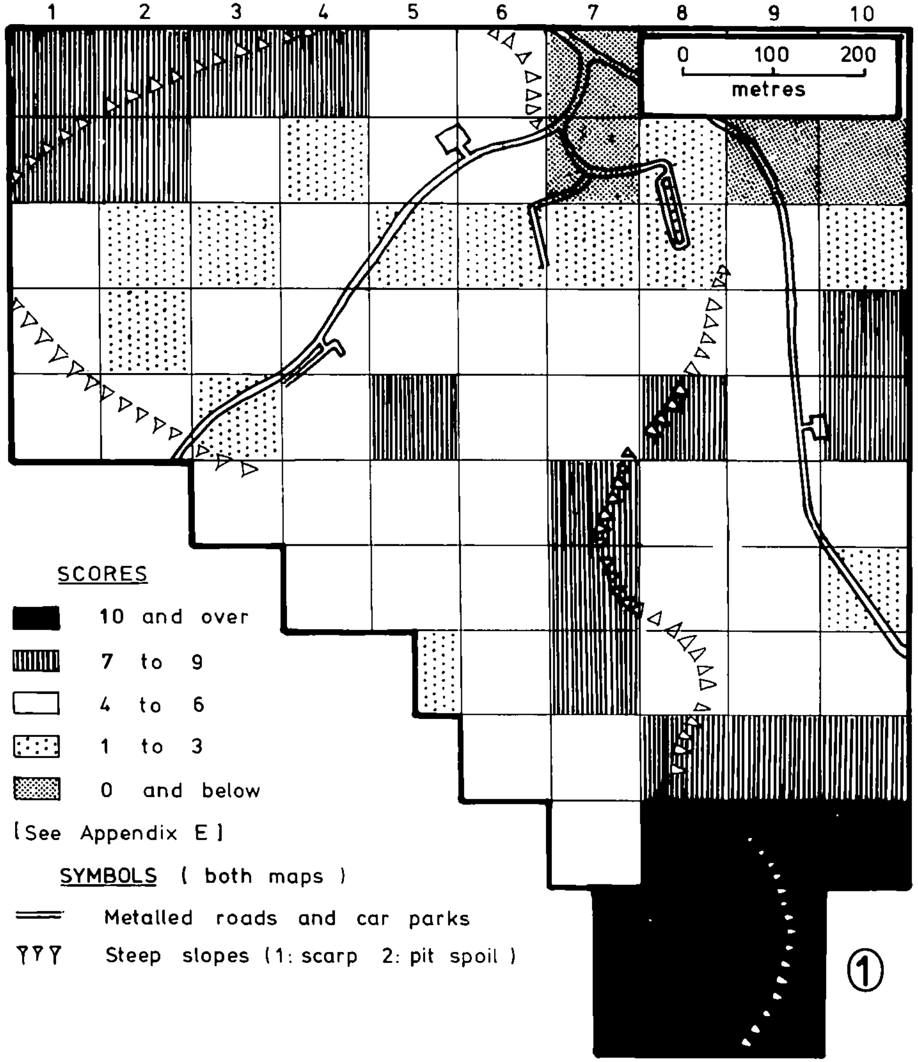

Fig. 23

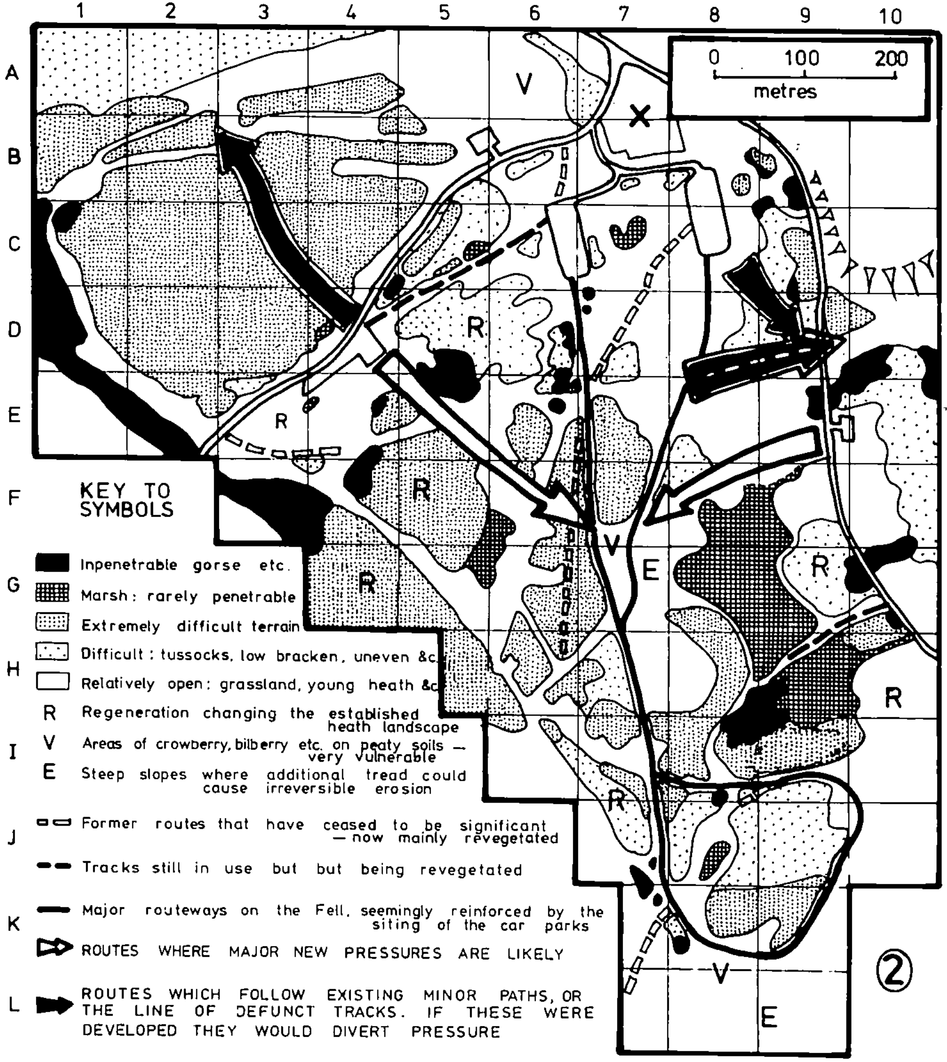

Fig. 24

Efficiency of the communication network

The efficiency of the communication network in linking the points of visitor dispersal (the car parks) with the recreational goals (the areas of scenic diversity) was tested.

This was done by measuring:

(i) the direct distance (Dd) to the mid point of squares of high scenic value from the point on the car park perimeter nearest to that square

(ii) the distance between those points along the actual pathway-system (Dp)

and expressing the efficiency coefficient of each path as $E = \frac{Dd}{Dp}$

The tracks leading to the northern scarp from the northern car park proved to be the most efficient on the Fell and permit an outward and return route that does not necessitate retracing a path already followed. The northern car park, however, is the least well positioned of all the car parks:

(i) it commands few outward views

(ii) it is surrounded by heath with little textural difference

(iii) it requires cross-traffic entry for the clientele approaching from the east - the direction used by the overwhelming majority of visitors to the Fell.

The tracks leading southward from Ellen Street and William Street car parks are also 95% efficient and the very slight detours they make are the result of the embayments in the steep scarp face (on the latter path) and the influence of a small rounded summit (on the former). The way in which the two most prominent tracks link the largest car parks with the zones of greatest scenic diversity, is likely to ensure that the most heavily pressurised zone of Waldridge Fell will continue to be the southern section of the S.S.S.I.

The least efficient track on the primary route system is now the western boundary track (B). At one time this track provided the easiest means of penetration for cars to the diversified terrain of the south (see Fig. 6f). Now a new path taking a more northerly diagonal route across the Fell is developing (see Fig. 24). The Tinkler Row car park thus contributes most of its pedestrian traffic to the section of the Fell already subjected to pressure from elsewhere.

This need not be the case. Tinkler Row parking area is the most readily seen from the main road and it could prove the most suitable site for an enlarged car park. Lying on the part of the Fell most heavily trampled in the past, it has the least interest botanically; and, after the scarred landscape near the old 'D' pit, its surroundings score lowest on the Tandy scale.

The Tinkler Row car park is therefore in a situation that would benefit from promotion.

Fig. 24 shows the better strategic positon of Tinkler Row car park for the more even distribution of pedestrian traffic across the Fell. In addition to the new route already described, the old route (B) is unlikely to completely disappear due to its mineral based surface inhibiting growth of some of the coarser heath species. The track (T) leads through species rich grassland and surveys have demonstrated that it will contimue to be used by visitors to the Fell. The important east-west track (C) lies immediately to the south of Tinkler Row and improvement of this route would most certainly redistribute pressure. Garbrecht (1971) demonstrated that people who have changed direction once, after entering an area strewn with evenly spaced obstacles, are more likely to make more major directional changes (1) than people who chose a peripheral route to a diametrically opposite objective. If the objective in the case of the 'Tinkler Row' visitors is a scarp top view point, reopening track (C) to extend the choice of routes would certainly be successful in diverting pressure from the South Burn area.

A further opportunity to promote the northern part of the Fell in the Tinkler Row area is restricted by the impenetrable nature of the vegetation immediately opposite the car park entrance. A suggested new route is marked on Fig. 24.

The way vegetation can channel movement within certain sections of the trackway system now becomes a significant factor in the management of the Fell. The remainder of this study is concerned with terrain penetrability and its effect on the distribution of trampling pressure.

The effects of vegetation on energy expenditure

There have been few studies of energy expenditure by outdoor recreationists in heathlands.

Millman (1970) classified terrain into four loosely defined categories ranging from "tough going" to "easy walking"; apart from the last, defined as "suitable for day trippers or tourist rambling - such as vehicle tracks etc. which are well drained and of gentle gradient", there seems to be no way to apply the categories to the survey of Waldridge Fell. However, Millman did examine the problems

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(1) See also Eliot-Hurst (1974); both he and Garbrecht were studying choice of path through a rectilinear pattern of streets in a city. A 'diagonal' made up of a series of small steps is the same distance as a major right angled route round the periphery, so the decision to skirt an area by striking in one cardinal direction, then completing the journey along the second coordinate, is now more usual for urban dwellers than the difficult exercise of trying to maintain a bearing through a landscape with low intervisibility.

of penetration of heathland where paths were absent or ill-defined; most other studies have been concerned with the effects of gradient rather than vegetation.

Bates (1950) referred to changes in herbage causing varying degrees of resistance to walking but he did not pursue the matter far before he concentrated on the influence of transverse gradient on ankle joints as an influence on pathway meandering; i.e. he was examining physical discomfort rather than physical effort. Huxley (1970) also referred to the effects of gradient on the efforts required to create footpaths and he recognised six types of path as demonstrating the different effects of terrain steepness. He made no attempt to delimit each type by angular measurements let alone by measurement of energy expenditure.

Bayfield (1971 a) referred to the way coarse vegetation limited tread to pathway surfaces - implying that less effort was needed on all bare surfaces except the most uneven and eroded.

In a specific study on energy expenditure, Cotes and Meade (1960) had been able to assess energy expenditure by measuring oxygen consumption and by measuring the volume of expired gases; but their work had been more concerned with walking speeds and effects of gradient than the effects of friction or obstacles.

Carlsöö (1962) examined the responses of leg muscles to the increase or reduction in friction on level surfaces. His apparatus necessitates laboratory conditions and once again the research is more concerned with conditions underfoot than the problems of negotiating impediments above ground level.

The most important study of energy expenditure testing, compatible with the study of vegetation on Waldridge Fell, is that conducted by Durnin and Passmore (1967). They were particularly concerned with the energy demands of walking at "normal"(1) speed across different kinds of terrain by individuals solely for leisure purposes. Using methods similar to Cotes and Meade, expired gases were collected in a portable apparatus in field experiments and from the differences in oxygen intake the energy expenditure in kilocalories per minute was calculated and presented in tabular form. Part of their findings are shown in Table 18 below, because they are comparable with the results of the penetrability test devised for this survey.

Pulse rate change as an indicator of effort

The five litres of blood that course through the human body carry the dissolved nutrients and oxygen necessary for the efficiency of the tissues and cells, the blood also carries the dissolved waste products of tissue activity and the carbon dioxide (for exhalation from the lungs). The amount of blood pumped in a unit of time varies with the needs of the moment but in one minute, with the subject at rest, all the blood in the body is pumped through the heart by the steady pulsation of its muscles. As greater demands are made on the body nerves, the cardiac centre in the brain indicates that more blood movement is necessary and the pulse rate quickens...... which explains why certain emotions make the heart beat faster (2).

---

(1) "Normal" walking speed is taken to be 5.5 k.p.h. on level, smooth surfaces. On steep slopes most people prefer to minimise effort. Although energy consumption rises with increase of gradient, at slow speeds of the order 2-3 k.p.h. the increase is constant until the slope exceeds 15° to 20°, when paths tend to zig-zag to negate the increased effect of slope and to maintain equilibrium of effort.

(2) The anticipatory stress factor was studied by Kozar (1964) and by Rutley and Mace (1972); rises of over 25% above normal requirements for energy consumption alone have been recorded, particularly by subjects conditioned to expect difficulty.

Davies (1968) examined both pulse rate and oxygen consumption during the transition period between rest and exercise and he found that the steepest rise in cardiac frequency and oxygen intake took place during the first minute of a test. After one minute the pulse rate levels out whereas two to three minutes may be necessary before oxygen intake has adjusted to the increased energy demands. Tests of the apparatus used in this survey (see below) confirmed that one minute of effort was normally sufficient to obtain equilibrium of pulse beat, certainly below the 120 beats per minute established as the threshold for terrain penetrability.

This rapidity of cardiac response to energy demands was seen to be an important factor influencing the choice of test. Despite the proven accuracy of respirometer tests for oxygen intake,(1) they must necessarily extend over several minutes to achieve equilibrium and the longer the effort is applied the sooner the onset of fatigue in subsequent tests. In addition, the longer the testing is prolonged throughout a day, the greater the likelihood of environmental temperature changes: Edholm *et al.* (1962) have demonstrated that pulse rate increments as a measure of energy expenditure may be misleading when the subjects are working in hot conditions. It is therefore important to monitor diurnal temperature changes carefully, but it is preferable to carry out tests over a short period, beginning a new test as soon as subjects return to basal energy demand conditions.

(1) Sharkey, McDonald and Corbridge (1966) saw pulse rate readings used as predictors of energy demands led to over estimates. To some extent this higher pulse rate could be a result of stress; Hermansen, Vokac and Lereim (1972) found that at high work rates oxygen intake was inhibited by the valves in the respirometer.

It was felt that for testing for energy expenditure changes in the field, measurement of pulse rate would be as accurate a measure as measurement of oxygen intake, particularly for the small stretches of terrain involved. It is hard to measure pulse rate in the field by the simple method normally used..... i.e. manual depression of an artery and counting impulses. As soon as the test conditions are discontinued the pulse rate begins to return to a normal 'at rest' rhythm. After the first few irregular beats at the end of the test there is an apparent state of equilibrium of beat, but during the half minute or more of counting it is in fact one of deceleration and the count at the end of the measurement period does not reflect the energy demands made on the subject during the test situation.

A method of counting pulse beats during the course of the test is essential. In a laboratory this can be achieved by attaching electrodes to subjects (who expend most of their energy at a fixed point, usually in a treadmill) and connecting these to an electro cardiagraph. In the field, apparatus had to be simple and light in weight and also had to leave arms and shoulders free to move. Two methods were tested.

(1) The electrode pulse meter

Two copper electrodes were attached to the subject's chest one on either side of the right and left ventricles of the heart, i.e. at points about central in the chest and to the left of the body, just below the breast. To ensure efficient contact they were smeared with electrode jelly and strapped down firmly; the wires leading to the recording apparatus were also strapped down securely to prevent accidental detachment of the electrodes during tests. Body hairs tend to inhibit contact so the chest of the subject was shaved before attaching the electrodes.

'Penetrability' measurement apparatus

The apparatus illustrated here consists of a San-Ei: 2D16 pulsemeter coupled to the microphone input of a cassette tape recorder in such a way that instructions about timing, and details about the terrain and vegetation, could be recorded simultaneously with the pulsebeat impulses from the instrument. Most energy expenditure tests require the analysis of expended gases from the lungs but test surfaces produced very satisfactory correlations between laboratory tests and pulse rate changes. It was possible to construct a table of penetrability for the different heath species, based on the results of pulse tests.

Plate 42

Photographed July 1977

Plate 43 Ref: 4-E

Photographed 5th July 1977

Plate 44. Ref: 2-E

Photographed 5th September 1977

43. Smooth level asphalt; pulsemeter reading 100
Smooth level cropped grass; pulsemeter 110
Thorn hedge: inpenetrable.

44. Tussocky Nardus and Festuca with Calluna at
pioneer phase; pulsemeter reading 115
Gorse (left skyline): inpenetrable.

Plate 45 Ref: 2-C

Photographed 5th
September 1977

Calluna vulgaris at
'building' and 'mature'
phase of growth cycle.
Pulsemeter 120

Plate 46 Ref:4-D

Photographed 31st
August 1977

Juncus effusus, waist high
(90 cms) Pulsemeter 130

Plate 47 Ref: 2-D

Photographed 31st
August 1977

Pteridium aquilinum,
shoulder high (150 cms)
Pulsemeter 140

Plate 48 Ref: 1-C

Photographed 31st
August 1977

Almost inpenetrable birch-gorse scrub on old pit
spoil. Pulsemeter 145+

The wire from the electrodes was connected to the input socket of a portable cassette recorder and the impulses from the heart were recorded directly on to tape.

So that information about the terrain being crossed, or instructions to the data processor on timing could be fed into the tape recording, a microphone switch was inserted into the circuit. The 'off' position allowed the impulses to be recorded and the 'on' position allowed verbal communication.

The number of pulse beats per minute could be counted during the replay of the tape recording either by direct audio detection or by reading off oscillations from an oscillograph connected to the loudspeaker output of the recorder.

<u>Advantages</u> of cheapness and simplicity of apparatus could be accompanied by certain <u>disadvantages</u> for testing on more than one subject in the field:

(i) Transfer from one subject to another is laborious and undignified, involving strapping electrode to bare flesh.

(ii) Electrode contact is not easy to establish.

(iii) There is a break in continuity of recording when verbal information is fed into tape recorder.

(iv) The whole of field recording time must be duplicated in the laboratory when retrieval of test data is made

(v) Audibility of impulses on tape varies with nature of activity.

(2) <u>The San-Ei pulse meter</u>

A San-Ei pulse meter, Type 2D16 with a finger pickup (type E115) was strapped to the microphone of a cassette tape recorder as shown on plate 42; the apparatus was carried in the subject's hand during walking tests - with the recorder in a small back-pack. Because of the close contact between the impulse emitting speaker on the pulse meter and the microphone, both impulse and commentary could be recorded simultaneously. A finger contact pickup is not so efficient for vigorous activity testing as an arm band, but it is rapidly transferable between subjects and it reacts to pulsebeats within two seconds of being attached. Two pulse beats are all that are necessary to give the time interval that is registered on a dial as the number of beats per minute. It was therefore possible to record the pulse meter reading within three seconds of completing the penetration test (i.e. when shaking and other movement of the finger pickup ceased).

Vegetation penetrability testing in the field

It was important that the effects of gradient should be constant for each test made so only short transects were possible in some vegetation stands. A 30 metre tape was pegged down and laid out to its full extent and three parallel traverses were made through the selected vegetation stand, care being taken not to follow an already trampled route. The 90 metres were to be completed in exactly one minute so that any energy conservation effected by a slow start would be compensated for by the additional efforts necessary to complete the course within the appointed time limit. In difficult terrain it becomes increasingly hard to maintain the desired speed. Through shoulder high bracken for example, high speeds cause the subject to stumble as feet become entangled in deep litter, so that rapid body movements in fact slow down the rate of penetration. The use of the whole body, including arms and chest, is necessary to force a way through dense bracken or through the close weave of branches in scrubland so that the slower speed does not appear to conserve energy input.

The results of the tests are directly comparable with those of Durnin and Passmore (1967) for a subject of the same weight and height as the subject used for Waldridge Fell and at the same walking speed of 90 metres/min. (5.4 k.p.h.).

Table 18 Energy expenditure on different surfaces

Terrain	Speed k.p.h.	Kilocal./ Min.	% rise over basic reading	Pulse rate*	Speed k.p.h.	Terrain
Asphalt road	5.5	5.6	-	100	5.4	Asphalt road
Grass track	5.6	6.2	10	110	5.4	Smooth short grass
Stubble field	5.2	6.8	20	120	5.4	Uneven tall grass
Ploughed field	5.3	7.6	35	135	5.3	Tussocks and rushes

Durnin/Passmore test		Waldridge Fell test	
Subject :	Age 23	Subject:	Age 42
Weight:	69 kg.	Weight:	70 kg.
Height:	175 cm	Height:	179 cm

* Subject's 'at rest' pulse rate is normally very low (< 55/min.) but the tests were carried out on a very hot dry day in summer when a standing pulse rate of 85 was recorded.

Attempts to produce a comparable scale of energy consumption readings using a Max Planck respirometer and a portable oxygen analyser were not successful. For low energy input conditions such as those required for negotiating tarmacadam surfaces and smooth short grass, exhalation of gases was variable and up to twenty minutes of continuous walking at 5.5. k.p.h. were necessary to collect a sample large enough for testing.(1) The result was that a meaningful percentage increase could not be calculated. However, ranking the order of increase in energy input as demonstrated by the pulse meter

(1) See above (p.113).

and respirometer methods produced a perfect positive correlation.(1)

The results of the pulse meter tests carried out on July 5th 1977 are therefore drawn up on Table 19 below and critical thresholds of penetrability by leisure visitors to a heathland are established. Three thresholds are used on Fig. 24 to establish five grades of terrain difficulty; and the implications of the terrain penetrability tests for the future of the landscape of Waldridge Fell are discussed in the concluding paragraphs of this thesis.

Table 19 Energy expended walking through different types of vegetation

(based on % increase in pulse rate)

Terrain	Pulse rate % increase	Classification
Asphalt road	100*	Footpath surfaces
Smooth short grass	110*	
Smooth short grass with light bracken	115	Open heath offering easy walking off path
Pioneer bilberry or crowberry	115	
Pioneer heath with hair grass	115*	
Mature heather	120*	Open heath with uncomfortable walking conditions
Grass heath (*Nardus/Festuca* grassland)	120*	
Threshold of normal penetrability		
Bramble with fescues	125	Terrain penetrated with difficulty
Mature mat grass tussocks	125	
Degenerate heath	130	Extremely difficult walking conditions
Wet heath (rushes)	135*	
Dense bracken	145*	Not normally pentrated by walkers

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(1) See Appendix D 4

Scrub and willow carr	150*	Inpenetrable except by using climbing actions and protective clothing
Gorse (mature)	Inpenetrable	

* illustrated in Plates 43-48

Problems associated with under-use of heathlands

Footpaths can be seen as effort minimising routes across heathland. Their bare or grass covered surfaces may require considerably less expenditure of energy than is necessary on the immediate off-path terrain even in grass heath. Where paths are bounded by coarser heath species such as Calluna vulgaris, Pteridium aquilinum and Ulex europaeus there is little likelihood of visitor penetration beyond the pathway margin and the likelihood of new paths being created on a Fell, already well served by an efficient communications system, is small. The system could be "frozen" by the difficulty of penetration of much of the terrain.

The open nature of the heath landscape is dependent upon a certain amount of trampling - the species-rich grassland has been correlated with extensive tread over a long period of time - but the problems associated with spread of gorse, regeneration of birch-oak woodland and the development of willow carr are relatively recent and appear to stem from the removal of grazing from the Fell.

Lowday and Wells (1977) have studied the problems associated with management of heathland once the main land-users are recreationists.

(i) Although the advantages of burning coarse inpenetrable stands of heather, gorse and bracken to maintain open heath are listed - particularly its cheapness as a method and the way it reduces the danger of accidental uncontrolled burning in dry seasons - the main finding of the survey is that grazing is the most satisfactory way of keeping semi-natural areas open.

(ii) Cattle in particular are seen to have the following advantages:

  (i) they maintain floristic diversity
  (ii) safe with people
  (iii) not susceptible to dog worrying
  (iv) they are attractive feature of landscape
  (v) sale of carcase etc. offsets some of cost
  (vi) certain breeds e.g. Galloways are ideal for reclaiming rough pasture and they are hardy.

Manchester Parks have used Galloways successfully, grazing 20 cows and 10 calves on only 17 hectares of rough grazing although the cattle are over wintered on the Manchester Parks department farm. (Waldridge Fell with its much larger area could sustain a similar sized herd all year round). The present position on hill farm subsidy is not clear but some of the costs are certainly offset by Ministry grants.

(iii) Cutting routes with a flail has proved successful in keeping forestry rides open and this method could be used in the early summer to open up routes through bracken and Nardus.

The choice for managers is seen to be wide but the need to make a choice is also urgent. What is certain in the case of Waldridge Fell, is that without an integrated cutting, burning and perhaps grazing policy the present open heath landscape will lose its scenic diversity as scrubland advances from the surrounding valley sides. The contribution of the footpath network to this change could not help but be significant.

Car Park below Winnats Pass, Derbyshire: Sunday in High Summer

"Man has a great capacity for spoiling the things he loves and strings of parked cars and heaps of litter can so quickly mar the finest landscapes".

(Zetter (1971) p.8)

This picture contrasts with the as yet underused car parks on Waldridge Fell (Plate 12). The price of popularity is very high....... and the Waldridge S.S.S.I. is perhaps fortunate in having no spectacular tourist attraction comparable with the Speedwell cavern and the crags of massive Carboniferous Limestone that lie adjacent to the car park shown on this photograph.

Plate 49

Photographed July 1975.

CHAPTER VI

SUMMARY AND CONCLUSIONS

(i) Pressures on commons and open rough grazing land, particularly those close to urbanised areas, had by the early 1960's created a demand for informal recreation areas that was met by the provision in the Countryside Act of 1968 for grant-aid to Local Authorities seeking to develop Country Parks.

Durham County was one of the first authorities to respond to the provisions of the Act, and Waldridge Fell is its most recently designated Country Park.

(ii) The Fell has had a long history of grazing and extensive trampling which has kept it open heathland since it was first won from the secondary forest growth on the Durham sandstone uplands in the Middle Ages. Refuges for recolonisation by arboreal species lie within the limits of the S.S.S.I. however, and the eastern Fell has closed up with birch-willow scrub in the last 50 years.

(iii) One of the chief objectives of the County Planning Dept. after its assumption of ownership was the preservation of the open moorland landscape; it also intended that use of the Fell should be limited so that the scientific interest of the site and its facilities for quiet enjoyment should be protected.

(iv) This study has monitored the first two years of limited access and it is suggested that tread is now likely to be focussed on a few of the existing paths. Rather than create new paths through difficult heath terrain, the majority of visitors will follow the already efficient routeway network. The most purposeful of the paths will continue to receive the heaviest use and little transgression onto the remainder of the heath is likely. The danger of parts of the Fell becoming under-used and therefore losing their open landscape is real (see below, par. xiii).

(v) Terrain damage was severe on the tracks formerly used as primary routes for motor vehicles and most severe on the wettest sections of those surfaces. The earthworks put up by the County Council to prevent vehicular access to the Fell have proved successful and regeneration is taking place throughout the whole of the trackway system where cars had formerly been driven.

(vi) No major physical conditions seem to be present that could inhibit future growth; trampling pressure appears to be the main factor that has suppressed vegetation regrowth. On steep slopes in excess of 11°, gullies should be regraded, reseeded and the earth compacted to prevent rainwash in the period before the seeds germinate. Because of the coarseness of the sandy soil, compaction cannot inhibit root penetration of young plants.

(vii) Where it is hoped to encourage the spread of coarser heath species, redressing the surface with a humus rich medium should be undertaken without delay; but wear resistant species such as Agrostis tenuis and Festuca rubra seem better able to withstand the competition of heath species on mineral based soils.

(viii) Of the main grass species, the following ranking is observable in their resistance to tread:

Agrostis tenuis -Festuca rubra -Festuca ovina -Nardus stricta. Deschampsia flexuosa on dry 'mor' and Molinia caerulea in wet places both appear to be vulnerable to tread. Wet soils tend to become disturbed by traffic; and Juncus species seem better able to withstand periodic trampling than Molinia. In wetter areas prone to puddling, Poa annua is the most successful grass; it is rare in the true heath.

(ix) Peaty soils are the most easily eroded by heavy traffic and in areas of bilberry or heather where paths have been produced by pedestrian traffic alone, narrow but deeply eroded tracks have resulted. Evidence points to the advantage of cutting back heath to form wider path surfaces: although traffic tends to favour one part of the transect - either the centre or the edge nearest a view - wide paths receive more evenly distributed wear. Wide paths therefore have the best chances of retaining a complete turf cover.

(x) Less intensive tread also encourages a species-rich grassland which enhances the appearance of the paths. In spring and early summer, when the surrounding Calluna heath is still sombre, the predominantly white and yellow flowers of the grassland species, together with the occasional carmine of Vicia angustifolia and red of Rumex acetosella add greatly to the interest of the extensively trampled areas. Later, when the Calluna vulgaris is in full bloom, Campanula rotundifolia adds a complementary pale blue in the grass of the paths.

2 metres of track width should prove sufficient in less frequented areas, and for main paths the track surface should be no less than 3 metres wide.

(xi) Evaluation of the landscape of Waldridge Fell has identified four zones that have the type of terrain and scenery that leisure visitors may seek out in future:

(a) The north western plateau rim

(b) The eastern part of the Fell near Waldridge Hall Farm

(c) The scarp of Wanister Hill

(d) The South Burn and Nettlesworth Hill area.

The two car parks that give access to the northern and eastern zones of scenic diversity are both badly sited; one is small and difficult to enter (it lies on the off-side of the road immediately after a corner on a steep hill) the other has almost inpenetrable terrain behind it - any footpaths near to the east car park lead pedestrian traffic towards the already pressurised Wanister Scarp.

Cutting a new path through the scrub behind the east car park would add to the amenity of that part of the Fell without damaging the ecology.... until 1920, several trackways penetrated the more open heath there.

Other management proposals are suggested on Figure 24. The most significant of these are:

(a) To open a path through the northern *Callunetum* to the varied terrain above Smithy Dene mine from the Tinkler Row car park.

(b) To retrieve similar diversionary paths from William Street car park towards the east.

(xii) It is essential for the retention of the present character of the Fell that pedestrian traffic circulation should be more extensive. Except for very young *Callunetum*, and also

Vaccinium myrtillus and Empetrum nigrum, most of the heath is difficult to penetrate by normal users of the area. The present system of dominant paths is not so satisfactory as a web of minor tracks; the former system tends to be frozen by increasingly inpenetrable senescent heath.

(xiii) To obviate the danger of closure of the Fell landscape by arboreal species, hand removal of seedlings of birch and other trees could be undertaken; burning cannot be satisfactorily undertaken without damage to the specimens selected for retention.

Burning of heather and gorse should be practised on a fifteen year cycle. At present there are approximately 20 hectares of Callunetum, in addition there is an increasingly vigorous pioneer stand in the grass heath close to the Edmondsley road. With due care exerted to prevent the spread of Pteridium aquilinum that excessive burning can encourage in the degenerate Calluna, 5 hectares of the oldest heath could be treated in the first year and thereafter small areas totalling 1 hectare per year should be treated. The resultant vigorous young heath would be less prone to accidental burning than degenerate woody Callunetum and less prome to bracken infestation.

(xiv) It should be pointed out, however, that the present landscape is largely a result of extensive grazing since the Middle Ages that has achieved its present diversity through neglect during the last hundred years.

To reintroduce a burning policy over the remaining 80 hectares of the Fell (away from the Callunetum) would be incompatible with the semi-wooded nature the landscape has now attained. Partial return to a grazing policy would restore some of the equilibrium.

(xv). There are at present 4 or 5 horses grazing the Fell(1) and their selective grazing is probably a negative rather than a positive influence: they graze the main paths and neglect the heath.

Grazing by sheep is now impracticable because of the number of dog-owning visitors to the Fell, but the keeping of a small herd of cattle (over the winter months at least) could be a feasibility. Cattle grids across the three access roads and renewal of the fences in the vicinity of Waldridge Colliery village would be necessary if such a means of management were decided upon. The main water supply of the Fell is close to the Nettlesworth gate and it is this southern area that would most benefit from the grazing activities of the cattle.

The cost of perimeter fencing would probably preclude the reintroduction of deer.

(xvi) Country Parks are still in their infancy and Waldridge Fell is one of the newest but whereas considerable preparatory research was put into ascertaining the need for them, the type of consumer that they would satisfy, and the legal and financial status that the designated areas would enjoy; and whereas the problem of human pressure, particularly vehicular pressure, could be anticipated and the worst effects remedied; the real problem facing the managers of Country Parks is that of maintaining the equilibrium of the vegetation under vastly different circumstances to that which operated during its evolution.

(1) 4 goats were reintroduced to the N.E. shoulder in March 1978

The managers of Waldridge Fell Country Park will need to constantly keep abreast the now growing research on vegetation management of heathland and on recreational ecology - because the semi-natural vegetation of Waldridge Fell S.S.S.I. is an important regional resource.

BIBLIOGRAPHY

1. Adams, I.H. (1976) Agrarian Landscape Terms : a Glossary for Historical Geography I.B.G. (Special pub. No.9) 1976.

2. Bailey, J. (1809) The State of Agriculture in Co. Durham London (1809).

3. Baker-Baker (1826) Durham Yeomanry Cavalry Books 1817-1826 Baker M/S Nos. 66-192 and 66-195 Durham Univ. Dept. of Palaeography.

4. Bannister, P. (1964 (A)) "Stomatal responses of heath plants to water deficits". J. Ecology Vol. 52 (1964) pp. 151-158.

5. Bannister, P. (1964 (B)) "The water relations of certain heath plants with reference to their ecological amplitude" (I;Germination). J. Ecology Vol. 52 (1964) pp 423-432.

6. Bannister, P. (1964 (C)) "Water relations of certain heath plants, II Field studies; III Experimental studies". J. Ecology Vol. 52 (1964) pp 481-509.

7. Barclay-Estrup, P. (1971) "The description and interpretation of cyclical processes in a heath community; III microclimate in relation to the Calluna cycle". J. Ecology Vol. 59 (1971) pp. 143-166.

8. Barrow, G.C. (1977) "Techniques for monitoring recreation use and ecological change". in : Rec. Ecol. Res. Gp. Report on York Conference (Feb.1977) (see also : R.E.R.G., 1976).

9. Bates, G.H. (1935) "The vegetation of footpaths, sidewalks, cart tracks and gateways". J. Ecology Vol. 23 (1935) pp. 470-487.

10. Bates, G.H. (1950) "Trackmaking by man and domestic animals". J. Animal Ecology Vol. 19 (1950) pp. 21-28.

11. Bayfield, N.G. (1971.A) "A simple method for detecting variations in walker pressure laterally across paths". J. Appl. Ecology Vol. 8 (1971) pp. 533-535.

12. Bayfield, N.G. (1971.B) "Some effects of walking and skiing on vegetation at Cairngorm". in: Duffey and Watt (1971) pp. 469-485.

13. Bayfield, N.G. (1973) "Use and deterioration of some Scottish hill paths". J. Appl. Ecology, Vol. 10 (1973) pp. 635-644.

14. Beaumont, P. (1967) "The Glacial Deposits of Eastern Durham" Unpub. Thesis : Ph.D Durham (1967).

15. Bellamy D.J. and Holland P.J. (1966) "Net annual aerial production of Calluna vulgaris" Oikos Vol. 17 (1966) pp. 272–275.

16. Bellamy, D.J. (1970) "Vegetation" (Waldridge) in : Dewdney J.C. (1970) p. 136.

17. Bellamy D.J. and Radforth J and N.W. (1971) "Terrain, traffic and tundra" Nature, Vol. 231 (1971) pp. 429–432.

18. Blacksell M. and Gilg A.W. (1975) "Landscape evaluation in practice – the case of south–east Devon". Trans. Inst. Brit. Geog. No. 66 (1975) pp. 135–140.

19. Board C. et alii (1972) "Leisure and the countryside : the example of the Dartmoor National Park". in : Chisholm M (ed.) Resources for Britain's Future. Pelican : 1972.

20. Bracey, H.E. (1970) People and the Countryside London (1970).

21. Brancher, D.M. (1969) "Critique of K.D. Fines : Landscape Evaluation". Reg. Studies Vol. 3 (1969) pp. 91–92.

22. Brenchley, W.E. (1918) "Buried weed seeds". J. Agric. Science Cambridge, Vol. 9 (1918) pp. 1–31.

23. Bridgewater, P. (1970) "Phytosociology and Community Boundaries of the British Heath Formation". Unpub. Thesis : Ph.D Durham, 1970.

24. British Standards Institution (1967) Methods of Testing Soils for Civil Engineering Purposes. British Standard 1377, H.M.S.O. (1967).

25. Brotherton, D.J. (1973) "The concept of carrying capacity of countryside recreation areas". Rec. News Supplement No.9. (July 1973) pp. 6–11.

26. Burden, R.F. (1969) "The Effects of People on the Nature Trail at Ranmore". Unpub. Thesis M.Sc. Univ. Coll. London, 1969.

27. Burden R.F. and Randerson P.F. (1972) "Quantitative studies of the effects of human trampling on vegetation as an aid to the management of semi–natural areas". Journ. Appl. Ecology; Vol.9 (1972) pp. 439–456.

28. Carlsöö, S. (1962) "A method for studying walking on different surfaces". Ergonomics Vol. 5 (1962) p. 271.

29. Catchpole, A.J.W. (1966) "Climatic Studies in North East England" Unpub. Thesis : Ph.D Durham, 1966.

30. Chester le Street R.D.C. (1939-60) Reports of Committees Bound minutes in District Offices, Chester le Street.

31. Chisholm, M. (1972) Resources for Britain's Future. Pelican (1972).

32. Clapham A.R., Tutin T.G. and Warburg E.F. (1952) Flora of the British Isles. Cambridge (1952). Second Edition 1962

33. Clouston, J.B. et alii (1973) "Ilkley Moor Experimental Restoration Project" The Countryside Commission/Ilkley U.D.C. (1973).

34. Cormack E. and Gimingham C.H. (1964) "Litter production by Calluna vulgaris (L) Hull". J. Ecology Vol. 52 (1964) pp. 285-297.

35. Cotes J.E. and Meade F. (1960) "The energy expenditure and mechanical energy demand in walking". Ergonomics Vol.3 (1960) pp. 97-119.

36. Countryside Commission (1969) Policy on Country Parks and Picnic Sites. London, March 1969.

37. Crofts R.S. and Cooke R.U. (1974) "Landscape Evaluation : A Comparison of Techniques". Un. Coll. of London, Dept. of Geog. Occ. Papers No.25 (1974).

38. Crofts, R.S. (1975) "The landscape component approach to landscape Evaluation". Trans. I.B.G. No.66 (Nov. 1975) pp. 124-129.

39. Croney D., Coleman J.D. and Bridge P.M. (1952) "The Suction of the Moisture held in Soil and other Porous materials". in : - Road Research Tech. Paper (No.24) H.M.S.O. (1952).

40. Dalton R., Garlick J. et alii (1972) Correlation Techniques in Geography. Geo. Philip (1972).

41. Darling, Robt. (1830) "Account of Stock on the Driving Day at Waldridge Common in the Manor of Chester Deanery". Deeds relating to Robert Darling, deceased. (Manuscript) dated July 1830. Durham County Record Office. D/X 106/4.

42. Davidson, D.A., (1976) "Prediction of soil moisture content profiles under impermeable surfaces". 'Area' (I.B.G.) Vol. 8 No.2 (1976) pp. 153-156.

43. Davies, C.T.M. (1968) "Cardiac frequency in relation to aerobic capacity for work". Ergonomics Vol.11 (1968) pp. 511-526.

44. Davies, W. (1938) "Tread on verges". J. Ecology Vol.26 (1938) pp. 38-48.

45. Dewdney, J. (Ed.) (1970) Durham City and County with Teesside British Association, Durham (1970).

46. Duffey, E. (Ed.) (1967) The Biotic Effects of Public Pressure on the Environment. Monkswood Experimental Station; Symposium No.3 (Nature Conservancy, 1967).

47. Duffey, E and Watt, A.S. (1971) The Scientific Management of Animal and Plant Communities for Conservation. Brit. Ecol. Soc. 11th Symposium (Blackwell Scientific, 1971).

48. Durham County Records (1962) Waldridge Infants' School Records 1898-1962. Durham Co. Rec. Office.

49. Durnin, J.V.G.A. and Passmore, R. (1967) Energy, Work and Leisure. Heinemann (1967).

50. Dutt, A.K. (1948) "Puddling and other treatments in relation to soil structure and crop growth". Amer. Soc. of Agronomy Journal Vol. 40 (1948) pp. 324-350.

51. Edholm, O.G., Adam, J.M. and Fox, R.H., (1962). "The effect of work on pulse rate in temperate and hot conditions". Ergonomics Vol. 5 (1962) p.86.

52. Edmond, D.B. (1966) "The influence of animal treading on pasture growth". Int. Grassland Congr. 10 (1966) pp. 453-458.

53. Ekwall, E. (1960) The Concise Dictionary of English Place Names 4th Edn, Oxford (1960).

54. Eliot-Hurst, M.E. (1974) "Micromovement and the Urban Dweller" in : Transportation Geography pp. 482-509 McGraw Hill (1974).

55. Elliott, R.J. (1953) "The Effects of Burning on the Heather Moors of the South Pennines". Unpub. Thesis : Ph.D Sheffield, (1953).

56. Environment, Dept. of : Transport and Road Research Lab. (1973). Soil Mechanics for Road Engineers. London, 9th Imp. (1973).

57. Eyre, S.R. (1968) Vegetation and Soils : A World Picture. Arnold, London, (1968).

58. Fines, K.D. (1968) "Landscape evaluation : a research project in East Sussex". Reg. Studies (1968) pp.41-55.

59. Fribourg, H.A., Overton, J.R. and Mullins, J.A. (1975) "Wheel traffic on regrowth and production of summer annual grasses". Agronomy Journal, Vol. 67 (1975) pp. 423-426.

60. Garbrecht, D., (1971) "Pedestrian paths through a uniform environment". Town Planning Review, Vol.42 (1971) pp. 71-84.

61. George III Act of XXXIV (1794) The Chester Enclosure Award Original Plan (1794) in Dept. of Palaeography. Un. Durham. (Halmote Court Record).

62. George III Act of XLIX (1809) The Framwellgate and Witton Gilbert Enclosure Award. Original Plan (1809) in Dept. of Palaeography, Un. Durham (Halmote Court Record).

63. Gilg, A.W. (1974) "A critique of Linton's method of assessing scenery as a natural resource". Scot. Geog. Mag 90 (1974) pp. 125-129.

64. Gimingham, C.H. (1949) "The effects of grazing on the balance between Erica cinerea (L) and Calluna vulgaris (L) Hull in upland heath, and their morphological responses". J.Ecology 37 (1949) pp. 100-119.

65. Gimingham, C.H. (1972) Ecology of Heathlands. London, Chapman & Hall (1972).

66. Godfree, J.S. (1975) "A Consideration of the Tree Layers in the Peat at Sites in the Northern Pennines". Unpub. Thesis : M.Sc Durham (1975).

67. Goldsmith, Munton, Warren (1970) "The impact of recreation on the ecology and amenity of semi-natural areas; methods of investigation in the Scilly Isles". Biol. Journ. Linnaeus Soc. Vol.2 (1970) pp. 287-306.

68. Goldsmith, F.B. (1974) "Ecological effects of visitors on the countryside". in :- Warren, A. & Goldsmith,F.B. "Conservation in Practice", pp. 217-231; (Wiley, 1974).

69. Grant, S.A. and Hunter, R.F. (1968) "Interactions of grazing and burning on heather moors and their implications in heather management". J. Brit. Grassland Soc. Vol. 23 (1968) pp. 285-293.

70. Gosling, Sir A. (1968) *Report on the Footpaths Committee (3)* Ministry of Housing & Local Govt., Welsh Office. (H.M.S.O. 1968)

71. Green, F. (1977) "Notes on accumulated temperature" Unpublished work: Oxford Un. Dept. of Agric. Science (March 1977).

72. Gregory, R. (1975) *The Cow Green Reservoir* in Smith, P.J. (1975) pp. 144-201.

73. Grubb (1971) "The Mechanism of acidification of soil by Calluna and Ulex....." in Duffey & Watt (1971).

74. Gupta, S.P. (1933) "Reaction of plants to density of soil" J. Ecology Vol. 21 (1933) pp. 452-474.

75. Hair, T.H. (1844) *Coal Mines of Durham and Northumberland - Waldridge Mine c. 1831.*

76. Hammond, E.C. (1967) "Visitor pressure at Wye and Crundale Downs N.N.R." (in Duffey, E. 1967).

77. Harley, J.B. (1975) *Ordnance Survey Maps : a Descriptive Manual* Ordnance Survey, Southampton (1975).

78. Harper, F.C., Warlow, W.J. and Clarke, B.L. (1961) "The forces applied to the floor by the foot in walking:
I level surface
II slope
III on stairs" Res. Papers Nat. Bldg. Stud. 32 (1961).

79. H.M. Government Cmmd. 462 (1958) *Report of the Royal Commission on Common Land 1955-58.* London H.M.S.O. (1958).

80. H.M. Government Cmmd. 2928 (1966) "*Leisure in the Countryside*" London H.M.S.O. (Feb. 1966).

81. Hermansen, L., Vokac, Z. and Lereim, P. (1972) "Respiratory and circulatory response to added air flow resistance". Ergonomics Vol. 15 (1972) pp. 15-24.

82. Hoskins, W.G. (1970) *The Making of the English Landscape.* Pelican (1970).

83. Hubbard, C.E. (1968) *Grasses.* Pelican edn. London (1968).

84. Hunter, R.F. (1954) "The grazing of hill pasture". J. of Brit. Grassland Soc. Vol.9 (1954) pp.195-208.

85. Huxley, T. (1970) *Footpaths in the Countryside.* Countryside Commission for Scotland (Perth, 1970).

86. Jeffreys, H. (1916/17) "The vegetation of four Durham Coal-measures fells". J. of Ecology Vols. 4 & 5 (1916/17).

87. Keble, Martin W. (1969) The Concise British Flora. 2nd Edn 1969/ Sphere (pocket) Edn. 1972.

88. Kershaw, A.P. (1967) "The Investigation of a Lowland Peat Bog in County Durham." Unpub. Thesis: M.Sc Durham 1967.

89. Kozar, A.J. (1964) "Anticipatory heart rate in rope climbing" Ergonomics Vol. 7 (1964) pp. 311-315.

90. LaPage, W.F. (1967) "Some observations on campground trampling and ground cover response". U.S. Dept. Ag. Forest Service Res. papers.(1967) NE 68 pp. 1-11.

91. Leney, F.M. (1974) "The Ecological Effects of Public Pressure on Picnic Sites". Unpub. Thesis : Ph.D Aberdeen, 1974.

92. Liddle, M.J. (1973) "The Effects of Trampling and Vehicles on Natural Vegetation". Unpub. Thesis : Ph.D Un. Wales, 1973.

93. Liddle, M.J. (1975) "A theoretical relationship between primary productivity of vegetation and its ability to tolerate trampling". Biol. Conservation, Vol.8 (1975) pp. 251-255.

94. Liddle, M.J. and Greig-Smith, P. (1975) "A survey of tracks and paths in a sand-dune ecosystem. Part I - soils; Part II - vegetation". J. Appl. Ecology Vol. 12 (1975) pp. 893-930.

95. Linton, D.L. (1968) "The assessment of scenery as a natural resource". Scot. Geog. Mag, 84 (1968) pp. 219-238.

96. Lowday, J.E. and Wells, T.C.E. (1977) The Management of Grassland and Heathland in Country Parks. Countryside Commission (May 1977).

97. Lutz, H.J. (1945) "Soil conditions of picnic grounds in public forest parks". J. Forestry 43 (1945) pp. 121-127.

98. McClintock, D and Fitter, R.S.R (1955) Guide to Wild Flowers Collins (1974).

99. MacGregor, D.R (1957) "Some observations on the Geographical significance of slopes". Geography No.197, Vol. 42 (1957) pp. 167-173.

100. Mancey, D. (1972) "Ecological Studies of a Country Park subjected to Public Pressure". Unpub. Thesis : M.Sc Durham, 1972.

101. Manley, G. (1935) "Some notes on the climate of north-east England". Quart. J. of Royal Met. Soc., Vol.61 (1935) pp. 405-410.

102. Manley, G. (1941) "The Durham meteorological record 1847-1940" Quart. J. of Royal Met. Soc., Vol.67 (1941) pp. 363-380.

103. Mawer, A. (1920) The Place-names of Northumberland and Durham Cambridge (1920).

104. Miller, G.R. and Miles, J (1970) "Regeneration of heather (Calluna vulgaris (L) Hull) at different ages and seasons in N.E. Scotland". Journ. Appl. Ecology Vol.7 (1970) pp. 51-60.

105. Millman, R (1970) "Outdoor Recreation in the Highland Countryside". Unpub. Thesis : Ph.D Aberdeen, 1970.

106. Ministry of Agriculture, Fisheries and Food (1964) Bulletin 165 : 'The Farmers' Weather'. London, H.M.S.O. (1964).

107. Ministry of Housing and Local Govt. (1968) "The Countryside Act, 1968: Circular 44168. London H.M.S.O. (August 1968).

108. Mitchell, C. (1973) Terrain Evaluation. Longman (1973).

109. Murray, A.C. (Ed.) (1967) Methods of Landscape Analysis: Landscape Res. Group Symposium (May 1967). Manchester (Oct. 1967).

110. Nicholson, I.A., Paterson, I.S. and Currie, A. (1970) "A study in vegetational dynamics : selection by sheep and cattle in Nardus pasture". in : Watson (1970) pp. 129-143.

111. Norcliffe, G.B. (1977) Inferential Statistics for Geographers Hutchinson (1977).

112. O'Connor, K.F. (1956) "Influences of Treading on Grasslands" Unpub. Thesis : Ph.D Cornell, 1956.

113. Oomes, M.J.M and Elberse, W.Th. (1976) "The germination of six grassland herbs in micro-sites with different water contents". J. Ecology Vol.64 (1976) pp. 745-755.

114. Ordnance Survey (1857) County Sheets. 1 : 2,500 Sheets XII. 16 and XIX. 4 (First Edition, surveyed 1855-57).

115. Ordnance Survey (1861) County Series: 1 : 10,560 Sheets VI, VII, XII, XIII, XIX, XX, XXVI, XXVII. (1st Edition, surveyed 1857).

116. Ordnance Survey (1896) County Sheets. 1 : 2,500 Sheets XII. 16 and XIX. 4 (Second Edition, Surveyed c. 1893).

117. Ordnance Survey (1920) County Sheets. 1 : 2,500 Sheets XII. 16 and XIX. 4 (Third Edition, revision of 1920).

118. Ordnance Survey (1961) National Grid series. 1 : 2,500 Sheets NZ 2449, 2549 (Revision of 1960).

119. Ordnance Survey (1972) 1 : 25,000 Sheets NZ 24/34
25/35
26/36
(Second series, revision of 1966-70)

120. Ordnance Survey (1976) 1 : 50,000 Sheet 88 (Revision of 1973).

121. Patmore, J.A. (1970) Land and Leisure. London (1970).

122. Peak Park Joint Planning Board (1974) "The Peak District National Park : Structure Plan - Report of Survey". Bakewell, 1974.

123. Penning-Rowsell, E.C. (1975) "Constraints on the application of landscape evaluations". Trans. I.B.G. No.66 (Nov. 1975) pp. 149-155.

124. Penning-Rowsell, E.C. and Searle, G.H. (1977) "The "Manchester" landscape evaluation method - A critical appraisal". Landscape Research Vol. 2 No.3 pp. 6-11 Manchester (1977).

125. Perring, F.H. (1967) "Changes in chalk grassland caused by galloping". In : The Biotic Effects of Public Pressure on the Environment. see Duffey (1967) pp. 134-142.

126. Prebble, J. (1963) The Highland Clearances. Penguin Edn. (1969).

127. Proctor, R.R. (1933) "Fundamental principles of soil compaction". Eng. News Record, Vol.9 (1933) pp. 245-248.

128. Poore, M.E.D. and McVean, D.N. (1957) "A new approach to Scottish mountain vegetation". Journ. Ecology 45 (1957) pp. 401-439.

129. Raine, J. (1828) St. Cuthbert. Durham 1828.

130. Raistrick, A. and Blackburn, K.B. (1931) "The late-glacial and post-glacial periods in the North Pennines; III : the post-glacial peats". North Nat. Union Trans. (1931) pp. 79-102.

131. Ralston, H.J. and Lukin, L. (1969) "Energy levels of human body segments during level walking". Ergonomics Vol. 12 (1969) pp. 39-46.

132. Randerson, P.F. (1969) "A Quantitative Investigation of the Effects of Public Pressure". Unpub. Thesis : M.Sc (conservation) Un. Coll. London, 1969.

133. Raunkiaer, C. (1913) see Raunkiaer (1934) "Life forms of Plants..."

134. Raunkiaer, C. (1934) The Life Forms of Plants and Statistical Plant Geography. pp. 303-342 "Plant formations on Skagens Odde". Eng. Trans. Oxford (1934).

135. Recreation Ecology Research Group (1976) Personal notes made during York conference 23.10.76 (see Barrow, 1977).

136. Road Research Technical Papers (1952). No. 15 Soil survey procedure
No. 17 Compaction of soils
No. 24 Suction
No. 33 Compaction
London, H.M.S.O. (1952).

137. Rogers, J.A. and King, J. (1972) "The distribution and abundance of grassland species in hill pasture in relation to soil aeration and base status". J. Ecology Vol. 60 (1972) pp. 1-18.

138. Rosenberg, N.J. (1964) "The response of plants to the physical effects of soil compaction". Adv. Agronomy, Vol. 16 (1964) pp. 181-196.

139. Royal Society of Arts (1965) "Outdoor Recreation : Active and Passive" - The Countryside in 1970. (Second conference of Study Group No.6). London (1965).

140. Russell, E.W. (1973) Soil Conditions and Plant Growth 10th Edn. Longmans (1973).

141. Rutley, K.S. and Mace, D.G.W. (1972) "Heart rate as a measure in road layout design". Ergonomics Vol. 15 (1972) pp. 165-173.

142. Shantz, H.L. (1917) "Plant succession on abandoned roads in eastern Colorado". Journ. Ecology 5 (1917) pp. 19-34.

143. Sharkey, B.J. McDonald, J.F., and Corbridge, L.G. (1966) "Pulse rate and pulmonary ventilation as predictors of human energy cost". Ergonomics Vol. 9 (1966) pp. 223-227.

144. Smith, D.M. (1975) Patterns in Human Geography. David & Charles (1975) (Penguin Edn. 1977).

145. Smith, D.R. (1967) "An Investigation to study the Movement and Distribution of Subgrade Moisture Conditions". Unpub. Dissertation : B.Sc. Dept. of Civil Eng. Sunderland Poly., 1967.

146. Smith, K. (1970) "Climate and Weather". in : Dewdney, J.C. (1970) pp. 58-74.

147. Smith, P.J. (1975) The Politics of Physical Resources Penguin (1975).

148. Streeter, D.T. (1971) "The effects of public pressure on the vegetation of chalk downland at Box Hill". in : Duffey & Watt (1971) pp. 459-468.

149. Surtees Society (1852) <u>Boldon Buke</u>. Vol. 25 (1852).

150. Surtees Society (1856) <u>Bishop Hatfield Survey</u>. Vol. 32 (1856)

151. Surtees Society (1972) <u>Parliamentary surveys of the Bishopric of Durham</u>. Vol. 185 (1972).

152. Tandy, C.R.V. (1971) "Landscape evaluation" – A revision of 1967 paper in <u>Murray (1967)</u>. Land. Res. Gp. Symposium.

153. Tandy, C.R.V. (1975) "The isovist method of landscape survey". Reprint pamphlet July 1975 C.R.V. Tandy/London SW6 5UL. <u>See Murray (1967) pp. 9-10</u>.

154. Tanner, C.B. and Mamaril, C.P. (1959) "Pasture compaction by animal traffic". Agronomy Journal Vol.51 (1959) pp. 329-331.

155. Tansley, A.G. (1939) <u>The British Islands and their Vegetation</u> Cambridge (1939).

156. Taylor, C. (1975) <u>Fields in the English Landscape</u>. Dent (1975).

157. Thayer, R.L. et al. (1976) "Validation of a natural landscape preference model as a predictor of perceived landscape beauty". J. of Leisure Res. Vol.8 (1976) pp. 292-299.

158. Thomas, A.S. (1960) "The trampling animal". Journ. Brit. Grassland Soc. Vol. 15 (1960) pp. 89-93.

159. Thomas, W.A. (1971) <u>Indicators of Environmental Quality</u> Philadelphia (1971).

160. Thorpe, H. (1949) "The Green Villages of County Durham". Transactions of the Inst. of Brit. Geographers (1949); pp. 153-180.

161. Tinsley, H.M. (1975) "The former woodland of the Nidderdale moors (Yorkshire) and the role of early man in its decline". Journ. Ecol. Vol. 63 (1975) pp. 1-26.

162. Turner, J. and Kershaw, A.P. (1973) "A late and post glacial pollen diagram from Cranberry Bog near Beamish, County Durham". New Phytologist Vol. 72 (1973) pp. 15-28.

163. University of Durham Observatory (1896) <u>Meteorological Data 1896-1976</u>. Unpublished Log books.

164. Unwin, K.I. (1975) "The relation of observer and landscape in landscape evaluation". Trans. I.B.G. No.66 (Nov. 1975) pp. 130-134.

165. Wagar, J.A. (1964) "The carrying capacity of wild lands for recreation". Forest Sci. Monograph No.7 (1964) pp. 1-24.

166. Wager, J. (1967) "Outdoor recreation on common land". Journ. of the Town Planning Inst. Vol. 53 (1967) pp. 398-403.

167. Ward, S.D., Perkins, D.F, Goodier, R, and Jones, A.D. (1970) "The use of aerial photography for vegetational mapping and vegetational interpretation". in : Goodier R. (ed.) The Application of Aerial Photography to the work of the Nature Conservancy. (1970).

168. Watson, A. (Ed.) 1970 Animal Populations in Relation to their Food Resources : Brit. Ecol. Soc. Symposium No. 10. (1970).

169. Watt, A.S. (1947) "Pattern and process in the plant community". Journ. Ecology No. 35 (1947) pp. 1-22.

170. Watt, A.S. (1955) "Bracken versus heather, a study in plant sociology". Journ. Ecology Vol. 43 (1955) pp. 490-506.

171. Wheeler, B.D. (1975) "The woodlands of the South Burn Valley" (The vegetation of Waldridge Fell, Co.Durham No.1). Vasculum Vol. 60 (1975) pp. 34-46.

172. White, J. (1971) "The Management of Country Parks" Unpub. Thesis : Ph.D Cambridge, 1971.

173. Witsell, L.E. and Hobbs, J.A. (1965). "Soil compaction effects on field plant growth". Agronomy J. Vol. 57 (1965) pp. 534-537.

174. Wong, M.H. (1973) "Soil Fertility as a Parameter in Land Evaluation of Moorland; Waldridge Fell : Co. Durham" . Unpub. Thesis : Ph.D Durham, 1973.

175. Zetter, J.A. (1971) The Evolution of Country Park Policy. (Countryside Commission, 1971).

APPENDICES

Appendix A.1

Earliest names of parishes and settlements contiguous to or within 10 km of Waldridge Fell

(based on Ekwall (1960) "Concise Dictionary of English Place Names" and on Mawer (1920) "The Place-names of Northumberland and Durham".

Columns refer to points as follows:

1. Present place name.
2. Earliest recorded spelling and other significant spellings.
3. Date of first recorded reference to the place.
4. Translation or probable meaning (underlined based on Ekwall).
5. Entry in Boldon Buke (B) or Hatfield Survey (H) referring to hunting or 'leisure' interests in surrounding waste (see Appendix A.2); (Phys) indicates names of a land-mark nature, (Agr) implies major clearing had already taken place.
6. Six figure reference on O.S. grid (NZ sheets).

Suffixes commonly used

-LEAH (LEY) : meadow, pasture or arable land where the forest has been cleared away

-WORTH : an enclosed homestead (used mainly for small clearings or 'intakes' from waste or forest)

-TON : farmstead (often a large nucleation of buildings)

-PETH : a holloway or deeply rutted routeway (implies concentrated pressure in difficult terrain e.g. a steep road or 'path').

1.	2.	3.	4.	5.	6.
Waldridge	Walrigge	1297	Cultivated "rigs" by the boundary wall	(Agr)	257497
Edmondsley	Edemennesleye	1190	LEAH of the shepherd (ede = flock of sheep)		232488
Nettlesworth	Nettelworth Netrehworth	1312 1297	Personal - WORTH Mawer 'nettle' (dub.)		250488
Plawsworth	Plausword Plauworth	1180 1297	'Play enclosure'	B.H.	263479
Chester-le-Street	Cuncaceastre	1050	(Roman CONCANGIUM)		275513
Tribley	Tribleia	1180	(? meaning) - LEAH	B.H.	240510

1.	2.	3.	4.	5.	6.
Aldin Grange	Aldingrig	1170	Ealda's "RIG"	(Agr)	246430
Aykley Heads	-	-	Oak-clearing		264438
Beamish	Bellus Mansus	1251	Beautiful mansion	(Hunt?)	212550
Bear Park	Beau repeyr	1267	(A country retreat)	(Hunt?)	243438
Birtley	Britleia	1180	Bright-LEAH	B.H.	274565
Brandon	Braindune	1190	Wild boar's hill?	(Phys)	232401
Broom	Brom	1153	Broom trees	(Phys)	235426
Broomy Holm	Broomywhome	1326	Broom covered 'holm' Hwamm = steep sided, but broad floored valley or "corner"	(Phys)	236503
Causey	Kaldeset	1277	Cold saetr	(Agr)	209560
Durham	Dunholm	995	?		273423
Esh	Esse	1196	Ash tree	(Phys)	198439
Finchale	Finkale	1190	Finch-Haugh Haugh = land in river bend	(Phys)	297470
Findon	Fyndon	1315	Hill with heap of wood	(Phys)	245460
Flass	Flass	1313	Marshy place	(Phys)	205425
Frankland	Frankleyn Park	1441	(A country retreat)	Hunt	285443
Hedley	Hedlay	1382	Clearing overgrown with heather		220560
Holmside	Holneside Holmeset	1214 1382	Slope with holly trees	B.H.	205497
Kibblesworth	Kybbleswurth	1185	Personal-WORTH		245468
Kimblesworth	Kymliswrth	1216	Personal-WORTH		256462
Kyo	Kyhou	1200	Cow pasture hill	(Agr)	175527
Lambton	Lambton	1421	TON where lambs kept	(Agr)	287525
Lamesley	Lamelay	1297	Lambs - LEAH		250578
Lanchester	Lanceastre	1180	(Roman LONGOVICIUM)	B.H.	167475
Langley	Langleiam Langeleye	1190 1232	LONG - LEAH		210467
Lumley	Lummalea	1050	LEAH by the pools	(Phys)	290491
Marley	Merleia	1190	Boundary clearing	(B)	206575
(cf. also Morley Heads, Plawsworth)					
Newton	Newton	1345	i.e. 'New' since Boldon Buke	(Agr)	280450
Ousterley	Houstre	1369	"House-tree" N.B. not a LEAH until late 15th century	(Phys)	209508
Ouston	Ulkestan	1328	Personal-TON	(Agr)	260545

1.	2.	3.	4.	5.	6.
Pelton	Pelton	1312	Personal-TON	(Agr)	250531
Pockerley	Pokerlege	1242	Goblin's - LEAH	(Phys)	222545
Ravensworth	Raeveneswurthe	1104	Personal-WORTH		231577
Sacriston Heugh	Segrysteyn Hogh	1312	Sacriston of Durham's HEOH (Hill)	(Phys)	234481
Sniperley	-	-	?		255445
Stanley	Stanley	1297	Rocky - LEAH		198537
Stobbilee	Stubbileia	1292	Stob = Stump of tree		215455
Stockley	-	-	Stood = trunk of tree		275465
Tanfield	Tamefeld	1175	Field by R.Team	(Agr)	187555
Twizell	Tuisela	1180	Fork of rivers O.E. tongue of land	(Phys)	219519
Urpeth	Urpathe	1297	Bison's - path	B.H.	238540
Ushaw	Ulveskahe	1200	Wolves wood	(Phys)	217436
Usworth (Gt. & Little)	Usworth	1180	Personal-WORTH	B.	313588
Warland	Warlandes	1311	?		215488
Washington	Wassyngtonam	1180	Hunters - TON O.E. Wapsige	B.H.	310566
Wheatley (Green)	Wetley	1311	-LEAH where wheat grown		192493
Whickham	Quicham	1197	-HAM (farm) with Quickset (thorn) hedge	(Agr)	209613
Witton Gilbert	Wyttone	1275	Woodfarm		235453

Appendix A.2

Entries in Boldon Buke (1180) or Hatfield Survey (1345) showing forest service or keeping of hunting dogs:

Holmside: (Langley)	"i hominem in forestra xl diebus in fownyson et xl diebus in ruyth". (i.e. 80 man-days forest service tending deer in fawning and rutting seasons).

Greyhounds were kept at the following Halls:

	1180	1345
Marley	1	?
Gt. Usworth	2	0
Little Usworth	2	0
Washington	2	2
Birtley with Tribley	2	2
Lanchester	2	?
Plawsworth	2	2
Urpeth	2	?

The evidence of these two lists suggests that major inroads had been made into the forest along the Tyne and along the Browney valley to the west of Durham (Lanchester - Witton Gilbert) but hunting was still important, and wasteland extensive along the Team and its tributaries, and along the Cong Burn.

Appendix A.3

An order concerning the prohibition of the burning of heather and gorse (c.1400)

"No maner person ne persons bryne ne more(1) fro the 16th day of March unto the fyrst day of Octobre, accordyng to the lawe and custome of this realme of long tyme used. And yf any person or persons bryne any more or whynnys(2) at any tyme fro this ordenans be publyshed, be it man, woman or chyld of what age soever he or they be .... he or she yf fownd gilty, to be comytt to pryson .... theyre to remane and abyde my sayd lordis pleasour."

Source p. xii
Surtees Society No.32 (1856)
Bishop Hatfield Survey

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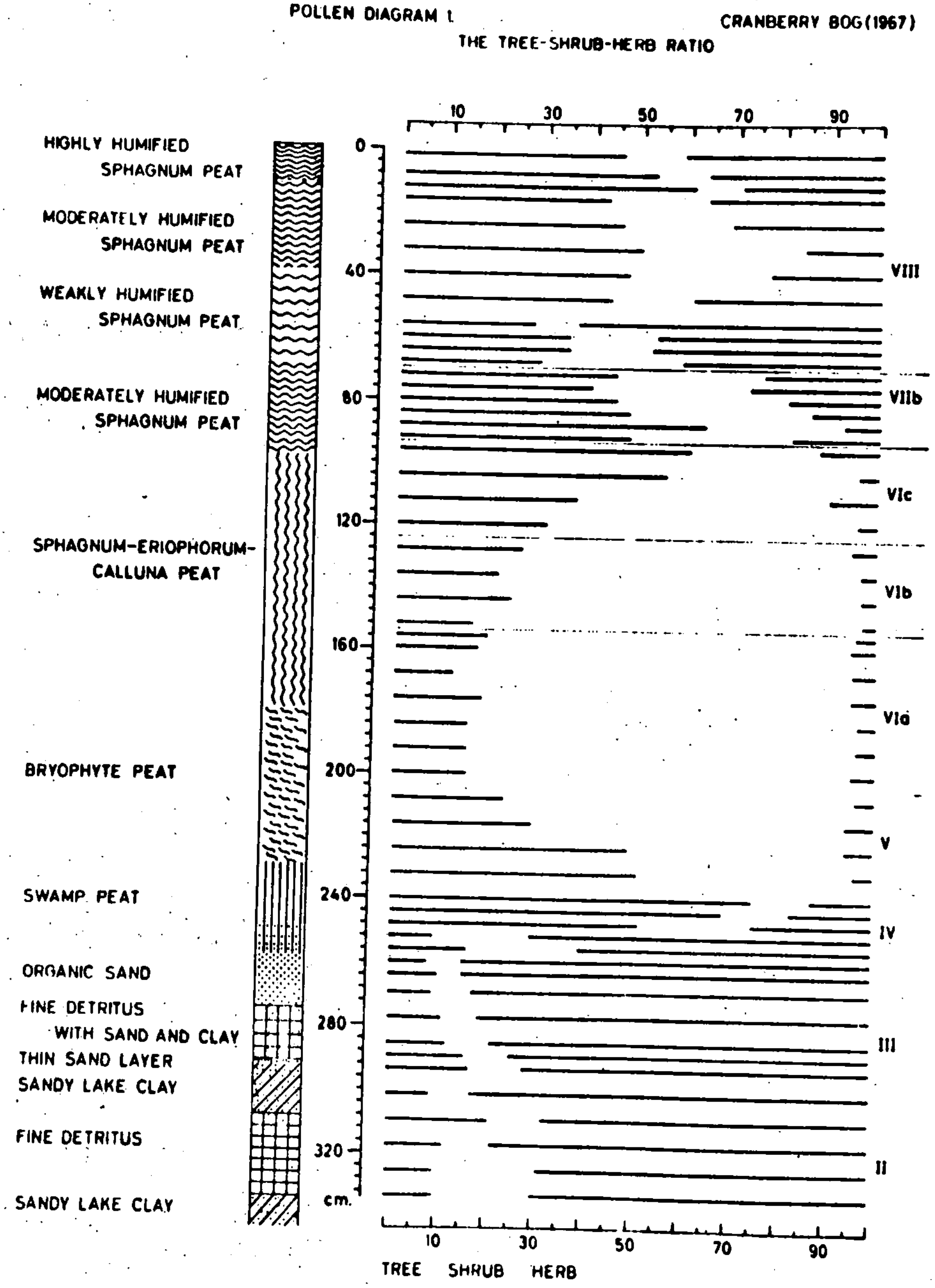
(1) more = heather (cf. moor)

(2) whynnys = gorse (cf. whin)

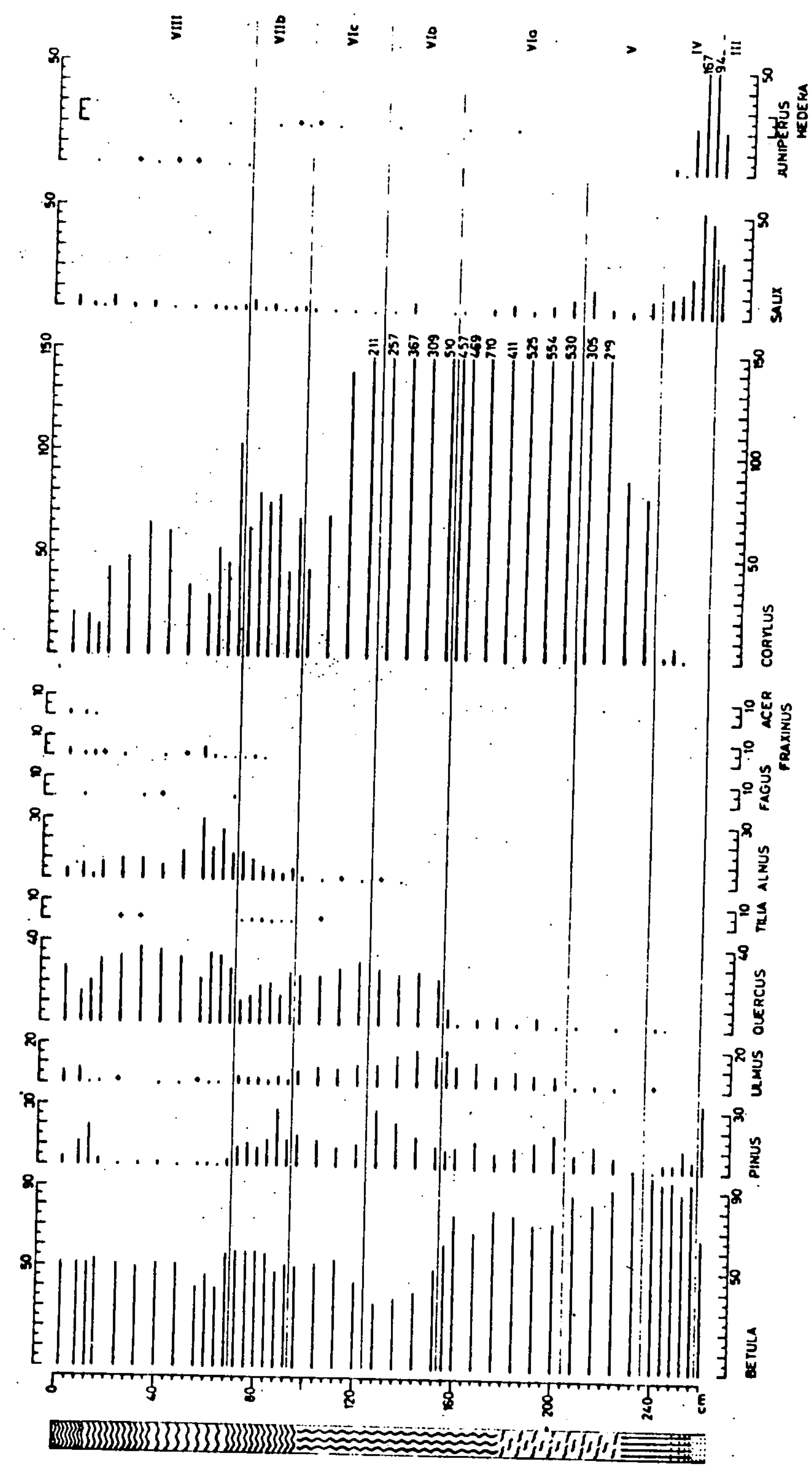
Appendix A.4



Pollen diagrams of prehistoric forest associations in County Durham.

Reproduction by permission of Peter Kershaw, Monash University. (Ref. Kershaw(1967))

POLLEN DIAGRAM 2 POST-GLACIAL TREE AND SHRUB VALUES (as percentages of total tree pollen) CRANBERRY BOG (1957)



Appendix B.1

Deeds relating to Robert Darling (deceased)(1830)
Durham County Record Office: Bundle D/X 106/4

Dated July 1830:
From Bailiff James Middleton:

Account of Stock on the Driving Day at Waldridge Common in the Manor of Chester Deanery.

Copyholder etc.	Beasts		Sheep
Thos. Coward			47
John Hislop			41
Wm. Murray			15
Robt. Darling			52
Ralph Cowel			26
Robt. Turner			31
Wm. Adamson	2 cows	2 Ass	29
Jos. Dickinson		3 Ass	24
Thos. Robson			13
			Horned Cattle
Mrs. Taylor			26 Kyloes*
Mrs. Nixon	4 horses		3
Mrs. Owens			4
Wm. Foster			2

* A small breed of hill cattle important in the 18th century in N. England.

Footnote: This totals: 41 large animals, 5 medium, 278 sheep; on approximately 100 hectares: equivalent of 4 sheep per hectare.

Appendix B.2

Mining activities on Waldridge Fell: Information supplied by N.C.B. Surveyors' Dept. (T.V.T.E.)

N.C.B. Shaft No. (if applicable)	Map Ref.	Name of Pit (etc.)	Date of closure or removal
1	A-8	Crosby	1820-1840
2	B-6	Hylton	1820-1840
135	AA-3	-	c.1830
136	AA-3	High Pit	before 1846
10	C-4	Ellen Pit	1830-1840 (reworked 1898-1900)
8	B-3	-	c. 1820
9	B-1	-	1830-1840
12	C-8	-	1831-1846
13	D-8	William Pit	1831-1846
15	E-5	-	1831-1846
16	E-4	George	1831-1846
106	D-01	Smithy Dene	
112	F-2	Drift mine	late 1940's
113	F-2		
-	I-01	Nettlesworth 'A' Pit (sunk c.1840)	1894
-	D-4	Tinkler Row cottages	(demolished 1920-1940)
34	0-5	Nettlesworth 'B' Pit (Sunk 1861)	1896-1919 (filled in 1958)
49-54	E/F-10 & E-11	South Burn and Beech wood Drift mine	1954
164	AA-7	Waldridge 'A' Pit (Sunk 1831)	1920-1940
3	B-9	Waldridge 'D' Pit (Sunk 1876)	1963 (filled in 1970)
4			
5	B-10		
-	B-7	Hylton Street	(demolished 1955)
-	C-6	Ellen Street Built 1876-1890	(demolished 1920-40)
-	C-8	William Street	
-	CC-3	Nettlesworth Dene Drift (Sunk 1952)	1974
-	C-02	Smithy Dene Drift (Sunk 1915-1940's)	Still in private working, 1977

Appendix B.3

Chester-le-Street R.D.C. minutes 1949-59

F. Reports by the fire officer to the Health, Cleansing and General Purposes Committee.

(These reports are chosen as representative of the period 1934-1974, prior to local government reform; listed are all reported separate actions by the Fire Brigade that involved fires on common land, or on large areas of open countryside. The importance of these fires in slowing the spread of gorse and probably tree regeneration is great. Heather seems to have been little affected. Proximity to new housing developments of the day is a factor influencing the incidence of fire outbreaks).

G. Reports to the same committee concerning public health and amenity. They are included as the only references to grazing on the Fell in the 1950's but also show the growing concern for the Fell as an AMENITY. 1957 in particular is confirmed as the beginning of pitfall problems and measures taken to improve the visual quality of the edges of the Fell.

H. Housing Committee reports confirming the abandonment of the last inhabited houses on the Fell and the reversion of the pond area to heath grassland.

Date	Code	Contents of minute
May 1949	F	Grassfire: Dene between Pelton and Waldridge
July 1949	F	Gorse (50 x 40 yds.): Silver Hill, Ravensworth
Sept. 1949	F	Grass & Gorse: Waldridge Fell
		Grass: Silver Hill
		Grass & Heather: Waldridge Fell
		Grass: Silver Hill
		Undergrowth: Silver Hill
		Grass: Blackburn Fell (Tinkler Fell)
		Gorse & trees: Silver Hill
		Grass & Gorse: Beamish forge woods
		Grass & Gorse: Waldridge Fell
		Bracken & Grass: Silver Hill
		Grass & underbush: Lamesley wood (Long Acre farm)
		Bracken: Square wood, Lamesley

Date	Code	Contents of minutes
Nov. 1949	G	Concern about horses straying on Fell
July 1950	F	An area of rough growth: Ravensworth woods
		Bracken: Silver Hill, Ravensworth
June 1951	F	Grass: Beggars wood, Lamesley
		Grass & woodland: Square wood, Lamesley
		Grass & Gorse: nr. West Farm, Waldridge
July 1951		Gorse: Waldridge Fell
		Grass & Gorse: Blackfell, Birtley
Oct. 1951	G	"The clerk was instructed to take up forthwith with the superintendant of Police the question of horses straying on Waldridge Fell."
June 1952	F	Grass & Woodland: Long Acre, Lamesley
		Grassland: Ravensworth Park
July 1952	F	Grass & woodland: Long Acre woods
		Grass & undergrowth: Ravensworth Park
		Grassland: Ravensworth Park
Sept. 1952		Grass & Gorse: Black Fell, Birtley
		Grass: Square wood, Lamesley
		Grass & Heather: Waldridge Fell
		Grass & Gorse: Waldridge Drift (Smithy dene)
Oct. 1952		Heathland: Ravensworth woods
		Gorse & rough grazing: Ravensworth woods
April 1953	F	Gorse & undergrowth: Ravensworth woods
		Grass: Lamesley woods
May 1953	F	Grass & Broom: Birtley Fell
		Brushwood: Ravensworth wood
June 1953		Grass & trees: Silver Hill
		Grass & bushland: Waldridge bankfoot
		Grass & bushland: Waldridge Fell, nr. Stables
Oct. 1953	H	Minute 5: "Resolved that the occupants of the last remaining properties on Hylton Street (namely 3, 5, 7, 9, 10, 12, 14) be rehoused before the coming of winter."
Apr. 1954	F	Grass: Fell edge drift mine, Waldridge
Oct. 1954	F	Gorse & scrub: The Blackings, Eighton Banks
May 1955	F	Gorse & Grass: Near 'D' Pit, Waldridge
		Grass: Waldridge Fell; near 'D' Pit
July 1955	F	Grass & Gorse: Eighton Banks

Date	Code	Contents of minutes
Sept. 1955	F	Grass & Gorse: Eighton Banks
		Grass: Eighton Banks
Oct. 1955	F	Grass: Eighton Banks
		Grass: Beamish forges
Nov. 1955	F	Grass: Waldridge Fell
		Gorse: Waldridge Fell
		Gorse: Eighton Banks
May 1956	F	Grass: near Waldridge Pit
		Grass: Square wood, Lamesley
		Grass & Gorse: The Dene, Waldridge Fell
		Gorse: Sacriston woods
		Grass & Gorse: Waldridge Fell
June 1956	F	Grass & Gorse: Waldridge Fell
		Grass: near Waldridge Club (N. part of Fell)
		Grass: near Waldridge Lane School
		Grass: Square wood, Lamesley
July 1956	F	Grass & Gorse: Waldridge Fell
		Grass, small area: Eighton Banks
April 1957	G	"Concern about pitfalls on Waldridge Fell paths" (probably path C)
July 1957	F	Grass & Undergrowth: Waldridge Fell
		Undergrowth: Ravensworth woods
Oct. 1957	F	Gorse & bracken (50 sq. yards): Waldridge Fell
Nov. 1957	G	"Write to N.C.B. over state of tipping on the spoil heap at Waldridge"
Jan. 1958	G	"Agree to take over and maintain the bus shelter at Waldridge"
Nov. 1958	G	"Agree to improve the state of Smithy Dene limiting tipping of refuse"

Appendix B.4 Car ownership in the Tyne/Wear area (Co. Durham): 1971

Abstracted from Census of England and Wales

Table I "Enumerated households and persons by number of cars available to households"

	Total car-owning households	Av. people per household	% of households with no car	No. of people per car	INDEX of car ownership (England & Wales=1.0)
Chester-le-Street R.D.*	6,965	2.93	56.26	5.95	0.86
Chester-le-Street R.D.*	3,310	2.79	54.50	5.42	0.88
Durham M.B.	3,770	2.77	50.78	4.84	0.95
Durham R.D.*	6,310	2.94	52.77	5.43	0.91
Houghton-le-Spring	4,405	2.93	60.28	6.66	0.80
Washington	3,305	3.00	60.51	6.86	0.80
Boldon	4,110	2.95	48.85	4.74	0.99
Sunderland	23,630	3.00	66.68	8.12	0.72
Gateshead	9,185	2.87	71.71	9.22	0.67
Felling	4,065	3.04	68.00	8.81	0.71
Hebburn	2,165	3.04	71.75	10.04	0.67
Jarrow	2,650	3.08	71.43	9.95	0.67
South Shields	9,745	2.82	72.20	9.20	0.68
Hetton-le-Hole	1,955	2.86	66.70	7.75	0.72
Tyneside Conurbation	94,645	2.85	65.87	7.42	0.73
N.E. Durham towns	85,570	-	-	-	-
England and Wales	n.a.	2.86	48.17	4.60	1.00

* Contiguous to Waldridge Fell

Appendix C.1 Severity of Winters: Summary of Climatic data in the record books of Durham University Observatory

1. These records were recorded in ^{o}F until after 1960, the figures listed below are conversions to centigrade.

2. 'Winter' is taken to be the months where the mean monthly temperature is 5.4°C or less (5.5°C being taken as the threshold temperature for lowland plants). In most years this threshold temperature is no longer reached from the early part of November and not until late April does the daily mean exceed 5.5°C. Thus 'winter' is taken to be the six months November - April.

3. 'Spring' is normally taken to be the three months beginning at the vernal equinox; but for the purposes of this study, aimed at assessing the severity of winter, the period covering the end of winter and ending before the summer solstice is taken to be 'spring', i.e. March-May inclusive. During this period the early growth of bracken and heather is initiated. The higher the mean temperature above 5.5°C, the milder is the spring.

4. Finally, the length of the winter (or coldness of spring) can be assessed by the lateness or otherwise of the last air frost. Grass minimum may fall below freezing point on still clear nights when air temperatures are some degrees above freezing point; in practice it was found that only a few days separated the last 'ground' frost and the last air frost. The lateness of frost was noted by date for each year for the 20 years before 1916 and expressed as a day number; e.g. May 27 is normally day 147.

The main details are presented in Figure 9.

Year	Spring mean °C	5 yearly mean °C	Day of last frost	Winter mean °C	5 yearly mean °C	5 yearly annual mean °C
1886/87	5.8	6.3	n.a.	3.3	3.9	7.7
1887/88	5.5			3.5		
1888/89	5.6			3.3		
1889/90	7.1			4.5		
1890/91	7.3			4.8		
1891/92	5.4	6.8	n.a.	3.3	3.9	7.9
1892/93	5.9			3.3		
1893/94	8.6			4.5		
1894/95	6.9			4.9		
1895/96	7.5			3.5		
1896/97	8.2	6.8	125	5.4	4.8	8.6
1897/98	6.3		147	4.1		
1898/99	6.6		147	5.5		
1899/1900	6.4		147	5.1		
1900/01	6.5		133	3.9		
1901/02	7.1	6.9	142	4.9	4.6	8.2
1902/03	6.5		134	4.1		
1903/04	6.8		132	5.2		
1904/05	7.0		141	4.2		
1905/06	7.2		129	4.7		
1906/07	6.4	6.7	142	4.4	4.3	8.2
1907/08	7.0		143	4.7		
1908/09	6.6		115	4.2		
1909/10	6.7		135	4.1		
1910/11	7.0		131	4.2		
1911/12	7.4	7.4	132	4.4	5.0	8.4
1912/13	8.0		136	5.1		
1913/14	7.1		103	4.8		
1914/15	7.8		109	5.8		
1915/16	6.8			4.7		

Year	Spring mean °C	5 yearly mean °C	Day of last frost	Winter mean °C	5 yearly mean °C	5 yearly annual mean °C
1940/41	5.8	7.6	n.a.	3.3	4.6	8.3
1941/42	6.7			3.7		
1942/43	8.5			5.5		
1943/44	7.9			5.2		
1944/45	9.1			5.4		
1945/46	7.8	7.9	n.a.	5.6	5.2	9.1
1946/47	7.0			3.5		
1947/48	8.5			5.8		
1948/49	8.4			5.8		
1949/50	7.7			5.4		
1950/51	5.8	7.3	n.a.	3.6	4.5	8.6
1951/52	8.8			5.2		
1952/53	8.1			4.6		
1953/54	7.1			4.8		
1954/55	6.6			4.2		
1955/56	7.1	7.6	n.a.	4.0	4.8	8.3
1956/57	8.3			5.7		
1957/58	6.0			4.2		
1958/59	8.8			4.9		
1959/60	8.2			5.1		
1960/61	6.2	6.6	n.a.	No record	3.8	7.7
1961/62						
1962/63						
1963/64						
1964/65	7.0					
1965/66	7.2	6.9	n.a.	3.5	4.0	8.2
1966/67	7.5			5.2		
1967/68	7.2			4.4		
1968/69	6.0			3.7		
1969/70	6.9			3.3		
1970/71	7.2	7.3	n.a.	5.1	5.1	8.6
1971/72	7.6			5.3		
1972/73	7.5			5.1		
1973/74	6.9			4.7		
1974/75						

Appendix C.2 Terrain denudation and substrate damage on principal tracks (May 18, 1976)

Ellen Street - south

Distance metres	Cover denuded	Substrate damage
15	5	5
30 (E.1)	5	5
45	3	5
60 (E.2)	5	5
75	4	5
90	5	5
105	5	5
120 (E.4)	2	5
135	5	5
150	5	5
165	5	5
180 (E.6)	4	4
195	3	4
210 (E.7)	5	4
225	5	4
240	4	4
255	5	4
270	4	4
285	4	4
300 (E.10)	4	4
315	4	4
330	4	4
345	4	4
360 (E.12)	3	4
375	5	4
390	5	5
405	4	3
420	2	4
435	2	4
450	4	4
465	5	4
480	1	3
495	1	3
510	2	3
525	2	3
540 (E.18)	3	4
555	4	5
570	4	4
585	5	5
600	5	5
615	2	3
630	2	3
645	4	4
660	3	4
675	3	4
690	2	4
710	2	4

William Street - Wanister

Distance metres	Cover denuded	Substrate damage
15	5	5
30	5	5
45	5	5
60	5	5
75	5	5
90 (W.3)	5	5
105	3	3
120	2	2
135	4	4
150	3	4
165	2	2
180	2	2
195	1	1
210	3	2
225	3	2
240 (W.8)	3	4
255	2	4
270	2	3
285	4	3
300	3	3
315	3	2
330	1	2
345	2	4
360	1	2
375	3	3
390	3	3
405	3	3
420 (W.14)	3	3
435	2	3
450 (W.15)	2	2

Central track from W.5 - west

Distance metres		Cover denuded	Substrate damage
15		1	3
30		0	2
45		0	1
60		0	1
75		1	4
90	(C.1)	0	3
105		0	3
120	(C.2)	2	3
135		1	1
150	(C.3)	0	3
165		1	2
180		2	3
195		1	3
210		2	2
225		0	2
240		1	3
255		1	1
270		1	2
285		1	3
300		1	2
315		1	2
330		1	3
345		2	3
360		1	3

Tinkler Row - Ellen Street

Distance metres		Cover denuded	Substrate damage
15		0	3
30		1	4
45		1	4
60		2	4
75		0	3
90	(T.1)	4	3
105		3	3
120	(T.2)	4	4
135		5	5
150		3	3
165		4	4
180		4	4
195		4	4
210		3	3
225		3	4

Footnote Sites noted in brackets = vegetation transects.

Appendix C.3 Mechanical sorting of soil samples

Site Code	Depth (cms)	Detail	Initial wt. gms	Dry wt. gms.	% moisture	Wt. (gms.) retained														
						Coarse			Medium			Fine		% of dry wt. passing						
						7	14	25	36	52	100	200	200	7	14	25	36	52	100	200
E.1/L	12	Dry	54.0	42.5	27.1	2.8	3.1	8.2	4.5	5.7	8.6	6.2	3.4	93	86	67	56	43	23	8
E.1	0-2	Dry	130.4	119.9	8.7	7.1	5.8	13.7	10.2	13.7	23.0	23.3	23.1	94	89	78	69	58	39	19
E.5/1	15	Wet	106.0	70.8	49.7	2.0	7.5	12.7	7.5	8.9	14.9	11.0	6.3	97	87	69	58	45	24	9
E.5	0-2	Wet	95.0	86.1	10.4	3.1	4.8	9.1	6.0	9.4	18.5	16.6	18.6	96	91	80	73	62	41	22
E.10/L	0-2	Dry	80.0	62.8	27.4	0.2	2.5	7.6	6.1	8.1	15.5	14.4	8.4	100	96	84	74	61	36	13
E.10/L	2-4	Dry	80.0	63.4	26.2	0.3	4.0	7.8	5.6	7.5	15.0	14.2	9.0	100	93	81	72	60	37	14
E.10/L	4-6	Dry	65.0	51.0	27.4	0.3	2.2	5.5	4.5	6.2	12.3	12.1	7.9	99	95	84	75	63	39	15
E.10	0-2	Dry	257.3	231.0	11.4	13.7	17.3	27.4	18.2	25.2	48.9	47.9	31.5	94	87	75	67	56	35	14
E.10	2-4	Dry	260.5	223.0	16.8	18.9	16.3	25.4	19.6	24.7	46.6	44.8	26.7	91	84	73	64	53	32	12
E.10	4-6	Dry	263.9	226.2	16.7	35.7	24.3	25.8	17.3	22.6	41.3	37.6	21.8	84	73	62	54	44	26	10
E.7/L	0-2	Dry	69.0	54.7	26.1	1.5	5.8	8.4	5.2	6.7	12.6	10.4	4.1	97	87	72	62	50	27	8
E.7	0-2	Dry	141.5	133.9	5.7	13.4	14.1	20.2	11.8	14.2	22.7	20.9	16.7	90	79	64	55	45	28	12
E.11	0-2	Wet	228.0	198.5	14.7	5.9	14.3	28.6	18.6	23.0	35.6	37.5	35.0	97	90	76	67	55	37	18
E.11	2-4	Wet	88.5	75.0	18.0	2.6	2.4	8.1	6.6	9.2	16.0	16.6	13.5	97	94	83	74	62	40	18
E.11	4-6	Wet	79.6	68.6	16.0	5.1	4.3	9.9	6.1	7.8	13.3	12.9	9.2	93	87	72	63	52	32	13
T.3	0	Wet	143.5	123.6	16.1	11.4	12.8	17.1	9.9	12.2	18.5	19.5	22.2	91	81	67	59	49	34	18
T.2	0	Dry	179.2	169.9	5.5	15.9	21.8	26.2	13.4	15.0	22.1	21.8	33.8	91	78	62	54	45	32	20
C.4	0-2	Dry	145.0	132.7	9.3	1.9	7.7	18.5	11.6	15.0	27.7	30.5	19.8	99	93	79	70	59	38	15
C.4	2-4	Dry	159.0	131.8	20.6	1.5	6.6	12.1	10.4	14.7	29.8	33.9	22.8	99	94	85	77	66	43	17
C.4	4-6	Dry	157.0	124.9	25.6	1.0	5.0	10.1	9.2	13.4	28.2	34.8	23.2	99	95	87	80	69	46	19

Appendix C.4 Determination of soil suction by suction plate method

h_1 (cm)	h_2 (cm)	h_2x13.54	H	Log 10 = pF	Wt.of wet soil (gm)	Wt.of dry soil (gm)	Wt.of moisture (gm)	% moisture content
E.1/L	Date of test 14.6.76 to 24.6.76							
16.0	--	-	16.00	1.204	7.729	5.028	2.701	53.72
16.0	2.0	27.08	43.08	1.634	7.386	5.028	2.358	46.90
16.0	5.0	67.70	83.70	1.923	7.327	5.028	2.299	45.72
16.0	9.3	125.92	141.92	2.152	7.268	5.028	2.240	44.55
16.0	19.0	257.26	273.26	2.436	7.162	5.028	2.134	42.44
16.0	37.0	500.98	516.98	2.713	7.118	5.028	2.090	41.57
16.0	61.4	831.36	847.36	2.928	6.721	5.028	1.693	33.67
E.1/2	Date of test 28.6.76 to 10.7.76							
16.0	-	--	16.00	1.204	7.278	5.366	1.912	35.63
16.0	2.0	27.08	43.08	1.634	7.167	5.366	1.801	33.56
16.0	4.0	54.16	70.16	1.846	7.112	5.366	1.746	32.54
16.0	8.0	108.32	124.32	2.094	7.079	5.366	1.713	31.92
16.0	16.0	216.64	232.64	2.367	7.034	5.366	1.668	31.08
16.0	30.0	406.20	422.20	2.626	6.965	5.366	1.599	29.80
16.0	61.0	825.94	841.94	2.925	6.818	5.366	1.452	27.06
E.5/L	Date of test 28.6.76 to 10.7.76							
16.0	-	-	16.00	1.204	5.929	3.866	2.063	53.36
16.0	2.0	27.08	43.08	1.634	5.788	3.866	1.922	49.72
16.0	4.0	54.16	70.16	1.846	5.707	3.866	1.841	47.62
16.0	8.0	108.32	124.32	2.094	5.648	3.866	1.782	46.09
16.0	16.0	216.64	232.64	2.367	5.587	3.866	1.721	44.52
16.0	30.0	406.20	422.20	2.626	5.498	3.866	1.632	42.21
16.0	61.0	825.94	841.94	2.925	5.246	3.866	1.380	35.70
E.5/2	Date of test 11.7.76 to 21.7.76							
16.0	-	-	16.00	1.204	4.071	2.794	1.277	45.71
16.0	2.0	27.08	43.08	1.634	4.071	2.794	1.277	45.71
16.0	4.6	62.28	78.28	1.894	4.068	2.794	1.274	45.60
16.0	8.5	115.09	131.09	2.117	4.037	2.794	1.243	44.49
16.0	18.0	243.72	259.72	2.415	3.979	2.794	1.185	42.41
16.0	35.0	473.90	489.90	2.690	3.950	2.794	1.156	41.37
16.0	61.0	825.94	841.94	2.925	3.901	2.794	1.107	39.62
E.10/2	Date of test 14.6.76 to 24.6.76							
16.0	-	-	16.00	1.204	10.680	8.211	2.469	30.07
16.0	2.0	27.08	43.08	1.634	10.342	8.211	2.131	25.95
16.0	5.0	67.70	83.70	1.923	10.247	8.211	2.036	24.80
16.0	9.3	125.92	141.92	2.152	10.235	8.211	2.024	24.65
16.0	19.0	257.26	273.26	2.436	10.184	8.211	1.973	24.03
16.0	37.0	500.98	516.98	2.713	10.134	8.211	1.923	23.42
16.0	61.4	831.36	847.36	2.928	10.001	8.211	1.790	21.80
E.11/2	Date of tests 11.7.76 to 21.7.76							
16.0	-	-	16.00	1.204	7.411	4.168	3.243	77.80
16.0	2.0	27.08	43.08	1.634	6.930	4.168	2.762	66.27
16.0	4.0	62.28	78.28	1.894	6.920	4.168	2.752	66.03
16.0	8.5	115.09	131.09	2.117	6.858	4.168	2.690	64.54
16.0	18.0	243.72	259.72	2.415	6.776	4.168	2.608	62.57
16.0	35.0	473.90	489.90	2.690	6.638	4.168	2.470	59.26
16.0	61.0	825.94	841.94	2.925	6.477	4.168	2.309	55.40

Appendix D.1 Species counts along transects across heath paths 1976 and 1977

1. Transects were belt transects 25 cm wide. Scores represent presence of named species in 10 cm bands along these transects within 5 cm cells; i.e. the maximum score for each species within each band is 10.

2. Up to four species were identified, if necessary, within each cell with no account taken of extent of cover - so that a heterogeneous band can have a score totalling 40 and a homogeneous band will have a maximum score of 10, yet terrain cover will be of the same density.

3. In addition, in the field bare earth was recorded by overshading so that communities which were still open can be recognised by the score for bare earth. It is possible for the graphic representation of this data to show a total score of 40 and yet have a score of 10 for bare earth - if all the species were at the seedling or pioneer phase.

4. Bare earth was taken as the indicator of former severity of wear or of disturbance of ground. Those species associated with bare earth surfaces were noted particularly. They were seen to be of three types:
   (i) pioneer colonisers such as mosses, algae and lichens; not necessarily wear resistant rather they are more suited to the peculiarities of the micro habitat of the exposed slope or raw humus
   (ii) dominant heath species suppressed by wear and now reasserting themselves on recently abandoned surfaces
   (iii) grassland and 'weed' species associated with over grazed or heavily trampled heathland, especially in those areas with a low humus residue.

Footnote: (i) and (ii) appeared often to be mutually dependent e.g. Zygogonium ericetorum colonisation and Nardus stricta or Deschampsia flexuosa.

Appendix D 1

Species on the paths and path margins of Waldridge Fell

Distribution / performance in 10 cm bands along selected transects. February 1976 & July 1977

Score: 1 = present in one 5x5 cm square
10 = Present in all sections of 10 x 25 cm band.
\- = Absent

Species Reference numbers (1 to 25 across the page)

1 Bare earth (see also 25)
2 Nardus stricta
3 Deschampsia flexuosa
4 Festuca ovina
5 Agrostis tenuis
6 Poa annua
7 Dactylis glomerata
8 Festuca rubra
9 Luzula campestris
10 Trifolium repens
11 Mosses (+ Pohlia nutans, ' Hypnum cupressiforme)
12 Galium saxatile
13 Juncus effusus
14 Compositae (See footnote below transect T 2/ July 1977)
15 Plantago lanceolata (" " " " " " " " " " " ")
16 Grasses not elsewhere specified (identified in a footnote)
17 Lichens and algae
18 Erica cinerea
19 Empetrum nigrum
20 Pteridium aquilinum
21 Ulex europaeus
22 Rubus fruticosus
23 Vaccinium myrtillus
24 Calluna vulgaris (* signifies defoliated stems)
25 Bare earth over whole square (no vegetation)

Numbers down Left hand margin: distance along transect in 10 cm units

10 ________ Represents apparent margin
11 of main tread.

Transect T 1 (4 metres S to N) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
3	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
4	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
8	-	10	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
9	4	10	-	-	5	-	-	-	-	-	-	-	-	1*	-	-	-	-	-	-	-	-	-	-	-
10	9	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	3	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
16	6	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
17	5	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
18	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	4	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
21	2	2	-	7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	7	4	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
23	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
24	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
25	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
26	10	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
27	6	1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
28	9	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
29	2	2	4	-	-	-	-	-	-	-	3+	-	-	-	-	-	2	-	-	-	-	-	-	7	-
30	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
31	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
34	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
38	-	6	1	-	-	-	-	-	-	-	2'	-	-	-	-	-	-	-	-	-	-	-	-	4	-
39	-	8	1	-	-	-	-	-	-	-	2'	-	-	-	-	-	-	-	-	-	-	-	-	2	-
40	-	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-

*	Hieracium pilosella
+	Pohlia nutans
'	Hypnum cupressiforme

Transect T 1

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	4	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	6	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	6	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
7	-	6	1	10	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	3	1	9	9	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
9	1	9	-	5	1	-	-	1	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
10	10	2	-	-	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
11	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	7	-	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
14	2	1	2	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
15	3	1	1	7	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
16	6	-	-	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
17	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
18	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
19	7	-	2	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
20	3	5	1	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
21	1	5	2	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	4	4	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
23	7	2	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
24	5	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
25	8	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
26	3	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
27	-	4	7	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
28	-	-	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
29	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
30	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
31	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
32	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
33	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
34	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
35	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
36	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
38	-	4	9	-	-	-	-	-	-	-	1'	-	-	-	-	-	-	-	-	-	-	-	-	4	-
39	-	5	3	-	-	-	-	-	-	-	3'	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	7	2	-	-	-	-	-	-	-	3'	-	-	-	-	-	-	-	-	-	-	-	-	-	-

' Hypnum cupressiforme

Transect T 2 (4 metres S to N) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
8	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
9	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
10	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
11	3	2	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	10	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
18	7	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
19	7	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	8	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
22	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
23	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
24	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	1	8	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
31	-	1	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
32	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
34	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
35	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
36	-	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-
37	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
38	-	8	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
39	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

Transect T 2 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	14a	14b	14c	15a	15b	16	-	21	22	23	24	25
1	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	1	7	1	-	-	-	1	-	-	-	-	3	1	-	-	-	-	-	-	-	-	5	-
8	-	1	5	-	3	-	-	-	-	-	1+	4	4	3	-	-	-	-	-	-	-	-	7*	-
9	-	3	6	1	6	-	-	-	-	-	-	2	3	1	1	-	-	-	-	-	-	-	10*	-
10	-	3	6	5	8	-	-	-	-	-	-	-	2	2	1	1	-	-	-	-	-	-	9*	-
11	8	2	-	-	2	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	8
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	9	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	7
14	5	-	-	-	4	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
15	6	-	-	-	3	-	3	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2
16	-	-	-	5	6	-	1	1	2	-	-	-	-	1	-	7	7	2	-	-	-	-	-	-
17	-	1	-	4	7	-	-	-	3	-	-	-	-	1	1	9	3	-	-	-	-	-	-	-
18	-	-	-	2	3	-	-	2	-	-	-	-	-	-	-	10	1	1	-	-	-	-	-	-
19	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	3
20	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	7
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
24	7	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
25	5	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
26	3	-	-	-	8	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
27	3	-	-	-	7	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3
28	7	-	-	-	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
29	9	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	7
30	1	3	-	-	8	-	-	6	-	1	-	-	-	-	1	-	3	-	-	-	-	-	-	-
31	-	4	-	2	6	-	-	1	-	1	-	-	-	-	-	-	2	-	-	-	-	-	2	-
32	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
33	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
34	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
35	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
36	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
38	-2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
39	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

14a	Hieracium species
14b	Hypochoeris species
14c	Leontodon autumnalis
15a	Plantago lanceolata
15b	Plantago major
16	Lolium perenne

Transect E 1 (5 metres W to E) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	10	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	7	1	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	8	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	6	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	9	-	4	1	1	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	5	-	-	1	3	-	-	-	-	5+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	3	-	-	-	-	9+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	3	-	-	1	-	7	-	-	-	-	5+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
14	10	-	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
15	10	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
16	10	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
17	10	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
18	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
34	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
35	7	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
36	2	-	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
37	2	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
38	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
39	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
40	8	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
41	2	6	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	10	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	10	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	10	-	1	1	-	-	1	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	10	-	7	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	10	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	8	1	5	-	-	-	-	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	10	3	5	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	10	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	10	-	4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-

Transect E 1 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	10	2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	10	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	10	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	10	5	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	8	2	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	8	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	6	1	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	3	-	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
12	-	1	-	3	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	2	-	-	2	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	10	-	-	-	-	7	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	3
15	5	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
16	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
17	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
18	10	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
34	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
35	1	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
36	3	-	-	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
37	-	-	-	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
39	8	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
40	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
41	-	8	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	8	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	10	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	10	-	4	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	9	-	9	1	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	10	7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	10	4	5	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	10	2	5	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	10	5	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	10	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

17 Cornicularia aculeta

Transect E 2 (5 metres W to E) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	9	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	10	2	10	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	1	8	3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	10	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	10	-	-	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	9
14	10	-	-	-	4	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	5
15	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
16	5	-	-	1	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
17	2	4	-	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
18	2	1	-	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	2
19	3	1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
20	5	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
21	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	10
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	9
30	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
31	6	4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
32	2	2	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
33	-	2	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	3	4	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
35	4	1	-	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
36	7	5	-	-	-	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
37	1	6	-	3	4	-	-	1	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	4	3	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
39	4	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
40	-	8	-	1	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	9	-	3	5	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	5	1	9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	7	-	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	2	6	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
45	2	10	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	2	10	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
47	1	9	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	1	9	-	4	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	9	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	9	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Transect E 2 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	8	2	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	3	7	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
9	-	9	4	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	9	10	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	8
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
14	9	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
15	6	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	5
16	4	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
17	-	-	-	1	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	4	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	1	2	-	6	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	5	3	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
21	1	-	-	4	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
22	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	10	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
30	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	1	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	1	-	-	4	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	4	-	-	-	7	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
35	-	3	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	5	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
37	4	4	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
38	-	1	1	4	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	3	4	-	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
40	-	9	-	5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	10	-	5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	10	-	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	9	-	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	2	10	-	9	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	2	8	-	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
46	-	10	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	10	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	6	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	4	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	7	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

17 = Cornicularia aculeta

Transect E 4 (6 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	1	-	-	9	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	1	-
2	1	2	4	-	3	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	2	-
3	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
4	-	4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
5	-	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
6	-	8	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
7	-	10	-	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
8	-	8	-	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	2	5	-	5	2	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	7	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	7	-	2	3	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	10	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	9	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	1	10	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	8	7	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	10	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
17	6	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
18	3	6	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	9	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
20	1	5	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21	2	4	-	4	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
22	1	-	-	4	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	5	-	-	5	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	2	-	-	3	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
25	5	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
26	7	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
27	7	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
28	9	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
29	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	4	1	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
33	-	10	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	-	10	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	-	1	-	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	3	-	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	9	-	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	-	10	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	10	4	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	1	9	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
42	5	6	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
43	-	10	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	10	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	1	9	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
46	5	5	3	-	2	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	2
47	-	7	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	2	8	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	10	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	5	5	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
51	2	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	2	8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-
56	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-
57	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
58	1	4	7	-	-	-	-	-	-	-	2+1'	-	-	-	-	-	-	-	-	-	-	-	5	-	-
59	2	-	8	-	-	-	-	-	-	-	3+1'	-	-	-	-	-	-	-	-	-	-	-	6	-	-
60	-	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-

Transect E 4 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	2	5	4	3	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	2	-
2	-	4	3	2	6	-	-	-	-	-	-	1	-	-	-	3	-	-	-	-	-	-	-	1*	-
3	-	6	2	1	5	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-
4	-	5	3	3	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4	-
5	-	2	6	-	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	3	8	1	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	6	-
7	-	10	2	8	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
8	-	10	1	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	10	2	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	10	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	2	2	3	7	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
12	-	4	4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	5	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	9	1	9	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	8	2	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	4	3	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	3	1	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	4	1	-	6	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	9	-	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	4	2	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	7	1	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	2	1	1	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
23	-	-	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	5	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
28	1	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
29	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
30	7	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
31	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
32	5	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
33	-	5	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	-	10	-	9	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	-	10	-	10	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	10	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	10	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	-	10	-	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	10	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	10	-	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	10	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	6	-	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	10	-	9	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	10	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	10	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	9	2	5	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	4	7	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	4	5	4	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
49	4	6	4	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
50	-	10	6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	7	7	-	-	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	2
53	4	10	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54	-	4	3	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	-	3	9	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	10	-
56	-	1	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10	-
57	-	4	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	8	-
58	-	10	5	2	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	6	-	-
59	-	4	1	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
60	-	-	6	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-

(16 = Holcus mollis)

Transect E 6 (4.3 metres W to E) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	9	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	3	-	-	-	6	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
10	1	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	8	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	10	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
18	9	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
19	-	-	-	3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	2	-	-	6	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21	1	-	-	-	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	5	-	-	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
23	9	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
24	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
25	7	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	-	10	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	1	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
35	2	8	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
36	2	8	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
37	-	10	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	-	10	2	2	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	8	3	3	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	4	-
40	-	9	5	-	-	-	-	1	-	-	1+	-	-	-	-	-	-	1	-	-	-	-	2	5	-
41	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	2	4	-
42	-	4	1	-	-	-	-	-	-	-	2+	-	-	-	-	-	-	5	-	-	-	-	4	-	-
43	-	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	3	-	-

Transect E 6

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	2	-	-	2	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	1	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	7	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	2	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	10	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
18	3	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
19	1	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
20	2	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
22	6	-	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
23	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
24	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
25	7	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	-	10	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	-	8	2	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	-	8	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	-	8	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	-	8	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
38	-	8	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
39	-	9	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
40	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	3	3	-
41	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	~~2~~	4	-
42	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	8	4	-
43	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	7	7	-

Transect E 7 (4.5 metres W to E) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
7	-	10	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	3	10	-	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	2	8	-	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	9	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	10	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	7	5	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
13	4	4	-	-	5	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
14	4	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
15	4	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
18	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
26	-	10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	5	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
34	7	3	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
35	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
36	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

Transect E 7 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	2	8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
8	-	7	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	6	8	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	10	4	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	9	1	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	5	7	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
13	5	5	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
14	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	1	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
16	7	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
17	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
18	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
25	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
26	6	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
27	-	-	1	3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	1	1	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	5	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
32	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
33	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
34	6	4	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
35	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

Transect E 10 (4 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
2	-	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
3	-	1	4	-	2	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	5	3	-	4	-	-	-	-	-	4+	-	-	-	-	-	-	-	-	-	-	-	-	2	-
5	2	10	-	-	2	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	2	-
6	-	1	2	-	2	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	7	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
8	-	8	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
9	1	4	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
10	1	5	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
18	1	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
20	2	6	-	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
21	3	3	-	1	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
22	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
25	9	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	-	8	-	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	5	-	8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	2	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
33	-	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
34	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-

Transect NE 10 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	4	–
2	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
3	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
4	–	5	3	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–
5	–	9	–	2	–	–	–	–	–	–	3+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6	–	8	1	3	6	–	–	–	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	6	–
7	–	1	3	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
8	–	–	7	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–
9	–	4	2	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
10	–	5	–	–	7	2	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11	8	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
12	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
13	10	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
14	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
15	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
16	7	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
17	9	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
18	1	9	–	5	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
19	–	5	–	9	6	–	–	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–
20	–	5	–	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21	2	2	–	5	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22	6	–	–	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
23	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
24	10	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
25	2	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
26	8	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
27	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
28	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
29	5	4	–	1	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
30	–	2	–	4	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	10	–	8	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	–	5	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
33	–	4	6	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	2	–
34	–	1	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–
35	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
36	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–
37	3	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	1	2
38	4	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	–
39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	–
40	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–	–

Transect E 12 (4 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	7	-	-	-	-	-	-	-	1'	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	5	4	-	-	-	-	-	-	-	7'	-	-	-	-	-	-	-	-	-	-	-	6	-	-
3	-	6	3	-	-	-	-	-	-	-	5'	-	-	-	-	-	-	-	-	-	-	-	5	-	-
4	-	4	5	-	-	-	-	-	-	-	2'	-	-	-	-	-	-	-	-	-	-	-	7	-	-
5	-	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
6	-	2	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
7	-	2	10	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	2	-
8	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
10	-	-	5	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
11	-	1	8	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	7	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	10	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
16	3	-	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
17	3	7	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
18	3	4	-	4	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
19	1	5	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
20	-	1	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	5	4	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
22	6	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
23	2	3	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
24	2	5	-	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
25	5	1	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
26	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	6	3	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
31	-	9	4	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	7	4	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	3	6	-	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	4	-	-
34	-	2	7	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	10	-	-
35	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
36	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
37	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
38	-	-	3	-	-	-	-	-	-	-	7+	-	-	-	-	-	-	-	-	-	-	-	10	-	-
39	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	10	-	-
40	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-

Transect E 12 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
3	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
4	-	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
5	-	6	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
6	-	8	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
7	-	5	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	-
8	-	-	9	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	10	-
10	-	-	8	-	4	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	10	-
11	-	-	9	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
12	-	6	-	1	6	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	10	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
14	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
15	6	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
16	2	-	-	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
17	7	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
18	4	-	-	-	1	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
19	-	9	-	2	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	10	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	10	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	2	7	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
23	-	5	-	-	5	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	1	1	-	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
25	-	2	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	8	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
27	8	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
29	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
30	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
31	-	9	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	7	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	7	1	6	-	-	-	1	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	1	-	-
34	-	7	-	6	-	-	-	-	-	-	4+	-	-	-	-	-	-	-	-	-	-	-	6	-	-
35	-	4	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
36	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
37	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
38	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
39	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
40	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-

Transect E 18 (4.5 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	10	-	-
2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	1	-	-
3	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
4	-	-	9	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	2	-	-	-	-	-
5	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
7	-	10	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
8	-	8	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	8	2	-	-	-	-	-	-	-	9'	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	-	9	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	9	-	1	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	4	9	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	2	9	-	3	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
14	-	9	-	5	1	1	-	-	-	-	4+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	10	-	5	1	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	10	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	5	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	5	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
23	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	5	-	9	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	7	-	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
27	9	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
28	-	8	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	10	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	10	-	8	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	5	5	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	8	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	9	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
34	6	-	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
35	3	-	4	9	1	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	5	-	-	5	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	4
37	-	1	2	-	-	-	-	-	-	-	8+	-	-	-	-	-	-	-	-	-	-	-	7	-	-
38	-	-	4	-	-	-	-	-	-	-	3+	-	-	-	-	-	-	-	-	-	-	-	7	1	-
39	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7	-
40	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	10	-
41	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-
43	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-
45	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10	-

Transect E 18

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	7	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	2	–	–	10	–	–
2	–	–	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	10	–	–
3	–	2	3	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	8	–	–
4	–	3	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	7	–	–
5	–	1	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–
6	–	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
7	–	10	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8	–	10	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9	–	10	2	3	–	–	–	–	–	–	3+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11	–	10	~~3~~	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12	–	10	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13	1	9	–	–	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
14	–	10	–	–	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16	–	10	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17	4	10	–	2	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
19	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
20	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
21	10	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	10
22	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	–	10	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	–	4	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	2	–	–	–	2	6		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
27	9	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7
28	–	10	–	1	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	–	10	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	–	10	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	9	–	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	1	–	–	–	7	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	8	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
34	6	–	–	4	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5
35	3	–	6	2	–	–	–	1	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	3
36	2	–	6	1	–	–	–	1	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	4	–	1
37	1	–	7	–	–	–	–	–	–	–	8+	–	–	–	–	–	–	–	–	–	–	–	8	–	–
38	–	–	6	1	–	–	–	–	–	–	4+	–	–	–	–	–	–	–	–	–	–	–	9	–	–
39	–	–	6	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	10	–	–
40	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	2	–
41	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	–
42	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	–
43	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	–
44	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	–
45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	–

Transect W 3 (5.5 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	10	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	3	-
2	-	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-
3	1	1	-	6	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	5	-	-	1	-
4	-	5	2	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
5	-	9	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	7	-	8	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	4	-
7	-	9	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	5	-
8	-	1	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	10	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
12	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
13	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
14	-	3	3	4	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	4	-
15	-	3	1	10	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	4	4	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
17	2	2	-	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	2	3	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	2	-	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	9	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
21	10	2	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
22	10	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
23	9	5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
24	9	3	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
25	3	6	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	3	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	3	4	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	5	1	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
29	2	-	-	10	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	3	1	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
32	4	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
33	6	3	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
34	10	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
35	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
36	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
37	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
38	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
39	10	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
40	10	6	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	5	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	-	-	9	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
43	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
44	-	-	-	3	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
45	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
46	-	-	5	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
47	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
48	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-
49	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
50	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
51	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
52	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
53	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
54	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-
55	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	5	-

11 = Pohlia nutans

Transect W 3

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	5	-
2	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-
3	-	-	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-
4	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-
5	-	2	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
6	-	7	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
7	-	6	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
8	-	3	-	3	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	8	-
9	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-	1	-	-	10	-
10	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
11	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
12	-	-	-	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
13	-	-	1	5	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
14	-	3	1	4	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-
15	-	5	-	2	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-
16	-	6	-	6	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	4	-	8	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	1	5	-	5	-	-	-	5	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	5	-	7	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	7	1	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
21	6	1	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
22	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
23	5	6	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
24	7	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
25	2	8	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
26	-	10	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	9	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	2	4	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
29	3	-	-	7	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
30	-	-	-	8	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	3	2	7	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	2	-	2	7	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
33	2	1	4	7	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
34	3	2	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
35	8	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
36	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
37	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
38	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
39	9	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
40	5	2	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	2	1	-	2	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	-	2	4	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
43	-	-	3	3	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
44	-	-	6	3	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
45	-	-	10	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
46	-	-	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	10	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
49	-	-	10	2	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
50	-	-	10	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	-	-	10	6	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	-	-	10	1	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	1	-	10	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
54	-	-	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
55	3	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	3

Transect W 8 (3.4 metres W to E) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
8	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
9	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
10	1	7	2	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	5	-
11	5	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
12	5	9	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
13	2	8	-	6	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	7	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
15	7	7	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
16	-	6	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	7	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	8	-	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
19	10	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	9
25	10	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4
26	6	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
27	-	-	6	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
28	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
29	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
30	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	10	-	-
31	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	10	-	-
32	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	10	-	-
33	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	10	-	-
34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	10	-	-

Transect W 8 **July 1977**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
7	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
8	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
9	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
10	-	4	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
11	-	10	-	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
12	-	10	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	5	10	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	10	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	8	-	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	3	-	7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	4	-	-	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
18	5	1	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
19	8	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
22	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
23	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
24	3	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	1
25	1	-	1	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	1	-
26	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	4	-
27	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	3	-
28	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
29	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
30	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
31	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	1	-
32	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	1	-
33	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	10	-	-
34	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	10	-	-

Transect W 14 (2 metres W to E) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	4	3	4	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	5	-
7	-	4	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	5	6	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	4	6	-	1	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	3
14	-	9	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-
15	-	-	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
16	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
17	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
18	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	10	-	-
19	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	-	-
20	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	-	-

Transect W 15 (1 metre E to W) February 1976

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
3	-	-	10	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	10	-	-
4	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
5	9	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3
6	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
8	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2	5
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	1	-
10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	1	-

Transect W 14 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
2	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
4	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
5	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
6	-	7	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
7	-	6	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	7	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	-	5	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
11	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
12	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
13	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
14	-	6	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
15	-	-	6	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
16	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
17	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	-	-
18	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
19	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	-	-
20	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	10	-	-

Transect W 15 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
4	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
5	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
6	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
8	5	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	2	-
10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-

Transect C 2 (4.1 metres S to N) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
2	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
3	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
4	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
5	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
6	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
7	–	1	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
8	–	4	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–
9	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
10	3	–	8	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
11	9	–	5	1	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
12	6	–	5	1	1	–	–	1	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	1
13	–	–	–	8	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14	–	1	–	6	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–
15	–	5	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–
16	–	6	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–
17	–	8	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–
18	–	5	2	3	2	–	–	–	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	4	–
19	–	–	2	5	–	–	–	5	–	–	9+	–	–	–	–	–	–	–	–	–	–	–	–	1	–
20	6	–	2	3	1	–	–	–	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	3
21	7	–	2	5	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3
22	–	–	–	9	5	–	–	–	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	4	–	6	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	1	6	2	–	1	–	–	1	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	2	2	–	4	8	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	–	6	–	2	4	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	–	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	–	10	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	–	10	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	–	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	–	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
36	–	4	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–
37	–	4	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	1	–
38	–	6	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	5	–
39	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	–
40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
41	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–

Transect C 2

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
2	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
3	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
4	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
5	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
6	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
7	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
8	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	10	–
9	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
10	–	1	10	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
11	9	1	5	3	1	–	–	–	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	1
12	6	–	4	6	1	–	–	2	–	–	4+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13	2	–	10	6	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14	–	1	9	3	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	–	8	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
16	–	10	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
17	–	10	2	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
18	–	9	–	6	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–
19	–	2	10	6	2	–	–	–	–	–	4+	–	–	–	–	–	–	–	–	–	–	–	–	2	–
20	–	1	5	4	4	–	–	–	–	–	8+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21	–	–	4	5	5	–	–	1	–	–	3+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22	–	–	4	10	6	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	7	5	5	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	1	8	2	4	4	–	–	–	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	1	10	3	1	7	–	–	–	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	–	9	3	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	10	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	–	10	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	–	10	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	–	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	10	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	–	10	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34	–	10	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
35	–	8	4	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	–
36	–	4	6	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	6	–
37	–	7	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	7	–
38	–	5	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	10	–
39	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
40	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–
41	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–

Transect C 3 (5 metres S to N) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	5	-
2	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	2	-
3	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
4	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
5	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	6	-
6	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	9	-
7	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
8	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
11	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	10	-
12	-	-	6	2	-	-	-	-	-	-	-	3	-	-	-	2	-	-	-	-	-	-	-	8	-
13	-	2	10	6	3	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	4	-
14	-	8	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	8	3	5	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	6	4	5	6	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	3	-	8	2	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	7	-	10	2	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	10	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	10	-	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	8	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	6	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	3	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	5	-	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	3	6	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
31	3	6	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
32	-	4	-	9	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	7	6	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
34	-	-	7	6	2	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	4	-
35	-	-	2	-	4	2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	6	-
36	-	-	4	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
37	-	-	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
38	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
39	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
40	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
41	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-
42	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
43	-	1	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
44	-	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	9	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
46	-	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
47	-	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
48	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

16 = Holcus lanatus

Transect C 3 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	3	-
2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
3	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
4	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
5	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	4	-
6	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	7	-
7	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
8	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	9	-
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	9	-
10	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	10	-
11	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	10	-
12	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
13	-	8	7	-	2	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	5	-
14	-	10	1	4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	10	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	10	-	3	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	10	-	5	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	9	-	10	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	8	-	10	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
20	-	10	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	10	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	10	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	8	-	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	10	3	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	10	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	10	-	3	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	6	-	7	7	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	4	5	-	9	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	2	10	-	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	2	10	-	4	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	9	-	9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	6	-	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
33	-	2	1	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
34	-	1	2	1	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
35	-	-	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
36	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
37	-	-	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
38	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
39	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
40	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
41	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-
42	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
43	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
44	-	7	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
45	-	9	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
46	-	10	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
47	-	7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
48	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
49	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-
50	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-

16 = Holcus lanatus

Transect S 1 (4 metres S to N) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
4	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
5	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
6	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
7	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-
8	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
9	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
10	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
11	2	3	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
12	10	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	2
13	10	-	2	-	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	5	-	3
14	9	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
15	9	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
16	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
17	2	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
18	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	2	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	2	-	-	8	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
25	2	-	-	9	-	-	-	-	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
26	2	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	2	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
28	5	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
29	8	1	-	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	4	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
34	-	-	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
35	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
36	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
37	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
38	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
39	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
40	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	10	-	-

Transect S 1

July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
3	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
4	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
5	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
6	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
7	–	–	10	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
8	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
9	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
10	–	3	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	1	–
11	–	3	4	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–	–
12	–	–	1	–	–	–	–	3	–	–	4+	–	–	–	–	–	–	–	–	–	–	–	2	–	–
13	–	–	3	–	–	–	–	1	–	–	3+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
14	–	–	3	–	–	–	–	–	–	–	7+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
15	6	–	–	5	–	–	–	–	–	–	2+	–	–	–	–	–	–	–	–	–	–	–	–	–	3
16	9	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8
17	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
19	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21	–	1	1	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
22	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	1	–	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	1	1	–	8	–	–	–	–	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	–	–	–	10	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	–	3	–	6	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	2	–	7	–	–	–	3	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	1	–	–	6	–	1	–	4	–	–	1+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	4	1	–	7	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	–	4	–	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	4	–	8	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	–	1	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
33	–	–	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34	–	–	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–
35	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
36	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
37	–	1	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
38	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
39	–	–	3	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
40	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	10	–	–

Transect S 2 (4 metres S to N) **February 1976**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	-	-	7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
2	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
3	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10	-	-
4	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	2	10	-	-
5	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
6	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
7	-	-	4	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
8	-	-	3	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
9	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-
10	-	-	5	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
11	4	-	4	7	-	-	-	-	-	-	4+	-	-	-	-	-	-	-	-	-	-	-	2	-	-
12	10	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	5
13	10	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
14	8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8
15	8	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
16	6	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
17	4	1	-	9	-	-	-	-	-	-	2+	-	-	-	-	-	-	-	-	-	-	-	-	-	1
18	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	1	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	4	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	8	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	10	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	10	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	3	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	1	9	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	10	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	8	2	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
32	-	6	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	-
33	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	8	-
34	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	3	-
35	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
36	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
37	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
38	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
39	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-
40	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-

Transect S 2 July 1977

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	–	–	7	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	–	–
2	–	–	1	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
3	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	10	–	–
4	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	10	–	–
5	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
6	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
7	–	–	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	–	–
8	–	–	1	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
9	–	1	–	10	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–
10	–	1	1	10	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	1	–
11	3	–	1	8	–	–	–	1	–	–	4	–	–	–	–	–	–	–	–	–	–	–	3	1	–
12	10	–	–	3	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	2
13	8	1	–	1	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	6
14	8	4	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6
15	5	–	1	4	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	–	–	–	3
16	6	–	1	5	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	3
17	2	–	–	9	–	–	–	2	–	–	2	–	–	–	–	–	–	–	–	–	–	–	2	–	–
18	–	–	–	10	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
19	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	–	5	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	1	–	–
22	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
23	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
24	–	10	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
25	–	9	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26	–	5	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
27	–	10	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
28	–	10	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
29	–	10	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
30	–	9	1	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31	–	7	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–	–
32	–	4	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	5	–
33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	10	–
34	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	10	5	–
35	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
36	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	2	–
37	–	–	3	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
38	–	–	2	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
39	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
40	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–

1	Most of the 'bare' surfaces have cover of Zygogonium ericetorum
16	Holcus lanatus

IDENTIFICATION OF SAMPLING POINTS ON WALDRIDGE FELL: WITH MAP OF SOIL CHARACTERISTICS

[APPENDIX C/D]

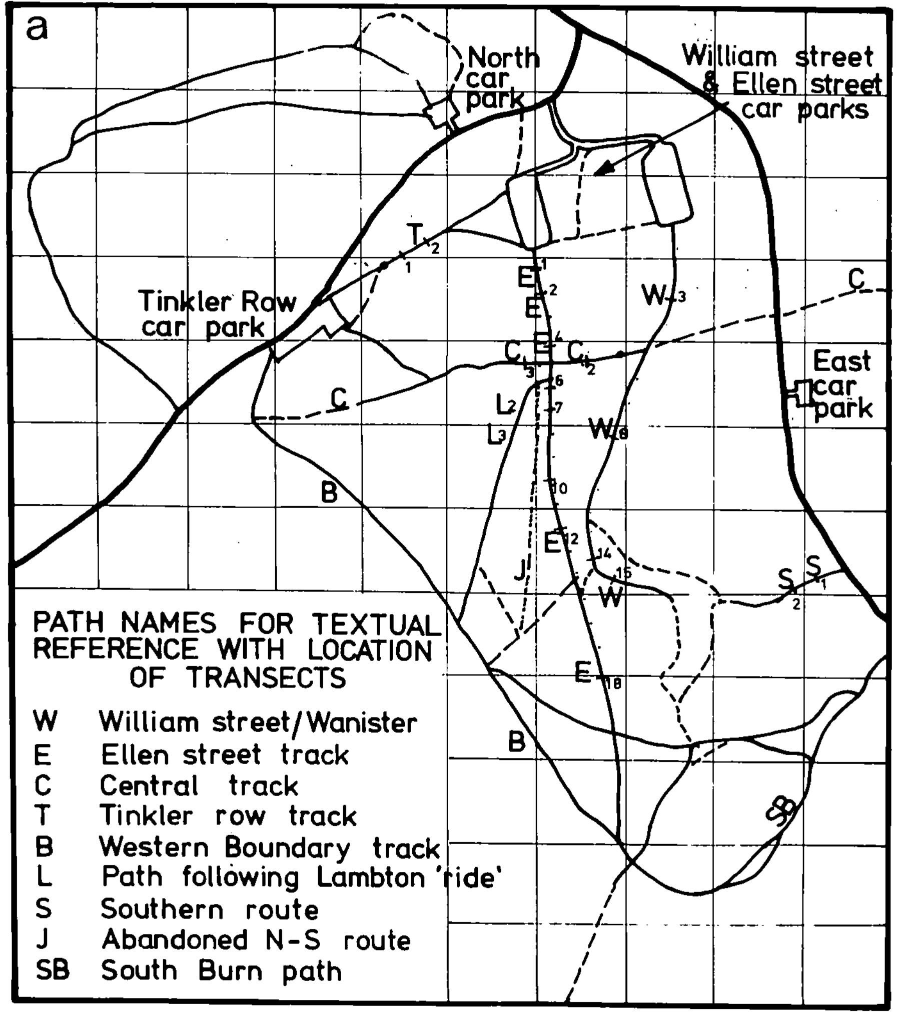


Fig. 25

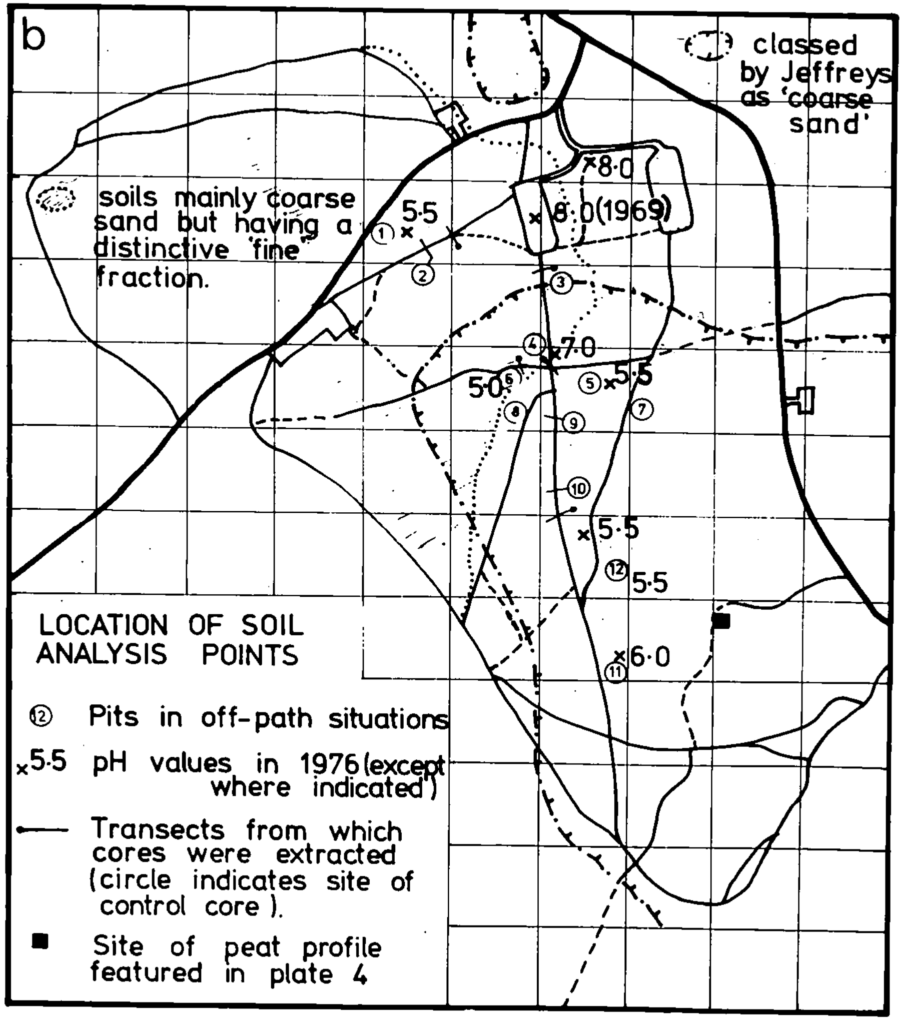


Fig. 26

Number of pins depressed on Trampleometers Spring of 1976

T 1	C 2	W 8	E 2	E 10a	E 10b	E 18	L 1/2	
-	-	-	-	-	-	-	-	1
-	-	-	-	-	-	-	-	2
-	-	-	2	-	-	-	-	3
-	-	-	-	-	-	-	-	4
-	-	-	-	-	-	-	-	5
-	-	-	-	-	-	-	-	6
-	-	-	-	-	-	-	-	7
-	-	-	2	-	-	-	-	8
-	-	-	1	-	-	1	-	9
2	-	-	-	-	-	-	1	10
2	1	1	-	1	1	-	1	11
3	-	-	1	-	1	1	1	12
3	1	-	1	1	-	-	2	13
1	1	-	1	1	1	1	3	14
1	2	-	1	3	2	1	2	15
1	2	2	3	5	2	1	3	16
1	2	-	3	6	1	-	3	17
1	1	1	3	5	-	2	4	18
3	-	3	2	5	2	3	2	19
3	1	6	3	2	3	4	5	20
1	2	2	1	2	2	1	2	21
2	2	3	2	1	2	2	4	22
1	3	4	2	1	2	-	1	23
2	1	2	1	3	4	1	4	24
1	3	4	-	-	-	1	3	25
1	2	1	1	2	-	-	2	26
1	-	1	3	4	-	-	2	27
-	2	-	2	3	-	1	3	28
-	-	-	2	2	1	2	1	29
-	2	-	1	2	1	1	2	30
-	-	-	1	4	1	3	-	31
-	-	-	2	1	-	2	1	32
-	1	-	1	-	-	-	-	33
-	1	-	3	1	-	-	-	34
-	-	-	2	3	-	1	-	35
-	-	-	1	-	-	1	-	36
-	-	-	-	3	-	-	-	37
-	-	-	2	-	-	-	-	38
-	-	-	-	-	-	-	-	39
-	1	-	2	-	-	-	-	40
	-		1	-	-	-	1	41
	-		1	-	-	-	-	42
	-		1	-	-	-	-	43
	-		5	-	-	-	-	44
	-		3	-	-	1	-	45
	-		2	-	-	-	1	46
	-		3	-	-	-	-	47
	-		3			-	-	48
	-		2			-	-	49
	-		-			-	-	50
			-			-	-	51
			1			-	1	52
			•			•	1	66
							1	71
							1	74
							1	75
							1	81
							1	88
							1	92
							1	96
							1	99

Appendix D.3

Plates 50 to 70: Flora of paths and path margins

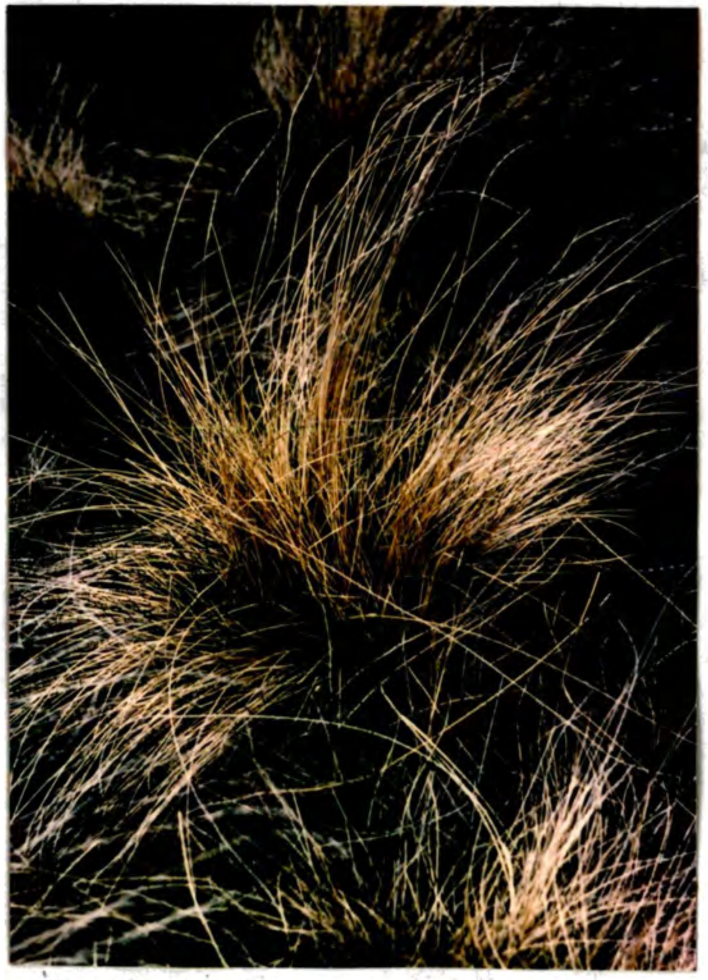
Flora of footpath surfaces and heavily trampled areas

50	Nardus stricta
51	Nardetum
52	Poa annua
53	Dactylis glomerata
54	Agrostis tenuis
55	Festuca ovina
56	Festuca rubra
57	Galium saxatile
58	Luzula campestris
59	Plantago lanceolata
60	Rumex acetosella

Flora of heath at path margins

61	Juncus effusus
62	Juncus squarrosus
63	Molinia caerulea
64	Deschampsia flexuosa
65	Empetrum nigrum
66	Vaccinium myrtillus
67	Calluna vulgaris
68	Erica cinerea
69	Rubus fruticosus
70	Ulex europaeus

50. Nardus stricta



51. Nardetum

52. Poa annua

53. Dactylis glomerata

54. Agrostis tenuis

55. **Festuca ovina**

56. **Festuca rubra**

57. Galium saxatile

58. Luzula campestris

59. Plantago lanceolata

60. Rumex acetosella

61. Juncus effusus

62. Juncus squarrosus

63. Molinia caerulea

64. Deschampsia flexuosa

65. **Empetrum nigrum**

66. **Vaccinium myrtillus**

67. Calluna vulgaris

68. Erica cinerea

69. Rubus fruticosus

70. Ulex europaeus

Appendix D.4 Energy expenditure testing using the Max Planck Respirometer, 20.3.77

Oxygen reading for environment = 20.3%

Conversion factor O_2/min. to Kilocalories (mixed diet) = 4.86

Surface	Distance & Time	Speed K.p.h.	Meter (start)	Meter (End)	Oxygen analysis	% O_2	Kilocal/ min.	Pulse
- (At rest)	- 10 mins	-	13502	13542	14.3	6.0	1.17	60
Tarmac	1000 m. 10 mins	6.0	11797	12140	16.3	4.0	6.66	100
Short grass	1000 m. 10 mins	6.0	12142	12527	15.5	4.8	8.98	108
Mat grass	500 m. 5 mins 8 secs	5.8	12527	12803	15.8	4.5	12.04	118
Heather	320 m. 5 mins	3.8	12803	13111	15.8	4.5	13.47	125

APPENDIX: LANDSCAPE EVALUATION SCORES

1. The survey area comprised 83 one hectare cells. These were numbered numerically from the north west corner to the Southern extremity; they were to be known by this cell number. For computer plotting they had to be redesignated under a 100 x 100 grid system with a false origin (0000) beyond the south western margin of the Fell. It has proved more satisfactory to identify the cells on a alphabetical/numerical system.

   1A is thus the north western cell and 9L the most extreme south eastern cell.

2. The computer print-out has more than six hundred cell enumerations - presenting the scoring of more than thirty assessors and these contained some errors in detail which were corrected by manual checking against a moderator's sheet and by examination of stereo pairs of aerial photographs.

3. The moderator was a 'trained' student engaged on testing landscape evaluation methods. It was not intended that his scores should be used but his landscape component list for each cell was found to be very accurate by the author and it is therefore presented here, together with his qualitative assessment of each component to show a statistical description of Waldridge Fell (List E1).

4. The total score for each cell is taken from the computer print-out and appears as list E2.

   E2/E1 correlation is presented visually on Maps. It can be seen that, in the middle range of evaluation (2-6), discrepancies can be effected by the rating given to 'distant' views and terrain cover. Correlation of assessment of terrain where there is a complete range of (or large numbers of) components, is positive and high. It was primarily the highly rated areas that were being sought by the evaluation exercise: these are the areas in dark shading on the maps.

APPENDIX E1 LANDSCAPE SURVEY SCORES C.R.V. TANDY METHOD

SCORING SUMMARY:- Example: Square 9L (South Burn Area)

	Component	Quantity		Quality	
9L	A Surface Cover; woodland with heath	2	x	2	4
	B Undulation; steep hillside (*The extremes of Quality should rarely be applied)	2	x	*1	2
	C Trees in mass; woodland	2	x	2	4
	D Trees singly; e.g. specimens, garden trees	0			0
	E Water; Stream	1	x	1	1
	F Artifacts; e.g. housing estate,coal mine	0			0
	G Views out; linear view along valley	1	x	1	1
		Total			12

Quantity Factor

0 (Not present) 1 (Some) 2 (Over most of cell
Quantity 2 can therefore only be applied to a
Maximum of TWO of components A,C,D,E,F)

Quality Factor

-2 intolerable -1 undesirable 0 acceptable +1 desirable
+2 highly desirable

1A	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	2	x	1	2
D	0			0
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				7

2A	(i)		(ii)	
A	2	x	1	2
B	1	x	2	2
C	0			0
D	1	x	2	2
E	0			0
F	0			0
G	2	x	1	2
				8

3A	(i)		(ii)	
A	2	x	1	2
B	1	x	2	2
C	1	x	2	2
D	1	x	1	1
D	0			0
F	0			0
G	2	x	2	4
				11

4A	(i)		(ii)	
A	2	x	1	2
B	1	x	2	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

5A	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				5

6A	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				6

7A	(i)		(ii)	
A	0	x	-1	0
B	0	x	1	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	-1	-2
				-2

1B	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	2	x	1	2
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				8

2B	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	2	x	1	2
D	0			0
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				7

3B	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	2	x	1	2
D	0			0
E	0			0
F	0			0
G	2	x	1	2
				8

4B	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	1	x	1	1
D	0			0
E	0			0
F	1	x	0	0
G	1	x	-1	-1
				2

5B	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				5

6B	(i)		(ii)	
A	1	x	1	1
B	1	x	0	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				3

7B	(i)		(ii)	
A	1	x	1	1
B	0	x	1	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-2	-2
G	2	x	-1	-2
				-2

8B	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	1	x	1	1
D	0			0
E	0			0
F	1	x	-2	-2
G	2	x	-1	-2
				-1

9B	(i)		(ii)	
A	1	x	1	1
B	2	x	-1	-2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-2	-2
G	1	x	1	1
				-1

10B	(i)		(ii)	
A	1	x	1	1
B	2	x	-1	-2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-2	-2
G	1	x	1	1
				-1

1C	(i)		(ii)	
A	1	x	1	1
B	2	x	0	0
C	0			0
D	2	x	1	2
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

2C	(i)		(ii)	
A	1	x	-1	-1
B	1	x	-1	-1
C	0			0
D	2	x	1	2
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				-1

3C	(i)		(ii)	
A	1	x	1	1
B	1	x	0	0
C	0			0
D	2	x	1	2
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				3

4C	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	0	x	0	0
D	1	x	1	1
E	0			0
F	0			0
G	1	x	1	1
				4

5C	(i)		(ii)	
A	2	x	0	0
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	1	x	1	1
				1

6C	(i)		(ii)	
A	2	x	0	0
B	1	x	-1	-1
C	0			0
D	1	x	0	0
E	0			0
F	0			0
G	1	x	1	1
				0

7C	(i)		(ii)	
A	2	x	0	0
B	1	x	-1	-1
C	0			0
D	0			0
E	1	x	1	1
F	1	x	-1	-1
G	2	x	1	2
				1

8C	(i)		(ii)	
A	2	x	0	0
B	1	x	0	0
C	0			0
D	0			0
E	1	x	1	1
F	1	x	-1	-1
G	2	x	1	2
				2

9C	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				5

10C	(i)		(ii)	
A	1	x	-1	-1
B	1	x	-1	-1
C	0			0
D	0			0
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				-1

1D	(i)		(ii)	
A	1	x	0	0
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

2D	(i)		(ii)	
A	2	x	1	2
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	0	0
G	1	x	-1	-1
				1

3D	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	1	x	1	1
D	0			0
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				3

4D	(i)		(ii)	
A	1	x	1	1
B	2	x	1	2
C	1	x	1	1
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				6

5D	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	1	x	1	1
				4

6D	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	1	x	1	1
				4

7D	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	1	x	1	1
				6

8D	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

9D	(i)		(ii)	
A	1	x	1	1
B	1	x	0	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				3

10D	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	2	x	1	2
E	0			0
F	2	x	1	2
G	1	x	0	0
				8

1E	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	1	x	1	1
D	1	x	1	1
E	0			0
F	1	x	1	1
G	1	x	0	0
				6

2E	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	1	x	1	1
D	1	x	1	1
E	0			0
F	1	x	0	0
G	1	x	1	1
				5

3E	(i)		(ii)	
A	2	x	0	0
B	1	x	-1	-1
C	0			0
D	1	x	0	0
E	0			0
F	1	x	0	0
G	1	x	-1	-1
				-2

4E	(i)		(ii)	
A	2	x	1	2
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	0	0
G	2	x	1	2
				4

5E	(i)		(ii)	
A	2	x	2	4
B	1	x	1	1
C	0			0
D	2	x	1	2
E	0			0
F	1	x	0	0
G	1	x	1	1
				8

6E	(i)		(ii)	
A	2	x	1	2
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				4

7E	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	0			0
E	0			0
F	0			0
G	2	x	1	2
				5

8E	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

9E	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				5

10E	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	2	x	1	2
E	0			0
F	0			0
G	2	x	1	2
				8

1F	(i)		(ii)	
A	1	x	-1	-1
B	1	x	1	1
C	0			0
D	1	x	1	1
E	1	x	-1	-1
F	1	x	-1	-1
G	1	x	0	0
				-1

2F	(i)		(ii)	
A	1	x	1	1
B	2	x	1	2
C	1	x	1	1
D	1	x	1	1
E	1	x	1	1
F	1	x	-1	-1
G	1	x	1	1
				6

3F	(i)		(ii)	
A	1	x	1	1
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				4

4F	(i)		(ii)	
A	1	x	1	1
B	2	x	1	2
C	0			0
D	0			0
E	0			0
F	0			0
G	2	x	1	2
				5

5F	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	0			0
E	0			0
F	0			0
G	1	x	1	1
				4

6F	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	0			0
E	0			0
F	1	x	0	0
G	2	x	1	2
				5

7F	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

8F	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	0			0
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				2

9F	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

10F	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	2	x	1	2
E	0			0
F	0			0
G	1	x	0	0
				5

4G	(i)		(ii)	
A	2	x	1	2
B	1	x	0	0
C	0			0
D	0			0
E	0			0
F	0			0
G	2	x	1	2
				4

5G	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				5

6G	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				6

7G	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

8G	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	0			0
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				2

9G	(i)		(ii)	
A	2	x	1	2
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	0	0
G	1	x	1	1
				3

10G	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	0			0
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

6H	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				5

7H	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0	x	0	0
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				7

8H	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

9H	(i)		(ii)	
A	2	x	1	2
B	0	x	1	0
C	0			0
D	1	x	1	1
E	1	x	-1	-1
F	0			0
G	2	x	1	2
				4

10H	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				5

6I	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	1	1
G	1	x	1	1
				7

7I	(i)		(ii)	
A	2	x	1	2
B	1	x	1	1
C	1	x	2	2
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	1	x	1	1
				6

8I	(i)		(ii)	
A	2	x	1	2
B	1	x	-1	-1
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				4

9I	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	1	x	2	2
D	0			0
E	0			0
F	0			0
G	1	x	1	1
				7

10I	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	1	x	2	2
D	1	x	1	1
E	0			0
F	0			0
G	2	x	1	2
				9

7J	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	0			0
D	1	x	1	1
E	0			0
F	1	x	-1	-1
G	2	x	1	2
				6

8J	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	1	x	2	2
D	1	x	1	1
E	1	x	0	0
F	0	x	0	0
G	2	x	1	2
				9

9J	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	2	x	2	4
D	1	x	1	1
E	1	x	2	2
F	0			0
G	1	x	1	1
				12

10J	(i)		(ii)	
A	2	x	2	4
B	2	x	1	2
C	2	x	2	4
D	0			0
E	1	x	2	2
F	0			0
G	1	x	1	1
				13

7K	(i)		(ii)	
A	2	x	2	4
B	2	x	2	4
C	1	x	2	2
D	1	x	2	2
E	1	x	1	1
F	1	x	-1	-1
G	1	x	1	1
				13

8K	(i)		(ii)	
A	1	x	2	2
B	2	x	1	2
C	1	x	2	2
D	1	x	1	1
E	1	x	1	1
F	0			0
G	2	x	1	2
				10

9K	(i)		(ii)	
A	2	x	1	2
B	2	x	1	2
C	1	x	2	2
D	0	x	0	0
E	1	x	1	1
F	0			0
G	1	x	2	2
				9

7L	(i)		(ii)	
A	1	x	2	2
B	2	x	2	4
C	1	x	2	2
D	1	x	1	1
E	1	x	2	2
F	1	x	-1	-1
G	1	x	1	1
				11

8L	(i)		(ii)	
A	2	x	2	4
B	2	x	1	2
C	2	x	2	4
D	0			0
E	1	x	1	1
F	0			0
G	1	x	1	1
				12

9L	(i)		(ii)	
A	2	x	2	4
B	2	x	1	2
C	2	x	2	4
D	0			0
E	1	x	1	1
F	0			0
G	1	x	1	1
				12

APPENDIX E2

Landscape Survey Scores : Cell means from Computer print-out

1A	7	2A	7	3A	6	4A	6	5A	5
6A	4	7A	3						
1B	8	2B	7	3B	4	4B	4	5B	4
6B	5	7B	4	8B	3	9B	-1	10B	-3
1C	5	2C	5	3C	5	4C	5	5C	5
6C	4	7C	4	8C	5	9C	6	10C	4
1D	5	2D	5	3D	4	4D	6	5D	6
6D	5	7D	6	8D	5	9D	5	10D	6
1E	6	2E	6	3E	4	4E	6	5E	9
6E	5	7E	5	8E	7	9E	4	10E	8
				3F	5	4F	5	5F	5
6F	4	7F	7	8F	5	9F	5	10F	5
						4G	4	5G	5
6G	4	7G	7	8G	6	9G	5	10G	2
								5H	3
6H	5	7H	6	8H	6	9H	4	10H	5
6I	5	7I	5	8I	9	9I	6	10I	7
		7J	6	8J	11	9J	14	10J	13
		7K	11	8K	10	9K	12		
		7L	11	8L	11	9L	12		

APPENDIX E3 LANDSCAPE SURVEY SCORES (ADJUSTED) C.R.V. TANDY METHOD

1A	7	2A	7	3A	9	4A	7	5A	5
6A	5	7A	0						
1B	8	2B	7	3B	6	4B	3	5B	4
6B	4	7B	0	8B	2	9B	-1	10B	-2
1C	5	2C	2	3C	3	4C	4	5C	3
6C	3	7C	2	8C	3	9C	5	10C	2
1D	4	2D	3	3D	4	4D	6	5D	5
6D	5	7D	6	8D	6	9D	4	10D	7
1E	6	2E	6	3E	1	4E	5	5E	8
6E	5	7E	5	8E	7	9E	5	10E	8
				3F	5	4F	5	5F	5
6F	5	7F	7	8F	4	9F	4	10F	5
						4G	4	5G	5
6G	5	7G	7	8G	4	9G	4	10G	3
								5H	3
6H	5	7H	7	8H	5	9H	4	10H	5
6I	6	7I	6	8I	7	9I	7	10I	8
		7J	6	8J	10	9J	12	10J	13
		7K	12	8K	10	9K	10		
		7L	11	8L	12	9L	12		

ENVIRONMENTAL QUALITY SCORES AS ASSESSED BY LANDSCAPE RESEARCH STUDENT AND MULTI DISCIPLINARY GROUP

[r = + 0·78]

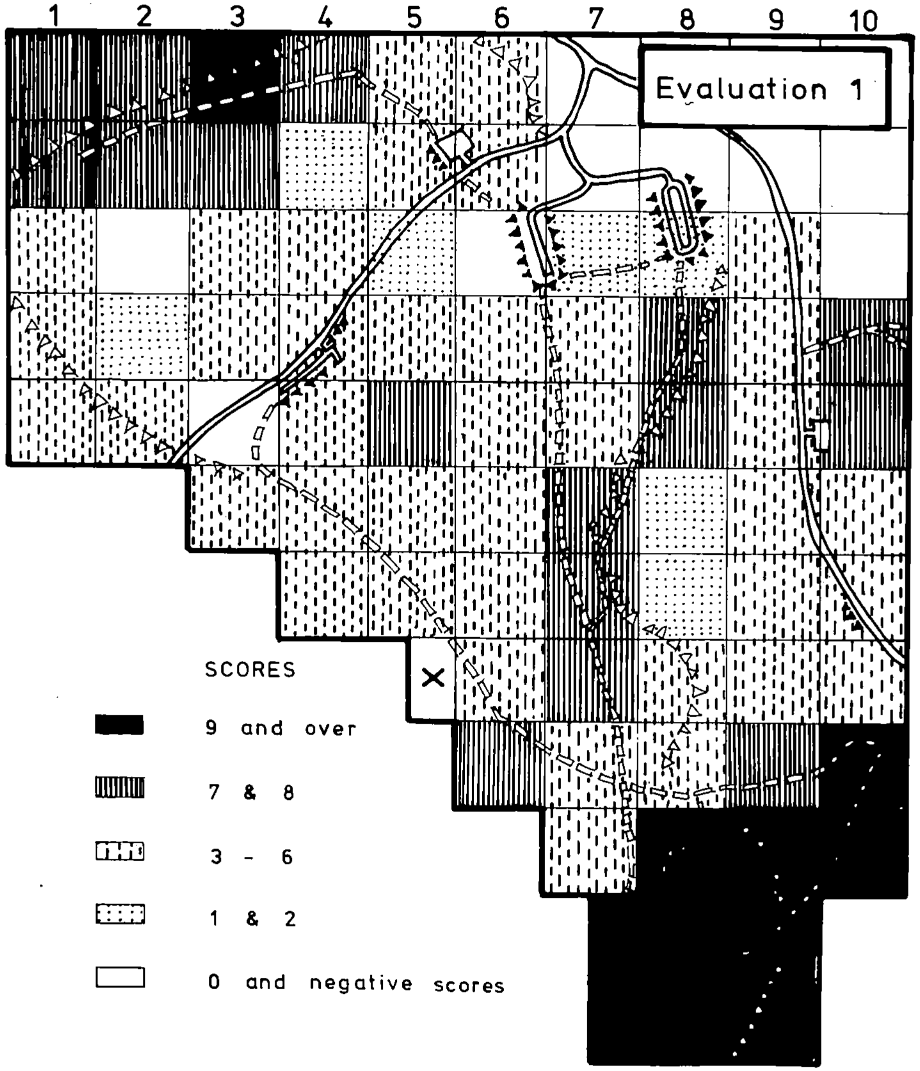


Fig. 27

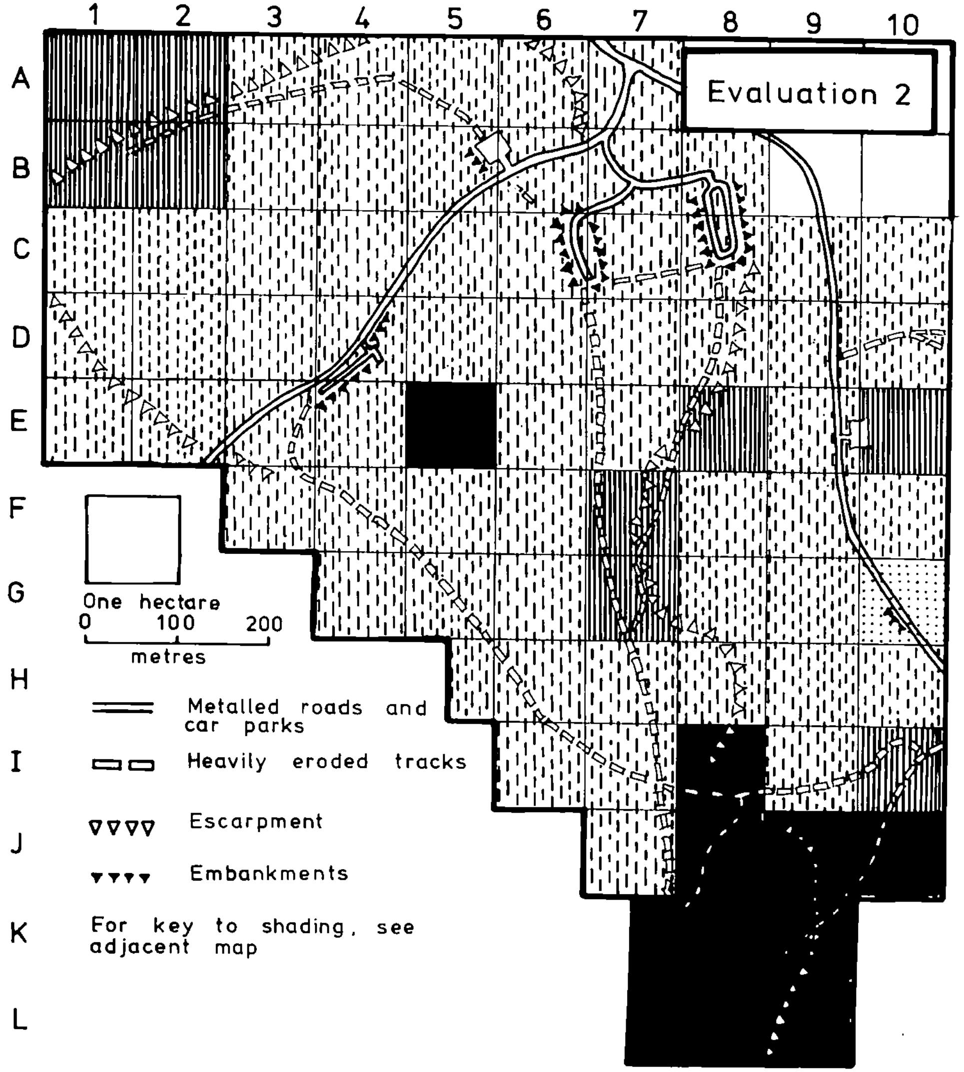


Fig. 28

APPENDIX E 5(a)

LANDSCAPE EVALUATION

A paper by CRV Tandy of Land Use Consultants; member of the Landscape Research Group.

The basic contents of this paper were briefly given at a Symposium on Methods of Landscape Analysis given by the Landscape Research Group in London on 3 May 1967.
The present revision, dated January 1971 has been produced to include minor modifications resulting from the method having been tested in the field, and adopted for work on the county survey by West Sussex County Council.

1. In spite of a call for a national landscape classification system at the time of the first Countryside in 1970 Conference in 1963, there is still no broad agreement on a common method. Several different methods are in use by County Planning Authorities and others, but there is little chance that these are mutually compatible. Some methods are content with recording the elements of landscape as seen, others attempt to relate landscape quality to a scale of values, of some kind.

2. One of the Counties engaged on this work is Hampshire, and much classification of landscape quality of the county has been done by a method introduced by R Hebblethwaite when he was landscape architect to the County Council. (This method is also described in the proceedings of the L.R.G. symposium mentioned above.)

3. In the Hampshire method each Quarter-Kilometre square on the One Inch Ordnance map is visited and given both a quantitative and a qualitative value by an experienced observer. To obtain reasonably constant evaluation by different observers, a list of all landscape elements likely to be found is given:

Undulation
Trees
Parkland
Farmland
Mineral Exc.
Heathland
Escarpment
Grassland
(Field size)

Quantitative analysis consists of recording the amount of each element noted as present in each square.

4. In studying the Hampshire method I was impressed by its ease of working, but troubled by two apparent gaps in the method:

1. that no value was given for the <u>prospect</u> from a locality
2. that there was no direct correlation between the quantitative analysis of the elements, and the subjective QUALITY value which the observer gave to the locality.

5. In an attempt to give some value for prospect, and also to evaluate the <u>total</u> quantity and quality of elements in a locality, I experimented with a system of point scoring, which is described below. The elements are taken from the Hampshire list, with the addition of VIEWS OUT; the scoring is kept to a maximum of five units (2 positive, 2 negative and a zero) to facilitate computer application.

6. The method is used as follows:

6.1 Identify areas according to the 1 Km square on a 1" Ordnance map.

6.2 In each square identify the following landscape elements, whether they be desirable or undesirable:

a	SURFACE COVER	eg	grass, heathland, arable land, etc
b	UNDULATION	eg	rolling, steep hillside, rockface, mining subsidence
c	*TREES IN MASS	eg	woodland, orchards, clumps; monoculture forestry
d	TREES SINGLY	eg	specimens, groups, parkland, hedgerows, garden trees
e	*WATER	eg	river, lake, reservoir, subsidence flash
f	ARTIFACTS (making a significant contribution)	eg	castle, mansion, housing-estate, road, coal mine
g	VIEWS OUT	eg	sea, hills, distant mountains, slag tips, factory complex

* (Note: if present in sufficient quantity, these become a partial <u>alternative</u> to the element (a) surface cover)

6.2 (cont)

It is advantageous to give a brief description of the character of each element to have a reminder of the reasons why an area achieved a high or low score. Particularly is it essential to record the items which make up the total surface cover of the area (which may be parts of a, c, and e – as note above).

6.3 Each element is given a QUANTITY factor of:

0 (none)   1 (some)   or 2 (all)

Note that the maximum (2) should only be given to VIEWS OUT for exceptional views in all directions.

6.4 Each element is also given a QUALITY factor of:

- 2 intolerable
- 1 undesirable
0 acceptable
+ 1 desirable
+ 2 highly desirable

Note that values 2 or -2 should only rarely be credited to the element "undulation".

6.5 The Quality and Quantity values are multiplied together to give a score for each element, and the scores totalled to give a score for the locality. It is of course possible to have an element which scores partly good and partly bad, but the maximum quantity: 2 (all) can only be given to one of the major elements (ie a locality cannot be all forestry and all water!). The theoretical maximum is 18, the theoretical minimum is - 18.

6.6 Some examples:

Example 1 (unattractive area):

a	Surface cover:	partly poor grassland	1 x -1	= -1
b	Undulation:	flat	2 x -1	= -2
c	Trees in mass:	none		= 0
d	Trees singly:	none		= 0
e	Water:	none		= 0
f	Artifacts:	mineral workings	1 x -2	= -2
g	Views out:	none		= 0
		Total score:		-5

6.6 (cont)

Example 2 (average area)

a	rough grass	2 x 0	=	0
b	gently rolling	2 x 1	=	2
c	well wooded	2 x 1	=	2
d	few single trees	1 x 1	=	1
e	no water		=	0
f	one derelict factory	1 x -2	=	-2
g	view of hills	1 x 1	=	1
	Total score:			+4

Example 3 (idyllic locality)

a	part heather and shrubs	1 x 2	=	2
b	scenic slopes	2 x 1	=	2
c	part ornamental woods	1 x 2	=	2
d	well tree'd	1 x 2	=	2
e	lake	1 x 2	=	2
f	historical manor house	1 x 2	=	2
g	distant mountain views	1 x 2	=	2
	Total score:			14

6.7 Having achieved a score for each square, a map can be shaded or coloured with a scale of tints representing scores of, say:

below -2; -1, 0, +1; 2 - 5; 6 - 9; 10 - 13; 14 and above

As squares with similar scores would tend to fall adjacent to each other, the map would then show the landscape graded into zones of quality.

7. This method is, of course, like all other such methods, dependent upon the subjective opinion of the surveyor, and some common acceptance of terms should be established among a team of surveyors. As a rough test of the method, it has been tried out on several paintings of classical landscape, which, predictably, scored very highly. It has also been field-tested by the West Sussex County Council Planning Department on a series of transects, and compared with other methods.

8. A copy of a typical field sheet by a West Sussex C.C. Surveyor using the method is included here by permission. The bottom line is a code for computer programming.

SCORING SUMMARY

LANDSCAPE EVALUATION TECHNIQUE (Quantitative and Qualitative)
to be applied to each Km sq on the 1" Ordnance Survey Map

ELEMENTS (which may have either good or bad qualities)		QUANTITY FACTOR	QUALITY FACTOR
a. SURFACE COVER	eg grass, heathland, arable land		
b. UNDULATION *	eg rolling, steep hillside, subsidence		−2 intolerable
c. TREES IN MASS	eg woodlands, orchards, clumps, forestry	0 (none)	−1 undesirable
d. TREES SINGLY	eg specimens, groups, parkland, garden trees	1 (some)	0 acceptable
e. WATER	eg river, lake, reservoir, subsidence flash	2 (all)	+1 desirable
f. ARTIFACTS	eg castle, mansion, housing estate, coal mine		+2 highly desirable
g. VIEWS OUT †	eg sea, hills, distant mountains, slag tips, factory complex		

Each element scores a multiple of Quantity factor x Quality factor; Each locality scores a total of the scores of its elements

NOTES:

1. (*) The Quality extremes (2 or −2) should only rarely be credited to this element (Undulation)
2. (†) The Quantity maximum (+2) should only be used for exceptional, all-round viewpoints
3. Some elements are alternatives, ie surface cover; water; forestry; hence one must not apply the Quantity maximum (2) to more than one major element
4. An element may be partly desirable and partly undesirable and so will score for each part (eg 1 x 1 and 1 x −1)
5. The theoretical maximum is 18; the theoretical minimum is −18

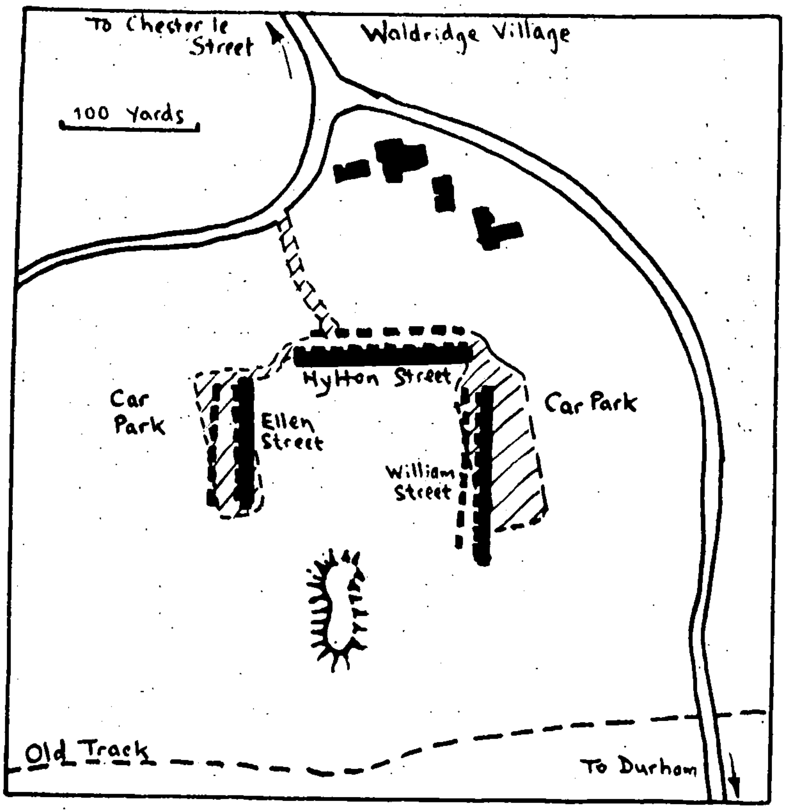
APPENDIX E 5(b)

Source: Linton (1968) Table (1) "The Assessment of Scenery as a Natural Resource" (Scot. Geog. Mag. Vol. 84)

Table 1

CATEGORY & RATING	URBANISED & INDUS-TRIALISED —5	CONTINUOUS FOREST —2	TREELESS FARMLAND +1	MOORLAND +3	VARIED FOREST AND MOORLAND +4	RICHLY VARIED FARMLAND +5	WILD LANDSCAPES +6
LOWLAND 0	Ayrshire Coast —5	Culbin Forest —2	Machars of Wigtown +1	Moors of Wigtown +3	Cromar +4	Strathearn +5	Colonsay +6
LOW UPLANDS 2	N.E. Lanarkshire —3	Darnaway Forest 0	N.E. Berwickshire +3	Loch Shin +5	Methven and Glenalmond +6	Gifford (East Lothian) +7	Gruinard Bay +8
PLATEAU UPLANDS 3	(*No example*) —2	Kielder Forest +1	Falahill (Midlothian) +4	Monadhliath +6	Potrail Water +7	(*No example*) +8	Mid Argyll +9
HILL COUNTRY 5	Bathgate Hills 0	Nethy Forest +3	Gala Valley +6	Crawick Water +8	Speyside +9	Middle Tweed +10	Loch Moidart +11
BOLD HILLS 6	Leadhills - Wanlockhead +1	Strathyre Forest +4	Loch Chon +7	Dalveen Pass +9	Bennachie +10	(*No example*) +11	Morvern and Sunart +12
MOUNTAINS 8	Kinlochleven +3	Loch Lubnaig +6	Glen Elchaig +9	Glen Clova +11	Achnashellach +12	(*No example*) +13	Coigach +14

Appendix E.6 WALDRIDGE FELL COUNTRY PARK



Car Park area as it was in the late 19th century, showing sites of new parking facilities.

Did you know that this car park stands on the site of old miners' cottages dating from the end of the nineteenth century? The rectangular mounds to the south of the eastern car park are some of the remains - and they include the sites of old earth closets.

The large mound to the south is part of the spoil from mineral workings.

The trackway that runs east-west is part of an old routeway that crossed a plateau which was heathland long before the coal miners came. Within a few feet of where you are standing you can find several moorland plants, some in flower. See if you can identify them from the illustrations on this sheet.

The Fell is now administered by Durham County Council as a country park and this car park is one of the most recent additions to the landscape of the Fell.

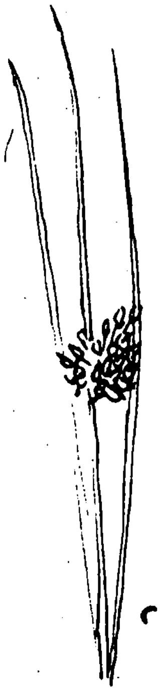
A Survey is being conducted to establish public reactions to this amenity; you could greatly assist by completing the accompanying form before you leave. *A collecting point will be situated at the exit but if you forget to hand it in and still wish to help you can post it to:-

L. Ellison,
Department of Geography & History,
Sunderland Polytechnic,
Chester Road,
Sunderland.

* Dark Green Marina LBR 126N (Note: ~~books~~ box and pencils provided)

Bilberry

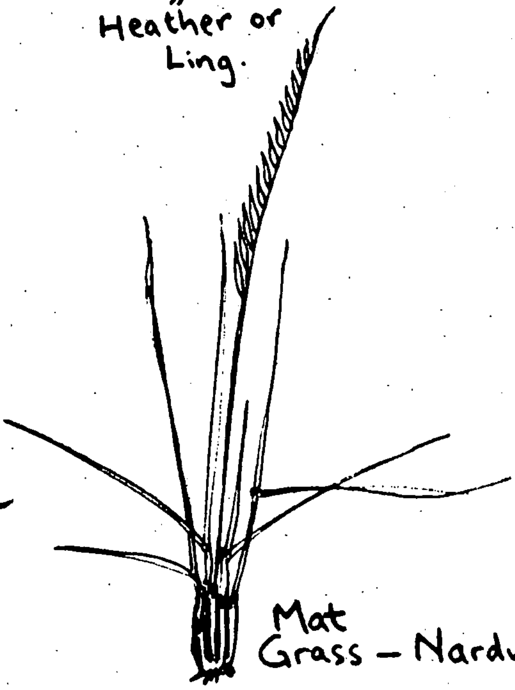
Heather or Ling.



rush

Heath Bedstraw

Gorse



Mat Grass – Nardus

Bracken

Waldridge Fell Country Park : Car Park Survey

You are invited to help our research by completing this Questionnaire. You are not required to write in your name or car number.

Please fill in spaces or tick your response.

1. Where did you set out from earlier today? ....
(If you are a visitor to the area and your party does not include a local resident, please write in your home town.) ....

2. Did you set out specially to come here ☐ Yes
☐ No

3. If 'yes', how did you know about this fell?
Nature Conservancy leaflet
County Council leaflet ☐
Newspaper or 'nature' journal ☐
Picked out from O.S. map ☐
Told by friends ☐
Chance discovery ☐
Other (give detail) ....

....

4. ~~If you discovered this area by chance,~~
Is this your first visit? ☐ Yes
☐ No

5. If 'yes', would you come again ☐ Yes
☐ No

Please give brief reason ....

....

6. If <u>not</u> a first visitor, how often do you visit this fell?
once a year ☐ Since .... (1973 etc)
2 - 3 times a year ☐
once a month ☐
more times than listed above ☐

7. Are you pleased with the car parking and other facilities?

☐ Yes

☐ No

Give reasons, particularly if you answered 'No'

....

....

....

....

....

8. Which of the following have you done / do you intend to do during your visit?

i) picnic in or near the car .... ☐

ii) picnic some distance away from the car (i.e. out of sight of parking area).. ☐

iii) walk along main pathways .... ☐

iv) explore wilder areas, off the paths .... ☐

v) engaged in leisure activity (e.g. kite flying, bird watching, cross-country training, dog-walking) Please specify .... ☐

....

vi) engaged in 'research' activity for school, college etc. .... ☐

9. How many people are there in your group?

Age	Number
0-9 years	
10-19 years	
20-34 years	
35-64 years	
over 65	

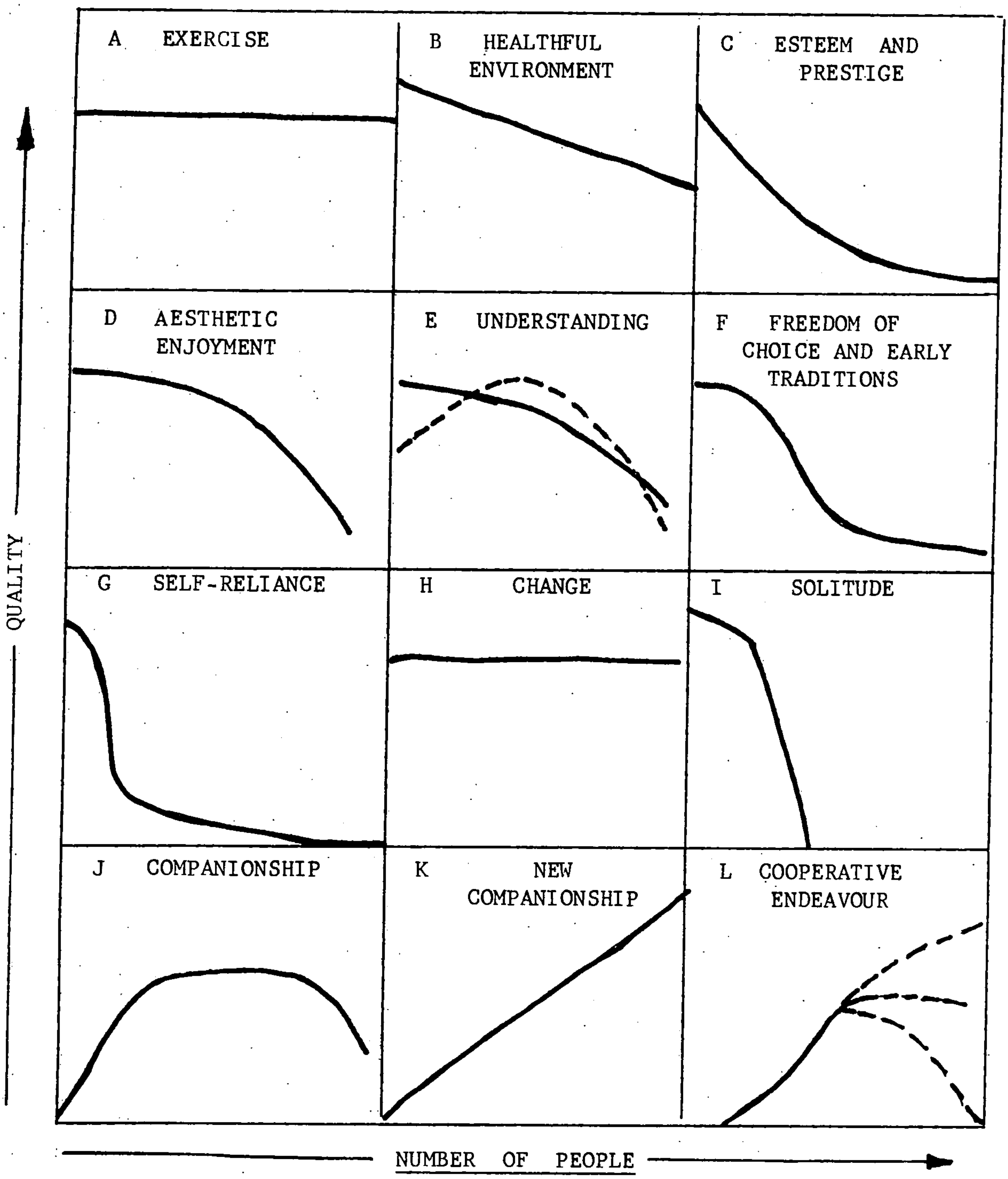


FIGURE 2. Effects of crowding on the quality which results from satisfaction of the needs that commonly motivate outdoor recreation. On the horizontal axes, number of people increases to the right. On the vertical axes, quality increases with height.

Based on Fig. 2 Wagar J.A.
"The Carrying Capacity of Wildlands for Recreation"
Forest Science Monograph No. 7 (1964)

APPENDIX F

Report of County Planning Officer to Durham County Council Environment Committee, Improvement Sub Committee

Chester-le-Street District - Waldridge Fell Country Park.

1. INTRODUCTION

In November 1974 the Committee agreed to the appropriation from the Education Committee of 115 hectares of land at Waldridge Fell. This was to enable the County Council to undertake the positive management and control of the Fell as a country park and to ensure its survival as an area of scientific value used for education and informal recreation. By designating the Fell as a country park the County Council could avail itself of 50% government grants for development work and warden services.

2. POLICIES FOR WALDRIDGE FELL

In my last report to Committee I described in detail the scientific, educational and recreational value of the Fell; the uses to which it is now put; the problems now apparent and the problems which might arise in the future if existing uses were intensified or new uses introduced.

I have now been able to prepare for the Sub Committee's consideration a plan for the initial establishment and development of the country park, taking into account information now available on its use. It is impossible to predict accurately how visitors will use the Fell in future and it may, therefore, be necessary to amend the plan. It is based on the following principles.

(i) The Fell should be maintained as a Site of Special Scientific Interest, in consultation with the Nature Conservancy Council

(ii) The open moorland landscape should be preserved

(iii) Derelict and damaged areas should be appropriately restored

(iv) Recreational facilities should be provided for the quiet enjoyment of the Fell by the general public

(v) Appropriate educational use of the Fell should be permitted and assisted

(vi) Use of the Fell should be limited so that the scientific interest and landscape are maintained and its recreational and educational resources protected

(vii) A Warden Service should be provided to supervise and control the use of the Fell.

3. A PLAN FOR THE ESTABLISHMENT OF A COUNTRY PARK

Recreational facilities should be concentrated in the northern part of the Fell, leaving the southern part primarily for educational use. (One nature trail for schools has already been established in this area and others could be developed).

Informal car parks for 185 cars could be provided in the northern part of the Fell using, wherever possible, existing grass areas with hard surfaced access roads. A toilet block and warden's store could be provided between the main car park and the bus stop. Vehicular access to other parts of the Fell needs to be prevented by the construction of shallow mounds and ditches. At the same time the rubbish dumped on the Fell needs to be cleared away.

Several public footpaths and bridleways cross the Fell, as well as other paths used by walkers. These paths need not be closed and there need be no restriction of public access on foot. The northern part of the Fell is the least used area at present and, to encourage visitors to use this part of the Fell, the footpaths could be waymarked and information boards provided at the main car parks. Formal footpaths and picnic tables would be out of place on the Fell but, where necessary footpaths should be drained and treated to prevent erosion. In the main they should be left as grass tracks. Simple wooden bench seats could be provided as appropriate on the main footpaths.

The pond at Smithy Dene has been so damaged by tipping that it no longer has any scientific value and the best course of action, on both landscape and wildlife grounds, would be to fill it in completely. At the same time a new pond for educational use could be created at a suitable site on the eastern side of the Fell, near the Field Studies Centre. A small number of trees could be planted on the edges of the Fell, for screening purposes.

The derelict land on the Fell and at the site of Nettlesworth Drift will be reclaimed in 1976/77. I shall submit detailed proposals to the Sub-Committee later but the reclamation scheme will include provision for a new car park near Nettlesworth Drift, for people using the northern part of the Fell. Part of the pit heap will also be retained for educational use (the study of recolonization by plants). There are several old shafts on the Fell and these will be fenced off where necessary, prior to being made safe during the reclamation scheme.

The estimated cost of these proposals is as follows:-

Appropriation	£12,000
Car parks, control of vehicles, disposal of rubbish, fencing shafts	£11,500
Drainage, repairs to footpaths, new pond	£6,000
Tree planting	£500
Signs and information	£1,500
Toilet block and warden's accommodation	£21,000
New car park at Nettlesworth Drift	£1,900
Photographs, etc.	£100
Contingencies (10%)	£5,500
Gross Cost	£60,000
Less 50% grant aid from Countryside Commission	£30,000
Net cost to County Council	£30,000

Provision has been made in the approved estimates for the current financial year and for 1975/76. Further provision will need to be made in 1976/77 financial year.

Since there is likely to be considerable benefit to the local population in the Chester-le-Street area from these proposals I suggest that the Chester-le-Street District Council should be asked to contribute to the net cost of the initial development of the Country Park (say one-third of the net costs). If the District Council agrees to do so then the net cost to the County Council would be reduced by approximately £8,000.

4. CONSULTATIONS

The proposals have been prepared in close consultation with the Director of Education, the County Land Agent and Valuer, the Nature Conservancy Council and local members of the Durham County Conservation Trust who know the Fell well. Chester-le-Street District Council have approved the establishment of the Country Park and the Waldridge Parish Council have also given their support. The Countryside Commission, who are responsible for grant aiding such schemes, have given their approval in principle.

The Fell is provisionally registered as common land. Because local people were worried about the future of the Fell a public meeting, chaired by Councillor R. Taylor, was held in Waldridge Village on 3rd January, 1975, preceded by an exhibition showing details of the proposed Country Park scheme. The 28 local people who attended the meeting welcomed the proposal to establish a Country Park and the detailed proposals in this respect take account of comments made at the meeting.

It will be necessary to obtain the approval of the Secretary of State for the Environment for any construction work (including car parks) because the Fell has been registered as common land.

5. FIRST STAGE OF ESTABLISHMENT WORK

This work would include the construction of mounds and ditches, car parks and access roads and could be completed during summer 1975. Three grass-surfaced car parks and one hard-surfaced car park would be provided near the Waldridge/Edmondsley Road and one small hard surfaced car park near the Waldridge/Chester Moor road. These car parks would accommodate a total of approximately 165 cars but would be constructed so that individual car parks can be closed off for repair or reseeding work in the future. Grass mounds and shallow ditches would be constructed along the roadside and around the car parks at points where cars have been driven onto the Fell in the past, causing considerable damage to the vegetation.

The County Engineer has indicated that he can do this work at an estimated cost of £7,625 This work should qualify for 50% grant and the net cost would therefore be £3,812.50.
This can be met within the approved estimates for 1974/75 and 1975/76.

6. MANAGEMENT OF THE FELL

From the observations of my own and the County Land Agent and Valuer's staff and the comments of the villagers, it is apparent that many of the existing problems on the Fell can only be dealt with by providing an efficient warden service as is the case with many of the Committee's other parks and picnic areas. These problems include rubbish dumping (domestic refuse and builder's waste), lighting of fires, peat digging and shooting.

I have discussed this with the County Land Agent and Valuer and we are agreed that there is urgent need for a warden now and that it is essential that a full-time warden is working on the Fell as soon as possible. Without supervision and immediate repair of any damage much of the initial work on the establishment of the Country Park could be wasted. Also, a warden involved at the establishment stage would be better able to understand subsequent patterns of visitor behaviour and maintenance problems and would bring valuable local knowledge and feed back from visitors at a stage when this could be of use in the initial establishment work. In this regard the County Land Agent and Valuer will prepare a report for submission to the February meeting of the Environment Resources Sub-Committee.

A management plan for the Country Park will also be prepared in consultation with the County Land Agent and Valuer, the Director of Education and the Nature Conservancy Council.

7. RECOMMENDATIONS

I hope the Sub-Committee will:

1. Approve the plan and estimates for the establishment of Waldridge Fell Country Park, referred to in this report on the principles on which they are based;

2. waive standing order 45(1)(b) (which requires the invitation of competitive tenders for work estimated to exceed £200 in value) so that the County Engineer can carry out the first stages of work and authorise me to place the necessary order, subject to the approval of the Countryside Commission for grant purposes;

3. authorise me to invite necessary tenders and quotations for the remaining work on the establishment of Waldridge Fell Country Park, as described in the plan above;

4. send a copy of this report to Chester-le-Street District Council and invite them to consider contributing one-third of the net cost of the initial establishment of Waldridge Fell Country Park.

J. R. ATKINSON

County Planning Officer

Planning Department,
County Hall,
Durham.
14th January, 1975.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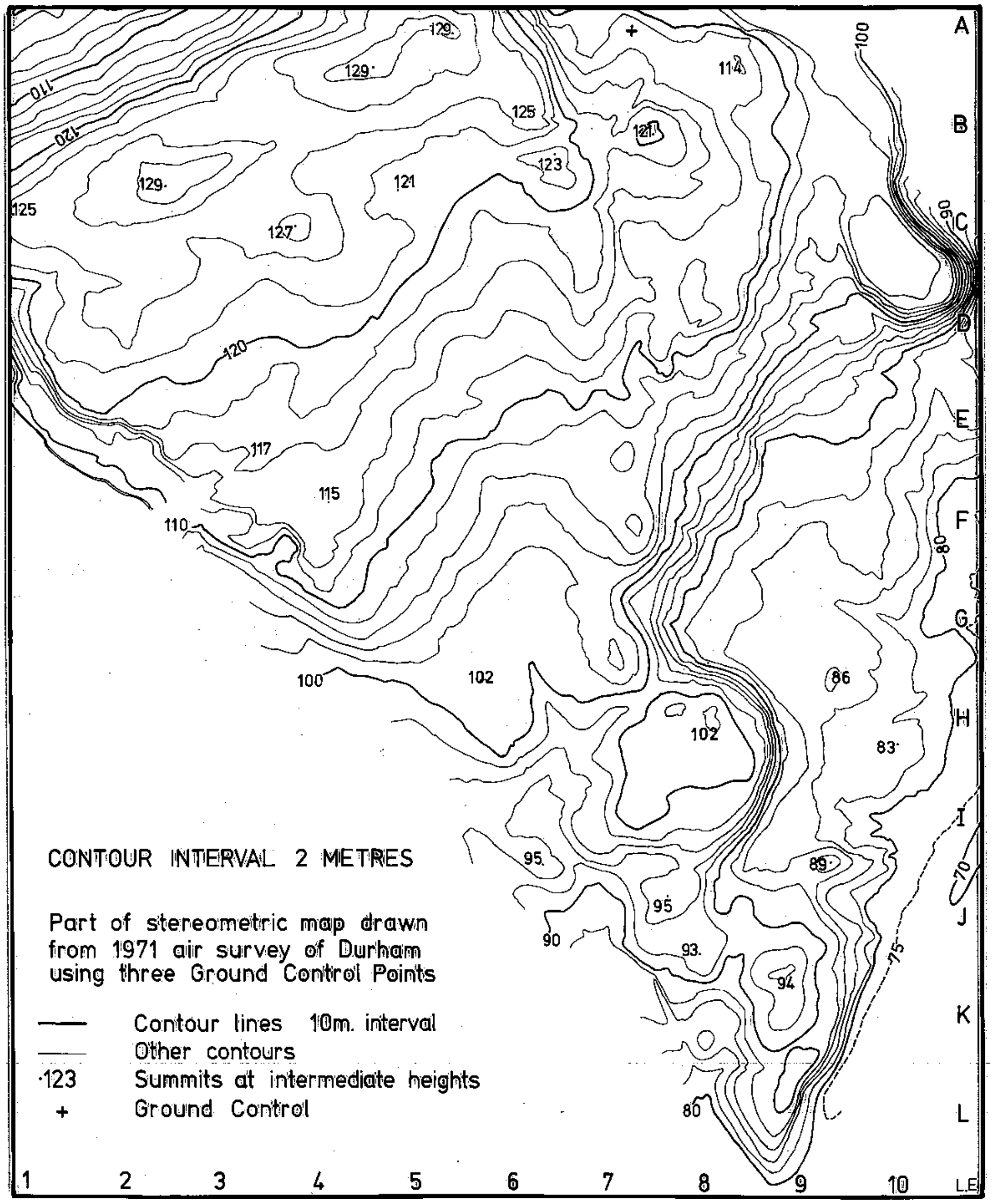
RELIEF OF WALDRIDGE FELL



THE COMMUNICATION NETWORK ON WALDRIDGE FELL