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D.O.E. CONTRACT DGR/483/23

INTERIM REPORT, 1.5.78.

ECOLOGY OF VEGETATION CHANGE IN UPLAND LANDSCAPES

(I.T.E. Project No. 522)

Project Leader: Dr. D. F. BALL, Bangor Research Station, I.T.E.

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MAIN CONTRIBUTORS TO INTERIM REPORT

Dr. D. F. BALL

Mr. R. HELLIWELL

Dr. J. SHEAIL

Mr. G. RADFORD (Advice and programmes for computer handling of data)

Mr. W. M. WILLIAMS

1 INTRODUCTION

1.1 Following a desk study (Upland Land Use (DGR 483/10)) carried out by the Institute of Terrestrial Ecology (ITE) under contract to the Department of the Environment (DOE), DOE together with the Countryside Commission (CC) concluded that they required more knowledge of upland landscapes, their vegetation, and the factors which influence them. CC commissioned from consultants the Upland Landscape Study (ULS), concentrating on landscape characteristics and the influence on them of present and anticipated farming types and methods. As a parallel study DOE has separately contracted ITE to carry out an ecological investigation of vegetation and its controlling factors in the upland areas chosen for ULS.

1.2

1.2.1 The objectives of this ITE contract, planned as a three-year study, are as given below, quoted from the draft contract document issued by DOE on 14.12.77:

DEPARTMENT OF THE ENVIRONMENT/DGR/483/23:

SCHEDULE 1 - PROGRAMME OF RESEARCH

GENERAL OBJECTIVE

1. To identify the rate and direction of vegetation change in Upland Landscapes and the relative influences of the main environmental and management factors; the study would be based on the (12) parishes selected for the Countryside Commission's Upland Landscapes Study.

Specific Objectives

(1) To identify and describe briefly the main vegetation categories (vegetation types and where appropriate their most important communities) in the parishes covered by the study.

(2) To characterise the environmental factors affecting vegetation (namely physiography, geology, climate and soil) within and between the selected parishes.

(3) To analyse the degree to which the parishes' ecological characteristics are representative of the Upland regions within which they occur and of the Upland

regions of England and Wales as a whole; this would include identifying types of environmental conditions and plant communities of landscape significance in the Uplands of England and Wales which are not represented in the selected parishes.

(4) a. To reconstruct (to the essential minimum) from historical records the pattern of land use and management in relation to vegetation change;

b. On the basis of these reconstructions, to identify and if necessary explain any relationships between the age of individual vegetation categories and their present-day vegetation characteristics, and to infer the succession of vegetation in areas of change.

(5) To relate the pattern of vegetation and land use (past and present) to the environmental factors in order to determine which combinations exert the major influences.

(6) To identify and describe briefly alternative practices for the management of the main vegetation categories.

(7) Having identified these alternatives, to produce a series of maps of future vegetation, under given environmental conditions and known time spans, indicating the likely vegetation pattern resulting from each management practice.

1.2.2 Although the contract document was designed to cover a three-year study, the initial contract is for one year to carry out part of the programme and submit an interim report at a date nine months into the one-year contract period. This "general interim report of about 50 pages", to include proposals for work in the remainder of the envisaged three years, as now submitted, is intended to form a basis for decision by DOE on the continuation of support in this field after 30 June 1978.

1.3

1.3.1 Work carried out by ITE between July 1977 and March 1978 has involved data collection and initial analysis for six of the twelve designated parish areas, to conform with the ULS timetable. These areas are: Bransdale, North Yorkshire; Shap Rural and Shap, Cumbria; Heptonstall, West Yorkshire; Glascwm, Powys; Ystradgynlais Higher and

Glyntawe, Powys; Widecombe in the Moor and Buckland in the Moor, Devon.

1.3.2 The approach adopted involves, initially, three lines of investigation.

(a) Analysis of the physical characteristics of the land to define the environmental factors influencing vegetation and land use and to allow comparisons of sites within and between parishes (Chapter 2).

(b) Characterisation of the current vegetation as a basis for assessment of past and future change and for correlation with environment and land use history (Chapter 3).

(c) Analysis of land use history up to 1945 to identify sites with known change in management. When correlated with vegetation, this can provide assessment of rate and direction of vegetation change (Chapter 4).

1.4 In fulfilment of the requirement that ITE should supply data to ULS, ITE have provided base key-maps and computer print-outs of map-derived land attribute data for 0.5 km x 0.5 km grid square units covering the study areas; summaries of land characteristics for the six parish areas; locations of the vegetation sampling points and classifications of the vegetation types recorded at these points; and maps of land use, plus text material, drawn from the historical studies.

1.5 Possible approaches to the study of upland vegetation and rates and trends of change were limited because ITE has been required to work in specified areas, with a timetable for their study controlled by the requirements of ULS. Because of this timetable, data were required immediately for half of the twelve nominated parish areas. The contract has run only eight months at the time this report was prepared so that interpretation has necessarily not been able to be completed. It is desirable therefore to

be clear what this interim report is intended to do. The purpose is to outline for the Review Committee the approach adopted and to give examples of presentation and interpretation drawn from the work carried out. It is not a comprehensive presentation of all the data obtained nor can it yet be a full analysis and interpretation of the relationships between the separate lines of information and the separate data to come from ULS.

2 LAND CHARACTERISTICS

2.1 Physiographic and topographic characteristics have been determined, from 1:25,000 OS maps, as quantitative measures for the networks of 0.5 km x 0.5 km grid squares covering the study areas. "Physiography" is used here to cover natural landform characteristics, and "topography" for surface features attributable to man's past or present settlement and land-use activities. Climatic, geological and soil characteristics have been obtained from existing information as summaries for the parish areas as whole units, rather than determined in detail for different sectors of the parish areas. The available data sources for these properties are generally not appropriate to such detail.

2.2 The 0.5 km x 0.5 km grid square is a sampling unit appropriate to the size of the study areas. Although this sampling unit substitutes artificial for natural boundaries to land features, it provides a ready means of data comparison, analysis and mapping, as shown later. Only grid squares of which the centre point lies within the parish boundary were treated as making up the study area for the purpose of land data extraction. The numbers of 0.25 km^2 grid squares for which land characteristics were recorded are: Bransdale, 128 (32 km^2); Shap Rural and Shap, 453 (113.25 km^2); Heptonstall, 92 (23 km^2); Glascwm, 147 (36.75 km^2); Ystradgynlais Higher and Glyntawe, 191 (47.75 km^2); Widecombe in the Moor and Buckland in the Moor, 202 (50.5 km^2). Appendix* 1 lists the OS maps which cover the study parish areas. Maps* 1-6, with a key map to parish

*Maps, tables, and appendices follow the report text.

location, illustrate the OS 1:25,000 base maps of the six parish areas.

2.3 Table* 1 gives the list of twenty physiographic and six topographic attributes drawn up to cover altitude, slope, aspect, river pattern, settlement density, road, footpath and field boundary patterns. For slope and aspect classes, maps were drawn by rapid manual measurement of contour spacings and orientation respectively. Quantitative measurement of areas was similarly a compromise between speed and accuracy, using a transparent overlay grid of 25 regularly spaced points in a grid square to give area measures in 4% units. Linear features (rivers, roads, footpaths, field boundaries) were determined as relative frequencies on a scale from 0-25, by counting the number of sub-squares, in a 5 x 5 transparent grid overlay to the 0.25 km^2 grid squares, in which the feature occurred. It would clearly be possible to seek more accurate measures of these characteristics but with, in the study areas, 1213 x 26 attributes to be recorded, a balance between effort and data quality relevant to the scale and requirement of the study was chosen.

2.4

2.4.1 Tabulated land characteristics for the grid squares in each study area were transferred in suitable format to computer storage so that statistical analyses and mapped distributions of characteristics can readily be obtained. A programme available for statistical analyses allows sums, means and standard errors to be calculated for measured characteristics of grid squares grouped in any desired arrangement, for example in classes from independent classifications, or for classes dependent on specified land-use, physical or settlement criteria.

2.4.2 A mapping programme produces from computer-stored data, schematic parish area maps, each 0.25 km^2 grid square being marked by a symbol. The complete output of this programme displays on a map the distribution of squares

which meet specified criteria, records the proportion of the area which meets the specification, lists the relevant squares, and prints out full data for these. Examples of the map part of the available output are shown in maps 7-10 for two contrasting study areas, Widecombe in the Moor and Buckland in the Moor (maps 7 and 8), and Shap Rural and Shap (maps 9 and 10). The example specifications are for the distribution of sectors dominated by relatively low ground combined with dominantly gentle or moderate slopes, and for those sectors which contain mapped buildings. Maps 7 and 9 show that the proportion of each parish area which meets the set physiographic specification is broadly similar but that its distribution within the two parish areas is quite different. In Widecombe and Buckland two zones cut centrally through the parish; in Shap there is one solid zone in the northeast of the area. Maps 8 and 10 for grid squares with mapped buildings show a wide distribution in Widecombe and Buckland, generally similar to the distribution of sectors that meet the particular physiographic specification displayed. In contrast in Shap, a much smaller proportion of the area contains mapped buildings and these sectors do not form a solid block in the northeast matching the physiographic specification, but occur only in part there and also in part follow valleys which extend through grid squares which are dominated by higher ground and steeper slopes, such as Swindale (up to grid squares 170, 171, 192) and Wet Sleddale (e.g. 290).

2.5 Appendix 2 gives a quantitative summary of the overall mean physiographic and topographic characteristics of the parish areas as units (i.e. averages of the individual grid square values recorded in the parish areas), while Table 2, based on these data, sets the six areas in relative overall order for major land properties. Appendix 3 brings together climatic data from different sources for the parishes as a whole, and Table 3 shows the overall relative ranking of the six parishes for climatic characteristics, growing season, and agricultural land classification. Geological and soil summary data, and agricultural land classification class proportions for the study areas as a whole are given in Appendix 4.

2.6 From these tables, the generalised land characteristics of the six study areas (not the diversity within them) can be outlined as follows:-

Bransdale is characterised by relatively low altitude and gentle slopes but also by low settlement density although it has relatively high access by road and footpaths. Although the driest of the six parishes, Bransdale is moderate to low in relative temperature with a moderate length growing season and moderate relative position in agricultural land classification. It has a high proportion of land dominated by very poorly drained peaty surfaced soils.

Shap Rural and Shap as a whole have a high altitude and strong relief but moderate slopes with low settlement and overall accessibility. This is relatively the coldest and wettest of the study areas with the shortest growing season and a low average agricultural land class, in conformity with the high proportion of land dominated by strongly acid peaty surfaced moderately drained soils.

Heptonstall, of relatively moderate altitude and low relief, has a relatively high settlement density though only a moderate average field boundary frequency. Settlement and access here is related to industrial rather than agricultural history. It is relatively moderately wet and cold with a short growing season and low average agricultural land class, in conformity with being mapped as dominated by very poorly drained peaty-surfaced and deep peaty soils.

Glascwm is relatively moderately high in altitude, with the strongest relief and steepest average slope. Settlement density is relatively low, because there is no additional population factor than agricultural use here, but access, and agricultural use as assessed by field boundary density, are relatively high. This reflects the relatively dry and warm climate giving a reasonably long growing season in an area dominated by freely-drained non-peaty mineral soils, and of relatively high agricultural land class average.

Ystradgynlais Higher and Glyntawe are of relatively high altitude but low average relief and gentle slope, with a moderate settlement density but low road density and agricultural intensity of use. Settlement here again has mainly an industrial basis. Climatically this area is relatively wet though of moderate temperature and hence length of growing season, but is lowest of the six in average agricultural land classification class, and shown as dominated by very poorly drained peaty-surfaced soils.

Widecombe in the Moor and Buckland in the Moor are of relatively low altitude but have steep slopes, with the highest average settlement, road and field boundary density but a perhaps surprisingly lowest average density of mapped footpaths. Climatically, though relatively wet, this area is the warmest with the longest growing season and a high agricultural land classification assessment reflecting the mapped dominance of freely-drained mineral soils, although these are in a more acid, leached soil group than the dominant Glascwm soils. This can be attributed to the higher rainfall of Widecombe and Buckland acting on a granitic parent material.

2.7 Application of the computer store of land characteristic data to provide map outputs has been reported in section 2.4.2. As implied there in discussion of maps 7-10, these land characteristic and other data stored on a grid square basis can be searched to identify and display the ways in which specified characteristics are correlated, and the location of sect[redacted]ors in which such correlations occur. As further examples maps 11-16 show for Glascwm some relationships of field boundary frequency to altitude class. Map 11 displays the 24 grid squares (out of a total of 147 for the parish) that contain no mapped field boundaries, while map 12, in which the specification calls for combined selection of those squares which meet this criterion but which are also dominantly (defined as $\geq 70\%$) over 1400 ft. in height, shows that 21 out of these 24 are in the designated altitude class. Maps 13 and 14 show that 11 squares contain a few field boundaries (defined here as a frequency score of 1-4

on a 0-25 scale) but that only four of these also meet the same altitude criterion. A list of the squares which meet the altitude criterion alone shows only five additional squares which fall outside the nil or "few" field boundary limits set. The altitude class chosen is thus in this parish area a close equivalent to these sectors with no or few field boundaries (as recorded on the 1:25,000 OS map). The reasons why a minority of grid squares deviate from such a general relationship can be sought in other listed data, or in field investigation and can in general (not necessarily in this example) be useful in interpreting actual or potential trends and in selecting "special cases" for further study. In contrast at the upper end of the field boundary frequency range, maps 15 and 16 show that 72 of the Glascwm 0.25 km^2 grid squares contain frequent field boundaries (defined as frequency counts ≥ 10) and that 58 of these are more than 70% below 1100 ft. in altitude. The greater part of two "intensive settlement" and "low settlement" sectors, as defined by field boundary frequency, could then in this parish be related to two simple altitudinal zones. Comparison of equivalent relationships in other study parish areas can display and interpret area differences attributable to interactions of physiographic, climatic, historic or other factors.

2.8

2.8.1 As an alternative to selection of single or grouped factors for distributional and quantitative analysis, it is desirable to see whether land classifications based on a wide range of characteristics provide in this instance classes which enable vegetation-history-land associations to be interpreted and predicted. The quantitative data set for physiographic and topographic characteristics at the grid square level has therefore been used to draw up a list (Table 4) of land attributes in a presence/absence format for each square in order to allow computer statistical classification by the Indicator Species Analysis (ISA)* method used in this study for vegetation classification

*Hill, Bunce and Shaw (1975)

(Chapter 3). There are alternative approaches to classification of such data which have not been pursued.

2.8.2 The theoretical advantage of "objective" classifications, e.g. by ISA, is that from consideration of an extensive list of attributes for each "individual" to be classified, an unbiased (other than the initial bias caused by the selected attributes) allocation is made of each individual to a class. This allocation is based on an equal weight being given to each attribute, rather than on a personal choice from the full data set of single or simple combinations of key attributes. Considerable effort has been devoted to examining ISA classifications based on physiographic attributes alone (1-34 in Table 4), and on a combination of physiographic and topographic attributes (1-34 and 38-58 in Table 4) in order to assess whether this theoretical advantage in practice gives classes that can be correlated more effectively or convincingly with vegetation and land-use categories, or allow more confident extrapolation of vegetation data from point sites, than is possible from the distribution of subjectively chosen land categories based on selected individual attributes. ISA land classifications of both types were derived for each parish individually, and for the six parishes as a set.

2.8.3 ISA works by making an initial division of the "individuals" making up a "population" (in this case the grid squares in a data set) into two approximately equal classes based on the balance of the occurrence of "key factors" for each individual of the population. These "key factors" emerge from the analysis as those attributes which most closely approach an "ideal" situation in which all individuals on one side of a division have on group of key factors present and one group absent, while individuals on the other side of the division have the former group all absent and the latter group all present. In practice in most situations (certainly with land classifications) such an absolute division does not occur because the relationship between attributes is not so clear-cut. Analysis then allocates each individual into

one or other class at a division by an assessment of the balance between presence and absence of the determined key factors, based on an involved statistical ranking of their relative importance as dividing factors, not on a simple numerical count of how many key factors defining each half of the division are present. The analysis continues with further divisions of each initial class into two, to a level of 2^n classes (2, 4, 8 etc.), as required, by further re-examination on each occasion of the entire attribute list for those individual grid squares in the class to be divided. In the land classifications, interpretation has been taken to the eight-class level.

2.8.4 Because division at earlier stages is not a resultant of mutually exclusive key factors, factors used at one stage of the analysis can reappear as key factors at later stages. This means that, with some data sets, it is often not easy to apply clearly distinguishing verbal descriptions to each class. The general character of a class can, however, as well as being described from the key factors which the ISA output records as effective at each division, alternatively be assessed from consideration of the frequency with which each presence/absence attribute occurs in individuals assigned to a class, or from the mean land characteristics summed from the original quantitative data for individuals in a class.

2.8.5 As an example of the type of classification derived in this way for land types within a parish, the character of the classes for an "in-parish" ISA based on topographic and physiographic attributes for Shap Rural and Shap can be outlined, at the eight-class level, as:-

1 - high altitude; low to moderate relief; moderate slope; no buildings; few roads, footpaths and field boundaries
(84 grid squares)

2 - moderate altitude; low to moderate relief; moderate slope; few buildings and settlement features
(84 grid squares)

3 - high altitude; high relief; moderate to steep slope; no buildings; few other settlement features
(65 grid squares)

4 - very high altitude and relief; steep to very steep slopes; no buildings; few other settlement features
(40 grid squares)

5 - moderate to low altitude; low relief and gentle slopes; few buildings and moderate other settlement features; easterly aspect dominant
(56 grid squares)

6 - as 5 but moderate to high settlement features and westerly aspect dominant
(43 grid squares)

7 - moderate to low altitude; moderate relief; gentle to moderate slope; few houses but moderate settlement features
(46 grid squares)

8 - low altitude; low to moderate relief and gentle to moderate slope; moderate houses and other settlement features
(35 grid squares)

Table 5 gives mean values for land characteristics of these classes calculated from the quantitative data set for individual grid squares. The variability of most of these attributes between the individual grid squares that make up a class is such, however, that only low statistical confidence can be placed in using these values to predict the characteristics of an individual square in a class. (Co-efficients of variation are high, from the 20-30% level to several hundred %.) The verbal description of a class similarly applies to the mean class character but will not represent correctly the nature of each square within a class. This contrasts with the plotting of specified quantitative characteristics, discussed earlier.

Map 17a shows the distribution of these classes in Shap Rural and Shap. The general picture is acceptable but the degree of similarity between squares in a given class can be low in one or more key characteristics.

2.8.6 From ISA land classifications carried out on the combined six-parish data, it is possible to consider comparisons between the general character of the different parish areas in terms of their physiographic and topographic land character. Table 6 gives the distribution of land classes within individual parish areas based on an ISA analysis using physiography and topography attributes on a six-parish basis. In an overall assessment, considering classes 1-4 as "hill" and classes 5-8 as "upland" categories, Table 6 shows again, as implied in direct consideration of physical characteristics (Section 2.6, Tables 2 and 3), that the relative physiographic and topographic "hill" character of the study areas decreases in the order Shap Rural and Shap → Ystradgynlais Higher and Glyntawe → Bransdale → Heptonstall → Glascwm → Widecombe and Buckland.

3 VEGETATION

3.1

3.1.1 In order to provide a base-line of information on the vegetation of each parish, recording was carried out in three types of situation, the most extensive recording being in type (a), the "main sites".

(a) fields (excluding arable fields) and moorland; using 5000 m^2 quadrats

(b) woodlands (excluding conifer and recent broadleaved plantations); using 200 m^2 quadrats

(c) roadside verges and hedgerows; using linear sample plots 10 m long.

The numbers of sites examined are given below:-

Parish	Number of sites at which vegetation was recorded in			Mean number of species per main site (from list of 198 species)
	(a) Fields and moorland (main sites)	(b) Woodlands	(c) Verges/ hedges	
Bransdale	88	15	10	20.4 ± 1.0
Shap Rural and Shap	115	14	16	30.9 ± 0.9
Heptonstall	70	14	8	16.5 ± 1.1
Glascwm	71	11	24	23.9 ± 1.0
Ystradgynlais Higher and Glyntawe	70	14	14	24.6 ± 1.3
Widecombe in the Moor and Buckland in the Moor	75	13	15	28.2 ± 1.6
Total	489	81	87	

3.1.2 (a) The field and moorland main sites were distributed on a regular grid basis, with one recording location per km^2 in sectors with uniform land use (e.g. all intensive farming, or all heather moorland), and two or four locations per km^2 in areas with a greater mixture of land uses or vegetation types. Quadrats were placed so as to avoid overlapping a management boundary (e.g. a wall or river) or a metalled road. A minimum of 70 "main site" locations per parish were recorded, in order to provide enough data for analysis on a within-parish basis.

(b) A minimum of ten woodland sites per parish were examined, sampling, as far as possible, all separate woodlands in the parish.

(c) Roadside verges, and a limited number of field hedgerows, were recorded at regular intervals. Some parishes had very few roadside verges that were not grazed as part of the adjacent moorland. Only verges shielded by a stock-proof wall, hedge, or fence were sampled. Few hedgerows were examined other than along roadsides. Hedgerows dividing fields appeared to have, in general, a similar or an impoverished version of the roadside hedge flora, but varied greatly, and a comprehensive examination would have been very time-consuming and not particularly relevant to this study.

3.1.3 It had been intended to sample river and stream banks as a separate habitat. On visiting the sample parishes this vegetation seemed not to differ greatly from surrounding fields, woods, or moorland. As, in most cases, stream courses did not form a separate management unit, no specific sampling of them was carried out.

3.2 While a reasonable attempt was made to identify all plants found, the occurrence of some uncommon species in one or two plots is not of any significance for the type of analyses carried out in this study, and did not justify the time that could be involved in their identification. There were also difficulties in identifying some species in the field, particularly where the vegetation was closely grazed or had been recently mown. It was therefore decided to use a standard list of 198 species for data analysis, with difficult-to-identify species and uncommon species omitted or aggregated. (All the woodlands and verges were surveyed by one person, and analyses based on complete lists of species gave very similar results to analyses based on the restricted list of 198 species.) Table 7 is the chosen list of species.

3.3

3.3.1 At the main sites, the presence of plant species was first recorded for a 1 m^2 quadrat. Additional species present

in concentric quadrats of increasing size; 4 m^2, 25 m^2, 100 m^2, 200 m^2 and 5000 m^2; were then recorded, together with the estimated percentage cover of species in five 1 m^2 quadrats (at the centre and at the corners of the 200 m^2 quadrat). The different sized quadrats were used as a means of standardizing the search pattern when recording species; as a means of relating this work to other studies, using quadrats of different sizes; and to allow testing of the merits of different sizes of quadrat for continuation of this study.

3.3.2 Four soil samples were taken at each main site for laboratory measurement of soil acidity, and brief field notes were made on soil texture and depth. Notes were also made on site factors such as drainage, presence of paths, stones, trees, bushes, streams, gullies, or signs of burning.

3.4

3.4.1 Indicator Species Analysis (ISA, as discussed in 2.8) was carried out on a listing of species present, and on the percentage cover data, for the main sites in each parish area separately and for the combined vegetation data set for the six parish areas. Within-parish data analyses have been taken to the eight-class level, and the six-parish analyses to the 16-class level. There is little difference between the number of sites allocated to the two initial divisions in each of the four analyses, as the two-class categories of "moorland" and "farmland" are fairly distinct, whether one is looking at the cover of plant species or their presence/absence, and whether one is looking at all six parishes or at each parish separately.

3.4.2 At the third and fourth divisions, a site may differ in its classification between cover and presence/absence analyses. Percentage cover of a species is likely to be more closely related to the character of the vegetation as perceived by the human eye and also more closely related to immediate management than is its presence, which is

likely to be related more to the basic land type and to the past history of the sample area. The two analyses therefore indicate somewhat different features of the vegetation, and an investigation of the differences between the two can be of importance. Preliminary analysis shows that a small number of sample plots in each parish show marked differences in their ordering in the analyses of cover data and presence/absence data, and a somewhat larger number show lesser differences in this respect. The sites showing these differences can be examined in relation to information on their current and past land use, in order to try and assess whether these differences are related to trends in vegetation change.

3.4.3 Analyses of data from six parishes combined show some of the resultant classes to consist mainly or entirely of sites from a single parish. This is particularly marked in the case of the presence/absence data. With the cover data, there is more similarity of class representation in different parishes. This is a reflection of the fact that although, in visual terms, very similar vegetation types can be described in all six parishes, and it is this which is largely assessed by the cover classifications, when the species assemblages in these apparently similar types are examined, they turn out to be appreciably different in composition. The relevance of these differences in terms of vegetation management and detailed visual impact requires further investigation.

3.4.4 It is not practical nor desirable to give details here of the results of all analyses and it would be premature to try to summarise the results with any finality. A sample analysis result is given in Table 8 while map 17b shows the location of these eight classes in grid square units of Shap Rural and Shap. It must be emphasised that the vegetation type relates to a record at a site within a grid square, not to the whole square.

3.5

3.5.1 In order to compare the data collected in this study with an existing vegetation classification, the sample plots were classified, as far as possible, using Evans, Hill and Ward's (1977) "dichotomous key" to British sub-montane vegetation. This key requires a check system to be followed, based on the occurrence of stated divisive species. 227 of the 489 plots could not be satisfactorily classified with this key, as they did not have any of the divisive species used by Evans et al. at one or more divisions. This is not unexpected, these sites being mainly pasture, which was not covered by their classification. The remaining 262 plots were classifiable into 19 of their 26 groups. As in the analysis of cover data for all six parishes, there was relatively little difference in the representation in each parish of different vegetation groups in this national assessment. Heptonstall stands out most distinctively, with a strong representation of heather/cotton grass vegetation types, while Shap, with Ystradgynlais Higher and Glyntawe, have most of the mat grass/heath rush vegetation. Widecombe and Buckland, Bransdale, and Glascwm do not stand out as being particularly characterised by certain vegetation groups. Distinctions between these parish areas on this national basis are in fact less than in the independent analysis of cover data.

3.5.2 The classification of Evans et al. was based on a combination of cover and presence/absence data, from sites in upland areas of England, Wales and Southern Scotland (but not including the North Yorkshire Moors). It represents a particular type of classification in common use in continental Europe, and it is instructive to refer to it, but it is less useful as an analytical tool than the analyses carried out as part of this study, which are clearly relatable to either cover or presence/absence of species.

3.6

3.6.1 At the woodland sample sites a similar recording procedure was followed, except that the sample plot size was restricted to 200 m^2 in order to fit within the smaller size of many of the woods, and the only estimate of cover was an estimate of the overall tree canopy cover. The data were analysed in a single woodland vegetation ISA, based on presence/absence of species in all woodland sites in all six parishes. In addition to this, the data from the 81 woodland sample plots were combined with the data for presence/absence of species in the 200 m^2 quadrats at the 489 field and moorland sample plots. An analysis of this set of data gave a fairly clear split between woodland sites and other sites at the third division indicating that, although many of these woodland areas did not contain very many conspicuous woodland plants, their vegetation was distinct from that of the surrounding areas.

3.6.2 In these analyses, the woodland sites divided initially into "base-rich" and "acidic" woodlands. At the eight-class level, Heptonstall woods and Widecombe woods each dominated one class, and the other six classes contained a mixture of sites from different parishes.

3.6.3 Using the key to British woodland vegetation of Bunce (in preparation) the 81 samples in this survey fall into 23 of his 32 classes. Again, Heptonstall stands out as distinctive from the other parishes, with a predominance of Bunce's classes 17 and 18 - "species-poor woodlands on very acidic sandy soil". Only Bunce's class 25 (Galium saxatile/Pteridium aquilinum type, described as a "westerly upland oakwood type") is represented in all six parishes, and each parish contains one or more types not represented in any of the other parishes. 85% of these woodland areas fall within 13 of Bunce's 32 classes, indicating that, although the sample areas cover almost the full north-south range of England and Wales, the woodlands in them are of a fairly restricted "upland" range of types.

3.6.4 The overall state of the semi-natural woodland cover appeared to be fairly static. Woodlands which regenerated some 50 or 100 years ago are not yet old enough to die out unless deliberately felled or under-planted with conifers. Looking to the future, there were young saplings present in several of the woodland samples in Widecombe and Buckland, and in Heptonstall. In the other four parish areas there were very few saplings, with none at all in Shap, indicating that, at some stage within the next 100 years or so, steps may be needed to secure regeneration, if the woods are to remain in these four parishes.

3.7 An ISA analysis of the total roadside verge data, based on the full width of the verge, up to the centre of the adjacent wall, bank, hedge or fence, gave classes which divide the verge sites very much on a parish basis, as shown below:-

Class in vegetation ISA classification of roadside verge sites, all parish areas	Main Parishes Represented (77 of total 87 verge plots)
1	Shap Rural and Shap - 5 out of 5 sample plots
2	Shap Rural and Shap - 8 out of 8 sample plots
3	Bransdale - 8 out of 17 sample plots Heptonstall - 7 out of 17 sample plots
4	Glascwm - 6 out of 14 sample plots Ystradgynlais Higher and Glyntawe - 5 out of 14 sample plots
5	Widecombe in the Moor and Buckland in the Moor - 6 out of 8 sample plots
6	Widecombe in the Moor and Buckland in the Moor - 8 out of 9 sample plots
7	Ystradgynlais Higher and Glyntawe - 7 out of 13 sample plots Glascwm - 4 out of 13 sample plots
8	Glascwm - 13 out of 13 sample plots

Roadside verges show the greatest difference in class distribution between parishes. This may be connected with the localised distribution of hedges, walls, and banks, which are abundant in some parishes but absent from others, and to the fact that roadsides are least likely to be affected by grazing or reseeding, which tend to make the vegetation of different areas converge towards a common norm. Woodlands and moorlands, which are, in most cases, grazed, show less distinction between parishes, and pasture types show least difference. The mean percentage of the largest number of plots in each ISA class that falls in a single parish is, for verge classes 76%, for the moorland classes, 64% (P/A data) and 51% (cover data); and, for the pasture classes, 48% (P/A data) and 36% (cover data).

4 HISTORICAL CHANGES IN UPLAND LAND USE

4.1 This section considers ways in which past land-use and management have influenced the development and distribution of present-day vegetation communities in the study parish areas, and gives examples of map presentation of land-use history data. Sequential separate accounts of the history of each parish area are not given now. Because differences in land-use and management evolved as a result of decisions by individual landowners and occupiers, the outlook and aspirations of each generation towards the natural resources of the uplands, as influenced by economic, political and social factors, must be considered as the basis for historical change. Some generally important themes in the use, management and appreciation of upland landscapes can be identified in the parish areas nominated for study. Key phases and influences in the history of upland land-use are discussed, with examples drawn from parish areas where their impact is well displayed. The phases identified overlap in time and do not follow each other consecutively, nor are they synchronous or equally important in all regions. The

parish areas where the effects of each phase are notably evident are set out in the table below:

Historical Phase	Parishes where the phases are particularly well displayed					
	Bransdale	Shap Rural and Shap	Heptonstall	Glascwm	Ystradgynlais Higher and Glyntawe	Widecombe in the Moor and Buckland in the Moor
Prehistoric origins	X					X
A pastoral economy						X
The monasteries	X					
Medieval settlement						X
Domestic industry			X			
Exploitation of minerals	X				X	X
Changing perceptions	X		X			
An agricultural revolution	X	X	X			X
Recent alternative land-uses	X	X	X			

4.2

4.2.1 For the earliest historical phases, sources of data have been books, papers, and theses which describe relevant palynological and archaeological investigations. For later periods, there is considerable variation in the amount of documentary information available for each parish. A search for manuscript evidence begins in the national and appropriate county record offices, thus visits have been made to the record offices at Carlisle, Kendal, Northallerton and Exeter, and to the Central

Library for Kirklees. Estate records such as those of the Lowthers in Shap parish have proved particularly important in discerning local trends in land-use and management. Information obtained from these manuscript sources can, in some cases, be extended and corroborated by that provided by published works and theses.

4.2.2 Clearly the most valuable evidence in studies related to vegetation history is in maps of readily identifiable parcels of land. Early maps may indicate field boundaries, farm layout and sometimes land-use. The Tithe Commutation Surveys, where undertaken, can more generally be used to reconstruct the patterns of land-use in the 1830s and 1840s. The changing distribution of rough pasture and woodland can be deduced from the large-scale maps published by the Ordnance Survey from the mid-nineteenth century onwards. For more recent times, the manuscript sheets of the first Land Utilization survey, preserved in the Department of Geography of the London School of Economics, have been used to reconstruct the pattern of land-use in the 1930s.

4.2.3 As an example of the type of detail that can be drawn from these relatively recent sources, maps 18 and 19 show transcribed maps for land-use in Glascwm in 1837 and 1932.

4.3

4.3.1 Turning to the first of the key historical phases in upland land-use, prehistoric impacts are well studied in Bransdale and in Widecombe. The wide moorlands of many upland areas are so extensive and striking that they were mistaken for the natural vegetation of the uplands. In his description of the heather-clad uplands and wooded dales of the North York Moors, Elgee (1912) assumed that "the higher wind-swept moors were never clad with arboreal vegetation". Recent archaeological and palynological studies have shown this assumption to be false (Spratt & Simmons, 1976). In the recovery from the Pleistocene ice-age, by 5000 BC an oak forest covered all but the highest

ridges in this region. Mesolithic hunting-and-gathering communities, whose flint sites occur in the north and west of Bransdale, made an extremely modest impact, perhaps using fire to extend the forest-edge effect, creating more open conditions locally.

4.3.2 Human influence increased in the Neolithic period, but man-induced large-scale change in plant succession did not occur in the North York Moors until the Bronze Age, around 1800-1700 BC, when a denser population apparently encouraged the use of even the highest parts of the interfluves (Fleming, 1971). Archaeological and palaeo-environmental studies suggest that there was extensive destruction of woodland to increasingly lower levels at this period (Spratt & Simmons, 1976). Cultivation and intensive grazing of the siliceous soils derived from the Jurassic sandstone rocks would have increased the inherent trend to podzolisation on these lime-poor rocks, expecially in the more oceanic climate of the Iron Age. As the land became impoverished and fell into disuse, Calluna vulgaris spread, representing in aggregate the transition from a forest/brown-earth ecosystem to a heathland/podzol system without forest regeneration.

4.3.3 According to Spratt and Simmons (1976), the essential features of the present-day Moors above 230 metres (800 ft.) are prehistoric. The forest never recovered from natural trends accelerated by human impact: by the first century BC, higher ground was dominated by growing blanket bog, with sedge and moss communities, and by Calluna moor and acid grasslands. Forest was confined to the dales and around some of the valley mires, and even here successive abandonment of the impoverished higher ground was beginning to create greater economic and social pressures for the clearing of the lower woodland.

4.3.4 The intensity of prehistoric development in some upland regions may be illustrated by reference to the "parallel reaves", found in the Widecombe area of Dartmoor (Gawne & Somer-cocks, 1968). These low banks of stone, usually

covered with earth, of which the largest system, covering some 12 square miles, runs roughly SW-NE from Holne Moor across Spitchwick Common to end in the West Webburn valley, are remnants of a phase of planned land settlement, guidelines laid down over a wide area in order "to allow for orderly expansion in a lengthwise and lateral direction as settlement grew in size and number". Where groups of Late Bronze Age and Early Iron age huts and fields occur, they give the impression of having been fitted into the existing system of reaves, and therefore suggest that the features date from those periods or earlier.

4.3.5 In summary, far from ignoring the uplands, prehistoric man exploited their resources so heavily that he destroyed or accelerated natural decay of the partial native woodland cover, leading to its replacement with more open communities of heath and moor.

4.4

4.4.1 Thus, by the late Iron Age, many parts of the uplands had become distinctive for their extensive, open moorlands, devoted primarily, and at times solely, to animal husbandry. As grazing grounds, the uplands played just as important a part in regional economies as the lowland areas of arable and wood. The continuing significance of the pastoral uplands throughout Roman-British, Anglo-Saxon, and medieval times, may be illustrated by reference to Dartmoor, where the establishment of a royal hunting ground in the ninth century (the "Forest of Dartmoor") may have led to a more conscious regulation of the intensity and periodicity of grazing, especially after the Norman Conquest. A tradition evolved whereby in about twenty "Venville" parishes on the edge of Dartmoor, including Widecombe, their inhabitants paid a rent to the Crown in return for pasture in the Forest and Common. The number of animals was restricted to those which the farmer could support in winter, but an extra payment could be made in return for depasturing animals that had been brought in (Fogwill, 1952 & 1954; Simmons, 1964). The court rolls

of such manors as that of Spitchwick in Widecombe provide an insight into the management of the grazing grounds peripheral to the Moor. One man was presented to the court for several consecutive years in the late seventeenth century "for surcharging this common by depasturing of his sheep and cattle on ye commons belonging to this Mannor more than his estate in this Mannor will winter".

4.4.2 Large-scale movement of livestock and integrated use of the Forest and adjacent moors ensured that the open environment created in prehistoric times was maintained and extended. The animals spent summer on the higher pastures, and winter on lowland farmsteads. The character of the plant communities reflected both natural and man-induced factors. In spring, animals returning to the moors were taken first to the "predas" or "lairs", where the pastures were better and provided an earlier bite, thereby accentuating the natural differences in the vegetation. The excavation of turf for fuel caused a further modification of the communities on the more accessible mosses and bogs. It is impossible to reconstruct from documentary sources the precise amounts of turf removed, but Dilley (1973) cites examples from Cumberland where digging was prohibited on some fells in order "to preserve the grass-cover from the stripping of the surface and to prevent loss of land from overdeep peat cuttings".

4.4.3 Where sufficiently large markets were assured, sheep and cattle shared the moor with rabbits, bred commercially for their meat and fur. The remains of sixteen rabbit-warrens have been found on Dartmoor, identified by earthwork "pillow-mounds" where the animals were encouraged to burrow and breed (Linehan, 1966). The antiquity, length of use and significance of most warrens remains unknown. One of the few pieces of documentary evidence is a lease of 1613 for Vaghill Warren on Spitchwick Common, where rabbit-grazing pressures may have led to further modification in the mosaic of plant communities.

4.4.4 The experience of Dartmoor through this long period of pastoral economy underlines the extent to which the distinctive resources of the uplands were highly prized and exploited. Far from being considered as wasteland, the uplands often made a vital contribution to the character and prosperity of the wider, regional economy and society. They were in turn affected by events and initiatives generated outside the uplands but which came to alter the pace and scale of land-use and management.

4.5

4.5.1 Turning back in time to an earlier phase of upland development, the North York Moors illustrate how the maintenance of an open environment could be affected by such political events as the Norman Conquest and the subsequent harrying of the North (Darby, 1977). Although it is unlikely that William's men ventured very far into the high moors, devastation of the lower ground may have encouraged a subsequently valleyward movement of population, leaving the main area of the Moors even more sparsely populated (Atherden, 1972, 41). Intensive and systematic management of the North York Moors for grazing was resumed after the establishment of the monasteries in the early 12th century. According to Waites (1957, 1967), the monasteries filled a niche left by the devastations, helping to consolidate and re-emphasise an earlier use pattern. The "grange" was the farm unit of exploitation; cotes or small lodges were established for the animals and their shepherds, scattered over the extensive properties which, in the case of Rievaulx Abbey, already included Farndale and Bransdale by the mid-twelfth century. Waites (1957, 296) comments that it was the "infinite capacity of the monks for adapting themselves to various conditions of physical and economic environment which ensured their success as farmers and merchants. For over 400 years, they imposed an annual cycle of movement between the sheltered dales and the higher moor-tops in summer. Atherden (1972, 222) has suggested that "the prolonged grazing pressure must have produced further profound changes in vegetation".

4.5.2 In the same way as the foundation of the monasteries had affected the management of the North York Moors, so their dissolution in the 1530s brought further changes. Their extensive land holdings were subdivided, characteristically being leased or sold in blocks of about 70 acres, so that the ranch of Rievaulx Abbey in Bilsdale was divided into 62 holdings. The higher moors were no longer grazed so systematically and intensively. Animal husbandry continued to be the main consideration of land-use, but the essentially peasant holdings concentrated rather more on the exploitation of the lower slopes, where efforts were made to increase the productivity of the pastures by intermittent cultivation.

4.6

4.6.1 There is both field and documentary evidence of profound shifts in the use and management of some upland land during the medieval and post-medieval periods. At their maximum extent, the arable lands of Widecombe were up to a third more extensive than at the present day. The importance of communal husbandry is suggested by field names and by the survival of blocks of now-enclosed strip-fields. The latter sometimes take the form of lynchets, which are particularly striking at Blackaton, and at Chillacombe in Manaton parish, where they reach a height of 1,400 feet (Gawne, 1970). There is some evidence that the communal pattern of management in the arable fields broke down as early as the fourteenth century, as adjacent strips were acquired by farmers and converted to severalty by erecting a hedge or wall, thereby fossilising the earlier strip pattern (Hoskins & Finberg, 1952). In some parts, an infield-outfield system evolved, whereby the intrinsically better soils or infield were devoted almost all the time to crops, receiving all the manure available. Additional crops would be grown, without manure, in the outfield or more distant areas. As soon as yields fell, the impoverished land was abandoned and another tract cultivated for a similarly short period.

4.6.2 Within this essentially flexible system of management with frequently changing use of particular sectors, though still geared principally to the needs of a pastoral economy, it is likely that cases of expansion and retreat occurred simultaneously on different parts of the Moor. Over sixteen deserted medieval sites have been located in Widecombe parish. It is difficult to be precise in dating the period of, or the reasons for, desertion, but the remains of the thirteen long-houses at Blackaton have been tentatively attributed to the twelfth-thirteenth centuries (French & Linehan, 1963; Linehan, 1965 & 1966). Altitude, climate and soil characteristics must have placed these settlements at a distinct disadvantage compared with holdings at lower levels. It is significant that none of the deserted medieval settlements has been discovered in the Forest itself. The Crown prevented the Forest being resettled until the thirteenth century, by which time the penalties of establishing holdings on the more marginal land may have been learned.

4.6.3 The medieval phases of advance and retreat produced what Hoskins (1943) has described as the present-day map of Devon, in parts down to the smallest detail, By 1550, the landscape was characterised by "small farms scattered singly over the hillsides or in deep combes, or sometimes clustered in twos and threes to form a hamlet". Each farm consisted of small, irregularly shaped fields, few of them more than three acres in size, and many only an acre or so, separated by massive hedge-banks, with the farm buildings usually at one corner of the farm near the stream and rarely conveniently placed in the middle. In many parts, the farms were still isolated from one another by stretches of open moor.

4.7 The influence of landownership, occupancy, and the attitudes and needs of a time on the pattern of upland development may be further illustrated by the example of Heptonstall (Raistrick, 1970; Wild, 1972). A modest start to improvement of the moors is found in the 12th century, when the Lord of the Manor of Wakefield founded nine cattle

"vaccaries" on the hillside benches of the Calder Valley. By the 13th century, some of these extensive summer grazing enclosures had become subdivided into permanently occupied farms. It was comparatively easy to obtain the freehold of the land, which soon led to multiple inheritance and the large-scale subdivision of farms. The new farmhouses were frequently built next to their parent farmsteads, creating a clustering effect. On account of the altitude, climate and soils, and compounded by their small size, most of these farms provided no more than "the meanest levels of subsistence", and there evolved under economic pressure an occupational link between agriculture and woollen-cloth making. The families on the small farms were particularly receptive to any opportunity to supplement their incomes, and the various processes of cloth-making could be taken up by members of the family, leaving the head of the household to continue working on the land. According to Watson (1775), there was "scarcely a single instance in the whole parish of a man's living entirely by farming". Once taken up, the cloth industry encouraged further colonisation of the moorland and subdivision of holdings, so that, by the eighteenth century, most farms sustained little more than a few cattle and poultry for domestic use and one or two horses to carry the wool and cloth between the homestead and market. The result was graphically described by Daniel Defoe on a journey from Rochdale (Cole, 1959). He wrote: "The sides of the hills, which were very steep in every way, were spread with houses, and that very thick; for the land being divided into small enclosures, that is to say, from two acres to six or seven acres each, seldom more; every three or four pieces of land had a house belonging to it".

4.8

4.8.1 The uplands not only contained minerals which could be exploited by the technology available to early man, but the pastoral economy of those areas frequently provided opportunities and incentives for minerals to be exploited because labour was readily available, especially on a seasonal or part-time basis.

4.8.2 On Dartmoor, along the West Webburn and other watercourses, tinners explored the alluvium systematically in search of the heavy black stones and sand containing tin ore. Alternatively ore lodes were excavated with the aid of powerful streams of water, obtained from leats constructed to carry water from streams across the outcrops of ore-bearing rocks. Where natural watercourses were not available, reservoirs were built such as the characteristically pear-shaped pond still to be found at Hameldon (SX 711785), above the large gully excavated in search of tin. The last years of the fifteenth century and early sixteenth century have been described as the heyday of the Dartmoor tin-industry. In addition to its impact on the local environment by mine-workings, leats and smelting houses (e.g. at Blackaton Ball Moor, SX 689781), the industry encouraged the building or enlargement of churches, including that at Widecombe (Harris, 1969).

4.8.3 On the North York Moors, coal mining was at one time of considerable importance to the Bransdale area, the earliest reference dating from 1715, when a lease gave a Fadmore yeoman the right to "all those veins of coal now opened in a certain plais called Anknesse ... with the liberty of sinkinge three new shafts or pitts". The largest group of pits was opened much later in the second half of the 19th century at Rudland, and remained in use until the 1920s. They are often regularly spaced, indicating some co-ordinated control, and the numerous heaps of grey shale show the scale of activity and disturbance (McDonnell, 1963, 459-60; Whitaker, 1969).

4.8.4 The prosperity of the parishes of Ystradgynlais and Glyntawe in Breconshire was profoundly affected by the development of widely scattered iron-works, which depended at first on charcoal and steam-power. Although the works were later converted to the use of coal, it was not until the 1830s that ways were found of using the local supplies of antracite in the blast-furnaces. Once the adjustments were made, thirty years of prosperity followed, until an increasing trend toward the use of steel, and a greater

volume of imports, led to spasmodic and eventually permanent closure of these iron-works. Meanwhile, construction of the railways had encouraged exploitation of the anthracite deposits and the growth of a flourishing export trade through the ports of South Wales. Because of the greater demands for anthracite, the area did not suffer as severely as those mining areas producing bituminous coal during the inter-war period (Minchinton, 1961).

4.9

4.9.1 The various attempts to raise the productivity of the pastoral economy, the advance and retreat of settlement and cultivation, resort to domestic industry, and search for minerals, led to changes in attitude to the "value" of higher and lower ground in many upland regions of England and Wales. The shift in outlook may be most clearly demonstrated in Bransdale and Heptonstall.

4.9.2 By the end of the medieval period, the striking contrast between the appearance and value of the moorland and dales had begun to break down, largely as a result of the destruction of the woodland habitat and economy of the dales. Upland routeways fell into disuse as the dales became drained and cleared of forest. No longer were the dales perceived only from "above"; now, they could be penetrated and exploited from "below" (McDonnell, 1963, 127-8). The low ground became the best for access, settlement and use. The change in relative importance was recognised administratively, belatedly, in the 19th century, when the present-day parish of Bransdale was created, enclosed by the high interfluves and focussed on the dale bottom.

4.9.3 The importance of the domestic textile industry made Heptonstall and the Halifax area generally particularly susceptible to change during the Industrial Revolution of about 1750 to 1860 (Hanson, 1920, 218-20). "In other parts of industrial England, all relics of an earlier period have disappeared as completely as if an ocean has rolled over the land, but about Halifax the tide of industrialisa-

tion never rose high enough to submerge the old landmarks. It is easy to follow the course of the great changes". The introduction of the water-frame led to the migration of production from moorland cottage down to the new factory-type mills, built on the banks of the fast-flowing Pennine streams. Mills were erected, for example, on the banks of Hebden stream, between Hardcastle Crags and Hebden Bridge. It was this response which made it difficult for the Heptonstall area to take advantage of the next phase in industrial development, the adoption of steam power (Wild, 1972). By the mid-nineteenth century, the centres of industrial development had shifted further away from the plateau moorland and from these streamside mills toward the principal valleys, where coal could be imported more easily along the Calder Navigation and valley roads and railways. Hebden (Hepton) Bridge eclipsed Heptonstall. The low-lying lands, which had previously been avoided and neglected, now became the foci of change and development (Raistrick, 1970).

4.9.4 At first, industrialisation brought prosperity to agriculture. Crump (1938, 127) described the early 19th century as "the Golden Age of Halifax farming", but soon the exodus of industry from the uplands was followed by one of population. Not only did hand-weaving and combing finally disappear, but the small farmer lost both his local market for farm produce and a source of local employment for his children as the mills and warehouses on the Pennine streams closed. The area of rough land broken up and ploughed for oats and potatoes may have reached a maximum during the years up to 1870, after which there was rapid decline, accentuated by the fall in wheat prices occasioned by the large imports from overseas. This general observation is not, however, strongly evidenced in the maps for Heptonstall between 1848 and 1892, where the farmed area fell by only some 3% of the parish area (4.2.5). Although the uplands did not produce wheat, the lower prices for this led to the abandonment by around 1900 of oats as an upland crop to use as a bread-corn.

4.10

4.10.1 Although almost completely dependent on pastoralism, many upland farms were characterised by their conservatism and backwardness in animal husbandry. They were essentially subsistence holdings, remote from large centres of population, and lacking both the resources and incentives to experiment with new methods of raising output or of achieving greater diversity of production. The market-potential of the uplands could not be realised until communications improved. On Dartmoor, this began in a dramatic fashion, following an Act in the 1770s for the construction of a road from Tavistock to Mortonhampstead. Over 15,000 acres of Dartmoor were enclosed with stone walls by the mid-19th century, while several miles of shelter belt were planted on Cator Common in Widecombe parish.

4.10.2 In the Lake District the development of a serviceable road network made it possible to substitute the farm cart for the pack-horse in transporting farm produce to distant markets (Darley, 1964, 29-32). The opening of the Kendal-Lancaster canal in 1819 provided further assistance and this was in turn displaced by the railways, the first of which was built over Shap in 1846. Intensive commercial farming, supplying the markets of industrial Lancashire and Yorkshire, began to affect the management of even the higher dales. In 1860, Mardale Green, to the west of Shap parish, sent 3,000 pounds of butter each week through Shap station and by rail to Manchester (Millward & Robinson, 1970). Improvements in communications were a stimulus to the enclosure of extensive areas of common, without which it had been generally impossible to carry out selective breeding or improve pasture quality. These commons included not only the high fells but also extensive tracts of more fertile lowland. The pace of enclosure in Westmorland was not impressive: several enclosure acts were never implemented, probably on account of the complexity and cost of making the awards in relation to the expected benefits. When enclosure was pro-

posed for Shap in 1766, tenants and landowners warned that "The High Fell or Peat Moss is incapable of any improvement", and that the land should be "measured or marked out for peat or turf only and the herbage as common". No one should be "obliged to make fences against all or any of the lands or manors adjoyning". Although the Act was passed, nothing was done and when the time came to repeal the measure and secure a fresh Act, the commoners again warned that "The nature of the Soil and Climate of the Commons in question renders the greatest proportion of it unfit for Arable Cultivation and only useful for the purposes of planting (trees) and pasturage". The new Act for Shap was eventually implemented in 1820. Improvement in communications and reduction of commons gradually led to improvements in livestock quality and in the carrying capacity. Parts of Sleddale and Wasdale were drained, and lands up to 1,600 feet on Shap Fell were improved (Darley, 1964, 35-6). Enclosure made it easier to counter the tendency of meadows to be "overmastered" with moss in the humid climate, by means of ploughing every 7-10 years and planting with corn until the moss was destroyed and a good sward established (Garnett, 1912, 19-21).

4.10.3 Many of these land-use "improvements" were speculative in nature and dependent on high agricultural prices. Consequently, there was great hardship when the large-scale import of animal products led to a marked fall in livestock prices in the last two decades of the 19th century. Reversion then became the dominant trend. Some farms were amalgamated, leading to the abandonment of the poorer lands and creation of a more viable holding out of the better fields of each. It was often difficult to adjust land-use to the new economic climate. In the central fells of the Lake District, Garnett (1912, 57) described how some farmers had grown corn till the land was impoverished and abandoned. Although others planted green crops of turnips, rye, clover or seed potatoes there was always a tendency "to keep the plough going to the ultimate deterioration of the land". When much of

this marginal land was abandoned following the decline in agricultural prices in the 1870s, a high proportion of this became rough grazing and moor, rather than remaining as improved meadow and pasture.

4.10.4 Writing of the North York Moors, on which, for example, Farra (1961) estimated that in Bransdale 250 acres were reclaimed between 1750-1850, with several large plantations laid out on the higher slopes, Chapman (1961, 282) observed that "for the student of reclamation and reversion, looking back from 1950, the changes might never have happened, so transient was their influence". Farra (1961, 255) calculated that about 89 acres of Bransdale were reclaimed between 1851 and 1955, and that 184 acres had reverted. Experience varied between and within the dales. In Bransdale and Farndale, the position of the moorland edge in 1955 was generally similar to that of 1851.

4.11

4.11.1 The decline in agricultural values of upland land and changing social and industrial conditions outside the uplands encouraged the introduction of alternative land-uses. During the 19th century, extensive areas in the North York Moors were used primarily for grouse-rearing, and Elgee (1912, 33-5) drew attention to the ecological effects of heather burning ("swiddening" locally), usually in March and April, on a 7-10 year rotation, to promote younger growth for the birds in spring. "Swiddening" was then probably the most important "disturbing factor in the plant life of the uplands", and may have led, over a period of time, to a decrease in species diversity. Since the 1930s, the practice has fallen into decline: the outbreak of accidental fires has become more important. Much of the western Moors, for example, was affected by fire in 1959, and a fire raged over the central Moors in 1960 (Chapman, 1961, 26).

4.11.2 The use of the uplands as water-storage grounds brought similarly striking local changes. According to Crump (1938, 186), the construction of the reservoirs in and around Heptonstall "enormously reduced the sheep-runs of the parish", and excluded all agricultural use of the gathering grounds. In Shap, some of the better agricultural lands have been flooded. In 1919, Manchester Corporation was given parliamentary sanction to raise the level of Haweswater by 95 feet, thereby causing a considerable length of Mardale to be flooded. Construction work began in 1927, but the reservoir was not tapped for water until 1941. There has subsequently been a more modest scheme in Wet Sleddale.

4.12

4.12.1 It is convenient for comparative study of the parish areas to produce simplified versions of land-use maps such as those illustrated in maps 18 and 19 (4.2.3). By considering the 0.25 km^2 grid square unit as being represented by the land-use recorded at the mid-point of the square, a single use for each grid square can be listed and entered to the computer data store. The mapping programme discussed in Section 2.4 can then output the land-use situation in this simplified form for each recorded stage. As examples, maps are shown for Glascwm and Heptonstall.

4.12.2 Maps 20-22 show the distribution of "heath and rough pasture" in Glascwm in 1837, 1888 and 1932. The proportion of the parish area in this use hardly changed, occupying an estimated 46.9% of the parish in 1837 and 1889, rising to 48.3% in 1932. Some individual squares, however, changed their use. As can be easily checked from the list printed on the complete computer map output, in 1888 two squares (indexed 85 and 115) had ceased to be identified, from their mid-points, as rough grazing but two others (nos. 12 and 127) had become so. Two further squares (nos. 62 and 83) were recorded as being rough grazing in 1932. Accepting equal reliability for the

data sources, and in view of the difficulty of distinguishing "heath and rough pasture" as a category from the more neglected types of farmland, these differences are so slight as to suggest little significant change on an area basis, of this land-use class over almost 100 years. Figures 23-25, of the farmed land distribution in Glascwm, show a dramatic decline in the extent of arable between the 1830s and 1930s. Woodland fell from three grid squares in 1837 (nos. 20, 25, 126) to one in 1888, remaining this same one in 1932 (no. 25).

4.12.3 Insofar as sources permit, this pattern of relative stability in the extent of improved land and the areas of heath and rough pasture can be discerned in the other sample parish areas, and perhaps most especially in Heptonstall. Maps 26-29, based on a comparison of data shown on O.S. and Land Utilisation Survey maps (that for 1969 being supplied by ULS), show that there was a fall in the proportion of farmed land of 3% of the parish area between 1848 and 1892, with a further 2% fall from then to 1969.

4.12.4 By relating the vegetation at sampling points to their location on land-use maps of different periods differences in history which may relate to present vegetation can be sought for specific points. From the simplified land-use computer maps, in which the grid square is defined by one mid-point observation, general trends in a parish area can be recognised and compared with other areas.

4.13

4.13.1 This chapter has identified a number of important phases and themes in the development of the uplands, as indicated by the experiences of the six parish areas (though no extensive record has been located of the experience of Glascwm). It has emphasised the antiquity of extensive areas of present-day vegetation, which evolved out of the land-use and management practices of prehistoric times. Far from being regarded as waste land, the pasture grounds

played an essential role in the local and regional economies of medieval and post-medieval times. Through custom and the entrepreneurial genius of the monasteries, the natural resources were exploited on a regular and comparatively intensive basis, thereby maintaining and extending the open habitat of the uplands.

4.13.2 Within this overall trend, many instances of reclamation and reversion have taken place, as expressed in the form of old field boundaries, intakes, and deserted settlement. Such disturbances have been promoted not only by climatic change, but also by economic and social trends in regional and national life. Improvements in communication, ability to take up domestic industries, periodic search for minerals, and more recent demands for grouse moors and water-gathering grounds, have had important repercussions on the extent and intensity of land exploitation.

4.13.3 So far, only six parish areas have been studied in detail. By taking further example areas, it should be possible to identify other themes in the development of the natural environment of the uplands, and to assess the extent to which these and the present identified phases are common, though of differing impact, to all parts of upland England and Wales. It should of course be emphasised, with reference to the most recent phase of upland use, that the ULS team are responsible for investigation of post-1945 land-use changes in the study areas.

5. VEGETATION RELATIONSHIPS TO LAND AND LAND USE TYPES

5.1

5.1.1 Chapter 2 discussed the recording of physiographic and topographic characteristics, and their presentation for the study areas as statistical and map computer outputs. The same computer map programme can produce simplified displays of parish area land-use history, as illustrated in Chapter 4. The vegetation site records and classifica-

tions outlined in Chapter 3 provide "point" data which can be considered in relation to land characteristics, land-use history, and to the present farming practice that is being studied by ULS.

5.1.2 If quantitative details of vegetation change in tightly controlled situations were to be considered the primary objective of this DOE contract, there would clearly have been much to be said for a methodology which first identified locations where contrasts in use and management were known to have been effective for particular periods. From this knowledge, concentration of observation, analysis and interpretation could be on sites where the resultant effects of uses through time on vegetation species composition, cover and classification could be determined. However, the contract specification contains the major requirement of provision of wider information covering the land, land-use history and vegetation of relatively extensive nominated example areas. This necessarily has directed effort more to the objectives of broader understanding of the range of vegetation in the uplands and its controls.

5.1.3 An aspect of the current approach to parish area study is to seek to bridge a gap between extensive understanding of relationships, and the detail of local situations, by correlation of identified land and land-use characteristics of sectors and "point" locations with vegetation classes determined from the field vegetation records. Quadrat vegetation information from field sites might be then used as a starting point for assessing the potential and probability of alternative vegetation type distributions on an area basis. If strong specific associations can be demonstrated between vegetation class, land type and land-use history, such probability extrapolations could reasonably be made from knowledge of the distribution of sectors with particular present and past land-use and with specified physiographic and topographic characteristics. Considerable effort has been devoted to working through alternative possibilities of identifying and specifying such associations, with particular attention to two methods outlined below.

5.2

5.2.1 The first method required a listing of land attribute categories at the "points" marked on parish area base maps as "main site" vegetation recording locations. This list, additional to the quantitative grid square-based data, gave one category each of attributes such as altitude, slope, proximity to houses, location with respect to field boundaries, etc. for each located point. From it, the land features which occur with high frequency at sites which fall into a particular vegetation class can be identified. Table 9, as an example of an "in-parish" correlation, lists for Shap Rural and Shap those land characteristics which occur with high frequency at the vegetation sites falling into classes of the vegetation classifications given in Table 8. This, and other in-parish tables of the same type, clearly display the broad associations which are to be expected, but they, not unexpectedly, do not demonstrate such strict correlations of the recorded vegetation with land attributes that it can be said definitively that particular vegetation types could only occur within tightly specified land situations. It is, however, possible that this approach might be looked at from another viewpoint. Individual sites which have characteristics which lie outside the general range of land properties most frequently associated with their vegetation class may be locations to which further study could be directed. Causes could be sought for such deviations from the norm, that could assist prediction of the possibility and probability of changes. Although possible, this is likely to be a laborious task in relation to its applicability.

5.2.2 Turning to the application of this "point" land characteristic/vegetation class correlation to combined six-parish data sets, a further consideration emerges. Table 10 sets out the land characteristics which occur with high frequency for sites in each parish that fall into one example vegetation class, "rushy moor", of the six-parish species presence/absence vegetation classification. This class is

present in all parishes but it will be seen that the site land characteristics with which it is associated differ substantially from parish to parish. No overall picture emerges of sufficient consistency to define a limited range of land characteristics on physiography and topography alone within which the actual or potential probability of finding or developing this vegetation class is high. Of course, climatic and soil differences between the parish areas are among those factors which understandably influence this situation. It does imply, however, that management proposals to retain or remove "rushy moor" could only be stated in the broadest terms (e.g. "It is desirable to sustain (or lower) the water-table."). Any precise management recipe and any calculation of rate of change under prescribed management could only apply to the vegetation type under some specified local site conditions, not as a general rule to even this six-parish area, leave alone to the total upland range. Extrapolation of the site data to area probabilities would again only be very general or require an uneconomic level of detail except in cases where management was actually intended.

5.3 The second main approach started from the situation that the vegetation recording site occurs within a specific 0.25 km^2 grid square which can be allocated to a land type by one of the land classifications (Section 2.8). A table can then plot the frequency with which each vegetation class occurs in each land type. As an example, Table 11a relates the eight classes of vegetation classification to these of a land classification for Shap Rural and Shap, while Table 11b is an abbreviated version of this correlation, using fewer vegetation categories and grouped land types. These tables show an occasional strong correlation between individual classes (vegetation class 8 - land type 1) and the expected broad associations of "moorland" and "improved grassland" with major land categories, but the general picture, seen over a large number of such associations tested, is of vegetation classes occurring in several or most land types, and of land types containing a range of vegetation classes. This in part results from the use of grid squares, which are

to varying degrees internally complex, as homogeneous units, and in part from the ability to modify management to create a similar end-product in different situations. The tables can, however, be interpreted positively as displaying the probability of occurrence of a vegetation class within a land type. For example from 11b, there is, for land type 1, an 85% probability of "pure moorland", a 12% probability of "mixed moorland" and a 4% probability of "rough pasture" being the vegetation class found at a sample site. In contrast, looking at land type 5 in Table 11a, this can include seven of the eight vegetation classes, at probabilities between 6 and 30%. Such an approach can identify land sectors of greater and lesser actual and potential vegetation diversity.

5.4 Other possible approaches for vegetation-land association investigations from these data are to count the frequency with which individual land attributes occur in grid squares within which a given vegetation class occurs, in a similar way to the use of "point" data (5.2); to seek correlations of vegetation classes with selected individual or simple combinations of land characteristics rather than with land classes; or to relate the vegetation type to present or past land-use patterns. Tests of these approaches once more produce general associations which confirm or reinforce expectation. The "moorland" vegetation types in Glascwm, for example, as maps 30-32 show, correlate strongly with grid squares shown as relatively high ground, and reasonably with those areas mapped in 1932 as heathland and rough pasture. The recent land-use maps for this parish, not made available when this report was prepared, would undoubtedly show a retreat of "heathland" land-use in this parish to a pattern closely similar to that of the "moorland" vegetation of the 1977 field recording. Field boundaries and altitude class associations also identify sectors of this parish with "moorland" vegetation types (see maps 12 and 14). Such relationships appear encouraging and certainly supply bases for general understanding of relationships between land character, land-use and vegetation. They are, however, providing mainly a range of alternative viewpoints for observa-

tion and presentation of what are already reasonably well-appreciated correlations, rather than certain means of closing the gap between general principles, and methods of detailed local practical management to achieve a particular aim, which usually will demand "one-off" site studies to give exact management recipes. The general picture from the total data sets should be reinforceable in detail by focussing later attention on sites which analysis of the data show to have specific histories and recent use patterns.

6 STUDY AREAS IN REGIONAL AND NATIONAL CONTEXTS

6.1

6.1.1 To achieve statistical sampling of the full range of land and land-use types in the uplands, small areas selected at random could have been sampled across this range, or within stratified upland categories based either on geographic regions or national land classifications. Although desirable, such sampling would have been logistically more difficult for field work and also would create problems in seeking applicable historical land-use data. The advantages of confident statistical treatment of such sample area data are probably outweighed by the practical convenience of fewer, concentrated locations such as are provided by the parish areas chosen by ULS.

6.1.2 The nominated study locations thus are a small number of relatively large areas, sited to give a general distribution through upland England and Wales, but with their exact selection modified by external factors. Although they can be expected to contain most of the main vegetation, land-use, land, landscape associations important in the uplands, they are nevertheless a series of case-study locations rather than a sample from which quantitative extrapolations can be applied with statistical confidence to their wider regions, or to the uplands as a whole.

6.2.1 However, the contract plan requires the parish areas to be set in regional and national contexts. How then is this to be done? One method would be to sample, in identical ways, a series of sites in the parish areas and compare these with a control series, more widely spaced, from the rest of the uplands. This, done with sufficient intensity, would in practice produce a random or systematic small-area sampling programme such as was mentioned above (6.1.1) and could not be carried out, both for time and cost reasons, as an additional overlay to the detailed case-study area approach to which this investigation was committed. It might be a useful sequel to the present project.

6.2.2 A second possibility would be to relate information from parish study sites to classes for which there is already regional or national distributional information so that, for example, generalisations about regional or national proportions of vegetation types, and hence about the extent to which potential vegetation changes could be applicable, can be made with some confidence. The ability to do this for vegetation in the present study will be aided if the significant vegetation classes obtained from ITE analysis of vegetation records in this project can be equated to a reasonable degree with vegetation map units identified on the c. 1970 maps of the 2nd Land Utilisation Survey (LUS), as now being re-recorded by ULS. If correlation of some or all key types is possible between these two vegetation approaches then, from existing LUS mapping outside the parishes, it might be practical to assess semi-quantitatively the importance, in a wider upland framework, of vegetation classes and trends recognised in the study parishes.

6.2.3 Thirdly, it will be possible to relate the vegetation classes recognised, with their land characteristic associations, to categories in national ecological surveys that are becoming available from current basic science projects of ITE, particularly the "Ecological Survey of Britain" (Project 424), based on a habitat type survey for a sample of 1 km x 1 km grid squares covering

the country, and a national classification of woodland types (referred to in Section 3.6.3). Such comparisons should give assessments, alternative to those suggested in 6.2.2, of the relative extent to which a particular vegetation-land association is likely to occur in the country as a whole. Of course at best these are probability measures. They cannot show that a particular vegetation, land, land-use association occurs at specific locations and that therefore management to achieve a desired objective should be applied at these locations. Exact distributional information can only be obtained by comprehensive surveys which, at the level of detail required, for practical application would be of prohibitive effort, except for sectors where actual active management is intended.

6.3.1 Finally, an interpretation of the relationship of the overall character of the study areas with that of their region, or with a national land class, can follow consideration of mean values for properties of a parish area as a unit in relation to those of the region or land class as a unit. In the desk-study, Upland Land Use, carried out by ITE for DOE (ITE Project 398), quantitative land data were accumulated for the 436 "upland" 10 km x 10 km grid squares in England and Wales. By combining these data for grid squares grouped into geographic regions, the overall mean characteristics of identified upland regions and their "core regions" can be determined. Additionally, a classification of these upland grid squares into eight classes was produced, based on computer analysis by ISA, using a combination of measured physiographic, climatic and soil characteristics to give a natural environmental upland classification. The grid squares in each of these classes can be combined to give mean properties of a national upland class to which the parish areas also can be compared. (An "upland" grid square was defined initially on an altitude basis as one with $\geq$4% land above 800 ft., and a "core upland" square as one with $>$ 50% land above 800 ft. The land classification divided the upland spectrum into two parts at its first division, closely similar in composition but not identical to the simpler

altitudinal identification of "marginal" and "core" upland sectors.)

6.3.2 This upland 10 km x 10 km data bank was necessarily quickly set up and, in the longer term, is best considered as a pilot study. This is because its data set is being superseded by a new data set covering the entire land surface of Great Britain at this scale, being produced in a basic science project of ITE (National Land Characteristics and Classification, ITE 534). Where available, better source material and more accurate data extraction methods are being employed than were possible in the pilot study. However, until the new material is available, the existing data set provides a reasonable means of comparing parish area, region and land class. Appendix 5a lists the 10 km x 10 km squares in which each parish area falls by the reference number in the unpublished 398 report to DOE and by their O.S. grid reference, with the percentage of each parish area in the grid square, and the percentage of the grid square within the parish area. Appendix 5b gives the upland region and national land class or classes, as discussed in the same report, into which these squares fall.

6.3.3 Tables 12(a) and (b) give comparative mean values for two study parish areas, Bransdale, and Ystradgynlais Higher and Glyntawe, to illustrate this basis for comparison of the parish as a unit with wider frames of reference.

6.3.4 From Table 12a, for Bransdale, its land characteristic relationships to locality, region and relevant national upland land class can be summarised as follows.

10 km x 10 km grid square/s in which the parish area is located	The parish has similar altitude, rainfall and agricultural land class (ALC) characteristics but is of gentler slope, with more peaty gley soils than is the case for the grid squares.

Region : The parish, in comparison with the North York Moors region, has more higher altitude ground, less land of higher ALC grades (2-3) and fewer non-peaty soils than the region. In relation to the small "core region" of the North York Moors, the parish has less land of moderate slope but is otherwise quite similar in average character.

Land Class : The parish area, and the grid squares within which it falls, have notably lower rainfall than the mean for the land class, although a conjunction of slope and soil parent material gives a higher proportion of poorly drained peaty-topped soils and less well-drained soils than is the average for the class as a whole.

In general, the parish area is at the low rainfall end of the range covered by the Northern High Upland land class, and in regional terms contains more of the higher ground-gentle slope terrain type than is the average for the North York Moors core region.

6.3.5 Ystradgynlais Higher and Glyntawe relationships can be outlined similarly from Table 12b:-

10 km x 10 km grid square/s in which the parish area is located : The parish has similar altitude, rainfall, agricultural land classification, and soil to its most closely associated grid square, but again has more ground of gentle slope than the average for the relevant grid square.

Region : The parish area, in comparison with the Brecon Mountains region, contains less lower altitude ground, more gentle slopes, has higher average rainfall, poorer ALC grades, and none of the dominantly freely drained mineral soil areas that characterise

: the region. In relation to the core region, the parish, although of similar mean altitude, contains on average less ground of steeper slopes, is of higher rainfall, of poorer ALC grade and fewer freely drained soils.

Land Class : The parish area and the grid square in which it mainly falls has notably more ground of gentle slope and is without the varied range of dominant soils which characterises the most closely associated land class - Western High Upland.

In general, the parish area has above average rainfall, below average slope, and less soil diversity than characterises the Western High Upland Land class, and in regional terms is wetter, with more peaty soils, and lower agricultural land class grading than typifies the Brecon Mountains region or core region.

7 INTERIM REPORT SUMMARY

It is too soon to set out conclusions from this work but some provisional points, rather than a comprehensive summary can be made:

7.1

7.1.1 Physiographic and topographic land characteristics can usefully be extracted from the 1:25,000 O.S. maps using 0.5 km x 0.5 km grid squares as the unit of recording. Computer storage of these data, with statistical and map output programmes, provide efficient means of summarising parish area characteristics as a whole or in sectors, and of displaying and comparing distributions of single or simple composite properties.

7.1.2 Land type classifications produced by Indicator Species Analysis from lists of attribute presence in grid squares, edited from the quantitative data sets, can be obtained reasonably quickly but their interpretation is time-consuming. Although such classifications give a broadly interpretable picture in conformity with expectation they produce, with the data sets and the range of attributes employed in this study, anomalies in the classification of individual grid squares that create difficulties in defining classes simply but comprehensively, either verbally or statistically. Interpretability of such land classes for their relationships with land-use history and with vegetation has not yet proved sufficiently more informative than using mapped distribution of selected characteristics that it justifies the same intensive input of effort in the remaining six parish areas intended for study. However, such analyses of the total set of data would be useful in clarifying contrasts in physical and settlement patterns between the parish areas and in assessing regional relationships, and should be carried out to a limited extent.

7.2

7.2.1 Historical evidence shows that a broad framework of the present upland pattern had been created in prehistoric-medieval times and consolidated by the 17th century. Economic, political and social influences on the attitudes of landowners and farmers to the uplands subsequently produced, at different periods, differing regional and local changes in the types and intensity of upland use. These changes, in large measure, have been transient advances and retreats around the laid-down broad framework. Where map evidence exists, simplified computer map output in a comparable format to that used for physical land characteristics provides a ready method of searching for and identifying correlations.

7.2.2 No generalisation as to a single sequential course of history applies to all parish areas, as it has been shown that the identifiable key phases of upland exploitation are represented in them to significantly differing degrees. Recent history of the parish areas over the hundred years or so to 1945, assessed from map sources, shows in general that no major changes in the balance of improved land and moorland took place over this period, though the vegetation within these broad categories may have responded to different types and intensity of management. In most parish areas this essentially stabilised situation has continued post-1945, Glascwm being the parish where post-war change has been most marked in extension of farmland.

7.3

7.3.1 Major changes in national policy affecting for example, tree crop production or the attitude to food supply from home sources, or in legislation affecting common lands or private land management options, could have substantial impact in the uplands but, without such changes, the impression is, in many areas, for a persisting situation of relatively minor change from the present, and in some cases long-established, balance of farmed land and moorland and mountain. Emphasis is likely to be on farm management methods which increase returns from the already improved sectors.

7.3.2 In the main site vegetation classifications, the initial split between "moorland" and "farmland" classes is fairly distinct, whether assessed from presence/absence of plant species or from their percentage cover. Within these broad categories some sites are classified differently if the classification is based on percentage cover of species rather than a list of species presence. It is possible that such deviant situations may reflect sites in the process of change between classes. Data examination is in hand to pursue this possibility. Considering the six-parish spectrum of vegetation classes, Heptonstall is

distinctive in being notably species-poor and acidic, whether on moorland, woodland or roadside verges. Other parish areas are not so distinct from each other, except in their verge vegetation.

7.3.3 Of habitats examined in the parish areas, roadside verges show the clearest distinction between parish areas, with each having its own assemblage of species, reflecting differences in the type of field boundary (e.g. walls, hedges, banks) and in climate and soil. In the case of woodland and moorland vegetation such distinctions between parish areas are less marked, and, in the case of pasture they are small reflecting the over-riding influence of the more intensive types of management. Although management methods may be relatively uniform, the economics of their applicability are controlled by site factors so that the physical range over which a particular intensity of use occurs differs between study areas.

7.3.4 The woodlands are limited throughout to acidic moist upland types of the natural woodland range, and the very few young trees recorded in four of the six parish areas are an adverse feature for maintenance of the small extent of those woodlands which remain.

7.3.5 Existing semi-natural vegetation is relatable to the following main factors (not in order of importance): climate, physiography, geology, soils, settlement history, recent and current management. It is not possible to put simple overall limits to a range of land conditions within which a farmland or moorland vegetation class can be found because of the complex interaction between these factors across the country. In the confines of a parish, especially where there are no major geological/soil discontinuities, simple physiographic categories can correlate strongly with land-use patterns and hence with vegetation. Contrasts in these relationships between parish areas, due to the intervention of other site factors, can help assessment of local, regional and national impact of factors affecting upland land and landscapes. There has not yet

been a thorough investigation of the relationship between vegetation and land-use distributions and broadly classified national upland classes. The data obtained from these parish area studies should increase the opportunity for such an investigation.

8 CONSIDERATIONS FOR DEVELOPMENT OF RESEARCH

8.1

8.1.1 The title and objectives of this project include emphasis on directions and rates of vegetation change under conditions in which relatively gradual differences in management are imposed. On the other hand, areas were allocated for study which, while they may contain situations in which change may be assessed from known conditions, will only do so fortuitously, since there is no information ab initio that they contain locations for which the required information exists. The parish area studies carried out so far, and intended, in the existing contract, to be carried out on the remaining six areas, provide a series of case studies that can give a sound basis for a broad understanding of the present general situation of upland vegetation and how this situation has been arrived at through natural physical controls, human history, and recent and current possibilities and attitudes to use of the upland land resource. They do not give a certain basis for quantitative determination of directions and rates of gradual vegetation trends, under what have been in any case inadequately defined concepts of which types of management over which periods of time are to be classed as "gradual" changes.

8.1.2 One key issue therefore is that the contract target should be defined more positively - what actually is the problem as perceived by the customer to which a solution is needed or at least about which more information is required? If the target is a more quantitatively supported and more comprehensive understanding of the present situation of

the major semi-natural and cultivated vegetation types in the uplands of England and Wales than is already available in general terms, then the present approach is in outline along the right lines and should be continued. If, however, the customer's main or only requirement is seen as a precise set of recipes for managing particular vegetation types to retain them or achieve desired changes over known periods of time this is unlikely to emerge from the present plan since effort is being directed at the wider view and the project is not sharply focused on this target. It is as well to consider, however, whether such a target is really justified in practical terms. Management to achieve a desired vegetation change must depend, in each specific case, on local survey and analysis for a choice of methodology. The most economic recipes for achieving change, and those most likely to be applied, will generally be ones which are well understood agricultural, grouse-moor, or forestry management methods, involving substantial perturbation of an existing situation in order to achieve a desired objective in a reasonable period.

8.2 Given a decision that improved understanding of the nature and distribution of the spectrum of upland vegetation types in relation to land and land-use features is of use to the customer, there are, in view of the study areas being those selected for the Upland Landscape Study, good external grounds for ITE to carry through a three-part land characteristics - land-use history - vegetation recording and classification study, broadly along present lines, on the remaining six nominated parish areas. From the internal point of view, use of the other six parish areas provides a wider cover of geographic region, upland land type, and land-use history in the range of sites at which vegetation would be studied. Analysis of the six-parish vegetation data suggests gaps in the range of classes represented, and the greater geographical range of the twelve parishes should fill most of these gaps. Generalisation about paths of change between vegetation classes would emerge from such a study but not, unless additionally built in to project planning, precise timetables of recorded change under defined conditions.

8.3 If change-rates, and practical management recipes to achieve such rates, are the principal or only objective of the customer, then it will be necessary to realign effort and to have a contract plan which involves seeking sites of known history, with assured control on management, on which direct observation of the situation as it is and as it develops can be made. It seems probable that much information on such sites will be known to experimenters and advisers in the agricultural, especially hill-farming, fields. Locations suitable for quantitative observation of change paths and rates may emerge from detailed study of site data from within the twelve parish areas, but most suitable sites are likely to be found outside the parish areas (e.g. on HFRO or other experimental farms, or in those localities already examined from land-use aspects by University workers in areas such as the Peak District and Dartmoor). Mathematical modelling of change probabilities may be possible on the basis of existing recorded sites or those detected in the parish study areas. It would be unrealistic to propose experimental or monitoring sites for study of change (item 7b of the "Programme of Work" in the contract document) without a full review of possible locations and until a well-argued case can be made that experimental studies are needed because existing knowledge of trends is inadequate; that "gradual" (however defined), rather than sharp, perturbations of upland vegetation are quantitatively sufficiently probable and extensive to justify study; and that something could practically be done to implement desired upland vegetation policies in the light of such knowledge. Recommendations and action in this respect will emerge therefore at the end of, rather than during, the contract.

8.4 The "management handbooks" called for (item 7a of the "Programme of Work" in the contract document) can arise naturally from the present contract if they are envisaged as generalised management guidelines based on previous knowledge and the findings of this study. More detailed guidelines in the form of precise practical recipes to achieve a desired end in a particular situation would depend on agro-

nomic and other land-management expertise, and would not arise naturally from the present contract plan.

8.5 Summarising the above points for consideration:-

8.5.1 (a) Customer reconsideration is required of what is seen as the main "problem" that should provide the target for investigation (8.1).

(b) Extension of the present approach, with minor amendments, to the remaining six nominated parish areas can give a better knowledge of the nature and relationships of present upland vegetation to land and land-use characteristics. If this is an acceptable objective to the customer then this aspect should form the basis of a revised plan (8.2).

(c) If quantitative assessment of rates of gradual change in specific local situations is the main target, the aim will need tighter specification and the plan substantial redirection. Review, rather than experimental, data on this aspect should be able to be provided as a supplement to the parish-based study (8.3).

(d) Handbooks on the relationship between different main vegetation types and management methods could emerge from the present approach if general principles and explanations of trends and pathways of change are acceptable as their content.

8.5.2 An outline plan for research continuation and development, 1978-1980, has been prepared as a separate short document.

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Table 1. Quantitative Physiographic and Topographic Attributes

1 Physiography

Altitude Class (as areas, in 4% units)

1.1	<400 ft. O.D.	1.4	1101-1400 ft. O.D.
1.2	401-800 ft. O.D.	1.5	1401-2000 ft. O.D.
1.3	801-1100 ft. O.D.	1.6	>2000 ft. O.D.

Altitude Range (as figures, in feet)

1.7 Lowest mapped contour or spot height
1.8 Highest mapped contour or spot height
1.9 Altitude range between lowest and highest recorded heights

Slope Class (as areas, in 4% units)

1.10 Area of land with slope between 0° and 5°
1.11 Area of land with slope between 5° and 11°
1.12 Area of land with slope between 11° and 22°
1.13 Area of land with slope $>22^{\circ}$

Aspect (as areas, in 4% units)

1.14 Aspect generally northerly (i.e. between NW and NE)
1.15 Aspect generally easterly (i.e. between NE and SE)
1.16 Aspect generally southerly (i.e. between SE and SW)
1.17 Aspect generally westerly (i.e. between SW and NW)

Rivers and Streams (as a relative measure by number count, 0-25, of the number of square sub-units of a 25 square grid intersected by one or more rivers)

1.18 Relative density of "river" network ("rivers" defined as watercourses mapped with lined banks)
1.19 Relative density of "stream" network ("streams" defined as unbounded single blue lines)

Water Bodies

1.20 Area occupied by water body (reservoir or lake) (as areas, in 4% units)

2 Topography

Settlement Density (as a number count)

2.1 Number of urban areas (solid grey-blocked built-over areas)
2.2 Number of individual mapped buildings (other than in urban areas)

Road and Footpath Density (as a relative measure by number count, see "Rivers and Streams", 1.17-18)

2.3 Principal roads (any road with solid or dashed colour overlay)
2.4 Other roads or tracks (any double-lined (solid or dashed boundaries) uncoloured road)
2.5 Footpaths

Field Boundaries (as a relative measure by number count, see "Rivers and Streams", 1.17-18)

2.6 Field boundaries

Table 2. Trends in Physiographic and Topographic Characteristics of Study Parish Areas

Bransdale - B, Shap Rural and Shap - S, Heptonstall - H, Glascwm - G, Ystradgynlais Higher and Glyntawe - Y, Widecombe in the Moor and Buckland in the Moor - WB

Overall Altitude	Lower ⟶ Higher B ⟶ WB ⟶ H ⟶ G ⟶ Y ⟶ S
Average Relief	H ⟶ Y ⟶ WB ⟶ S ⟶ G B
Average Slope	Gentler ⟶ Steeper Y ⟶ H ⟶ S ⟶ WB ⟶ G B
Dominant Aspects	B = W,E,S; S = E,N,W; H = N,E,W; G = W,N,E; Y = S,W; WB = W,E (Aspects occupying > 20% of area)
River Density	Lesser ⟶ Greater G ⟶ WB ⟶ S ⟶ B ⟶ Y ⟶ H
Buildings	More ⟶ Fewer WB ⟶ H ⟶ Y ⟶ G ⟶ B, S
Roads	WB ⟶ G ⟶ H ⟶ S ⟶ Y B
Footpaths	H ⟶ G ⟶ Y ⟶ S ⟶ WB B
Field Boundaries	WB ⟶ G ⟶ H ⟶ Y B S

Table 3. Climatic Factors - Summary of Trends in Parish Areas

Rainfall — Drier → Wetter

Alternatives

Parish Data from Rainfall Maps	G, B → H → WB → Y, S
Geographic Region data from National Upland Data set	B → H → Y → S; G → WB
Agroclimatic Area data	G, B → H → WB → Y, S
Days with Heavy Rain	B → G → H, WB → Y, S
Winter Rain Excess	B → G → H → WB → Y, S

Overall assessment

Drier → Wetter

B → G → H → WB → Y → S

Temperature — Warmer → Colder

Alternatives

January Mean Temperature	WB → G → B, Y → H → S
July Mean Temperature	WB → G, Y, H, B → S
Winter Cold	WB → G → B, Y → H → S
Daily Average	WB → Y → G, H → B → S

Overall assessment

Warmer → Colder

WB → G → Y → B → H → S

Snowfall — Lighter, Shorter → Heavier, Longer

Snowfall and Snowlie at artificial <200 ft. level	Y, WB → G → H, S, B

Growing Season — Longer → Shorter

WB → G → B, Y → H → S

Grazing Season

WB → H → S?; B, G, Y?

Overall assessment

Better → Poorer

WB → G → Y, B → H → S

Effective Transpiration — Higher → Lower

(related to solar energy input over the growing season)

WB, Y → G, B, H → S

Agricultural Land Classification — Higher Category → Lower Category

G → WB → B, H → Y, S

Bransdale = B
Heptonstall = H
Ystradgynlais Higher and Clyntawe = Y
Widecombe in the Moor and Buckland in the Moor = WB
Shap Rural and Shap = S
Glascwm = G

Table 4. List of Physiographic and Topographic Attributes used for Land Classification by ISA

ISA Attribute Number	
1	Land <800 ft. occupies 4-24% of square
2	Land <800 ft. occupies 28-48% of square
3	Land <800 ft. occupies ⩾52% of square
4	Land between 800 and 1400 ft. occupies 4-24% of square
5	Land between 800 and 1400 ft. occupies 28-48% of square
6	Land between 800 and 1400 ft. occupies ⩾52% of square
7	Land above 1400 ft. is present in square
8	Land above 2000 ft. is present in square
9	Altitude range <100 ft.
10	Altitude range 100-300 ft.
11	Altitude range >300 ft.
12	Slope Class 0-5° occupies 4-24% of square
13	Slope Class 0-5° occupies 28-48% of square
14	Slope Class 0-5° occupies ⩾52% of square
15	Slope Class 5-11° occupies 4-24% of square
16	Slope Class 5-11° occupies 28-48% of square
17	Slope Class 5-11° occupies ⩾52% of square
18	Slope Class 11-22° occupies 4-24% of square
19	Slope Class 11-22° occupies 28-48% of square
20	Slope Class 11-22° occupies ⩾52% of square
21	Slope Class >22° occupies 4-24% of square
22	Slope Class >22° occupies 28-48% of square
23	Slope Class >22° occupies ⩾52% of square
24	Aspect northerly in 4-48% of square
25	Aspect northerly in ⩾52% of square
26	Aspect easterly in 4-48% of square
27	Aspect easterly in ⩾52% of square
28	Aspect southerly in 4-48% of square
29	Aspect southerly in ⩾52% of square
30	Aspect westerly in 4-48% of square
31	Aspect westerly in ⩾52% of square
32	River and stream density score 1-5
33	River and stream density score 6-15
34	River and stream density score >15

Table 4. (continued)

ISA Attribute Number	
35	Ridge crest the dominant landform feature
36	Hill slopes the dominant landform feature
37	Valley floor the dominant landform feature
	(These subjectively assessed landform classes were included in one set of ISA analyses and omitted in another set, the latter being those discussed in this report)
38	Urban area present
39	Individual buildings absent
40	1-4 individual mapped buildings
41	5-9 individual mapped buildings
42	⩾10 individual mapped buildings
43	-
44	-
45	No roads mapped in square
46	Principal roads present, density score 1-4
47	Principal roads present, density score ⩾5
48	Other roads present, density score 1-4
49	Other roads present, density score ⩾5
50	No footpaths mapped in square
51	Footpaths present, density score 1-4
52	Footpaths present, density score ⩾5
53	No field boundaries mapped in square
54	-
55	Field boundaries present, density score 1-7
56	Field boundaries present, density score 8-15
57	Field boundaries present, density score 16-25
58	Water bodies occupy >50% of square

Table 5. Shap Rural and Shap: Mean Values of Land Characteristics from Classes of In-parish ISA Land classification Based on Physiographic and Topographic Attributes

Land Classification Class	Altitude (ft.)[1]						Altitude range (ft.)		Slope (°)[1]				Aspect				Topography			
	0-400	400-800	800-1100	1100-1400	1400-200	>2000	Lowest	Highest	0-5	5-11	11-22	>22	N	E	S	W	Buildings (No.)	Roads (relative measure)	Footpaths (relative measure)	Field Boundaries (relative measure)
1	0	8	6	21	63	2	1329	1524	27	59	7	1	44	18	12	20	0	0.7	0.4	1.1
2	0	4	23	36	32	5	1225	1428	22	71	6	1	11	57	11	13	0.1	1.1	0.6	3.1
3	0	3	13	28	54	2	1204	1644	8	36	34	19	37	11	27	22	0	0.6	0.7	3.0
4	0	0	8	16	52	25	1362	2012	1	20	31	45	18	42	15	22	0	0.3	1.3	2.7
5	0	1	87	9	3	0	942	1052	85	10	1	3	20	48	6	25	0.4	3.8	1.8	9.4
6	0	7	88	5	0	0	876	965	85	14	1	0	14	22	1	63	3.5	8.4	2.7	16.5
7	0	8	79	12	1	0	861	1093	35	37	14	7	21	29	10	13	0.9	4.5	4.4	8.3
8	0	40	47	10	3	0	804	983	46	43	5	5	28	27	11	33	2.0	7.1	2.9	9.2

[1] Figures as percentage of category in land class.

Table 6. Distribution within each Parish Area of Land Classes from the 6-Parish ISA Land Classification Based on Physiographic and Topographic Attributes

	Land Class		Number of grid squares in class (% of total squares)	Parish Area											
				Bransdale		Shap Rural and Shap		Heptonstall		Glascwm		Ystradgynlais Higher and Glyntawe		Widecombe in the Moor and Buckland in the Moor	
				a	b	a	b	a	b	a	b	a	b	a	b
1	High, moderate relief and slope	very low settlement	264 (21%)	16	8	29	50	14	5	13	7	31	21	11	9
2	High, very strong relief, moderate-very steep slopes	very low settlement	168 (14%)	4	3	24	63	2	1	16	14	9	10	8	9
3	Moderate to high, low relief, gentle slopes	very low settlement	139 (12%)	21	19	10	33	17	12	3	3	20	27	4	6
4	Moderate, moderate relief, varied slopes	very low settlement	84 (7%)	12	18	6	35	7	7	5	9	8	19	5	12
5	Low to moderate, moderate relief and slope	moderately high settlement	208 (17%)	15	9	7	15	35	15	20	14	7	7	41	40
6	Low, strong relief, moderate slopes	high settlement	122 (10%)	13	14	4	16	9	7	20	24	9	15	15	24
7	Low to moderate, low relief, gentle slopes	high settlement	117 (10%)	10	11	13	50	4	3	9	11	6	10	8	15
8	Low to moderate, moderate relief, varied slopes	moderately high settlement	111 (9%)	9	11	7	30	12	10	14	18	10	17	8	14
Total number of grid squares			1213 (100%)	128 (11%)		453 (37%)		92 (8%)		147 (12%)		191 (16%)		202 (17%)	

(a) as percentage of parish in class, and (b) as percentage of class in parish

Table 7.

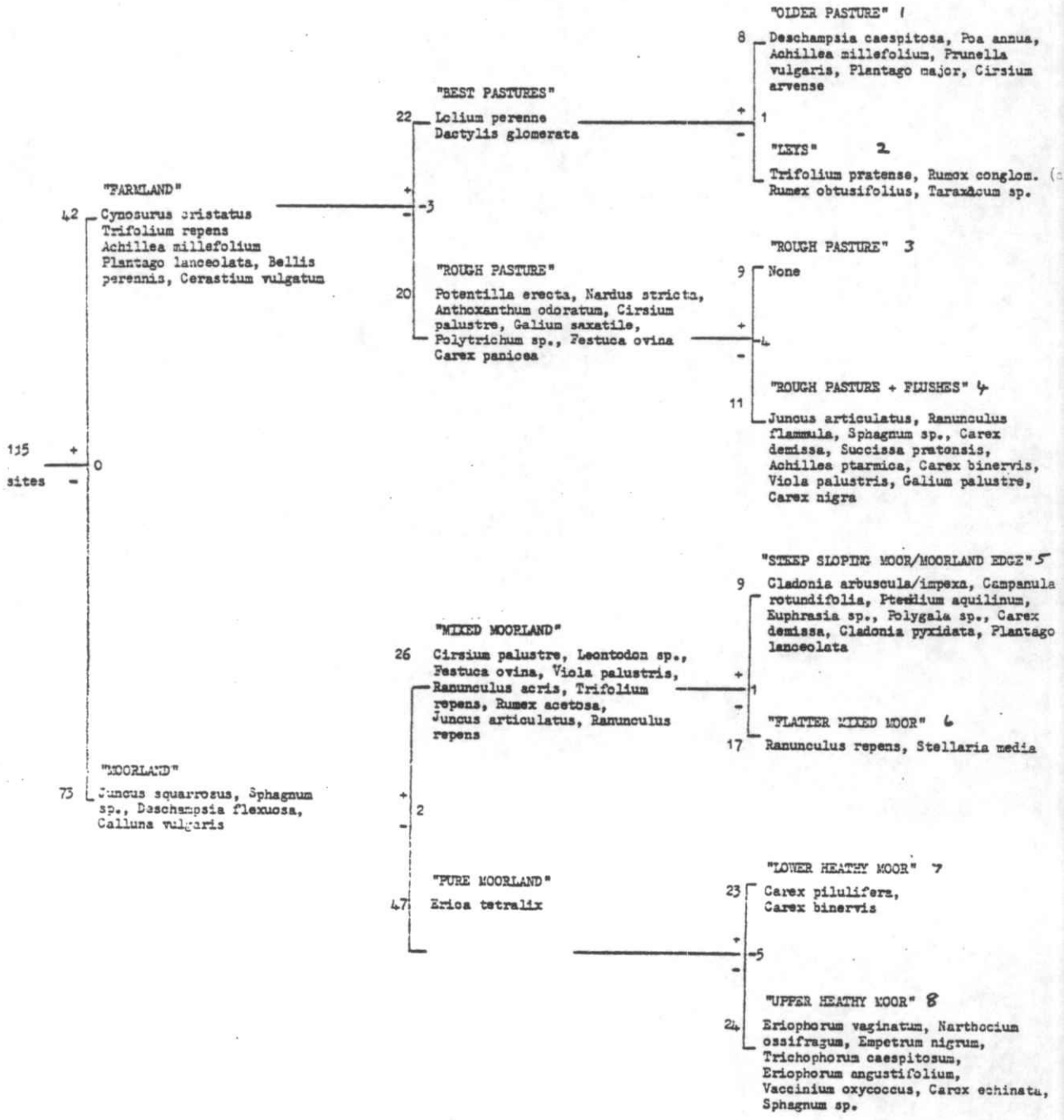
Project 522 List of species codes for main plots

143	*Acer pseudoplatanus*
1	*Achillea millefolium*
2	*Achillea ptarmica*
5	*Agropyron repens*
3	*Agrostis canina/stolonifera*
4	*Agrostis setacea*
6	*Agrostis tenuis*
147	*Aira praecox*
152	*Ajuga reptans*
153	*Alnus glutinosa*
154	*Alopecurus geniculatus*
7	*Alopecurus pratensis*
155	*Anemone nemorosa*
8	*Anthoxanthum odoratum*
9	*Arrhenatherum elatius*
156	*Athyrium filix-femina*
10	*Bellis perennis*
157	*Betonica officinalis*
11	*Betula spp.*
12	*Blechnum spicant*
13	*Briza media*
14	*Bromus mollis*
15	*Calluna vulgaris*
16	*Campanula rotundifolia*
158	*Capsella bursa-pastoris*
17	*Cardamine flexuosa*
159	*Cardamine hirsuta*
18	*Cardamine pratensis*
19	*Carex binervis*
160	*Carex demissa*
20	*Carex echinata*
21	*Carex nigra*
22	*Carex panicea*
23	*Carex pilulifera*
24	*Centaurea nigra*
25	*Cerastium vulgatum*
26	*Cheropodium album*
27	*Chrysanthemum leucanthemum*
28	*Cirsium arvense*
29	*Cirsium palustre*
30	*Cirsium vulgare*
31	*Conopodium majus*
161	*Corylus avellana*
32	*Crataegus monogyna*
33	*Cynosurus cristatus*
34	*Dactylis glomerata*
35	*Deschampsia caespitosa*
36	*Deschampsia flexuosa*
37	*Digitalis purpurea*
162	*Drosera rotundifolia*
38	*Dryopteris filix-mas*
39	*Dryopteris dilatata*
40	*Empetrum nigrum*
41	*Epilobium angustifolium*
42	*Epilobium montanum*
163	*Epilobium obscurum/tetragonum*
43	*Epilobium palustre*
44	*Equisetum arvense*
45	*Erica cinerea*
46	*Erica tetralix*
47	*Eriophorum angustifolium*
48	*Eriophorum vaginatum*
49	*Euphrasia spp.*
50	*Festuca ovina*
51	*Festuca rubra*
52	*Filipendula ulmaria*
164	*Fraxinus excelsior*
53	*Galium aparine*
165	*Galium palustre*
54	*Galium saxatile*
166	*Galium verum*
167	*Geranium dissectum*
168	*Geranium molle*
55	*Geranium robertianum*
169	*Glyceria fluitans*
56	*Heracleum sphondylium*
57	*Hieracium pilosella*
58	*Holcus lanatus*
59	*Holcus mollis*
170	*Hypericum humifusum*
171	*Hypericum pulchrum*
172	*Hydrocotyle vulgaris*
173	*Ilex aquifolium* — Jasione montana
60	*Juncus articulatus*
174	*Juncus bufonius*
61	*Juncus bulbosus*
62	*Juncus conglomeratus*
63	*Juncus effusus*
64	*Juncus squarrosus*
175	*Lapsana communis*
65	*Lathyrus montana*
66	*Lathyrus pratensis*
67	*Leontodon spp.*
176	*Linum catharticum*
68	*Lolium multiflorum*
69	*Lolium perenne*
70	*Lotus corniculatus*
177	*Lotus uliginosus*
71	*Luzula campestre/multiflora*
178	*Luzula pilosa*
179	*Lychnis flos-cuculi*
180	*Lysimachia nemorum*
72	*Matricaria matricoides*
73	*Molinia caerulea*
74	*Nardus stricta*
75	*Narthecium ossifragum*
76	*Oxalis acetosella*
77	*Pedicularis sp.*
78	*Phleum pratense*
181	*Pinguicula vulgaris*
79	*Plantago lanceolata*
80	*Plantago major*

Table 7.

81	*Poa annua*
82	*Poa pratensis*
83	*Poa trivialis*
84	*Polygala sp.*
182	*Polygonum arenastrum*
85	*Polygonum aviculare*
86	*Polygonum persicaria*
183	*Polypodium vulgare*
87	*Potentilla anserina*
88	*Potentilla erecta*
184	*Potentilla reptans*
185	*Potentilla sterilis*
89	*Prunella vulgaris*
186	*Prunus spinosa*
90	*Pteridium aquilinum*
91	*Ranunculus acris*
92	*Ranunculus flammula*
93	*Ranunculus repens*
94	*Rhinanthus minor*
187	*Rosa spp.*
95	*Rubus chamaemorus*
96	*Rubus fruticosus*
97	*Rubus idaeus*
98	*Rumex acetosa*
99	*Rumex acetosella*
100	*Rumex conglomeratus*
101	*Rumex crispus*
102	*Rumex obtusifolius*
188	*Rumex sanguineus*
103	*Sagina procumbens*
104	*Sarothamnus scoparius*
105	*Sedum acre*
106	*Sedum anglicum*
189	*Senecio aquaticus*
107	*Senecio jacobaea*
190	*Senecio sylvaticus*
191	*Senecio vulgaris*
108	*Sesleria caerulea*
109	*Sieglingia decumbens*
192	*Silene dioica*
110	*Sorbus aucuparia*
111	*Stellaria alsine*
193	*Stellaria graminea*
194	*Stellaria holostea*
112	*Stellaria media*
113	*Succisa pratensis*
114	*Taraxacum sp.*
115	*Teucrium scorodonium*
195	*Thelypteris oreopteris*
116	*Thymus drucei*
117	*Trichophorum caespitosum*
196	*Trifolium dubium*
118	*Trifolium pratense*
119	*Trifolium repens*
197	*Trisetum flavescens*
120	*Ulex europaeus/gallii*
121	*Urtica dioica*
122	*Vaccinium myrtillus*
123	*Vaccinium oxycoccus*
124	*Vaccinium vitis-idaea*
125	*Veronica chamaedrys*
126	*Veronica officinalis*
127	*Veronica serpyllifolia*
128	*Vicia cracca*
129	*Vicia sepium*
130	*Viola palustris*
131	*Viola riviniana*
132	*Acrocladium cusipdatum*
198	*Atrichum undulatum*
133	*Cladonia arbuscula/impexa*
134	*Cladonia pyxidata*
135	*Dicranella*
136	*Dicranum spp.*
137	*Eurhynchium praelongum*
138	*Hylocomium splendens*
139	*Hypnum cupressiforme*
140	*Mnium hornum*
141	*Mnium undulatum*
142	*Pellia sp.*
144	*Plagiothecium undulatum*
145	*Pleurozium schreberi*
146	*Polytrichum spp.*
148	*Pseudoscleropodium purum*
149	*Rhytidiadelphus squarrosus*
150	*Sphagnum spp.*
151	*Thuidium tamariscinum*

Table 8. Indicator Species Analysis of presence/absence of plant species at 115 field and moorland sample plots at Shap



Class names are interpretive, based on species characteristics and general site character; numbers are as used in other tables and maps.

Table 9 . Dominant "point" land characteristics at recorded sites, in relation to a vegetation classification

Parish Area: Shap Rural and Shap

Vegetation Classification ISA: In-parish, species presence/ absence (see Table 8.)

Class	Most frequent point characteristics of vegetation sites in class
1 Older pasture	Moderate altitude, gentle slope, near roads, moderately near houses, inside field boundaries, mineral soils of high to very high pH
2 Leys	Low and moderate altitude, gentle and moderate slopes, near roads and houses, inside field boundaries, mineral soils of high pH
3 Rough pasture	Moderate altitude, gentle and moderate slopes, near roads, moderately near and distant from houses, mainly inside field boundaries, mineral soils of high pH
4 Rushy pasture and flushes	Varied, mainly moderate altitude, gentle slopes, especially outside field boundaries, mineral-organic soils of moderate to high pH
5 Steep sloping moorland edge	Moderate and high altitude range, moderate to very steep slopes, away from roads and houses, outside fields, mineral-organic soils, very acid to acid pH
6 Flatter mixed moor	High altitude, moderate to steep slopes, away from roads and houses, outside fields, mineral-organic soils of acid to moderate pH
7 Lower heathy moor	Moderate and high altitude, gentle to moderate slopes, especially away from houses, outside fields, especially organic soils of very acid to acid (occasional moderate) pH
8 Upper heathy moor	High altitude, moderate slopes, especially north and east aspect, away from roads and houses and outside fields, organic soils of very acid to acid pH

Table 10. Land characteristics at sampling points, in each parish area, of vegetation classified in a single class on a six-parish analysis

Vegetation Classification ISA: Six-parish, species presence/absence

Class - 7 "Rushy Moors"

Parish	Dominant characteristics of sites at which class occurs in parish
Bransdale	400-1100 ft., general slopes mainly moderate and steep; aspect mainly west; near or moderately near road; random with respect to houses; inside fields; varied slope at quadrat; soils clayey and peaty, moderate to deep, very acid to acid pH
Shap Rural and Shap	800-2000 ft.; varied general slopes; varied aspects, mainly northerly; random with respect to roads; mainly distant from houses; outside fields; varied slope at quadrat; soils clayey and peaty, varied depth, very acid to moderate pH
Heptonstall	800-1400 ft.; gentle and moderate general slopes; varied aspects; near roads, random with respect to houses; mainly inside fields; gentle slopes at quadrat; soils of varied texture, moderate depth, varied pH
Glascwm	800-1400 ft.; moderate and steep general slopes; north and east aspects; varied with respect to roads, houses and fields; varied slope at quadrat; soils of varied texture, deep, acid pH
Ystradgynlais Higher and Glyntawe	400-2000 ft. (especially 400-1100 ft.); gentle and moderate general slopes; varied aspects; random with respect to roads, houses and field boundaries; varied quadrat slope but mainly gentle; soils of varied texture, moderate depth, moderate to high pH
Widecombe-in-the-Moor and Buckland-in-the-Moor	400-800 ft.; steep general slopes; southerly aspects; near roads; moderately near houses; outside field boundaries, gentle quadrat slope; soils of loamy and clayey texture; deep, moderate pH

Table 11a Vegetation Class: Land Type Correlation - Shap Rural and Shap

Land Types (in-parish physiography and topography ISA)	Vegetation Classes (in-parish species presence/absence ISA)							
	1 Older pasture	2 Leys	3 Rough pasture	4 Rough pasture and flushes	5 Steep sloping moorland edge	6 Flatter mixed moor	7 Lower heathy moor	8 Upper heathy moor
1 (Unsettled, high ground, moderate relief and slope)				1	2	1	3	18
2 (Very lightly settled, moderately high, moderate relief and slope)		2	1	1	1	4	7	3
3 (Unsettled, high ground, strong relief, moderate to steep slope)			1	1	1	6	2	2
4 (Unsettled, very high ground, very strong relief, steep to very steep slopes)			1	2	4	2	2	
5 (Highly settled, moderate height, very low relief, gentle slope, N and E aspects dominant)	3	1	3	2		2	5	1
6 (Settled, moderate height, low relief, gentle slope, S and W aspect dominant)	4	5	2					
7 (Lightly settled, moderate height and relief, gentle to moderate slope, N and E aspect dominant)	1	3	1	4	1	1	3	
8 (Settled, low to moderate altitude, moderate relief, gentle to moderate slope, no dominant aspect)		3				1	1	

Table 11b Vegetation Class: Land Type Correlation - Shap Rural and Shap

(Condensed version of Table 11a)

Land Types (in-parish physiography and topography ISA)	Vegetation classes (in-parish species presence/absence ISA)			
	Best Pastures	Rough Pastures	Mixed Moorland	Pure Moorland
6 + 8 (Settled, low-moderate altitudes, low to moderate relief, gentle to moderate slopes)	12	2	1	1
5 + 7 (Lightly settled, moderate altitudes, low to moderate relief, gentle to moderate slopes)	8	10	4	9
2 (Very lightly settled, moderate-high altitude, moderate relief and slope)	2	2	5	10
1 (Unsettled, high ground, moderate relief and slope)		1	3	21
3 + 4 (Unsettled, high-very high ground, steep-very steep slopes)		5	13	6

Table 12a Comparative land characteristics for parish area; 100 km^2 grid squares; upland region and upland land class - BRANSDALE

Northern High Upland (Class 8): Described from dominant range of characteristics as - moderately high altitude, moderate relief, gentle slopes, moderate rainfall, Peaty Gley, Gley, Brown Earth and Podzol soils, rough grazing and improved grass land use, in ALC classes 4 and 5, moderate settlement density.

	Natural Environmental Upland class characteristics	North York Moors (Region 7) characteristics		10 x 10 km grid square characteristics		Parish area characteristics
	8	Region	Core Region*	83 (86)	98 (102)	
Altitude						
>800 ft. %	62	30	57	64	52	69
>1400 ft. %	14	0	0	0	0	3
>2000 ft. %	1	0	0	0	0	0
Slope						
0-11° %	72	73	57	70	50	85
12-22° %	27	27	43	30	50	14
>22° %	1	0	0	0	0	1
Rainfall (%)						
<30"	0	19	0	0	0	0) Parish annual
30-40" 760-1014 mm	23	72	73	60	64	65) mean,
40-60" 1015-1524 mm	58	9	27	40	36	35) alternative
60-90" 1525-2284 mm	19	0	0	0	0	0) assessments 32-38" pa
A.L.C. grade						
2	0	1	0	0	0	0
3	8	27	4	4	8	0
4	26	18	17	16	12	15
5	54	39	72	72	72	75
Urban	3	3	0	0	0	0
Other uses	9	12	7	8	8	10
Dominant soil types in mapping units						
Brown Earths	17	9	0	0	0	0
Gley Soils	25	47	40	50	50	25
Brown Podzolic Soils	1	0	0	0	0	0
Podzols and Peaty Podzols	17	0	0	0	0	0
Peaty Gleys	29	44	60	50	50	75
Peat	11	0	0	0	0	0

*The NYM core region contains only three 10 x 10 km grid squares, of which 83 and 98 are two.

Table 12 Comparative land characteristics for parish area: 100 km^2 grid squares: upland region and upland land class - YSTRADGYNLAIS HIGHER AND GLYNTAWE

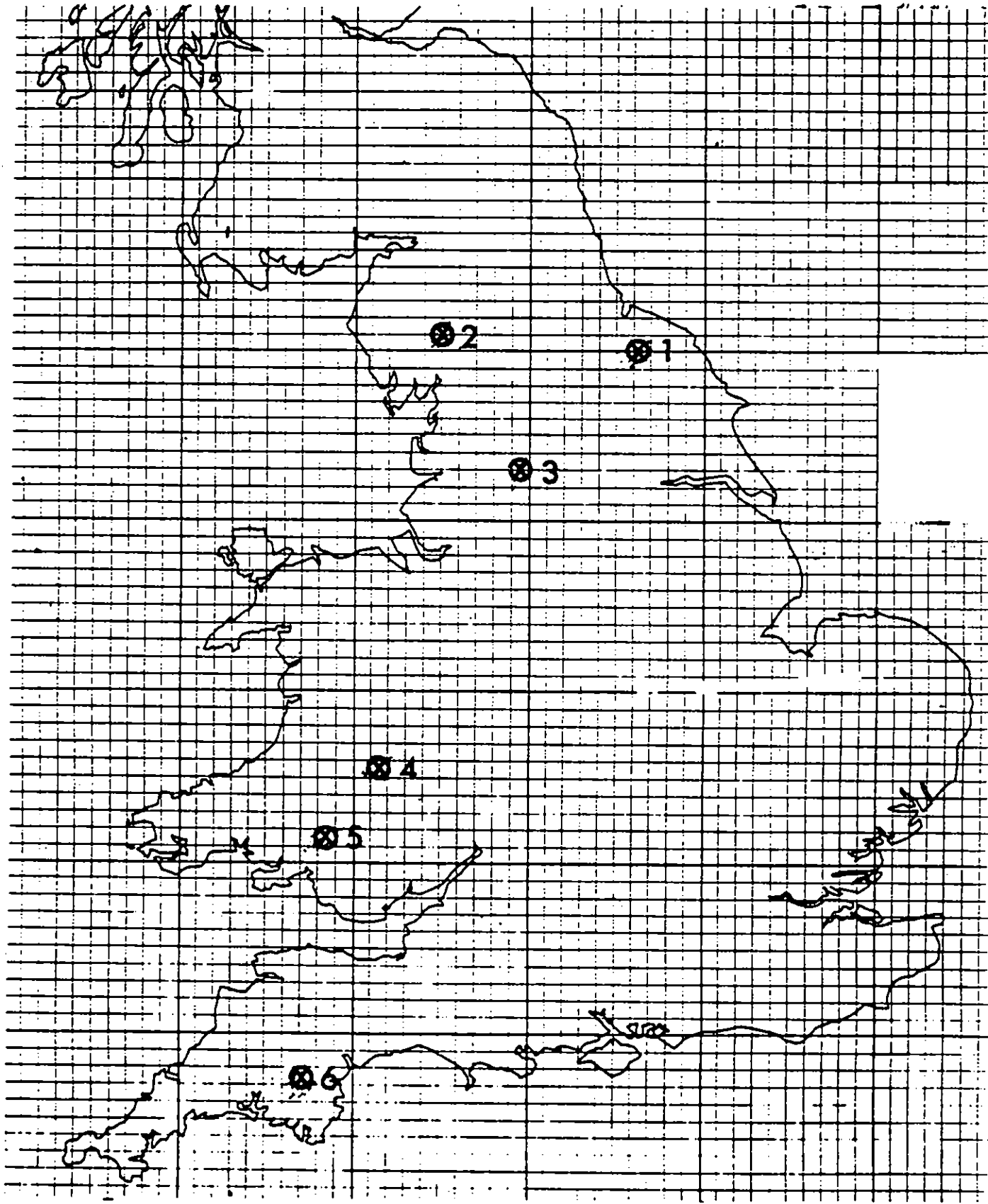
Mainly in Western High Upland class (class 6): Described from dominant range of characteristics as - high altitude, strong relief, steep slopes, high rainfall, Brown Earth, Podzol, Peaty Gley and Peat soils, improved grass and rough grazing land use, in ALC class 5, low settlement density.

Marginally in Montane Upland class (class 5): Described from dominant range of characteristics as - very high altitude, very strong relief, very steep slopes, very high rainfall, Podzol, Brown Earth and Peaty Gley soils, rough grazing and improved grass, in ALC class 5, low settlement density.

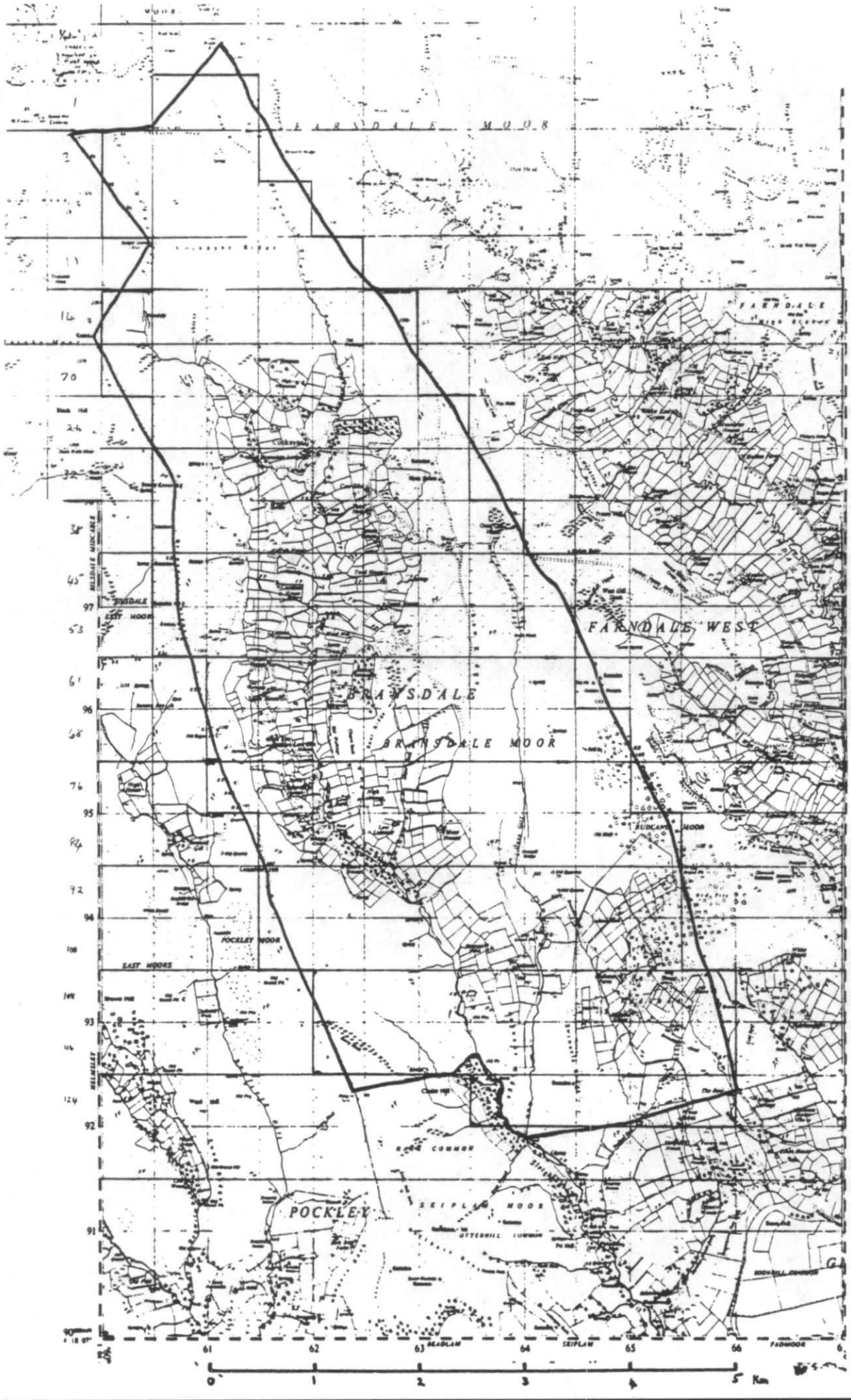
	Natural Environmental Upland class characteristics		Brecon Mountains (Region 17) characteristics		10 x 10 km grid square characteristics		Parish area characteristics
	6	5	Region	Core Region*	332 (340) (Class 5)	344 (352) (Class 6)	
Altitude							
>800 ft. %	73	76	57	77	88	88	84
>1600 ft. %	27	34	16	24	20	32	32
>2000 ft. %	3	9	3	4	8	4	3
Slope							
0-11° %	26	14	37	38	40	40	86
12-22° %	63	54	55	55	60	60	11
>22° %	11	32	8	7	0	0	3
Rainfall							
30-40"	1	1	18	2	0	0	0
40-60"	18	30	49	54	24	0	0
60-90"	74	41	31	41	64	96	90
90-125"	7	22	2	3	12	4	10
>125"	0	6	0	0	0	0	0
A.L.C. grade							
2	0	0	2	0	0	0	0
3	1	1	11	3	0	0	0
4	21	18	37	29	28	8	10
5	61	69	35	49	52	88	85
Urban	1	1	2	2	0	0	5
Other uses	16	11	13	17	20	4	0
Dominant soil types in mapping units							
Brown Earths	37	27	62	50	30	0	0
Gley Soils	4	4	9	6	0	0	0
Brown Podzolic Soils	0	0	0	0	0	0	0
Podzols and Peaty Podzols	28	45	0	0	0	0	0
Peaty Gleys	17	16	29	44	70	100	100
Peat	14	8	0	0	0	0	0

*Core region contains sixteen 10 x 10 km grid squares

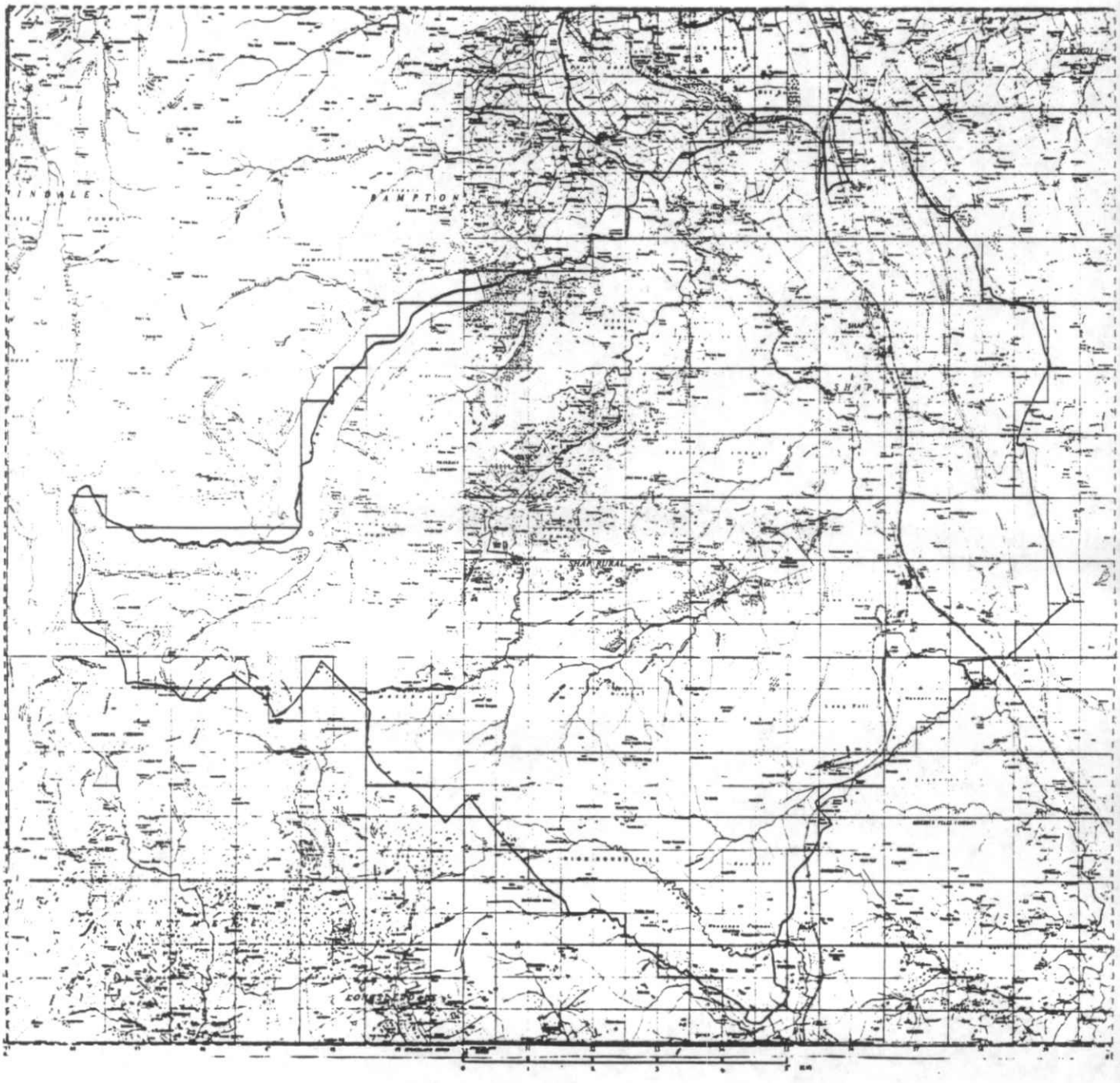
Location of Study Parishes - 1977 - 78



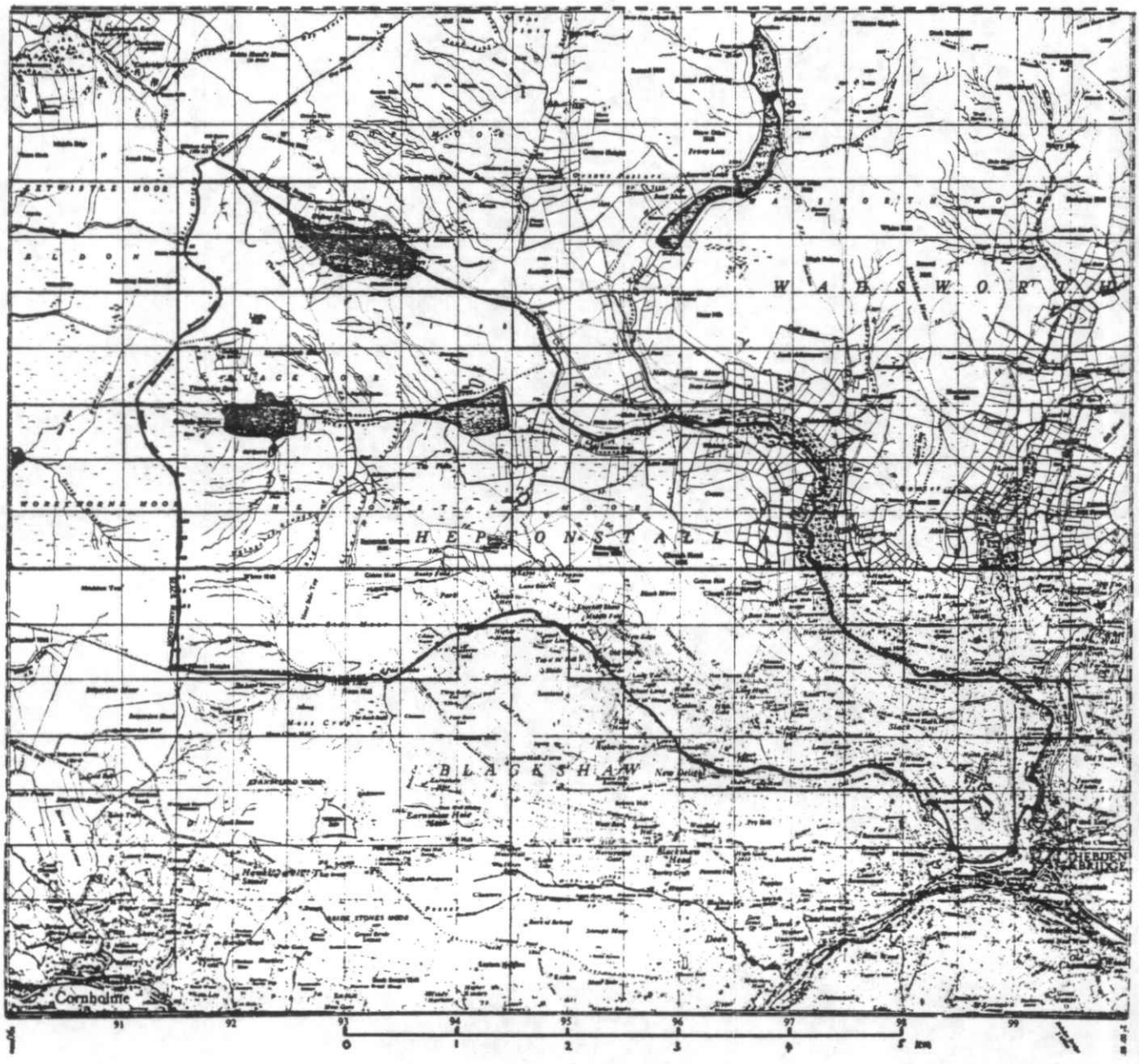
1. Bransdale.


FARNDALE MOOR
FARNDALE
FARNDALE WEST
BRANSDALE
BRANSDALE MOOR
BUDCAMP MOOR
POCKLEY MOOR
EAST MOORS
POCKLEY
SKIPLAM MOOR
OTTERHILL COMMON
ROOKHILL COMMON
BLAKEY
BILSDALE MIDCABLE
EAST MOOR
61
62
63
64
65
66
HEADLAM
SKIPLAM
FADMOOR
0
1
2
3
4
5 Km

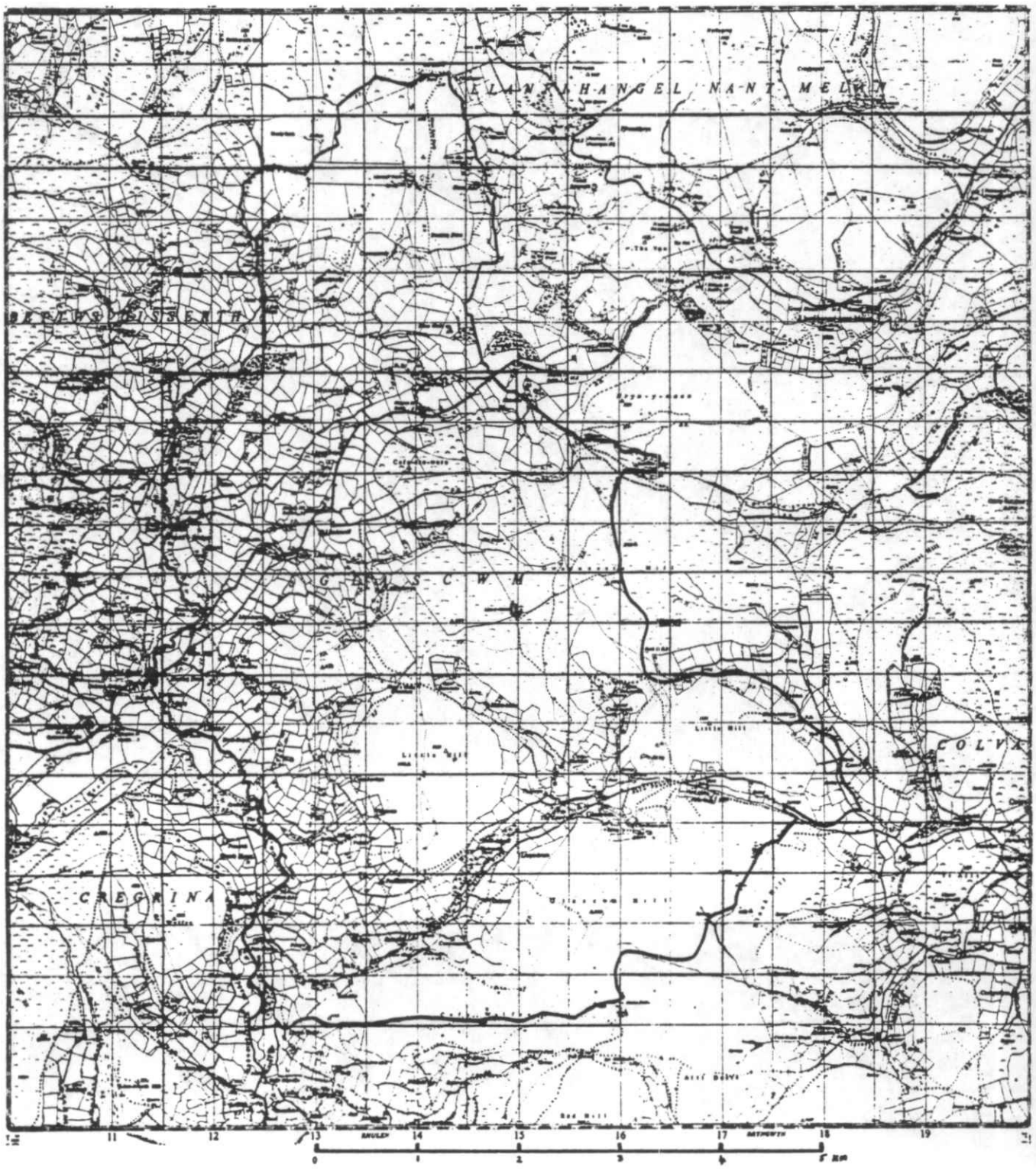
2. Shap and Shap Rural.



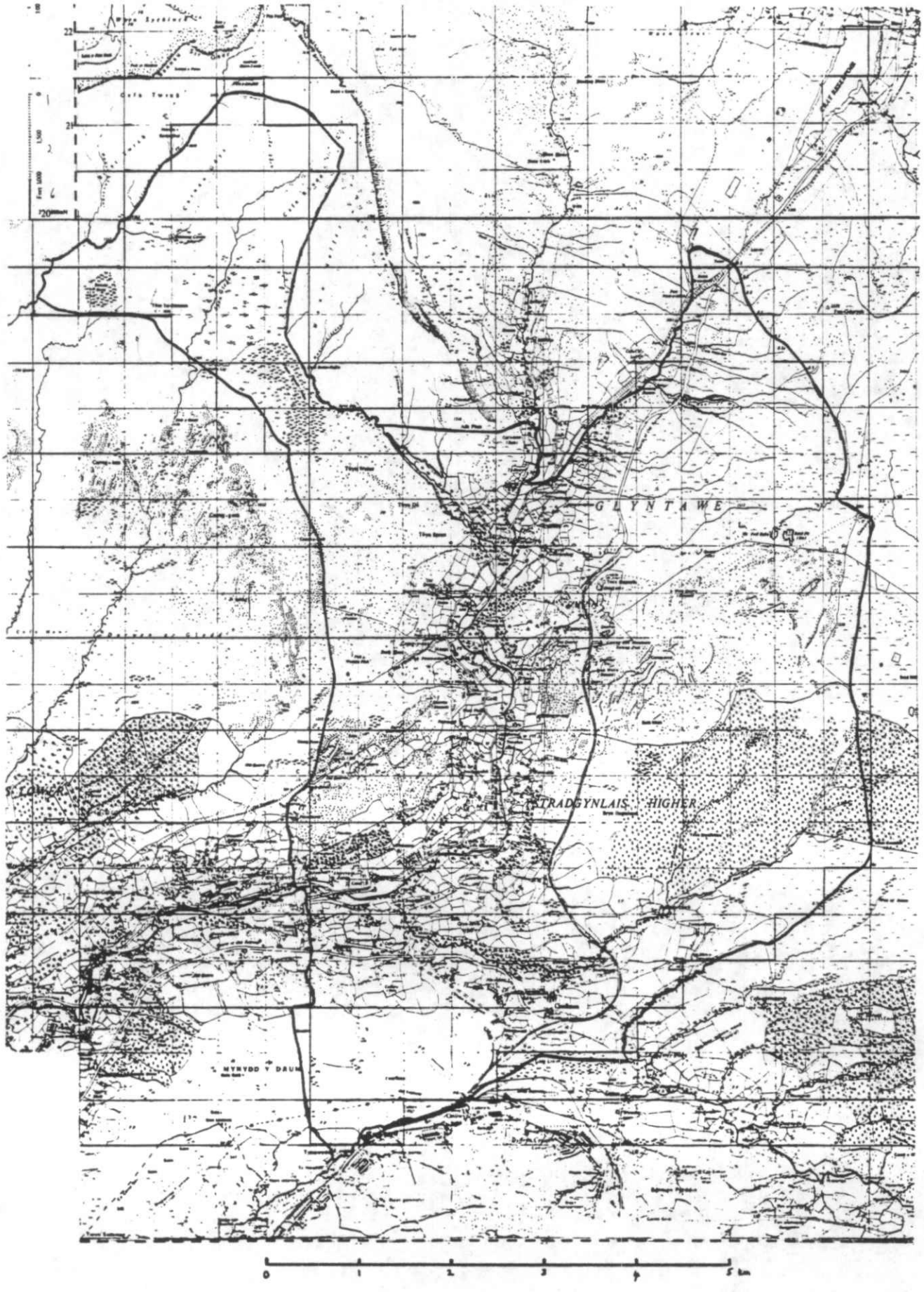
3. Heptonstall.



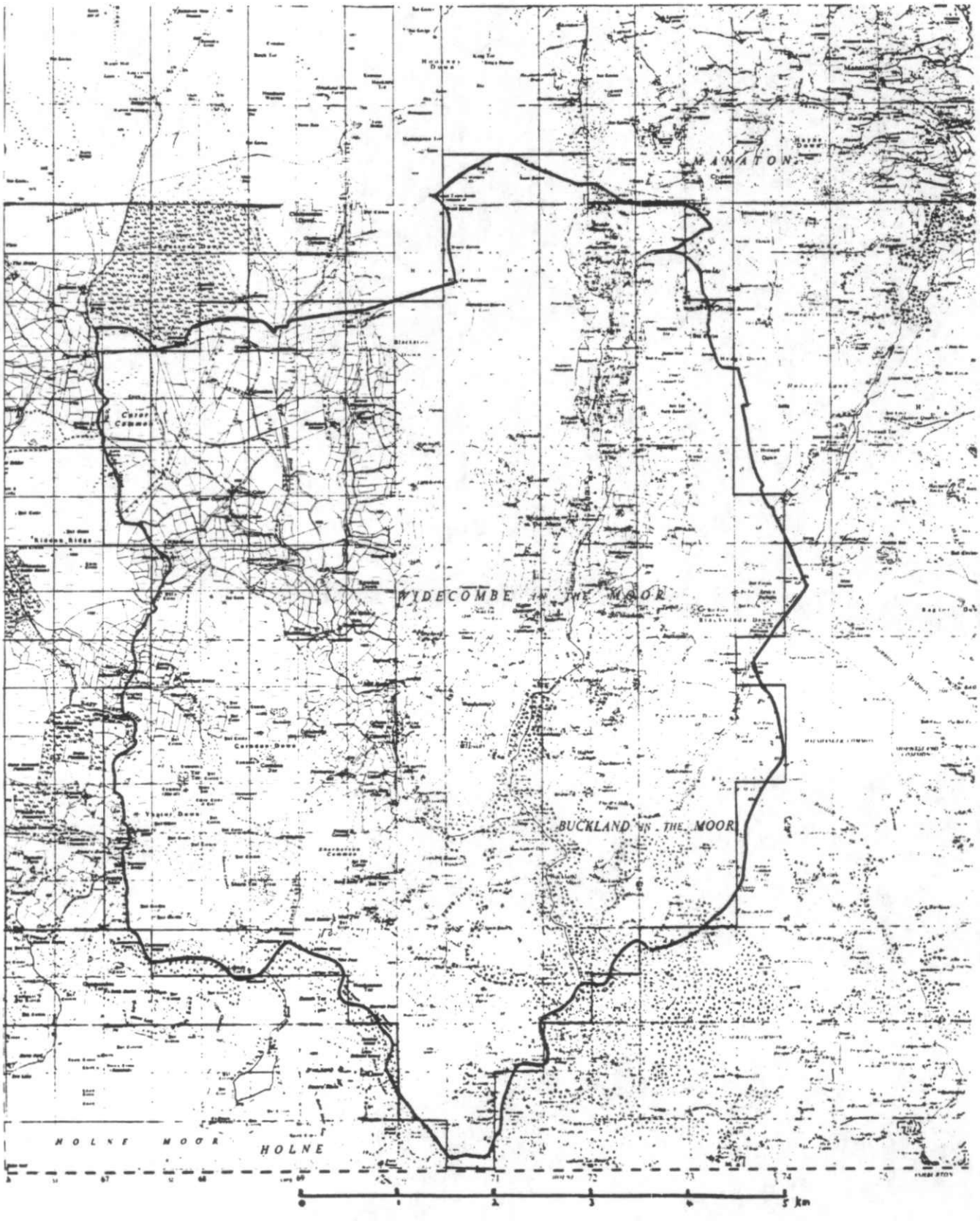
4. Glascwm.



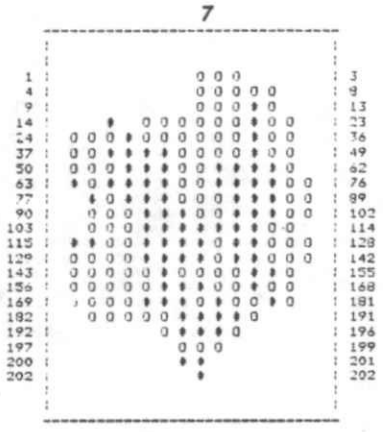
5. Ystradgynlais Higher and Glyntawe.



6. Widecombe in the Moor and Buckland in the Moor.



7



WIDECOMBE AND BUCKLAND

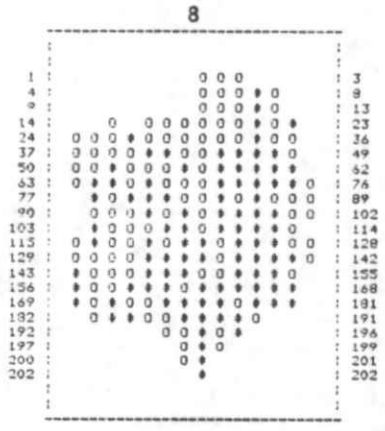
(PHYS,1,2,3,>70)AND(PHYS,10,11,>70)

♦ SQUARES WITH >70% BELOW 1100FT AND >70% OF GENTLE OR MODERATE SLOPES

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 82 OR 41 PERCENT OF PARISH SQUARES

8



WIDECOMBE AND BUCKLAND

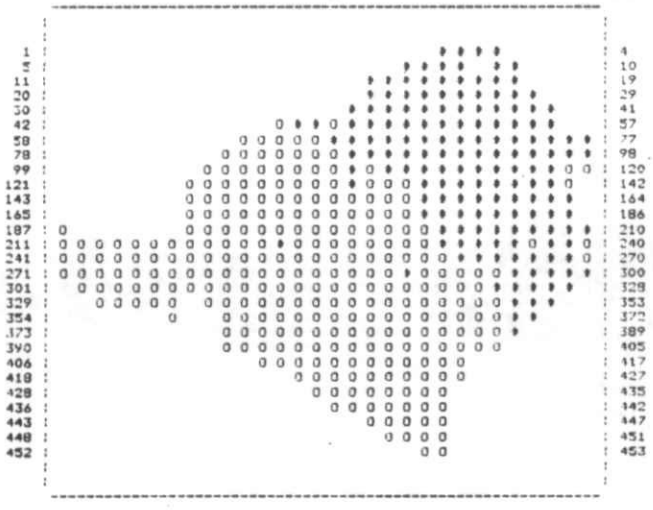
(TOP,2,>0)

♦ SQUARES WITH MAPPED BUILDINGS PRESENT.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 98 OR 49 PERCENT OF PARISH SQUARES

9



SHAP AND SHAP RURAL

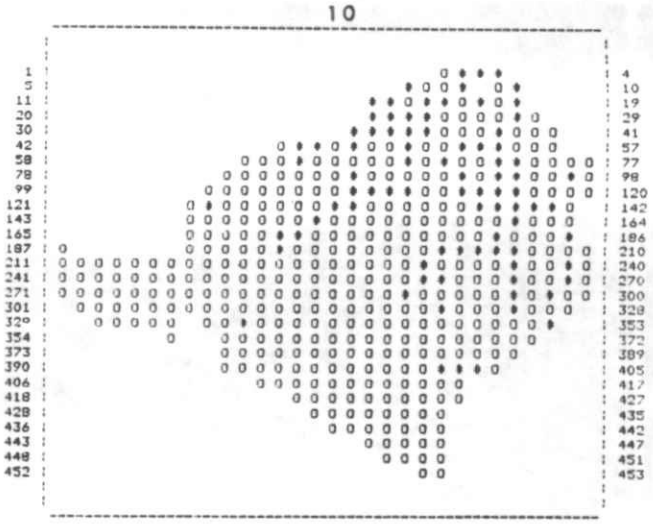
(PHYS,1,2,3,>70)AND(PHYS,10,11,>70)

♦ SQUARES WITH >70% BELOW 1100FT AND >70% OF GENTLE OR MODERATE SLOPES.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 163 OR 36 PERCENT OF PARISH SQUARES

10



SHAP AND SHAP RURAL

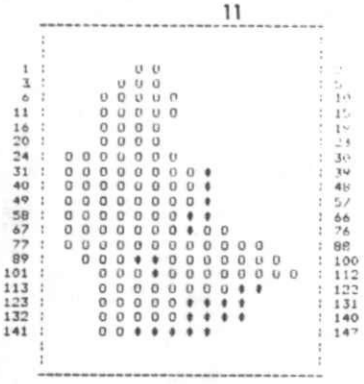
(TOP,2,>0)

♦ SQUARES WITH MAPPED BUILDINGS PRESENT.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 85 OR 19 PERCENT OF PARISH SQUARES

11



GLASCWM

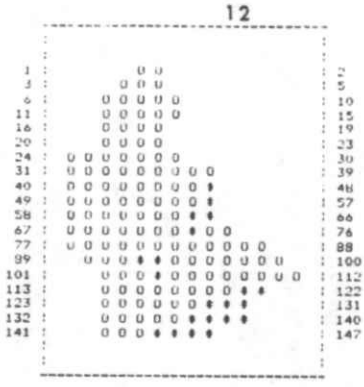
(TOP,6,=0)

* SQUARES WITH NO FIELD BOUNDARIES.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 24 OR 16 PERCENT OF PARISH SQUARES

12



GLASCWM

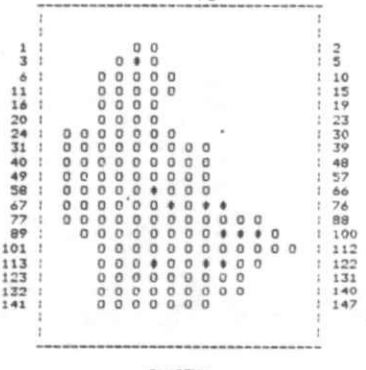
(TOP,6,=0)AND(PHYS,5,6,>70)

* SQUARES WITH NO FIELD BOUNDARIES AND >70% >1400FT.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 21 OR 14 PERCENT OF PARISH SQUARES

13



GLASCWM

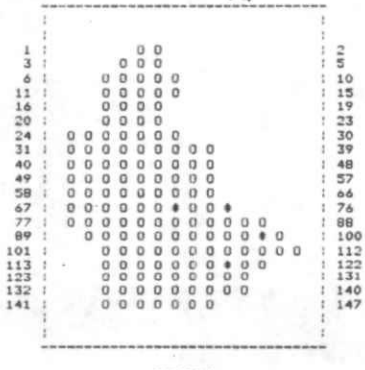
(TOP,6,<5)

* SQUARES WITH FEW FIELD BOUNDARIES.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 11 OR 7 PERCENT OF PARISH SQUARES

14



GLASCWM

(TOP,6,<5)AND(PHYS,5,6,>70)

* SQUARES WITH FEW FIELD BOUNDARIES AND >70% >1400FT.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 4 OR 3 PERCENT OF PARISH SQUARES

15

GLASCWM

(TOP,6, 10)

* SQUARES WITH FREQUENT FIELD BOUNDARIES.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 72 OR 49 PERCENT OF PARISH SQUARES

16

GLASCWM

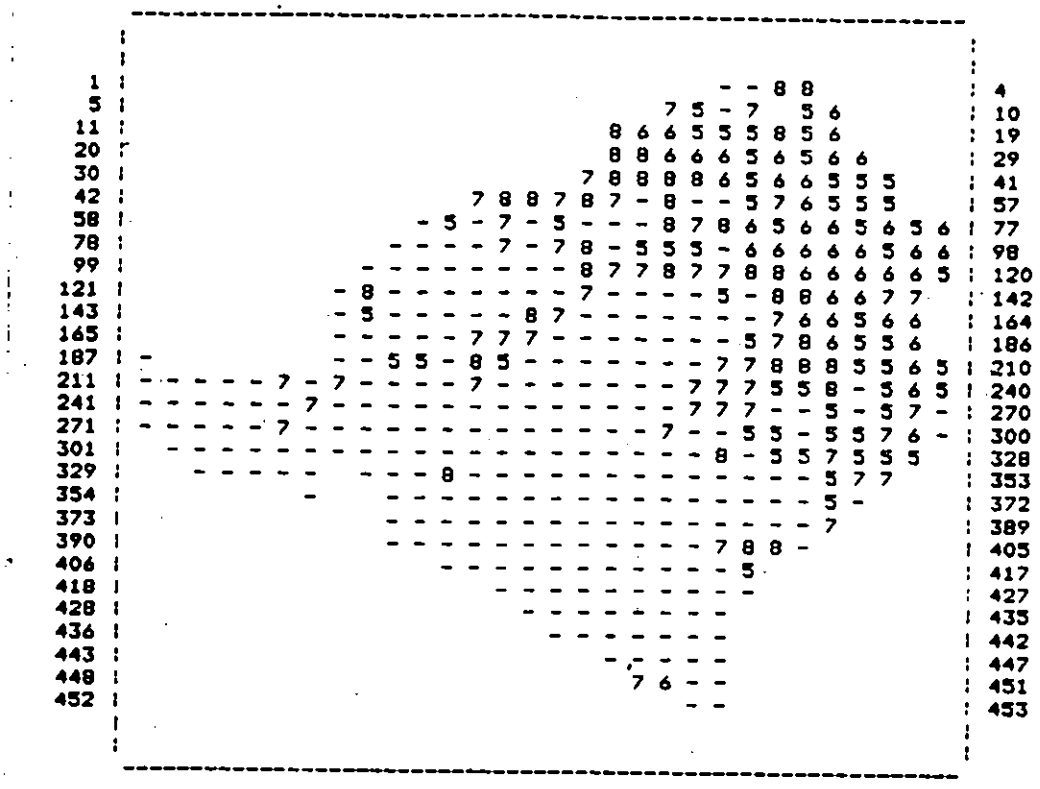
(TOP,6, 10)AND(PHYS,1,2,3, 70)

* SQUARES WITH FREQUENT FIELD BOUNDARIES AND >70% BELOW 1100FT.

O IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 58 OR 39 PERCENT OF PARISH SQUARES

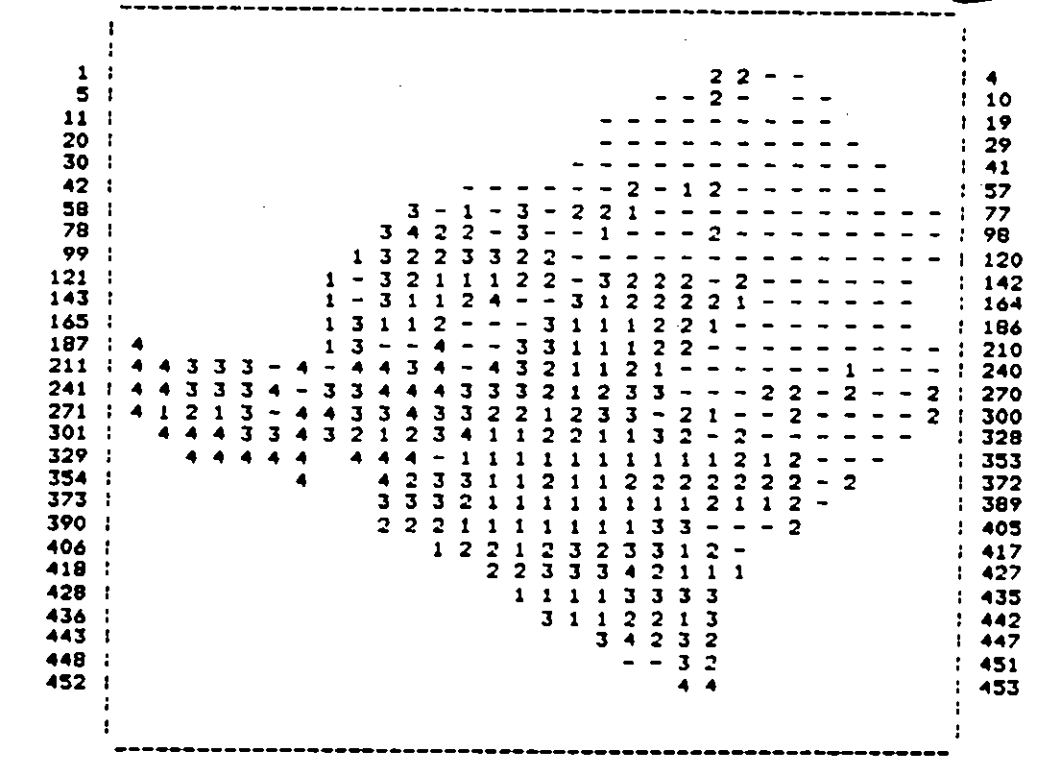
Land Classes in In-Parish Classification on Physiography and Topography Attributes. (see 2.8.5)



SHAP AND SHAP RURAL

"SETTLED" LOWER ALTITUDE CLASSES.

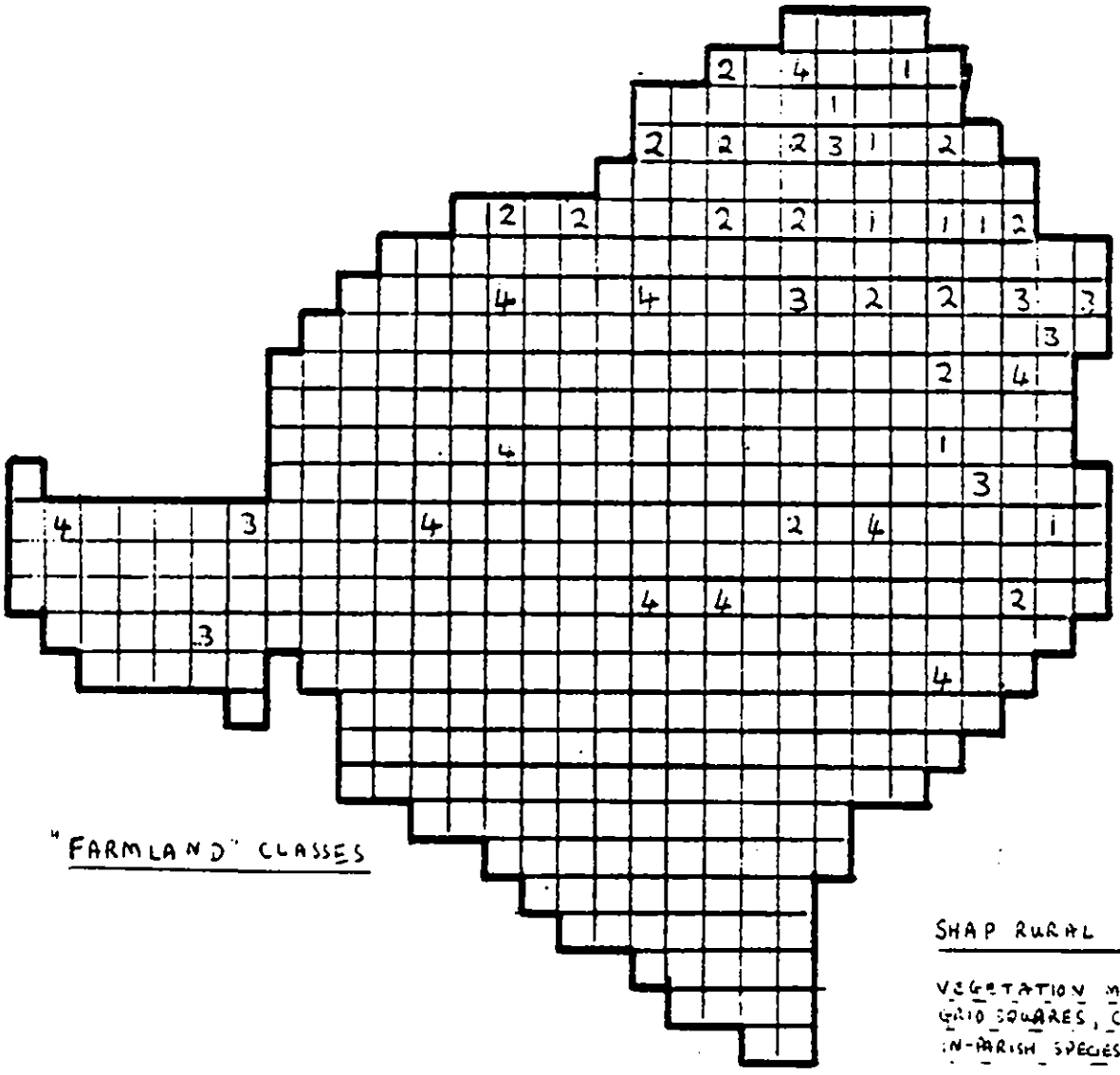
NUMBER OF RELEVANT RECORDS IS 180 OR 40 PERCENT OF PARISH SQUARES



SHAP AND SHAP RURAL

"UNSETTLED" HIGHER ALTITUDE CLASSES.

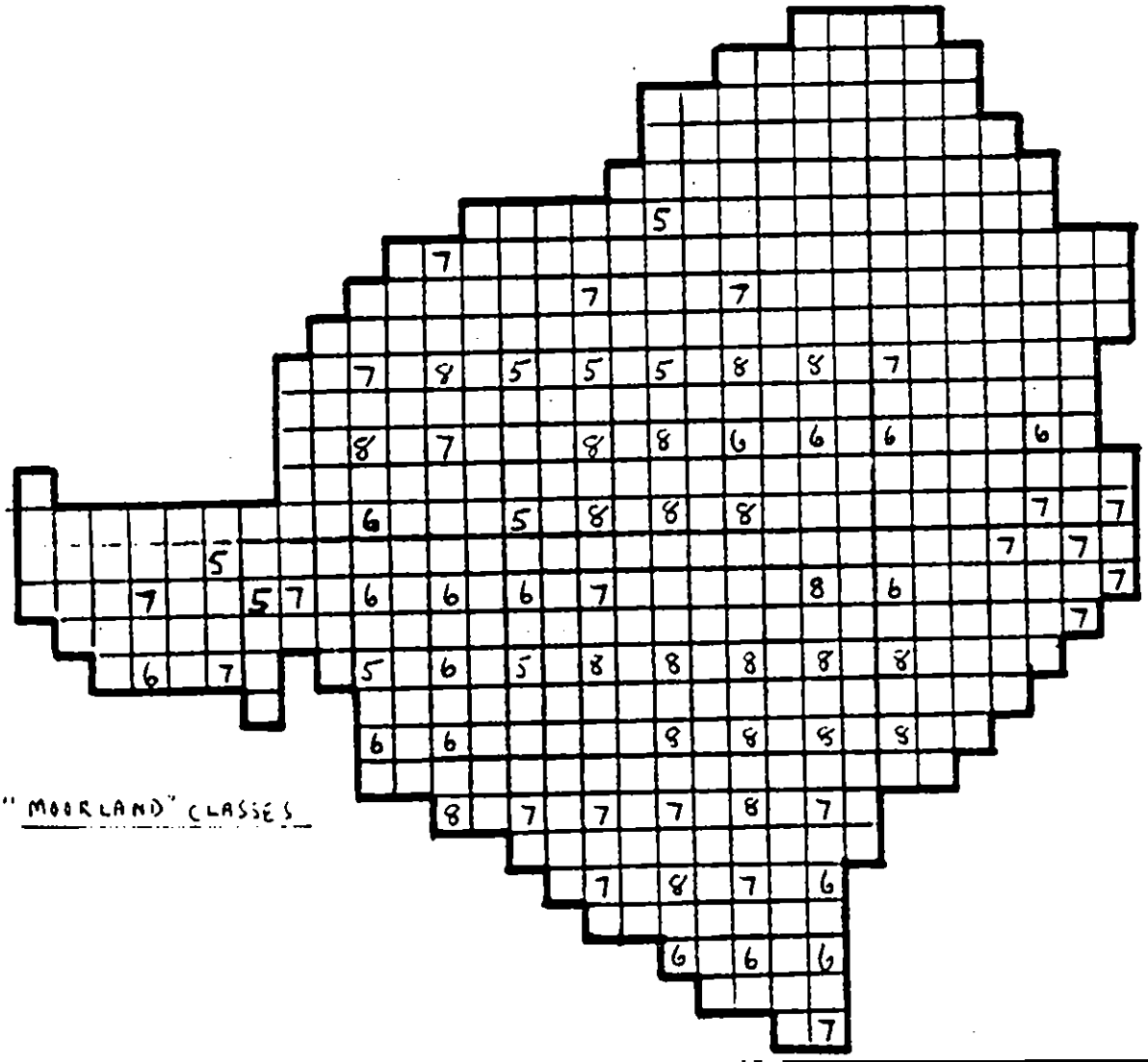
NUMBER OF RELEVANT RECORDS IS 273 OR 60 PERCENT OF PARISH SQUARES



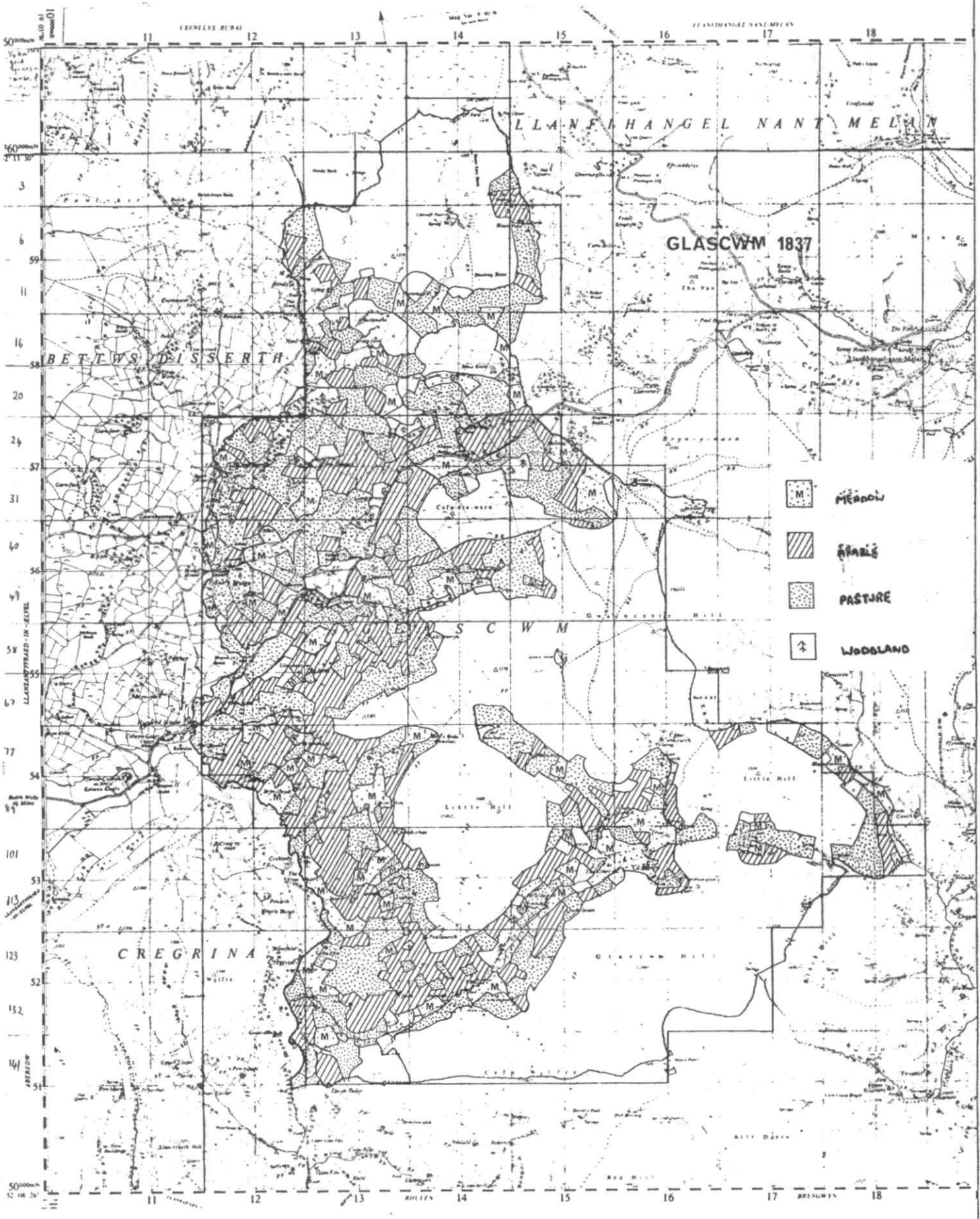
"FARMLAND" CLASSES

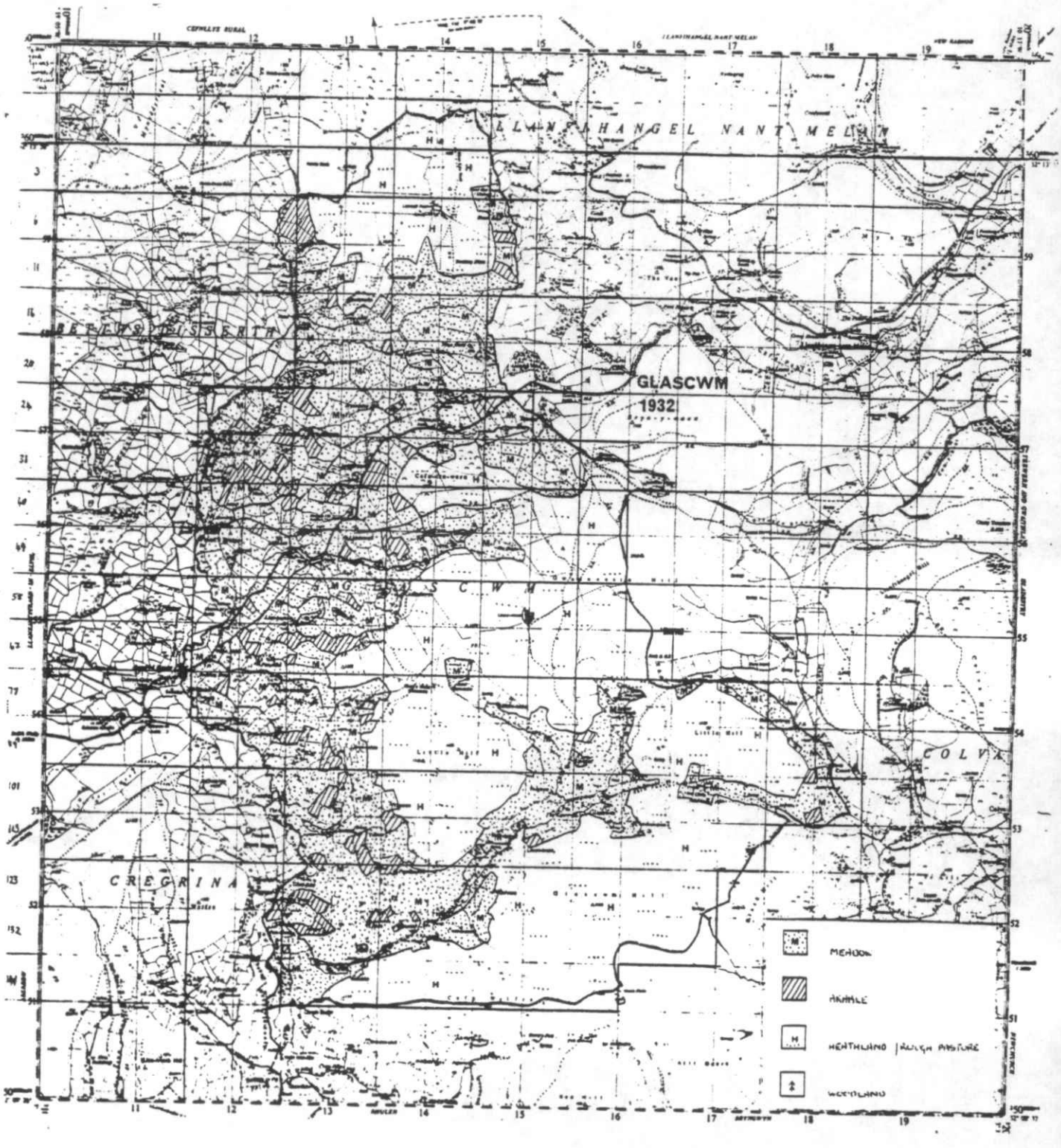
SHAP RURAL AND SHAP

VEGETATION MAIN SITES IN GRID SQUARES, CLASSIFIED ON IN-PARISH SPECIES PRESENCE/ABSENCE

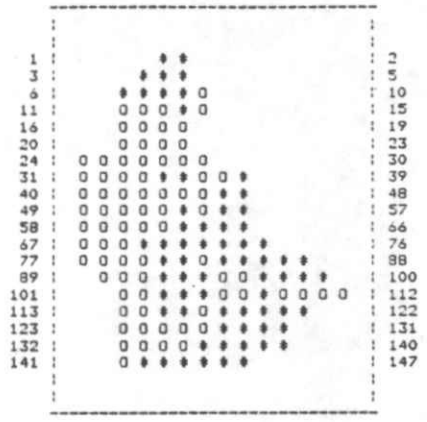


"MOORLAND" CLASSES


GLASCWM 1837
LLANFIHANGEL NANT MELAN
BETWS DISSERTH
CREGRINA
M MEADOW
ARABLE
PASTURE
WOODLAND


LLANFAHANGEL NANT MELAN
GLASCWM
1932
GLASCWM
COLVA
CREGRINA
MEADOW
ARABLE
HEATHLAND | ROUGH PASTURE
WOODLAND

20



GLASCWM

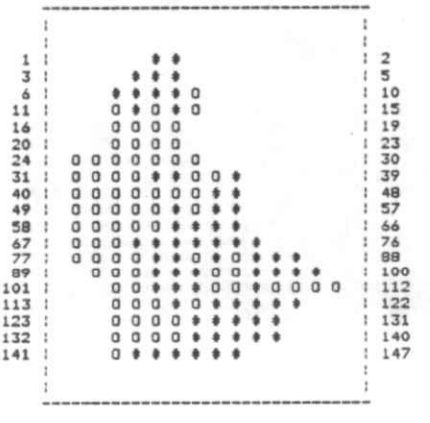
(MASK,10,>3)

* SQUARES WITH HEATHLAND, ROUGH PASTURE 1837.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 69 OR 46.9388 PERCENT OF PARISH SQUARES

21



GLASCWM

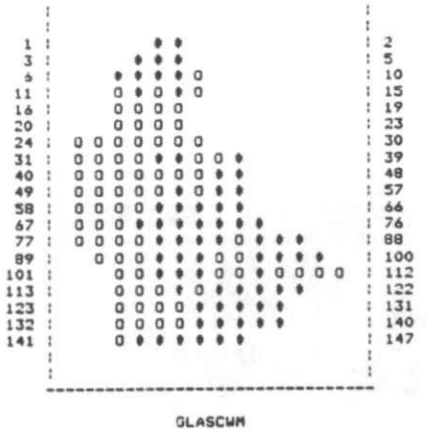
(MASK,11,>3)

* SQUARES WITH HEATHLAND, ROUGH PASTURE, 1888.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 69 OR 46.9388 PERCENT OF PARISH SQUARES

22



GLASCWM

(MASK,12,>3)

* SQUARES WITH HEATHLAND, ROUGH PASTURE,1932.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 71 OR 48.2993 PERCENT OF PARISH SQUARES

23a

GLASCWM

(MASK,10,<2)

\# SQUARES WITH ARABLE FARMLAND, 1837.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 22 OR 14.966 PERCENT OF PARISH SQUARES

23b

GLASCWM

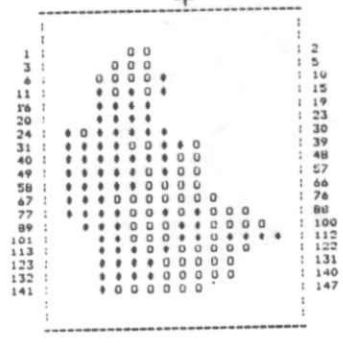
(MASK,10,>1)AND(MASK,10,<3)

\# SQUARES WITH PASTURE FARMLAND, 1837

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 53 OR 36.0544 PERCENT OF PARISH SQUA

24



GLASCWM

(MASK,11,>1)AND(MASK,11,<3)

\# SQUARES WITH FARMLAND, 1888 (ARABLE FARMLAND NOT MAPPED SEPARATELY AT THIS DATE.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 77 OR 52.381 PERCENT OF PARISH SQUARES

25a

GLASCWM

(MASK,12,<2)

\# SQUARES WITH ARABLE FARMLAND, 1932.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 3 OR 2.04082 PERCENT OF PARISH SQUARES

25b

GLASCWM

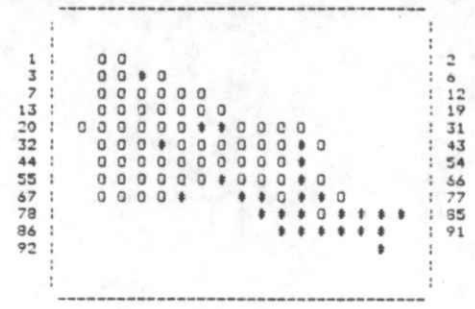
(MASK,12,>1)AND(MASK,12,<3)

\# SQUARES WITH PASTURE FARMLAND 1932.

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 72 OR 48.9796 PERCENT OF PARISH SQUARES

26



HEPTONSTALL

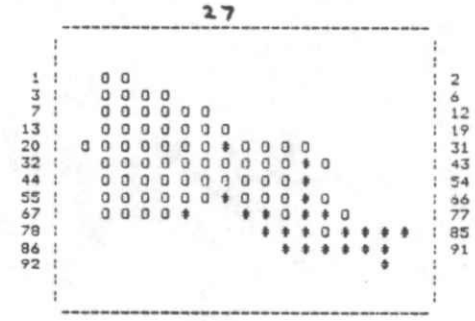
(MASK,10,>1)A ND(MASK,10,<3)

* SQUARES WITH FARMED LAND, 1848

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 27 OR 29.3478 PERCENT OF PARISH SQUARES

27



HEPTONSTALL

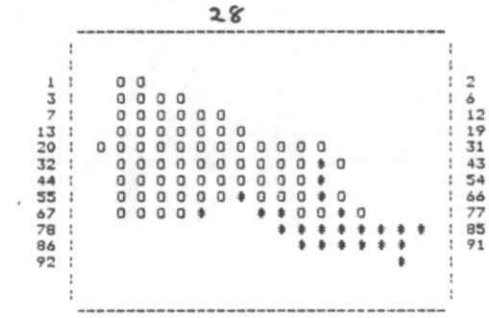
(MASK,11,>1)AND(MASK,11,<3)

* SQUARES WITH FARMED LAND, 1892

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 24 OR 26.087 PERCENT OF PARISH SQUARES

28



HEPTONSTALL

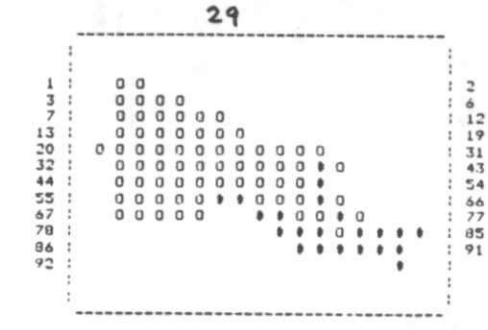
(MASK,12,>1)AND(MASK,12,<3)

* SQUARES WITH FARMED LAND, 1932

0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 23 OR 25 PERCENT OF PARISH SQUARES

29



HEPTONSTALL

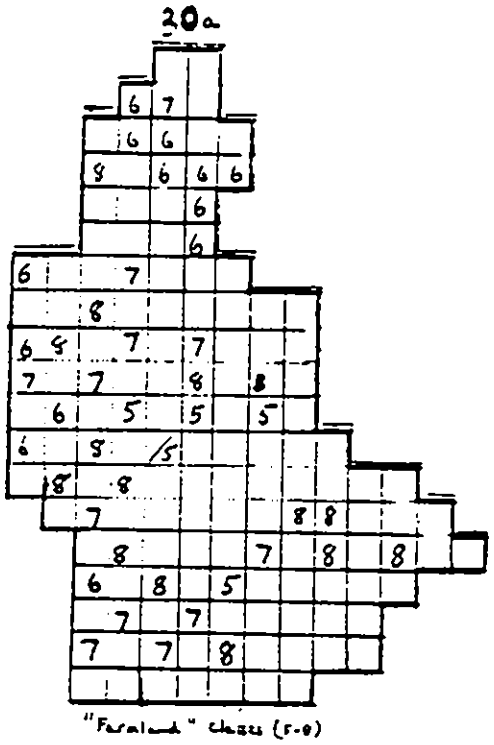
(MASK,13, 1)AND(MASK,13, 3)

* SQUARES WITH FARMED LAND, 1969

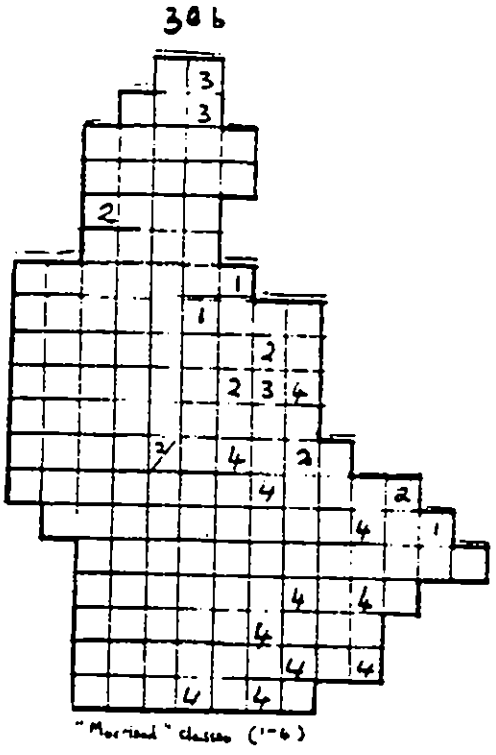
0 IRRELEVANT PARISH SQUARES

NUMBER OF RELEVANT RECORDS IS 22 OR 23.913 PERCENT OF PARISH SQUARES

GLASCWM

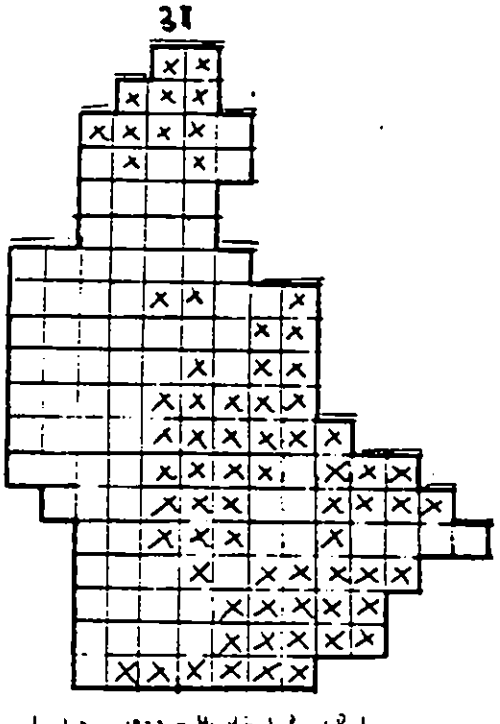


"Farmland" classes (5-8)

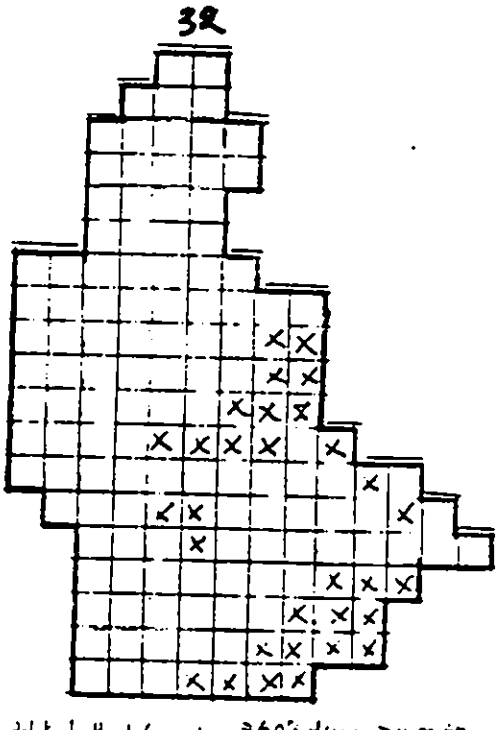


"Moorland" classes (1-4)

VEGETATION CLASSES - IN-PARISH SPECIES PRESENCE/ABSENCE
(Presence in class occurs in grid square)



Land Rise, 1972 - Moorland, Rough Pasture



Relatively High Ground - 360's of squares > 1000 ft

APPENDIX 1.

Maps Covering Study Areas

Parish/es	Ordnance Survey Map Numbers			Geographic Region
	1:50,000 New Series	1:63,360 Old Series	1:25,000	
Bransdale	94	86	NZ, 50, 60; SE 59, 69	North York Moors
Shap Rural and Shap	90, 91	83, 89	NY 40, 41, 50, 51	Lake District
Heptonstall	103	95	SD 92, 93	Southern Pennines
Glascwm	148	128, 141	SO 15, 16	Radnor-Clun Forests
Ystradgynlais Higher and Glyntawe	160	140, 153	SN 71, 81, 82, 80/90	Brecon Mountains
Widecombe-in-the-Moor and Buckland-in-the-Moor	191, 202	175, 187	SX 67, 68/78, 77	Dartmoor

APPENDIX 2

Physiographic and Topographic Characteristics - Mean Values for Study Parish Areas

Characteristic		Bransdale (32 km²)		Shap Rural and Shap (113.25 km²)		Heptonstall (23 km²)		Glascwm (36.75 km²)		Ystradgynlais Higher and Glyntgwe (47.75 km²)		Widecombe-in-the Moor and Buckland-in-the Moor (50.5 km²)	
		a	b	a	b	a	b	a	b	a	b	a	b
Altitude Class	< 400 ft.	0	0	0	0	0	0	0	0	0	0	1.2	2
	401-800 ft.	9.8	31	8.3	7	1.8	8	5.5	15	7.7	16	7.1	14
	801-1100 ft.	12.2	38	43.8	38	8.3	36	14.4	39	13.2	28	23.4	46
	1101-1400 ft.	9.1	28	22.0	20	10.8	47	8.6	23	11.5	24	16.0	32
	1401-2000 ft.	0.9	3	34.9	31	2.1	9	8.3	23	13.9	29	2.8	6
	≥ 2000 ft.	0	0	4.3	4	0	0	0	0	1.5	3	0	0
Altitude range (ft.)	Average of lowest height in grid square	851		1116		1008		982		1090		903	
	Average of highest height in grid square	1069		1370		1210		1256		1305		1139	
	Average height difference in square	218		254		202		274		215		236	
Slope Classes		a	b	a	b	a	b	a	b	a	b	a	b
	0-5°	13.7	43	40.8	36	7.9	34	9.3	25	18.7	39	12.0	24
	5-11°	13.5	42	45.8	40	10.7	47	19.3	53	22.4	47	29.3	58
	11-22°	4.6	14	13.7	12	2.7	12	7.3	20	5.3	11	7.1	14
	≥ 22°	0.2	1	9.8	9	1.0	4	0.7	2	1.4	3	2.1	4
Aspect Classes	Northerly	0.3	1	30.3	27	7.3	32	9.7	27	5.5	12	4.2	8
	Easterly	12.0	38	38.9	34	7.4	32	6.0	16	8.7	18	17.9	36
	Southerly	6.9	21	13.8	12	6.3	28	8.2	22	17.7	37	8.3	16
	Westerly	12.8	40	27.1	24	1.3	5	12.7	35	15.9	33	20.1	40

APPENDIX 2 (Continued)

Characteristic		Bransdale ($32\ km^2$)	Shap Rural and Shap ($113.25\ km^2$)	Heptonstall ($23\ km^2$)	Glascwm ($36.75\ km^2$)	Ystradgynlais Higher and Glyntawe ($47.75\ km^2$)	Widecombe in the Moor and Buckland in the Moor ($50.5\ km^2$)
River frequency[c]		0	0.4	0.9	0.1	0.5	0.5
Stream frequency[c]		4.4	3.4	5.7	2.8	4.4	2.8
Area of water body		a b	a b	a b	a b	a b	a b
		0 0	3.2 3	0.7 3	0.02 0	0 0	0 0
Settlement	Urban areas	0	0	0	0	0	0
	Buildings mapped, either individually or in villages	d e	d e	d e	d e	d e	d e
		77 0.6	293 0.6	161 1.8	145 1.0	242 1.3	454 2.2
Roads	Principal roads	1.1	1.1	1.2	1.1	0.9	3.1
	Other roads and tracks[c]	4.0	1.6	3.6	4.3	1.2	3.8
Footpaths[c]		2.4	1.5	5.9	2.6	1.9	1.3
Field Boundaries[c]		7.0	5.7	7.4	10.0	6.0	12.7

(a) As area in km^2
(b) As percentage of parish area
(c) As a relative frequency count from a minimum value of 0 to a maximum value of 25
(d) As total number counted in parish
(e) As average number per 0.25 km^2 grid square

APPENDIX 3

Climatic Data for Study Parishes, 1977-1978

The attached tables summarise available climatic data. It must be remembered that the national or regional distributions from which most of these data are derived are based on extrapolated values, generalised to sea-level, to "low altitude", or to a mean height for the region. They are thus an indication of the character of the climate in the parishes rather than precise measures of climatic variables for these locations. Within each parish there is of course a lesser or greater variation in climate, dependent on the size of the parishes and on aspect and altitude differences within them. The data and the relative climatic status tables are thus to be taken as a broad assessment of overall parish climatic character.

APPENDIX 3

(a) Climatic Data for Agroclimatic Areas within which Parish Areas are located

(or which are judged most relevant to them)

(from Smith, L.P., The Agricultural Climate of England and Wales (Annual Averages 1941-1970), Min. of Agric. F. Fd. HMSO 1976)

Parish/es		Bransdale	Shap Rural and Shap	Heptonstall	Glascwm		Ystradgynlais Higher and Glyntawe	Widecombe in the Moor and Buckland in the Moor	
					Located in 49S near to boundary of 25N, closest in character to 25N			On boundary of 43N and 43S, closest in character to 43N	
"Agroclimatic Areas"		7	6	10	25S	49S	51	43N	43S
Temperature Monthly Mean (°C) (estimated visually from plot of "sea-level" temperature adjusted to average height of area)	Jan.	2.5	1.0	1.7	3.3	2.5	2.5	3.6	5.1
	Mar.	4.7	3.2	3.9	5.6	4.6	4.6	5.6	6.7
	May	9.7	9.2	9.8	11.3	10.2	10.2	10.2	11.4
	Jul.	14.5	13.2	14.5	16.0	14.5	14.6	14.8	15.9
	Sept.	12.7	11.3	12.3	13.7	12.3	12.5	13.0	14.2
	Nov.	5.8	4.4	5.0	6.3	5.5	5.6	6.8	8.1
Annual Range of Monthly Mean Temperatures (°C)		12.0	12.2	12.5	12.7	12.0	12.1	11.2	10.8
Sunshine, as average number of hours of bright sunshine	Jun.	6.1	5.4	5.7	6.6	6.2	6.4	6.5	7.1
	Dec.	1.1	0.9	0.9	1.6	1.0	1.2	1.4	1.9
Growing Season (in days) based on time for which 30 cm soil temperature is $>6.0^{\circ}C$		230 (April 16-Nov. 22)	190 (April 26-Nov. 2)	209 (April 16-Nov. 11)	253 (March 24-Dec. 7)	229 (April 8-Nov. 23)	229 (April 6-Nov. 21)	257 (March 25-Dec. 7)	293 (March 8-Dec. 25)
Grazing Season (in days) based on adjustment for altitude to "growing season"		160 (April 16-Sept. 23)	? (May 12-?)	119 (April 30-Aug. 27)	210 (April 1-Oct. 28)	133 (April 8-Sept. 5)	? (April 21-?)	125 (April 7-Aug. 10)	203 (March 14-Oct. 3)

APPENDIX 3

(a) (Continued)

Parish/es		Bransdale	Shap Rural and Shap	Heptonstall	Glaseum		Ystradgynlais Higher and Glyntawe	Widecombe in the Moor and Buckland in the Moor	
					Located in 49S near to boundary of 25N, closest in character to 25N			On boundary of 43N and 43S, closest in character to 43N	
"Agroclimatic Areas"		7	6	10	25N	49S	51	43N	43S
"Effective transpiration" (as measure of solar energy input over the period without limitations due to soil moisture deficit or soil temperature) (in mm)		354	316	343	387	370	410	415	445
Rainfall Monthly Mean (mm) (estimated from a calculated annual mean by a formula with constants for each area and month)	Jan.	75	170	110	66	124	184	167	114
	Mar.	50	103	69	49	79	113	121	79
	May	59	99	74	64	81	106	95	72
	Jul.	71	117	89	63	81	110	90	73
	Sept.	74	171	119	65	111	166	117	88
	Nov.	84	175	117	76	130	193	163	118
Annual Rainfall mm (inches)		808 (31.8)	1663 (65.6)	1151 (45.3)	746 (29.4)	1190 (47)	1728 (68)	1449 (57.0)	1048 (41.3)
Excess Winter Rain (mm) (amount of rain between return to field capacity and the end of March, less evapotranspiration from surface)		360	1200	670	270	710	1200	900	525

APPENDIX 3

(b) Additional Climatic Data for Parish Area Locations

(from Climatological Atlas of the British Isles, Met. Off. 488, HMSO 1952)

Parish/es		Bransdale	Shap Rural and Shap	Heptonstall	Glascwm	Ystradgynlais Higher and Glyntawe	Widecombe in the Moor and Buckland in the Moor
Rainfall	Average number of days with ≥0.4" rain (1901-1930)	20	50	40	30	50	40
Snowfall	Average annual days of snowfall below 200 ft. (1912-1938)	22.5	20	20	10	7.5	10
	Average number of days of snowlie below 200 ft. (1912-1938)	20	20	20	10	5	5
Temperature	Average daily maximum °F (1901-1930)	55	55	55	57	57	57
	Average daily minimum °F (1901-1930)	43	42	44	42	44	46
	Average daily mean °F (1901-1930)	49	48	49	50	51	51
	Average number of days with minimum temperature ≤32°F (1913-1940)	50	50+	50+	50+	50	25
Wind	Average wind speed, m.p.h., at 33 ft. above ground level in open situations (1926-1940)	10	12.5	10	10	12.5	12.5
	Average number of days with gale force wind (1926-1940)	5	10	5	2	5	20

APPENDIX 3

(c) Rainfall Class Distribution in Parish Areas

(as percentage of parish area in rainfall class, from count of classes at mid-points of 1 km x 1 km squares)

Rainfall Class (from 1:250,000 England and Wales Rainfall Map, Water Resource Board, 1975)	Parish					
	Bransdale	Shap Rural and Shap	Heptonstall	Glascwm	Ystradgynlais Higher and Clyntawe	Widecombe in the Moor and Buckland in the Moor
<24" (<610 mm) p.a.						
24-30" (610-759 mm) p.a.						
30-40" (760-1014 mm) p.a.	65			100		
40-50" (1015-1269 mm) p.a.	35		15			
50-60" (1270-1524 mm) p.a.		10	85			15
60-70" (1525-1779 mm) p.a.		25			30	85
70-80" (1780-2029 mm) p.a.		20			45	
80-90" (2030-2284 mm) p.a.		15			15	
90-100" (2285-2539 mm) p.a.		10			10	
>100" (>2540 mm) p.a.		20				

APPENDIX 3

(d) Alternative Assessments of Average Annual Rainfall for Parish Areas (inches)

Parish/es	Bransdale	Shap Rural and Shap	Heptonstall	Glascwm	Ystradgynlais Higher and Glyntawe	Widecombe in the Moor and Buckland in the Moor
From calculation based on isohyets of 1:250,000 England and Wales rainfall map, allocating each rainfall class as having a rainfall level of the mid-point of the class	38	80	54	35	75	63
From relevant upland geographic region (National Upland data set)	35	69	47	40	56	59
From location of parish on map of average annual rainfall, 1901-1930 in Climatic Atlas of the British Isles, H.M.S.O., 1952	35	80	50	40	60	60
From "Agroclimatic Area" data (The Agricultural Climate of England and Wales, H.M.S.O., 1976)	32	66	45	29	68	57

APPENDIX 4

(a) Geological Summary: Parish Areas

(as percentages of parish area in category, from sketch-maps, based on class at mid-point of 1 km x 1 km grid squares)

Parish/es	Stratigraphy (of sedimentary and volcanic strata) (1)							Lithology (1)				
	Cambrian, Ordovician and Silurian	Devonian	Carboniferous	Jurassic	Drift, Alluvium (2)	Peat (2)	Non-Drift (2)	Intrusive Acid Igneous (1)	Extrusive Acid Igneous	Hard Sandy Sedimentary Rock	Hard Clayey Sedimentary Rock	Hard Calcareous Sedimentary Rock
Bransdale				100		15	85			75	20	5
Shap Rural and Shap	75		20		45	15	40	5	55		20	20
Heptonstall			100			40	60			55	45	
Glascwm	100						100				100	
Ystradgynlais Higher and Glyntawe		15	85		45		55			55	15	30
Widecombe in the Moor and Buckland in the Moor			15		5		95	85			15	

(1) These columns total 100%

(2) " " " "

(3) " " " "

APPENDIX 4

(b) Soil Mapping Unit Summary: Parish Areas

(as percentages of parish area occupied by unit, from sketch-maps, based on class at mid-point of 1 km x 1 km grid squares)

Parish/es	Soil Mapping Unit (1:1,000,000 Soil Map of England and Wales)							
	60 Brown Earths + Rankers or Rendzinas and Bare Rock	63 Brown Earths + Stagnogley and Brown Podzolic Soils	64 Brown Podzolic Soils + Brown Earths	66 Stagnopodzols + Stagnohumic and Humic Gley Brown Podzolic Rankers and Peaty Soils	68 Stagnogley Soils + Brown Earths	69 Stagnogley Soils + Brown Earths, Brown Podzolic Soils and Stagnohumic Gley Soils	70 Stagnohumic Gley Soils + Peat Soils, Humic Gley Soils and Stagnopodzols	71 Raw Peat Soils + Stagnohumic or Humic Gley Earth Peat and Stagnopodzols
Bransdale					25		75	
Shap Rural and Shap	10			85		5		
Heptonstall				10			40	50
Glascwm		95		5				
Ystradgynlais Higher and Glyntawe							100	
Widecombe in the Moor and Buckland in the Moor		10	80	10				

APPENDIX 4

(c) Dominant Soil Group Summary: Parish Areas

(as percentage of parish area in category, from sketch maps, based on dominant soil in map class at mid-point of 1 km x 1 km grid squares)

Parish/es	Dominant Soil Group in Mapping Units (on 1:1,000,000 Soil Map of England and Wales)						
	Brown Earths	Rendzinas and Calcareous Soils	Gley Soils	Brown Podzolic Soils	Podzols and Stagnopodzols	Stagnohumic Gleys	Peat Soils
Bransdale			25			75	
Shap Rural and Shap	10		5		85		
Heptonstall					10	40	50
Glascwm	95				5		
Ystradgynlais Higher and Glyntawe						100	
Widecombe in the Moor and Buckland in the Moor	10			80	10		

(Because the mapping units at the scale of the 1:1,000,000 map are inevitably broad, the "dominant soil group" is only to be taken as occupying the estimated percentage of the study area in association with other soils, particularly those shown in Table 7(b).)

APPENDIX 4

(d) Agricultural Land Classification Summary: Parish Areas

(as percentages of parish areas in class, based on class at mid-point of 1 km x 1 km grid square, from Ministry of Agriculture, Fisheries and Food, A.L.C. 1:63,360 maps)

Parish/es	Agricultural Land Class						
	1	2	3	4	5	Urban	Other uses
Bransdale				15	75		10
Shap Rural and Shap				20	75		5
Heptonstall				20	70		10
Glascwm				50	45		5
Ystradgynlais Higher and Glyntawe				10	85	5	
Widecombe in the Moor and Buckland in the Moor			5*	30	55		10

*Although mapped as 3 the area indicated is above the height and rainfall limits above which land is *usually not graded higher than 4*, according to the A.L.C. specifications.

APPENDIX 5a

Parish Area/10 km x 10 km grid square associations

Parish Area	10 km x 10 km O.S. grid squares
Bransdale	98, 460490 (90-26); 83, 460500 (10-3)
Shap Rural and Shap	62, 350510 (57-64); 75, 350500 (22-25); 61, 340510 (16-18); 75, 340500 (5-5)
Heptonstall	139, 390430 (61-14); 145, 390420 (39-9)
Glascwm	294, 310250 (100-36)
Ystradgynlais Higher and Glyntawe	344, 280210 (94-46); 332, 280220 (4-2)
Widecombe in the Moor and Buckland in the Moor	422, 270070 (60-30); 421, 260070 (40-20)

Data given as: grid square numbered as in 398 report, O.S. grid reference of SW corner of square (percentage of parish in square - percentage of square in parish)

APPENDIX 5b

Study Parish Areas in Relation to National Upland Land Classes

Parish Area	Upland Geographic Region ("Core" regions are those 10 x 10 km grid squares which have >50% land above 800 ft., c. equivalent to squares falling in classes 5-8)	Class/es of 10 x 10 km grid square/s in which parish area falls, in Natural Environmental Upland classification (based on Physiography, Climate, Soil)							
		Marginal Upland Classes				Core Upland Classes			
		1 (Midland Marginal Upland)	2	3	4	5 (Montane Upland)	6 (Western High Upland)	7 (Midland High Upland)	8 (Northern High Upland)
Bransdale	North York Moors (core region)								83 (86)* <u>23</u> (102)
Shap and Shap Rural	Lake District (core region)					61 (64) 74 (77)	75 (78)		<u>62</u> (65)
Heptonstall	Southern Pennines (core region)							145 (150)	139 (144)
Clasemm	Radnor and Clun Forests (core region)							294 (302)	
Ystradgynlais Higher and Glyntawe	Brecon Mountains (core region)					332 (340)	<u>344</u> (352)		
Widecombe-in-the-Moor and Buckland-in-the-Moor	Dartmoor (part core region (421) part marginal sector of region (422))	422 (432)							421 (431)

*Numbers of grid squares as originally listed in Project 398 report, with revised computer-stored numbers in brackets. Underlining shows major part of parish area to lie in this square.