An Ecological Survey of Cumbria

Structure Plan Working Paper 4

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Cumbria County Council Institute of Terrestrial Ecology Lake District Special Planning Board

CUMBRIA COUNTY COUNCIL
and
LAKE DISTRICT SPECIAL PLANNING BOARD

AN ECOLOGICAL SURVEY OF CUMBRIA

Working Paper 4

INFORMATION AND ANALYSES USED TO PRODUCE THE RELEVANT INPUT TO THE REPORT OF SURVEY, 'CHOICES FOR CUMBRIA'

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Foreword

This working paper includes the information and analyses used to produce the relevant input to the Structure Plan document 'Choices for Cumbria', which was published in May 1976. As such it forms the basic document on which future monitoring and extensions to the analytical work will be built.

It is the result of close co-operation between Cumbria County Council and the Institute of Terrestrial Ecology. It has been co-ordinated and written by Dr R G H Bunce (ITE) and Dr R S Smith (CCC), with assistance from staff at the Lake District Special Planning Board, particularly Miss M Booy, at the ITE's Merlewood Research Station and at CCC's Planning Department. In particular Miss J Heap (ITE) carried out much of the original map work, and Mr C J Barr (ITE) helped considerably in the analysis of data. Mr I Bishop was responsible for the computer modelling and has allowed us to use some of his results.

Abstract

Classification of land has involved a wide variety of approaches in recent years the majority of which have largely relied upon personal decisions or simple criteria for specific purposes. The ecological survey of Cumbria stemmed from an investigation of the application of multivariate methods to regional survey with the primary objective of increasing the degree of standardisation to the classification of land. Every observer sees the land from his particular viewpoint and not the underlying framework that is present. The basic land forms need to be separated from the superficial features superimposed upon them; a basic requirement being to assign the intermediate landforms to classes since extremes are readily identifiable.

The first requirement was that the basic data should be cheap to acquire and be readily available. Such a source was available in the 1:63360 Ordnance Survey maps and accordingly the first phase was to record as many attributes as possible from the maps and subject them to multivariate analysis. 11% of the km squares in the county were recorded from a sample grid and the data used to classify the squares into 16 classes. The analysis was used to assign the remaining 89% of squares in the county to the classes. The classes show well defined patterns of distribution within the county that relate well to known geomorphological features but which also showed interesting patterns not readily apparent from direct observation.

The second phase was to visit a random sample of squares from each class and record the vegetation. Analysis of this data by multivariate methods showed clearly defined vegetation types that were strongly and significantly associated with the land classes. The high correlations present made it possible to predict the vegetation composition of squares which had not been visited but where the land class was known. The accuracy of these predictions was assessed by enumerating the land class composition of three areas, predicting the vegetation present and then carrying out a ground survey of the vegetation. The fit between the observed and expected vegetation was very good in all three cases. The high correlations enabled comparisons to be made between areas where the likely environmental impact of planning decisions needs to be assessed rapidly. The total vegetation resource of the county was assessed and it is shown that 50% of the county is covered by only 8 vegetation types which provide the uniform backcloth against which another 24 types are distributed.

The high correlations between the land classes and their vegetation composition make it possible to advocate their use as strata on which to base other environmental surveys. The main advantage of such an approach is that once the framework has been laid down other surveys can be based on the same squares and not only can further information be acquired from as wide a range of land as possible but it can be used to add detail onto the interpretation of the characteristic features of the squares. Accordingly three other surveys have been carried out for tree cover, hedgerows and landscape. The land classes enabled a small number of squares to be surveyed in detail and then related to the whole county to make wide generalisations. All relevant information has now been incorporated in enlarged descriptions of the land classes. Another survey in progress, that of land classes 12, 4 and 11 has been made possible by the detail now available on these classes which has shown that they contain most of the marginal farming land in the county. This demonstrates a further feature of the land classes in that they enable studies of problems to concentrate on areas where these problems are most likely to occur.

The land classes were also used to examine the characteristics of the Lake District National Park in comparison with the rest of Cumbria and show the upland nature of the Park and how any area may be fitted into a regional context. Similarly the land class composition of valleys in upland Cumbria are compared in order to examine their affinities with each other. Such an exercise is important in assessing the representativeness of any particular valley for detailed study of its physical features and for assessing the importance of planning decisions relating to it. The characteristics of the land classes could be used to compare these valleys as to their biological content. The accuracy of such comparisons depends upon the uniformity of the land class distribution and upon the extent of the area being considered; the smaller the area the greater the chance of inaccuracies although differences from the norm can be used to assess the difference from a typical area of the county. The land classes are also used as a framework to assess the distribution of areas set aside as having high conservation value. Finally, having demonstrated the wide range of correlations held by the land classes they are used to identify rural areas within which policies could be followed for the agricultural and forestry use of land. This is one of the major applications in providing a standardised basis for zoning areas for planning purposes.

1 Introduction

1.1 LOCAL GOVERNMENT PLANNING IN CUMBRIA

1.1.1 The county of Cumbria was set up during the reorganisation of local government in 1974. It incorporates the whole of the old counties of Westmorland and Cumberland, part of the old West Riding of Yorkshire and the Furness area of Lancashire. It contains the whole of the Lake District National Park and part of the Yorkshire Dales National Park. A general description of the geography of the county, together with its physiography, climate and land use patterns, is given in 'Choices for Cumbria', published by the County Planning Department as part of the Structure Plan.

1.1.2 The six district councils in Cumbria are Allerdale District, Copeland Borough, Carlisle City, Eden District, Barrow Borough and South Lakeland District. They are responsible for the control of development and the production of local plans. The Lake District Special Planning Board carries out all the planning functions which would otherwise be undertaken by the county or district council; these include the preparation and review of structure and local plans and the control of development, as well as the production of the National Park Plan. The latter is a hybrid plan in that it is not only a policy document but is also a management plan for the Park. Cumbria County Council and the Lake District Special Planning Board are responsible for a joint County Structure Plan. The county council is responsible for major 'county matter' developments requiring planning permission outside the Lake District National Park.

1.1.3 Ecological information is necessary for the County Structure Plan for two reasons. Firstly, the conservation of ecosystems and the wildlife they contain is one of the duties of local government. The 1968 Countryside Act stipulates that government departments and local authorities must have due regard for wildlife and amenity in the exercise of their functions. The 1949 National Parks and Access to the Countryside Act enabled a local authority to set up a Local Nature Reserve with the agreement of the Nature Conservancy (Council). For the Structure Plan, ecological information should provide an overview of tracts of countryside which will complement knowledge about specific sites of high conservation value. Secondly, such nature conservation assessments need to be used in conjunction with statements concerning the extent of the resources available in terms of agriculture, forestry and landscape. Areas may then be defined in the county within which different groups of Structure Plan policies can be considered. The definition of such areas provides an important backcloth against which to consider the social and economic factors which dictate the use of land and their implications for the conservation of its landscape and wildlife interest. Various ways in which the results of the survey may be used in these contexts are given in Chapter 6.

1.1.4 At present the main type of ecological information used for planning purposes is based upon the identification of sites highly valued for nature conservation. Section 23 of the 1949 National Parks and Access to the Countryside Act, as amended by the 1973 Nature Conservancy Council Act, requires the Nature Conservancy Council (NCC) to notify Sites of Special Scientific Interest (SSSI's) to the local planning authorities, who in turn are required to consult the NCC before granting any planning permission affecting these sites. There are 148 SSSI's in Cumbria covering approximately 13% of its total area. Nature reserves are similarly highly valued sites, some of which are also SSSI's. There are seven National Nature Reserves in Cumbria owned by or leased to the NCC; Cumbria County Council has one Local Nature Reserve; Cumbria Naturalist's Trust owns or leases 23 nature reserves, and the Royal Society for the Protection of Birds has two reserves in Cumbria.

1.1.5 Two of the principles underlying the ecological survey carried out for the County Structure Plan are particularly important in a planning context. Firstly it was accepted that it was impossible to completely survey the whole county on a site by site basis in the time and with the resources available. Since details of important sites of nature conservation interest were already available, the most important need was for a definition of the range of variation within the ecosystems occurring most widely in the county. The aim was to provide a framework within which a local survey can be slotted in order that its relevance to the whole county can be assessed. Changing circumstances can make a 'doomsday book' irrelevant in planning the future use of land.

1.2 THE ECOLOGICAL SURVEY

1.2.1 Previous approaches to regional ecological surveys have involved observation in the field, followed by interpretation of the observed features and the direct recording of these interpretations in the field usually by mapping, for example, Coleman (1977). Data collection has usually been confined to strata defined mainly on the basis of visual homogeneity, eg woods, heathlands, grasslands. Whatever the sophistication of the subsequent analysis the overall effectiveness of the survey is limited by the initial quality of the interpretation of the strata which are present. Such surveys also need to cover the whole area in the field, so that the rate of survey is slow unless the data collected are very simple. Whilst there have been successful classifications produced in this

way, they usually deal with specific aspects of regional surveys such as agricultural land use or forestry. There have been few attempts to define strata which are suitable in linking together the various types of data collected in regional surveys.

1.2.2 The basic principle underlying the ecological survey of Cumbria is that the complex of features which interact together to produce a given land class are reflected in observable characters present on Ordnance Survey maps. The analysis of such maps should therefore provide a series of land classes which could provide strata for subsequent sampling, provided that they contain sufficient information about the overall environment. Detailed samples on particular topics can then be related to the stratum from which they are taken and the survey results related to the whole county.

1.2.3 The methods used have been standardised to a greater extent than has been possibly previously so that they can be used by different observers and in a way that others can repeat at a later date. Whilst it is recognised that observer error and misinterpretation of the instructions are to some degree inevitable, the possibility of these occurring has been reduced wherever possible, and hence the data collected is as far as possible, reproducible. The methods used also enable standardised comparisons to be drawn between different areas of the region surveyed. As more detailed surveys are undertaken using the same basic sampling framework provided by the land classes, the opportunity is available for a data bank system that will enable comparisons to be drawn for a variety of resources, eg vegetation types, hedgerows, and agricultural productivity.

1.2.4 The derivation of land classes from the characters found in grid squares on maps was originally tested in Grizedale Forest and the Lake District National Park (Bunce et al, 1975). A later survey of Shetland using a similar approach showed that the strata produced enabled a rapid survey of the vegetation to be carried out. Shetland is an extreme example and could only be used as an indicator of the likely success of the approach elsewhere, although a high statistical correlation was demonstrated between the vegetation survey and the land classes.

1.2.5 At the start of the survey of Cumbria various methods of deriving strata for subsequent sampling were reviewed, including the use of aerial photographs, altitude and natural divisions on observed features. Aerial photography was ruled out because although part of the county has coverage on a suitable scale, there is not a uniform cover over the whole region. The original Lake District Study showed that altitude dominated the classification into 8 land classes but it was considered that altitude alone would not incorporate a sufficiently wide range of the variation to be found in Cumbria. This was confirmed by the separation of the Lake District Fells from the Pennines in the land classes described in section 2.2. It is possible to divide the county into regions, such as the Eden Valley and Langdale Valley, which have similar general features, but here the problem is where to draw the boundaries of such regions and in the selection of diagnostic features.

1.2.6 The adopted method outlined in para 1.2.2 was chosen using a 1 sq km grid, which in this case was the National Grid; although any grid system superimposed across a region would have sufficed. It has the advantage that the km square had previously been found to be a convenient unit to sample in the field and with approximately 7,100 in the county was likely to provide a reasonable degree of detail on the whole county scale. Further advantages are that a simple reference system is provided for computer mapping and for fitting into the National Grid; and also grid squares can be combined into natural units such as valleys and administrative units such as parishes and districts. Disadvantages are the very large number of km squares in Cumbria and the fact that square boundaries will always result in arbitrary combinations of map characteristics when they cut across natural features.

1.2.7 The characteristics of the land classes can be defined firstly from the data used in the analysis and secondly from features observed during subsequent surveys stratified on the basis of the classification. Using these characteristics generalisations can be made concerning the whole county and its structure as shown by the pattern of distribution of the different land classes. The analysis described in Chapter 2 can be seen to have distilled the main features of Cumbria from the mass of information presented on the Ordnance Survey maps.

1.2.8 The most important objective of the analysis of the map characteristics present in km squares of Ordnance Survey maps is to produce land classes which serve as strata from which representative squares may be drawn for subsequent sampling. These samples enable predictions to be made about the composition of each land class and the whole county. Surveys of the vegetation types, tree cover, hedgerows and landscape have been carried out partly to demonstrate the effectiveness of the stratification and partly for specific purposes eg the case of the tree cover in relation to Dutch Elm Disease. A rapid assessment of the full range of variability has been achieved for each survey and a basis has been laid down for monitoring the change in vegetation types and tree cover in the future. Similarly the loss of

hedgerows can be followed in subsequent years. For example, comparison of the present state of hedgerows with the 1937 series Ordnance Survey maps has shown that loss of hedgerows was virtually confined to one land class.

1.2.9 Further surveys for specific purposes are possible using the strata and interactions between the various surveys can be examined. Previously specialist surveys have tended to adopt their own criteria for sampling. The land classification increases the degree of standardisation possible and can, therefore, increase the usefulness of such surveys. Although the land classification employs statistical analytical procedures the application of the results does not need such knowledge; in a similar way the user of a radio or car does not need to know how it is made.

1.2.10 The use of land classification enables 'grey' areas of the county to be defined as well as the extremes, which are readily recognisable. Many of the conclusions may be considered obvious once completed but would not emerge clearly without the analysis to simplify the data and highlight the principal features.

2 Definition of the land classes

2.1 THE DATA BASE AND ITS ANALYSIS

2.1.1 The procedure followed in the definition of the land classes is given in Fig 2.1. A grid of squares was drawn from the whole county by taking the central square from blocks of 3 x 3 km squares, constituting an approximately 11% sample. The list of map characteristics recorded from the sample is given in Table 2.1. The characteristics included in this analysis consisted of all those that could readily be recorded from one inch scale Ordnance Survey maps and, with the exception of the geological attributes, have been discussed by Bunce et al, (1975). Attributes such as buildings and roads were included because, although they may not be considered as a direct response to the environment, they nevertheless were likely to be indirectly informative. The geological characteristics were included to widen the range of features and were used directly. Drift was excluded as adequate maps were not available.

2.1.2 The allocation of the sample squares to appropriate classes was done by Indicator Species Analysis (Hill et al, 1975). The method, with its implicit assumptions, identifies characteristics that discriminate efficiently between the groups of samples at each stage of the analysis. Reciprocal Averaging Ordination (Hill, 1973) was the other method of analysis employed to assess the relationship of the squares along trends and these scores are used to test for correlations between various analyses. In the remainder of this report the two methods will be referred to as ISA and RA respectively.

2.2 THE LAND CLASSES

2.2.1 The hierarchy of the land classification (Fig 2.2) demonstrates the affinities of the land classes and is used as a dichotomous key to classify the remaining squares (Fig 2.3). In general terms the relationships between the land classes can be expressed by noting that types with contiguous numbers are generally similar in characteristics, although there are exceptions to this general rule. The indicator characteristics (Fig 2.2) enable a general interpretation of the course of the analysis to be achieved. These may be compared at various divisions in the hierarchy. The first division is made on the basis of altitude characteristics, although the presence of the human artefact characteristics demonstrates that this is not the whole story. At the second level (divisions 2 and 3 in Fig 2.2) altitude dominates to a greater

Fig.2.1
Analysis procedures: land classification

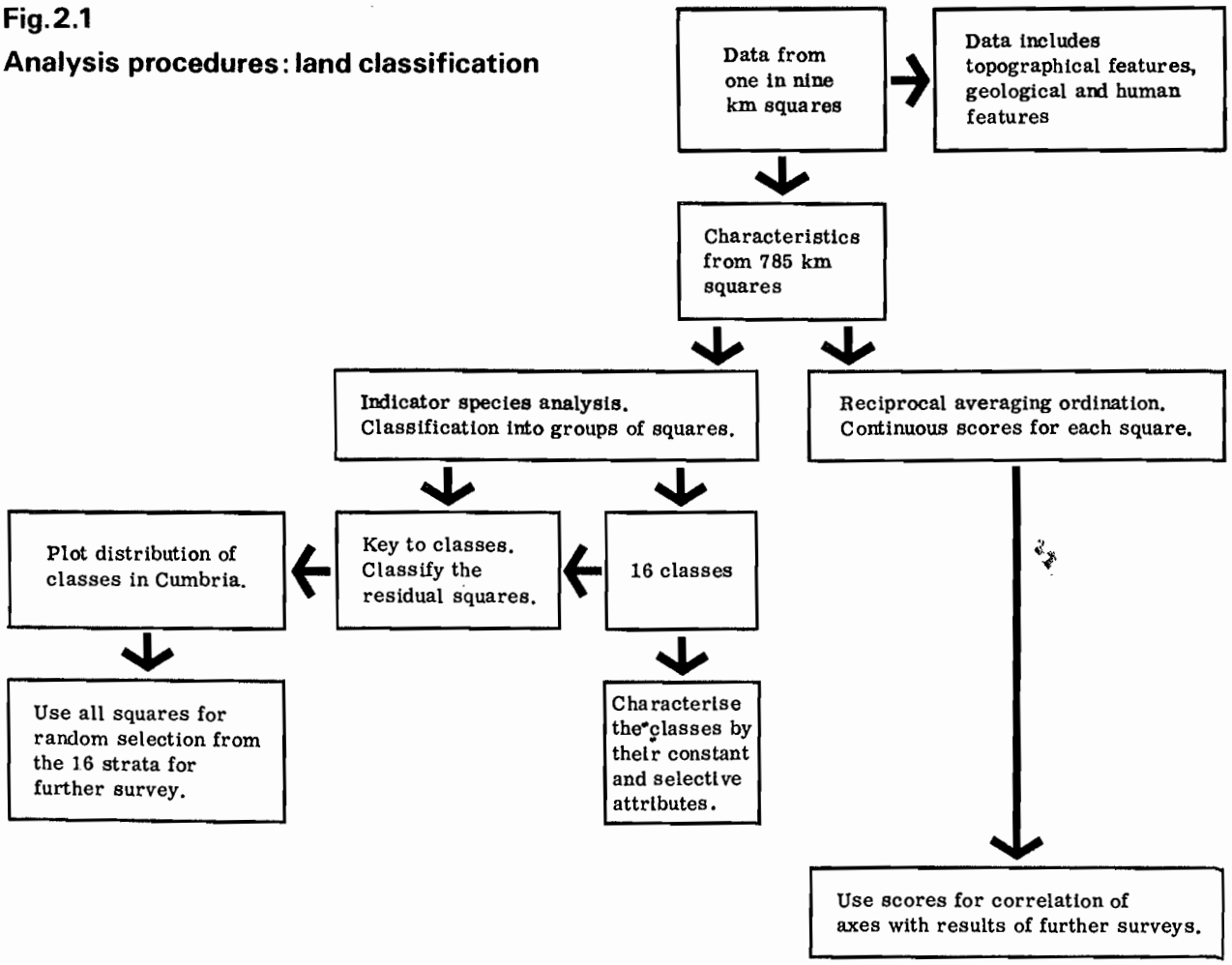


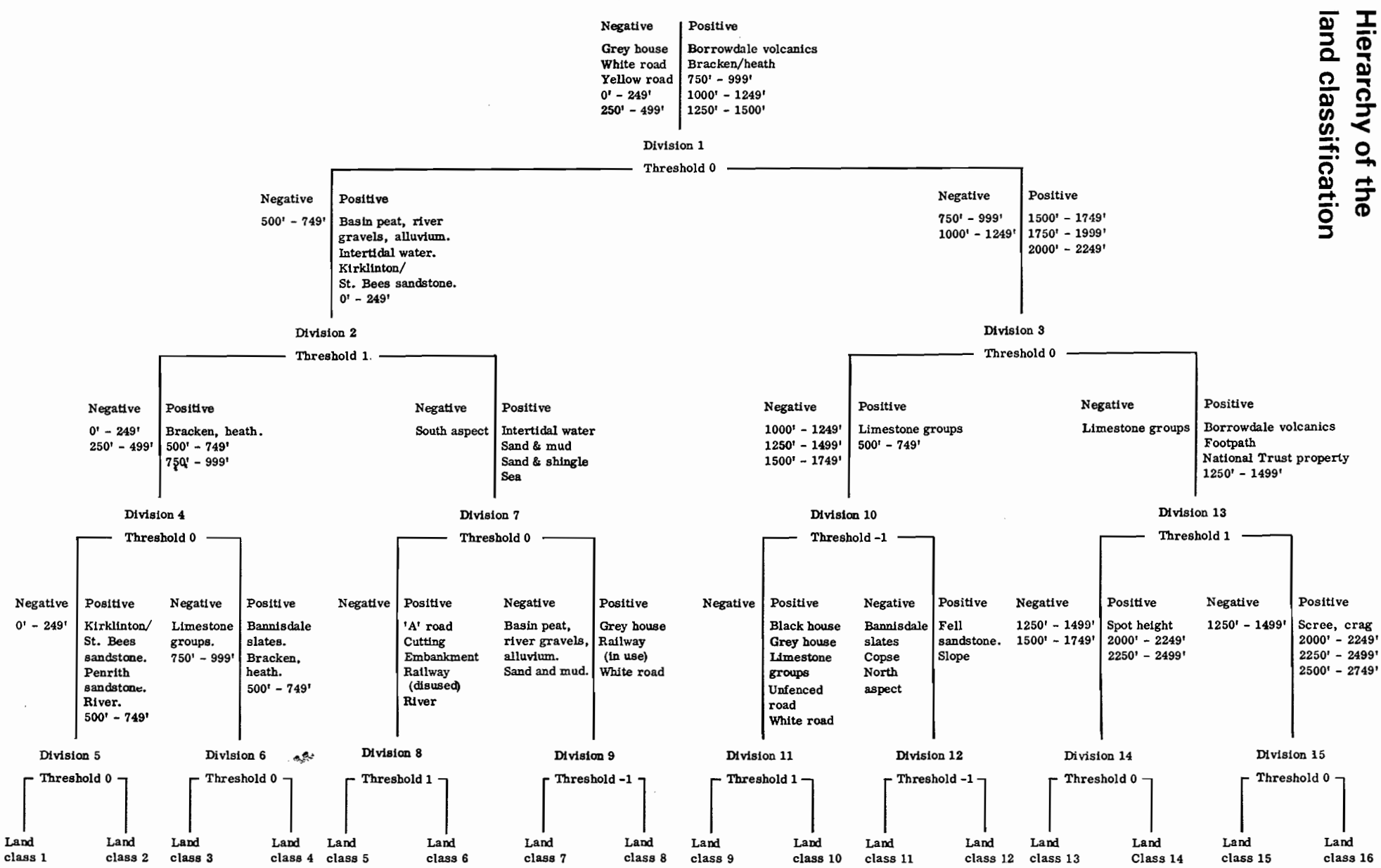
TABLE 2.1
CHARACTERISTICS USED IN THE LAND CLASSIFICATION

Code no	Name	Code no	Name	Code no	Name
1	'A' Road	65	Club house	129	Roundabout
2	'B' Road	66	Town hall	130	Road bridge over road
3	Yellow road	67	Public convenience	131	Road tunnel
4	White road	68	Pylons	132	Works
5	Unfenced road	69	Pipe line	133	Viaduct
6	Station	70	Mile-stone	134	Ford
7	Railway (in use)	71	Mile-post	135	Open pit
8	Railway (disused)	72	Information point	136	Ancient monument
9	Footpath	73	Earthworks	137	Pier
10	Bridleway	74	Stone circle	138	Ferry
11	River	75	Cairn	139	Mineral line etc
12	Stream	76	Settlement	140	Beacon
13	Weir	77	Field system	141	Ski hut
14	Road used as public path	78	Castle	142	Motorway
15	Inter tidal water	79	Roman castle/house	143	Abbey
16	Bridge over railway	80	Roman road	144	Chimney
17	Waterfall	81	Standing stone	145	Hanging stone
18	Bridge over water	82	Monument	146	Boat house
19	Steep hill (road)	83	Tumulus	147	Level crossing
20	Land between 0-249 ft	84	Religious monument	148	Well
21	Land between 250-499 ft	85	Quarry	149	Old canal
22	Land between 500-749 ft	86	Mine	150	Giants' graves
23	Land between 750-999 ft	87	Wood - conifer	151	Thunderstone
24	Land between 1000-1249 ft	88	Hardwood	152	Tower
25	Land between 1250-1499 ft	89	Mixed wood	153	Coastguard lookout
26	Land between 1500-1749 ft	90	Marsh	154	Dock
27	Land between 1750-1999 ft	91	Parkland	155	Lifeboat station
28	Land between 2000-2249 ft	92	Bracken/heath	156	River mouth
29	Land between 2250-2499 ft	93	National Trust property	157	Aerial ropeway
30	Land between 2500-2749 ft	94	School	158	Sand and shingle
31	Land between 2750-2999 ft	95	Sea	159	Sand and mud
32	Land above 3000 ft	96	Tarn depth 0-25 ft	160	Airfield
33	Aspect North	97	Tarn depth 26-50 ft	161	Dunes
34	Aspect South	98	Tarn depth 51-75 ft	162	Beacon
35	Aspect East	99	Tarn depth 76-100 ft	163	Basin peat, alluvium, river and gravels
36	Aspect West	100	Tarn depth 101-125 ft		
37	Viewpoint	101	Tarn depth 126-150 ft	164	Kirklinton, St Bees sandstone plus St Bees shales
38	Island	102	Tarn depth 151-175 ft		
39	Spot height	103	Tarn depth 176-200 ft	165	Penrith sandstone plus brochram
40	Triangulation point	104	Tarn depth 201-225 ft	166	Upper coal measures
41	Scree/crag	105	Tarn depth 226-250 ft	167	Middle and lower coal measures
42	Black house	106	Tarn size 10 acres	168	Millstone grit
43	Grey house	107	Tarn size 10-50 acres	169	Limestone groups
44	Hall	108	Tarn size 51-100 acres	170	Basement beds (conglomerate etc)
45	Hamlet	109	Tarn size 101-500 acres	171	Bannisdale slates, Coniston flags, Stockdale shales
46	Village	110	Tarn size 500 acres		
47	Town	111	Golf course	172	Coniston limestone
48	Post Office	112	Cliff	173	Skiddaw slates
49	Public house	113	Slope	174	Basaltic lavaes (carboniferous)
50	Inn	114	Embankment	175	Andesites, rhyolites and tuffs (Borrowdale volcanic series)
51	Hotel	115	Cutting		
52	Telephone	116	Television and radio mast	176	Gabbro
53	Caravan site	117	Enclosure	177	Dolorite, diorite and diabase etc of Isle of Man
54	Camp site	118	Copse		
55	Church with steeple	119	Sheep fold	178	Quartz - felsite
56	Church with tower	120	Adjacent to town square	179	Granophyre
57	Church with neither	121	Railway tunnel	180	Granite
58	Thwaite	122	Footbridge over water	181	Blown sand
59	Mountain rescue post	123	Moat	182	Fell sandstone
60	Climbing hut	124	Windpump	183	Lower lias
61	Youth hostel	125	Cave	184	Keuper marl
62	Shooting box	126	Railway bridge over water	185	Raised beach
63	Hospital	127	Firing range	186	Basalt and dolerite in sheets
64	Cemetery	128	Parking place		

extent and the frequency with which these characteristics are used throughout the hierarchy emphasises the significance of altitude in Cumbria.

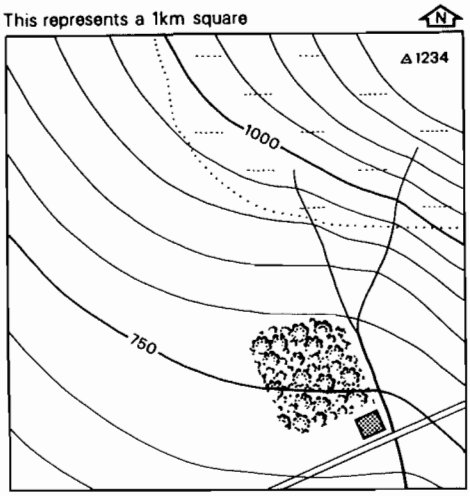
2.2.2 Within Cumbria the major division on a broad scale is between upland and lowland. Such a separation is demonstrated in Fig 2.4. The patterns of the mountain chains are demonstrated within this figure and indicate the major regions within the county that are likely to reflect differences in a wide range of features, from geomorphology to land use and communication patterns. At lower levels in the hierarchy detailed interpretations are possible. The sequence of land classes in the ordination is not in strict numerical order and the series starts with the most extreme classes being numbers 7 and 8. These are both coastal classes with 7 being predominantly open mud or sand. Classes 6, 5 and 1 are distinguished by characteristics most strongly associated with the lowlands, with 6 being strongly linked to lines of communication. Class 4 is distinguished by being a lowland class, but with a geology more usually associated with

Fig. 2.2 Hierarchy of the land classification



*See Fig 2.3 for an example of the use of the hierarchy as a dichotomous key.

Fig. 2.3
Example of the use of the land classification key



Geology: Bannisdale slates

Division number	Indicator attributes present	Score	
1	750'-999' (+) 1000'-1249' (+) Bracken/heath (+) White road (-) Grey house (-)	+3 - 2 = +1	Threshold is 0 or less. Therefore, go to division 3.
3	750'-999' (-) 1000'-1249' (-)	-2	Threshold is 0 or less. Therefore, go to division 10.
10	1000'-1249' (-) 500'-749' (+)	+1 - 1 = 0	Threshold is -1 or less. Therefore, go to division 12.
12	Bannisdale slates (-) Copse (-)	-2	Threshold is -1 or less. Therefore, square is Land Class 11.

the uplands; it would therefore be expected to be a complex class. Class 3 is in some respects parallel to 4, but is particularly linked with limestone geology; whereas class 2 is linked to the sandstone series. These classes have comparatively altitudinal ranges at the lower division levels and it is their geological associations that separate them. In the uplands classes 11 and 12 are associated with the middle altitudes, again being distinguished largely by geology. Classes 9 and 10 are higher on the fells, with the latter having more valley features and the former having relatively few distinguishing map characteristics. Classes 13 and 14 parallel 15 and 16. The former pair are associated with the Pennines and are separated at the eight class level (division 13, Fig 2.2) from the central lakeland fells (classes 15 and 16) largely on the basis of geology and associated features. Classes 13 and 15 are the slopes; whereas 14 and 16 are mainly the higher summits of both areas. Although altitude exerts a dominant influence throughout, the divisions, particularly at the lower levels, are made on other characteristics, notably geology. The separation of the Pennines from the central Lake District fells is a particularly useful example to show that the separation into classes is not based solely on altitude.

2.2.3 Descriptions of the land classes can be based on the relative frequencies of the map characteristics. Some guide to these is given in Fig 2.2. The following descriptions of the land classes convey a general picture of each class. They are not only derived from the map characteristics but also from the subsequent surveys based upon the land classes.

Land Class 1:
Lowland map characteristics predominate in this class, which is located on the Solway Plain, the southern lowlands and the western coastal plain. The land forms are more or less flat with a few small woods and hedgerows. Agricultural land is of medium quality, mainly pasture but with many leys, and with an appreciable amount of land not farmed. The soils are rather variable, mainly brown earths, often of a high nutrient status.

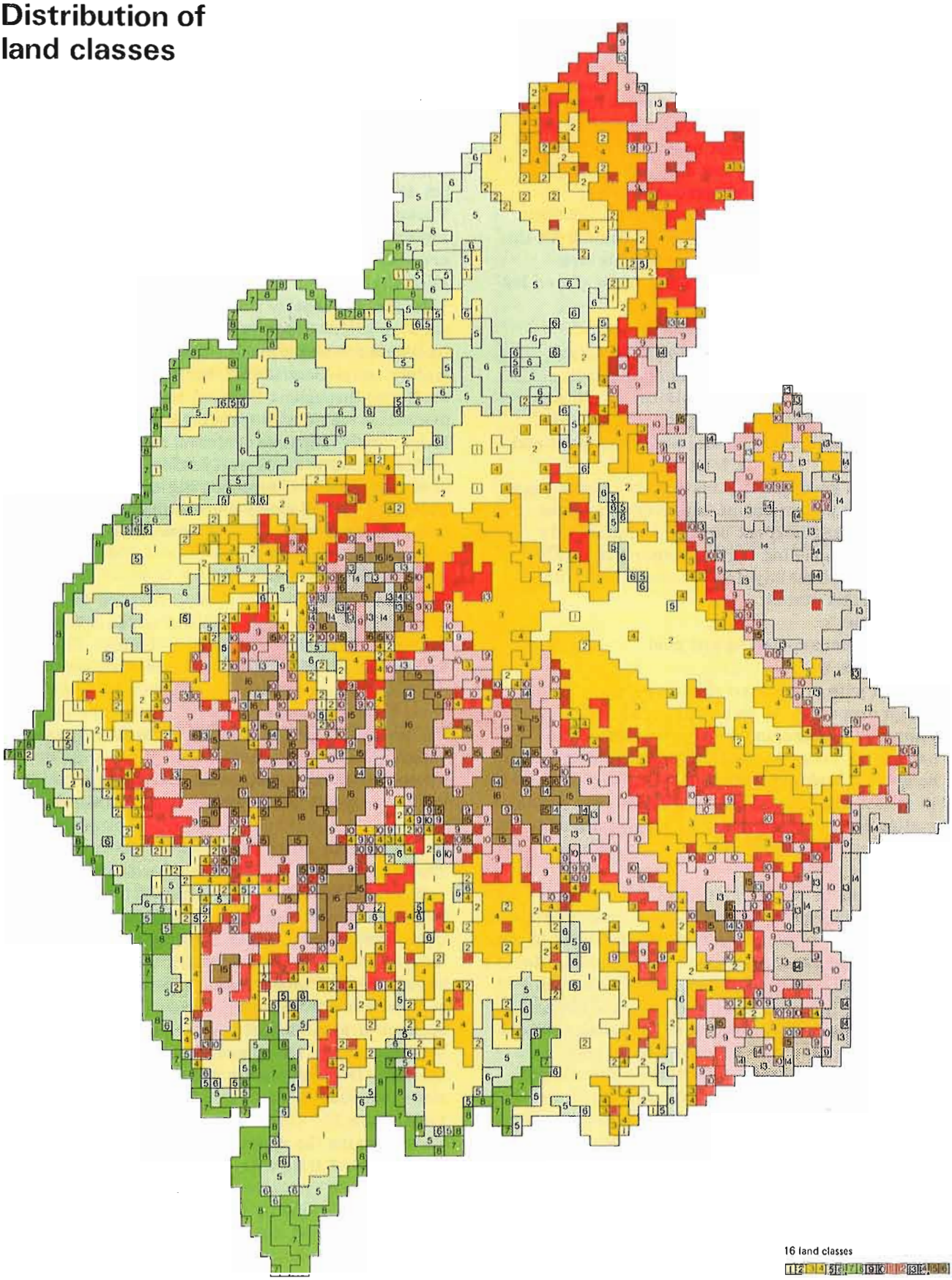
Land Class 2:
This class is at a slightly higher elevation than class 1, but with lowland map characteristics still predominating. It is located in the Eden Valley and Solway Plain. The land forms are undulating with smooth slopes, a few small woods and abundant hedges. Agricultural land is of medium to good quality, predominantly leys but with some arable land. There is little land that is not intensively farmed. The soils are mainly deep brown earths with a high nutrient status.

Land Class 3:
This class contains many lowland map characteristics, although it is at a higher elevation, 152-229m (500-750 ft), than classes 1 and 2. It is concentrated on the western side of the Eden Valley. Its limestone landforms are undulating with some low hills. Small woods and hedgerows are widespread. Agricultural land is of medium to poor quality, permanent pasture being most common but with leys and improved pastures also present. The soils are mainly brown earths with a high calcium status and are often rather stony.

Land Class 4:
Whilst occurring at the lower altitudes this class contains many upland features in close proximity to lowland ones and virtually mixed with them. It is widespread throughout the county, concentrated on the margins of the central fells. The topography varies with alluvial plains in juxtaposition with hilly landforms. Coniferous and broadleaved woods are widespread with some hedges. Agricultural land varies from medium-good to poor quality, giving a mix of intensively managed and relatively unmanaged land. Although

Fig. 2.4

Distribution of land classes



improved pasture is most common the frequent presence of well drained moorland indicates the contrasts to be found here, these being reflected in the very variable soil types.

Land Class 5:
Apart from the coast this is the most lowland class in the county, consisting of the alluvial plains of the Solway, west coast and southern lowland. There are a few shelterbelts and copses, and abundant hedgerows. The agricultural land is of good quality with mainly arable land and short term leys. Almost all the land is intensively farmed. The soils are usually deep brown earths, sometimes gleyed but with a high nutrient status.

Land Class 6:
The lowland class is associated with human artefacts relating to communications and urbanisation on the alluvial plains. Although widespread in the lowlands it is concentrated mainly in the north. There are few copses and many hedges. The agricultural land is of medium to good quality, mainly short term leys with a high proportion of improved grassland. Almost all the land not built up is intensively farmed in a grazing regime rather than arable. The soils are mainly deep brown earths with a high nutrient status.

Land Class 7:
Coastal, estuarine sand and mud.

Land Class 8:
Coastal with much bare sand and mud. There is a high proportion of shoreline as well as improved pasture and leys on the land that is present. There is very little woodland although hedges on banks are common. Agricultural land is of medium to good quality, intensively managed mainly for livestock rearing. The soils are deep, sometimes gleyed with a high nutrient status.

Land Class 9:
This is a markedly upland class at intermediate elevations, comprising mainly the foothills of the Lake District and Pennines. The landform is one of gently rounded slopes, often with gentle gradients. Trees, when present, are almost entirely conifers planted in large blocks. There are no hedges. Agricultural land is poor, predominantly uniform moorland, in particular badly drained moorland. Its main use is for the free range grazing of sheep. Soils are highly organic, acid and usually waterlogged.

Land Class 10:
An upland class with lowland affinities containing valley bottoms as well as mountainsides. It occurs widely throughout the central Lake District fells and also on the edge of the Pennines. The wide range of landscape features is reflected in the vegetation contrasts between improved pastures of the valley floor, and upland grasslands and well drained moorland of the mountainsides. The small amount of woodland and hedgerows is confined to the valley floor. The agricultural land is of poor quality with variable soils which are usually shallow, acid brown earths.

Land Class 11:
This complex class occupies the variable ground of the middle fells with elements from both upland and lowland situations. It parallels class 4 in its general distribution, but it occurs at a higher elevation between the high fells and the valley floors. Broadleaved woods are widespread with some hedgerows. Agricultural land is poor, predominantly upland grassland but with a wide range of other vegetation. There is much marginal land grazed by sheep and cattle. The soils are very variable but are usually shallow, acidic, brown earths.

Land Class 12:
This class is mainly featureless low fells showing little change in their relief patterns, at intermediate elevations. The class occurs mainly on the Scottish border but it is also scattered throughout the rest of the county. There are extensive coniferous plantations and a few hedgerows. Agricultural land is poor with improved pasture and well drained moorland predominating. There is a big contrast between the sheep grazed areas and the plantations. The soils are generally acidic brown earths, but with peat soils widely present.

Land Class 13:
The landforms here are steep, rounded slopes on the margins of the Pennines and the Skiddaw massif. There are virtually no trees. The agricultural land is poor with badly drained moorland predominating although there is a considerable amount of well drained grassland on the steeper slopes. Most of the land is grazed extensively by sheep and cattle. The soils are characteristically deep peats and peaty gleys with acid brown earths on the better drained slopes.

Land Class 14:
This class contains high altitude mountain summits and plateaux with exposed low gradient slopes. It occurs mainly in the Pennines but it is also to be found on the Skiddaw massif and the Howgill Fells. There are no trees and few boundaries. The agricultural land quality is poor with badly drained moorland predominating and well drained moorland on the steeper slopes. It is open range sheep grazing with some grouse moors. Deep peat soils are common, but peaty gleys and peaty podsols are also present.

Land Class 15:
This contains the upper slopes of the central Lake District fells with many rugged mountain features, and virtually no trees. Agricultural land is of poor quality with badly and well drained moorland and upland grassland. It is almost entirely open range sheep grazing. The soils are mainly peat with peaty podsols and rankers depending on local conditions.

Land Class 16:
Summits and highest slopes of the central Lake District fells. The most mountainous land in Cumbria with many extreme mountain features. There are no trees. Agricultural land is poor with vegetation similar to class 15 but with less

grassland. The soils are peats and peaty podsols, deeper than in class 15.

2.2.4 The relative amounts of each land class in the county gives a summary of its structure (Table 2.2). The differences between the sample and the complete enumeration are small and show no particular pattern. There is considerable variation between the class frequencies with those at the extremes of the trend, the coastal and upland classes, being relatively infrequent. The lowland classes are generally more frequent than the upland; reflecting both a greater homogeneity in the lowlands and the greater extent of lowland than upland. Land classes 10 and 11 are transitional between upland and lowland; they are relatively infrequent and will be shown to be highly variable.

2.2.5 Some land classes tend to occur in large blocks, eg classes 1 and 2; whereas others, notably 4 and 11, tend to occur in small groups. The km squares of the upland land classes form more cohesive patterns with each other than the squares of the lowland classes, which tend to occur in larger blocks and hence are most strongly associated with km squares of their own land class than other land classes (Table 2.3). The reason for these differences lies in the pattern of geomorphology in the uplands, where valleys dissect the highland and lead to heterogeneous land forms.

2.3 SUMMARY AND CONCLUSIONS

2.3.1 The characteristics recorded from one inch scale Ordnance Survey maps are given together with the methods of data analysis. The hierarchy of the land classification shows that the major division in Cumbria is between upland and lowland. The 16 land classes derived from the analysis differ also in geological and land use characteristics. Summary descriptions of each land class are given based partly on subsequent surveys. The relative amounts of each land class show that nearly two thirds of Cumbria can be classed as lowland.

TABLE 2.2
FREQUENCY OF THE 16 LAND CLASSES

Land class	Frequency from all squares	Frequency from 1 in 9 sample	Frequency at 8 level	Frequency at 4 level	Frequency at 2 level
7	2.1	1.7	5.4	20.3	
8	3.3	3.3			
6	4.0	4.1	14.9		63.5
5	10.9	9.7			
1	12.6	9.9	23.6	43.2	
2	11.0	11.5			
4	12.0	10.8	19.6		
3	7.6	10.8			
11	4.8	6.3	8.7	23.5	
12	3.9	4.4			
10	5.1	4.9	13.8		36.4
9	8.7	7.8			
13	5.4	4.4	8.3	13.9	
14	2.9	4.2			
15	1.7	3.5	5.6		
16	3.9	2.8			

Note:
The land classes are ordered according to their scores on the first RA axis. This ordering puts classes which are closely related in terms of their map characteristics next to each other.

TABLE 2.3
ASSOCIATION BETWEEN LAND CLASSES

Land Class	Associated Land Classes
7	7, 8
8	5, 7, 8
6	5, 6
5	5, 6
1	1
2	2
4	4
3	3
11	3, 4, 11
12	3, 9, 12
10	9, 10, 11
9	9, 10, 15, 16
13	10, 13, 14
14	13, 14, 15, 16
15	9, 15, 16
16	9, 15, 16

Note:
The land classes are ordered according to their scores on the first RA axis. This ordering puts classes which are closely related in terms of their map characteristics next to each other.

3 The vegetation survey

3.1 DATA COLLECTION AND ANALYSIS

3.1.1 Three km squares were chosen at random from each of the 16 land classes. They were fairly evenly scattered throughout the county (Fig 3.1) and were selected from the complete enumeration of about 7,100 km squares, so as to include the error caused by the use of the dichotomous key. Sixteen points were chosen at random within the first two squares from each land class. As the range of variation within one km square was less than anticipated the number of sample points in the third km square was reduced to eight. Sample points in lakes were repositioned at random within the remaining part of the square but those in the sea were omitted since, in these coastal land classes, such squares often had a very small amount of land which would then have been oversampled.

3.1.2 The sampling procedure followed closely the system described by Bunce and Shaw (1973) and will therefore only be outlined briefly. Each sample point was located from 1:10,000 maps by pacing along a compass bearing from an easily recognised land mark. The exact point was at the final pace of the requisite number. Species were recorded successively from 4 sq m, 25 sq m, 50 sq m, 100 sq m and 200 sq m plots. All vascular plants were listed, together with mosses, some larger liverworts, lichens, seaweeds. The majority of the smaller bryophytes were omitted because of identification difficulties and a greatly simplified key was used for the genus Sphagnum. Where it emerged that a species had not been consistently identified it was excluded, but most species presented few taxonomic problems. Such a conclusion is usual in surveys of this type and means that, provided a person shows application, an adequate knowledge of species identifications can be built up relatively rapidly, without the necessity for acquiring specialist taxonomic experience. Of a total of 484 species recorded, only 309 were used in the analysis, because 175 occurred in fewer than 3 of the 609 plots included. A small number of plots were rejected since they were in an extreme position (ie saltmarshes and beaches) relative to the remainder of the plots as assessed by a preliminary analysis.

3.1.3 An auger was used to sample the soil in the centre of each plot and a sample of the top 10cm taken for pH determination. A record of habitats present within the plot and within 50m of its centre was then made. The slope and aspect across the highest and lowest edges of the plot was measured. A field handbook was prepared for those who collected the data to ensure a degree of standardisation between different workers.

3.2 THE VEGETATION TYPES

3.2.1 The description of the results from the vegetation analysis needs to be considered in various degrees of detail for different purposes. In describing the outline of the strategies adopted in the approach to the various surveys, detailed presentation of the vegetation analysis is unnecessary. Discussion here is restricted to the broad outlines and principal conclusions. The main descriptions of the vegetation types, in considerable phytosociological detail, are given in a supplement.

3.2.2 The analytical procedure followed is given in Fig 3.2 with ISA and RA used for the analysis. The hierarchy of the vegetation analysis is determined on the basis of 10 species at each stage. These species indicate certain environmental characteristics, as shown in Fig 3.3. The hierarchy has only been interpreted to eight groups of vegetation types, which are readily recognisable without resort to the analytical methods used. However, the use of such methods enables numerical comparisons to be made between areas and the descriptions are simplified to give a pen picture of the type of vegetation involved. Brief names have been given to the 32 vegetation types (Table 3.1). They are designed for the non-specialist and break many of the rules usually adhered to in phytosociological work. The first division in the hierarchy is based on species that indicate a broad separation into upland and lowland vegetation types. However, upland vegetation types can occur in the lowlands and vice versa. It is generally true that the lowland species are very limited in their occurrence in the uplands; whereas the upland species are present much more commonly in the lowlands. The next division on the lowland side separates a group of species generally indicative of cultivated land from one generally associated with non-cultivated pasture. On the upland side the corresponding division divides a group of species particularly linked to moorland situations as opposed to those that are widespread components of upland grassland. It is also possible to separate in general terms the next division. Such major separations are not usually so easy to make in numerical analyses and are attributable to the scale of the survey and the range of vegetation covered. Within the lowland cultivated group the next division is with species most commonly present in reseeded leys as opposed to those associated with arable land. Within the non-cultivated lowland division the separation in many respects parallels this, in that species characteristic of reseeded or improved pastures are distinguished from those from permanent pastures, ie less intensively managed. Within the moorland series the separation is on the basis of species characteristic of badly drained situations as opposed to species linked to relatively well

Fig. 3.1

The 48 sample squares used for further surveys

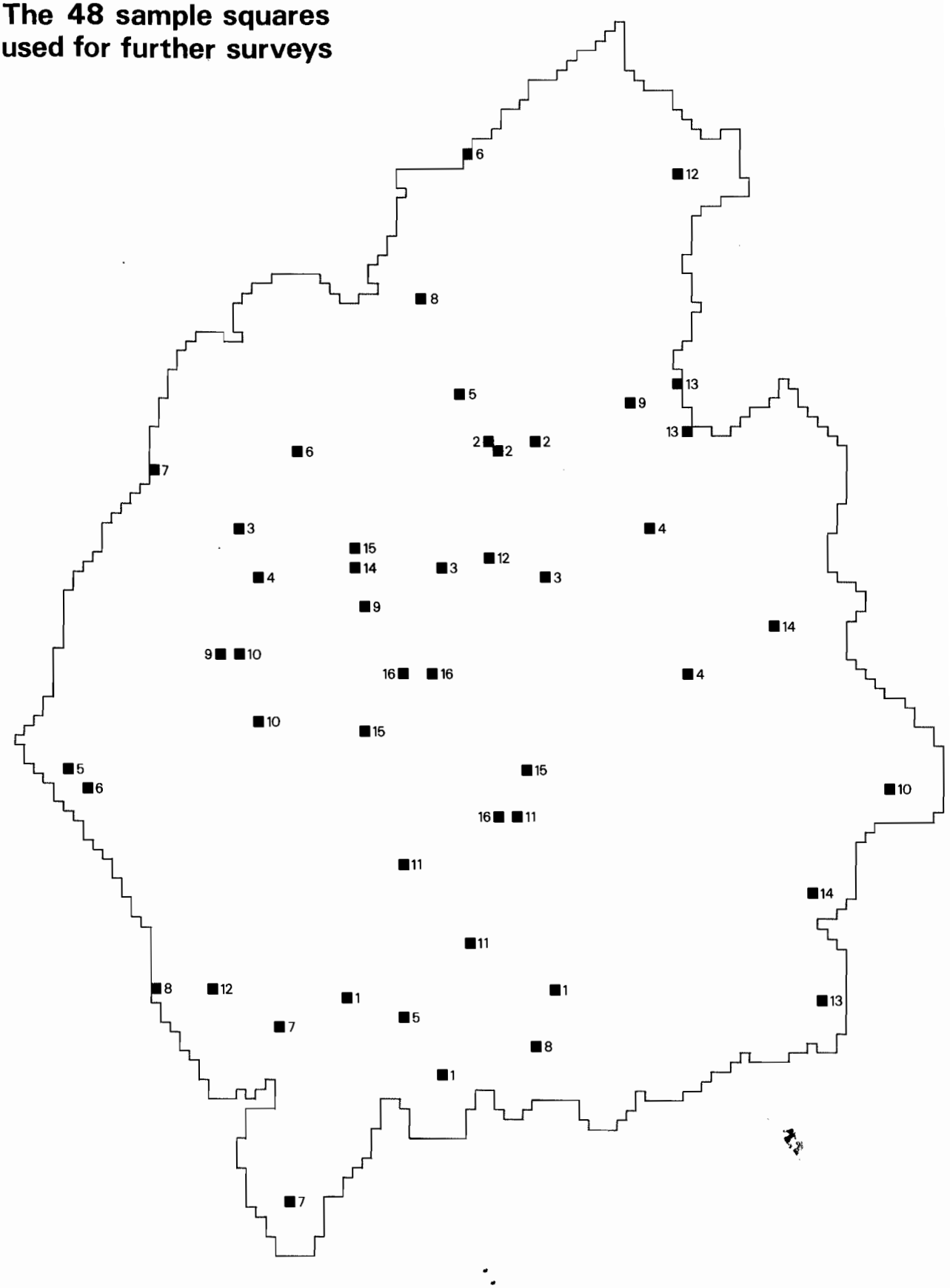


Fig. 3.2
Analysis procedures: vegetation classification

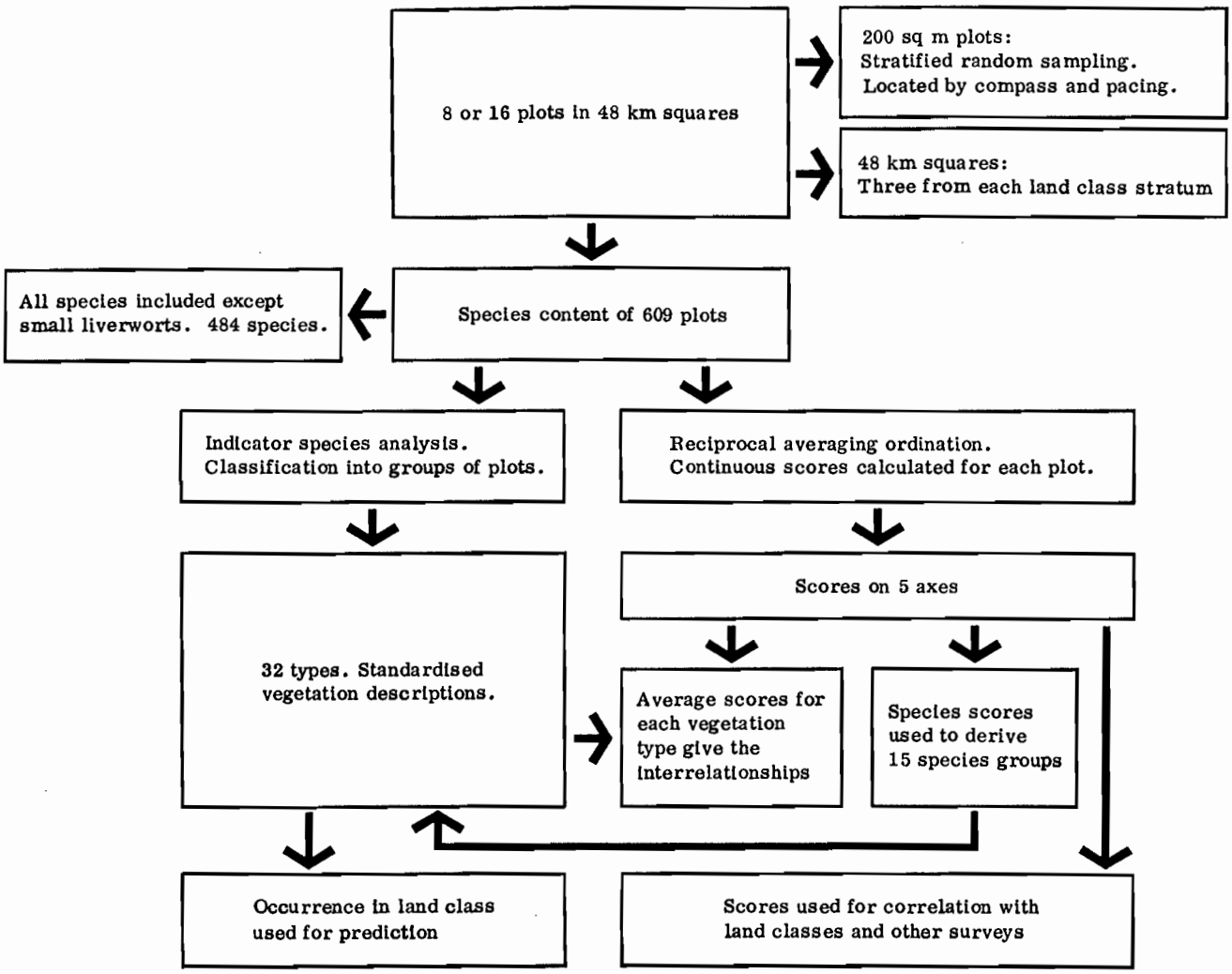
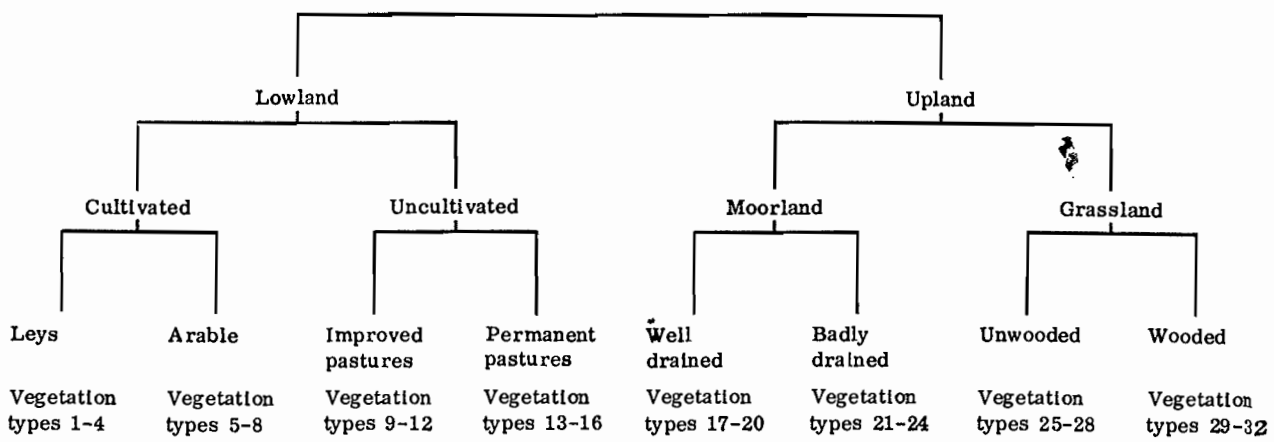


Fig. 3.3
Hierarchy of the vegetation analysis



drained slopes within the moorland context. The final divisions (types 24-32) are more difficult to interpret but the general separation is between species generally common in unwooded grasslands and those with woodland of some description.

TABLE 3.1
STANDARDISED NAMES FOR VEGETATION TYPES WITH A SIMPLIFIED INTERPRETATION OF THE PRINCIPLE HABITAT FEATURES

5	Matricaria matricoides/Hordeum vulgare	Arable fields
8	Polygonum lapathifolium/Hordeum vulgare	" "
7	Convolvulus arvensis/Hordeum vulgare	" "
6	Polygonum persicaria/Hordeum vulgare	" "
1	Lolium multiflorum/Lolium perenne	Short term leys
2	Phleum pratense/Lolium perenne	Long term leys
3	Rumex obtusifolius/Lolium perenne	Invaded leys
4	Arrhenatherum elatius/Lolium perenne	Arable hedgerows
9	Poa trivialis/Lolium perenne	Recently improved pasture
10	Achillea millefolium/Lolium perenne	Improved pasture
11	Crataegus monogyna/Lolium perenne	Hedgerows associated with 9
12	Geum urbanum/Lolium perenne	Hedgerows associated with 10
13	Sagina procumbens/Trifolium repens	Permanent pasture
14	Festuca pratensis/Cynosurus cristatus	Old permanent pasture
16	Filipendula ulmaria/Agrostis tenuis	Complex marginal habitats
15	Veronica chamaedrys/Agrostis tenuis	Upland permanent pasture
32		Sitka spruce plantations
30	Carex sylvatica/Deschampsia caespitosa	Basic woodland
29	Lonicera periclymenum/Deschampsia caespitosa	Neutral/acid woodland
28	Cardamine pratensis/Agrostis tenuis	Mineral flushes
26	Sieglingia decumbens/Pteridium aquilinum	Rocky, damp slopes
31	Dryopteris dilitata/Pteridium squilinum	Acid woodland
27	Epilobium palustre/Juncus effusus	Wet, mineral flushes
25	Festuca ovina/Pteridium aquilinum	Steep, mountain slopes
24	Carex demissa/Calluna vulgaris	Peat flushes
18	Pseudoscleropidium purum/Pteridium aquilinum	Rocky grassland
21	Sphagnum recurvum/Juncus effusus	Acid seepages
20	Erica cinerea/Pteridium aquilinum	Rocky moorland
17	Polytrichum commune/Nardus stricta	Moorland
19	Hylocomium splendens/Nardus stricta	High level slopes
22	Eriophorum vaginatum/Calluna vulgaris	Blanket peat
23	Trichophorum caespitosum/Calluna vulgaris	High level peat

Note:
Vegetation types are ordered according to their relative similarity to each other.

When the series is recorded according to their relative positions on the first axis of the ordination, taking groups of four types rather than the individual positions, the following sequence is produced which shows the relationships between the groups of types, those next to each other being the most similar in terms of their species composition.

Types 5-8 Lowland cultivated arable
" 1-4 Lowland cultivated leys
" 9-12 Lowland uncultivated improved pasture
" 13-16 Lowland uncultivated permanent pasture
" 29-32 Upland grassland wooded
" 25-28 Upland grassland unwooded
" 17-20 Upland moorland well drained
" 21-24 Upland moorland badly drained

3.2.3 Constant species are those that occur with a frequency of 100% in any one vegetation type. The distribution of the 22 constant species amongst the vegetation types is given in Table 3.2. The principal cover species are those that occur with over 5% average cover in more than one vegetation type. The 30 species are distributed amongst the vegetation types as shown by Table 3.3. Only 9 out of 30 species forming the cover also appear in the constant species list, indicating that although a species may be frequent it does not necessarily have a high cover eg Galium saxatile. The species cover patterns show greater contrasts than constancy patterns with fewer species achieving high values, notably Lolium perenne in vegetation types 1-16 and Pteridium aquilinum and Nardus stricta in types 17-24. However, all the species show well defined patterns and emphasise the strength of the associations within the vegetation data in that a similar trend is running through the cover values, even though the classification is determined on attribute data.

3.2.4 As a summary of the vegetation analysis, it is useful to provide a list of the types together with some indication of their characteristics.

TABLE 3.2
CONSTANT SPECIES IN THE VEGETATION TYPES

	Vegetation Type																												
	5	8	7	6	1	2	3	4	9	10	11	12	13	14	16	15	30	29	28	26	31	27	25	24	18	21	20	17	19	22	23
Polygonum lapathifolium	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hordeum vulgare	46	100	80	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum persicaria	55	100	60	88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum aviculare	100	67	30	63	19	0	56	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lolium perenne	82	100	30	75	100	100	92	100	93	94	92	91	89	57	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dactylis glomerata	9	50	10	63	22	76	84	100	55	77	100	91	0	0	91	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa trivialis	9	100	80	0	63	83	60	43	85	83	58	82	83	0	73	73	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus repens	27	83	100	63	88	86	92	64	98	89	100	92	100	74	91	87	0	0	88	0	0	87	0	0	0	0	0	0	0	0	0
Crataegus monogyna	0	0	0	0	0	0	0	64	0	0	100	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Holcus lanatus	9	0	0	50	0	45	76	86	95	89	92	91	94	100	100	100	0	0	0	77	0	93	25	0	0	30	0	0	0	0	0
Thuidium tamariscinum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	25	0	22	0	0	0	0	0	0
Cirsium palustre	0	0	0	0	0	0	0	0	0	0	0	0	78	78	100	0	0	0	69	0	0	73	10	0	0	0	0	0	0	0	0
Agrostis tenuis	0	0	0	38	0	0	32	0	78	86	75	73	50	100	0	100	0	0	100	100	0	73	100	0	100	53	89	97	88	26	41
Anthoxanthum odoratum	0	0	0	0	0	0	0	0	28	37	0	73	83	74	100	80	0	0	94	92	0	100	90	75	94	87	70	77	94	38	50
Potentilla erecta	0	0	0	0	0	0	0	0	0	0	0	0	50	65	91	93	0	0	69	92	0	93	75	100	78	87	48	63	69	31	64
Rhytidiadelphus squarrosus	0	0	0	0	0	0	0	0	0	0	0	0	50	87	100	93	0	0	75	92	0	93	70	0	94	66	26	63	75	67	0
Galium saxatile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	100	0	100	100	67	100	93	96	90	94	67	64
Festuca ovina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	100	0	93	100	100	94	87	82	97	84	79	46
Carex panicea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	19	0	0	0	0
Nardus stricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	62	0	93	75	100	89	62	56	97	94	62	73
Deschampsia flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	77	0	53	90	0	100	94	96	100	94	91	73
Sphagnum rubellum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	25	0	91

The naming of vegetation types produced by numerical analysis has long been a problem and no final satisfactory solution has been produced. A major danger is that summary titles of a few words can only provide an indication of the overall characteristics of the type and cannot necessarily be used to identify that type, as has widely been the custom with traditional classification. The danger is therefore oversimplification, particularly where convergent types are involved ie types that have a similar assemblage of species that have been derived from different combinations of environmental conditions. Another major problem is that it is often tempting to combine habitat terms with the species, eg 'heather moor', whereas this procedure confuses the predicted (ie the habitat factors) with the predictor (ie the vegetation). It is the latter that determines the types not the former, although many ecologists immediately derive the characteristics of the type through its species composition. The most useful procedure that has been found previously is to provide two species names for each type, giving a binomial system, the first name being that species which occurs on average more in that type than any other and the second from the species that has the highest average cover value in the type. In addition, in the present analysis it has been possible to attach general habitat names to many of the types and accordingly these are given in Table 3.2 which includes all the names. Some types are given the same habitat name since they are variants relating to management and are not from separate habitat types.

3.2.5 For an overall view of the types of vegetation produced by the analysis each type is discussed below in broad terms. The types are taken in the groups of four described above and are given in the same order.

Types 5-8:
Lowland cultivated arable.
These are the most uniform of all the types with species from lowland pasture, leys and arable habitats being frequent. The differences between the types are partly determined by management and partly by the underlying geology. Types 5 and 6 are the most uniform both being most common in the Eden Valley; type 5 consisting mainly of weed species and type 6 often also having a wide range of other crop plants. Types 7 and 8 have a wide range of species present and are distributed generally in richer soils mainly on the Solway Plain and elsewhere on the coastal plain. Type 7 is perhaps indicative of soils with a higher nitrogen content and type 8 is more associated with sandier soils. This group has little differentiation between the types in comparison with the majority of groups described below.

Types 1-4:
Lowland cultivated leys.
These types are more variable than those discussed above. Type 4 stands out as being rather different since it has hedgerows represented in addition to species from permanent pastures, lowland pastures and leys which are mainly present in the other types. Although this group of types is most widespread in the Eden Valley it occurs widely throughout the lowlands. Within the types 1-3 the distinctive features are mainly related to management, in terms of the time that has elapsed since reseeding and the consequent stage of colonisation by other species. Thus type 2 is primarily recently sown leys, whereas type 3 has accumulated more species. Type 1 is the simplest and most closely related

TABLE 3.3
PRINCIPAL COVER SPECIES IN THE VEGETATION TYPES

	Vegetation type																												
	5	8	7	6	1	2	3	4	9	10	11	12	13	14	16	15	30	29	28	26	31	27	25	24	18	21	20	17	19	22	23
Solanum tuberosum	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hordeum vulgare	39	45	52	36	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Matricaria matricoides	5	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lolium multiflorum	2	0	7	9	8	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phleum pratense	1	0	0	4	9	6	3	5	2	0	2	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa annua	1	4	2	0	2	1	3	2	1	1	1	2	6	0	2	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
Lolium perenne	4	8	2	21	46	52	36	39	26	18	23	9	7	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dactylis glomerata	0	1	0	1	1	10	2	3	2	4	4	4	0	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poa pratensis	1	5	10	1	4	1	5	3	4	1	1	2	0	0	3	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Poa trivialis	1	2	2	0	3	5	4	3	12	8	3	9	8	5	5	5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Cynosurus cristatus	0	0	0	0	0	0	0	0	3	6	1	1	6	13	1	6	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium repens	0	6	0	1	11	9	8	4	9	6	8	2	8	3	1	4	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0
Agrostis stolonifera	0	2	2	1	0	2	4	3	3	2	4	3	6	3	2	1	3	0	2	0	0	0	0	0	0	1	0	0	0	0	0
Holcus lanatus	0	0	0	3	0	1	2	1	4	7	4	4	4	11	5	7	2	0	6	3	0	2	1	0	0	0	0	0	0	0	0
Festuca rubra	0	0	0	0	0	0	0	1	3	9	1	2	3	8	3	5	1	0	2	2	0	0	0	0	0	1	0	0	0	0	0
Juncus articulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	9	2	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0
Agrostis tenuis	0	0	0	2	0	0	1	0	5	11	2	4	4	12	6	23	1	1	13	22	5	8	11	4	12	3	7	11	7	1	1
Juncus effusus	0	0	0	0	0	0	0	0	0	0	0	0	4	2	5	0	0	0	4	1	0	25	2	1	1	17	0	2	0	1	1
Anthoxanthum odoratum	0	0	0	1	0	0	0	0	0	1	0	3	5	3	6	6	2	2	5	10	0	7	6	1	5	4	1	5	1	2	0
Pteridium aquilinum	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	1	3	0	24	22	1	23	13	20	1	45	3	5	0	0
Festuca ovina	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	7	0	0	10	9	0	7	18	2	13	8	10	16	6	5	1
Molinia caerulea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8	0	2	0	0	0	0	0
Nardus stricta	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3	1	0	8	6	14	14	7	4	23	39	8	6
Deschampsia flexuosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6	3	3	1	6	8	9	5	7	6	1
Vaccinium myrtillis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	1	6	1	3	3	7	7	1
Juncus squarrosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	1	1	3	10	0	7	9	13	15
Calluna vulgaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	17	5	1	5	7	5	24	25
Erica tetralix	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1
Trichophorum caespitosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	11
Eriophorum vaginatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0

to the arable types. Type 4 however mainly consists of plots that have included an element of hedgerow species and also tends to be on soils of a higher base status.

Types 9-12:

Lowland uncultivated improved pasture.

The types that are nearer the centre of the overall lowland/upland trend tend to become more heterogeneous and have more species present. A wide range of different elements is present with species from lowland pastures and permanent pastures the most common, but with species from leys, hedgerows, woodlands, and upland grasslands also present. Within the types the differences are mainly upon the degree of agricultural improvement that has taken place and upon the extent and composition of hedgerows within the sample area. The main difference between types 9 and 10 is that the former contains a narrower range of species and has been more extensively improved. Types 11 and 12 are both associated with hedgerows, type 11 being more closely related to the less diverse pastures of type 9, and type 12 similarly to type 10. There are also other differences in that type 12 is more closely linked to woodland. The types have similar distributions in the county, being widely distributed in the lowlands.

Types 13-16:

Lowland uncultivated permanent pasture.

This group contains the most heterogeneous types of the 32 identified. Although the most abundant species are similar to the previous group of types there is a wide range of other species present. Type 13 is particularly common in the Eden Valley and has the strongest affinities with the previously described types. It has, however, a more acid soil and is more variable in its species content. Type 14 contains less well managed permanent pasture with impeded drainage and has a more pronounced upland element than type 13 also mainly in the Eden Valley. Types 15 and 16 are separated from the previous types as they represent the poorer (in nutrient terms) permanent pastures elsewhere in Cumbria away from the Eden Valley. The difference between these types rests mainly in type 16 being associated with additional habitats, such as hedges and streams, in addition to the permanent pasture.

Types 29-32:

Upland grassland wooded.

This group of types contained few plots in the analysis because of their relatively infrequent occurrence in the county. They are therefore relatively ill defined. The vegetation is in general very heterogeneous with a wide range of species but in relatively low numbers. Species from open woodlands, woodlands and upland grasslands are the only ones to be present in any numbers but a wide range of other species are present intermittently. The small number of plots comprising these types makes it difficult to give sufficient general descriptions of them. However types 29 and 30 have species from slightly higher pH conditions, whereas types 31 and 32 are from very acid situations with 31 representing generally acidic oak/birch woodland and 32 consisting largely of dense plantations of spruce. Woodland as a habitat type is so distinctive that plots falling within woodland may be referred to a detailed key for woodland types (Bunce et al, in press).

Types 25-28:

Upland grassland unwooded.

This group of types is extremely variable in the species present. Moreover the species present are from the widest range of habitat types, from the lowland grasslands to those with mainly upland affinities. Thus the species most abundantly represented are from general moorland, upland grassland, permanent grass and lowland pasture. The differences between the types within this group are rather pronounced. Thus type 25 contains steep, freely drained slopes with' shallow soils and is relatively poor in species and acidic in comparison with the other types. Type 26 is more widespread and represents more rocky situations than type 25 with rock outcrops emerging from rather damper slopes often associated with steamsides. Both these types have bracken forming the dominant ground cover whereas types 27 and 28, both being flush types, have Juncus effusus (27) and Agrostis tenuis (28) as their main ground cover species. Type 27 is more characteristic of flushes in peat reflected in the deep organic horizon whereas type 28 contains predominantly mineral flushes (reflected in the higher pH).

Types 17-20:

Upland moorland well drained.

These types are all relatively homogeneous but are still more variable than types 5-8. They are all widespread throughout the mountains and form the background vegetation throughout much of this zone. The widespread species are from general moorland, upland grassland and rocky slopes. Type 17 primarily consists of Nardus grasslands on mountainous slopes at intermediate elevations, with rather poor drainage and deep surface litter. Type 18 represents similar slopes that are broken by rocky outcrops with bracken as the major cover species and with a wider range of species present. Types 19 and 20 are in some respects parallel to the previous types in that they are dominated by Nardus and bracken respectively. The former type is at higher altitudes on steep slopes whereas the latter is from rockier situations which are more freely drained and extend into the lowlands.

Types 21-24:

Upland moorland badly drained.

These types are more variable than those in the previous group. The main species present are from general moorland and upland grassland but those from peaty situations are also common. Type 21 stands out as being very different from the other three types being characteristic of very wet valley bogs in the uplands with Juncus effusus growing on a deep organic layer. However, the

types are readily separated on both vegetation and environmental characters. Thus type 22 comprises the characteristic blanket peat bogs of the Pennines, whereas 23 is a comparable type found at higher altitudes mainly in the central Lake District fells. Type 24 on the other hand comprises a rich collection of species associated with flushes in streams with a mineral bottom in otherwise peaty situations.

3.3 THE DISTRIBUTION OF THE VEGETATION TYPES

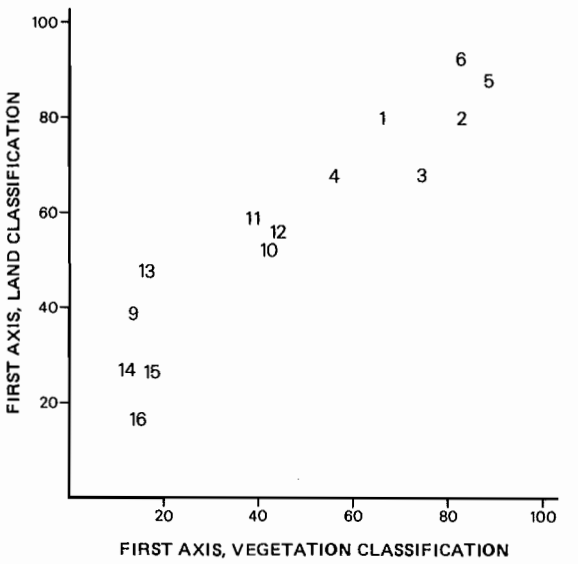
3.3.1 Table 3.4 shows the relationship between the 8 groups of vegetation types and the land classes. The ordering of land classes and vegetation types according to their similarities, ie their first RA axis scores, simplifies a complex situation and results in a diagonal structure illustrating the strength of the correlation between the two classifications. Divergences from the overall trend reveal features concerning particular land classes. Land class 10, for example, contains an appreciable proportion of improved pasture (vegetation types 9-12) because it contains valley bottom land amongst the mountains. Land classes 5 and 2 contain the highest proportions of the arable vegetation types 5-8, although they are not at the extreme lowland end of the land class trend.

3.3.2 A detailed comparison may be obtained by examining the occurrence of the individual vegetation types in the land classes (Table 3.5). The diagonal element is again well defined, as well as the continuity between the groups overall. Individual vegetation types show patterns that can readily be interpreted in relation to the land classes. The pattern of such occurrences, based as it is on the whole of Cumbria, can be used as a norm against which the character of sub regions or sites within the county can be compared.

3.3.3 In order to examine the statistical correlations between the land classes and the vegetation types, the land classification was held constant and used as the framework for the comparison. The strongest correlation is between the first axes of both analyses showing that the major trends run parallel to each other (Table 3.6). The second axis of the land classification also shows a high correlation with the first axis of the vegetation classification partly because it is not orthogonal to the first axis and partly because it represents slope rather than direct altitude. Other significant correlations are present and represent complex patterns that are difficult to interpret in detail. The scatter of points showing the correlation between the first axes of both analyses is evenly spread along each axis indicating that the high coefficient is not an artefact (Fig 3.4).

Fig. 3.4

Correlation between the first axes of the vegetation and land classifications



Note: Classes 7 and 8 (estuarine sand and mud and sea coast) absent due to lack of co-ordinates on vegetation axis

TABLE 3.4
COMPOSITION OF THE LAND CLASSES IN TERMS OF THE 8 VEGETATION GROUPS

	Land Class														
Vegetation group:	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
Lowland cultivated arable (5 - 8)	15	10	40	0	15	0	0	0	0	0	0	0	0	0	0
Lowland cultivated leys (1 - 4)	25	53	35	25	57	14	21	0	9	2	0	0	0	0	0
Lowland uncultivated improved pasture (9 - 12)	30	30	12	43	13	36	19	10	9	23	0	0	0	0	0
Lowland uncultivated permanent pasture (13 - 16)	3	5	3	12	10	4	54	23	28	15	0	0	0	3	0
Upland grassland wooded (29 - 32)	0	3	5	5	3	7	4	3	3	2	0	0	0	0	0
Upland grassland unwooded (25 - 28)	0	0	0	8	3	7	0	35	16	23	5	34	5	20	7
Upland moorland well drained (17 - 20)	0	0	5	8	0	20	0	20	25	25	43	3	25	38	46
Upland moorland badly drained (21 - 24)	0	0	0	0	0	7	2	10	9	11	53	63	70	40	48

Notes:
Land class 7 has been omitted because it is estuarine
Both land classes and vegetation groups are ranked in order of their first RA axis scores

3.3.4 The strength of these correlations justifies characterising the land classes in terms of their most constant species, their principal cover species and their most frequent vegetation types. This is given in Table 3.7 from which a general impression can be gained of the composition of each land class. The trend through the series of land classes shows the high degree of correlation with the vegetation analysis in the general gradient from lowland to upland.

3.3.5 Predictions can be made about the vegetation types found in the whole of Cumbria on the basis of the km squares sampled from the land class strata. Without high correlations between the land class analysis and the vegetation analysis this could still be done. However, in this case the accuracy of the predicted distributions would be poor. The high correlations actually achieved enables a high level of confidence to be placed in the distributions of the vegetation types predicted from the frequencies of each vegetation type in each land class. The broad separation of lowland vegetation types 1-16 and upland vegetation types 17-32 (Figs 3.5 and 3.6) produces a readily interpretable picture of the major division of the vegetation of the county. A note worthy feature is that upland vegetation can occur widely, albeit infrequently, in the lowlands, but the converse is not true.

TABLE 3.5
PERCENTAGE FREQUENCY OF THE VEGETATION IN THE LAND CLASSES

		Land Class														
Vegetation type:		8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
5	Arable fields	10.0	2.5	0.0	0.0	10.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Arable fields	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Arable fields	0.0	2.5	22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	Arable fields	5.0	5.0	2.5	0.0	5.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	Short term leys	7.5	20.0	12.5	2.5	25.0	5.4	2.1	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0
2	Long term leys	5.0	15.0	5.0	2.5	17.5	5.4	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Invaded leys	5.0	12.5	7.5	17.5	10.0	1.8	2.1	0.0	3.1	2.1	0.0	0.0	0.0	0.0	0.0
4	Arable hedgerows	7.5	5.0	10.0	2.5	5.0	1.8	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0
9	Recently improved pasture	12.5	10.0	2.5	15.0	5.0	10.7	8.3	2.5	9.4	16.7	0.0	0.0	0.0	0.0	0.0
10	Improved pasture	12.5	2.5	5.0	15.0	5.0	16.1	10.4	5.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0
11	Hedgerows associated with 9	5.0	12.5	5.0	2.5	2.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	Hedgerows associated with 10	0.0	5.0	0.0	10.0	0.0	7.1	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	Permanent pasture	2.5	2.5	2.5	0.0	7.5	1.8	16.7	0.0	6.3	2.1	0.0	0.0	0.0	0.0	0.0
14	Old permanent pasture	0.0	0.0	0.0	0.0	2.5	0.0	31.3	5.0	9.4	4.2	0.0	0.0	0.0	0.0	0.0
16	Complex marginal habitat	0.0	0.0	0.0	7.5	0.0	0.0	4.2	5.0	9.4	2.1	0.0	0.0	0.0	0.0	0.0
15	Upland permanent pasture	0.0	2.5	0.0	5.0	0.0	1.8	2.1	12.5	3.1	6.3	0.0	0.0	0.0	2.5	0.0
32	Sitka spruce plantations	0.0	0.0	0.0	0.0	0.0	1.8	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	Basic woodland	0.0	2.5	0.0	5.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	Neutral/acid woodland	0.0	2.5	0.0	0.0	0.0	3.6	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0
28	Mineral flushes	0.0	0.0	0.0	0.0	2.5	0.0	0.0	12.5	0.0	6.3	0.0	12.5	0.0	7.5	0.0
26	Rocky, damp slopes	0.0	0.0	0.0	7.5	0.0	3.6	0.0	10.0	0.0	6.3	2.5	0.0	0.0	0.0	0.0
31	Acid woodland	0.0	0.0	2.5	0.0	2.5	1.8	0.0	2.5	0.0	2.1	0.0	0.0	0.0	0.0	0.0
27	Wet mineral flushes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.3	0.0	0.0	18.8	5.0	2.5	6.8
25	Steep mountain slopes	0.0	0.0	0.0	0.0	0.0	3.6	0.0	10.0	9.4	10.4	2.5	3.1	0.0	10.0	0.0
24	Peat flushes	0.0	0.0	0.0	0.0	0.0	7.1	0.0	7.5	0.0	0.0	0.0	0.0	0.0	12.5	0.0
18	Rocky grassland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	3.1	4.2	12.5	0.0	0.0	12.5	9.1
21	Acid seepages	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.5	6.3	6.3	17.5	43.8	22.5	5.0	18.2
20	Rocky moorland	0.0	0.0	5.0	7.5	0.0	16.1	0.0	17.5	0.0	8.3	2.5	0.0	0.0	2.5	0.0
17	Moorland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.9	0.0	10.0	3.1	15.0	7.5	22.5
19	High level slopes	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	12.5	17.5	0.0	10.0	15.0	15.9
22	Blanket peat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	2.1	35.0	18.8	37.5	0.0	11.4
23	High level peat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	10.0	22.5	18.2

TABLE 3.6
CORRELATIONS BETWEEN THE AXES OF THE LAND AND VEGETATION ANALYSES

Land class axes	1	1.00											
	2	-0.93***	1.00										
	3	-0.19	0.45	1.00									
	4	0.11	0.03	0.02	1.00								
	5	-0.07	0.00	0.27	-0.47	1.00							
Vegetation type axes	1	0.96***	-0.88***	-0.07	0.08	0.00	1.00						
	2	0.11	-0.30	-0.50*	0.01	0.06	0.00	1.00					
	3	0.36	-0.17	0.27	0.20	0.18	0.35	-0.50*	1.00				
	4	0.19	-0.01	0.29	0.25	-0.06	0.24	-0.50*	0.61*	1.00			
	5	-0.53*	0.57*	0.31	-0.51*	-0.05	-0.52*	-0.46	-0.17	-0.07	1.00		
		1	2	3	4	5	1	2	3	4	5		
		Land class axes					Vegetation class axes						

*significant at 5% probability
***significant at 0.1% probability

Fig. 3.5

Predicted distribution of lowland vegetation types 1-16

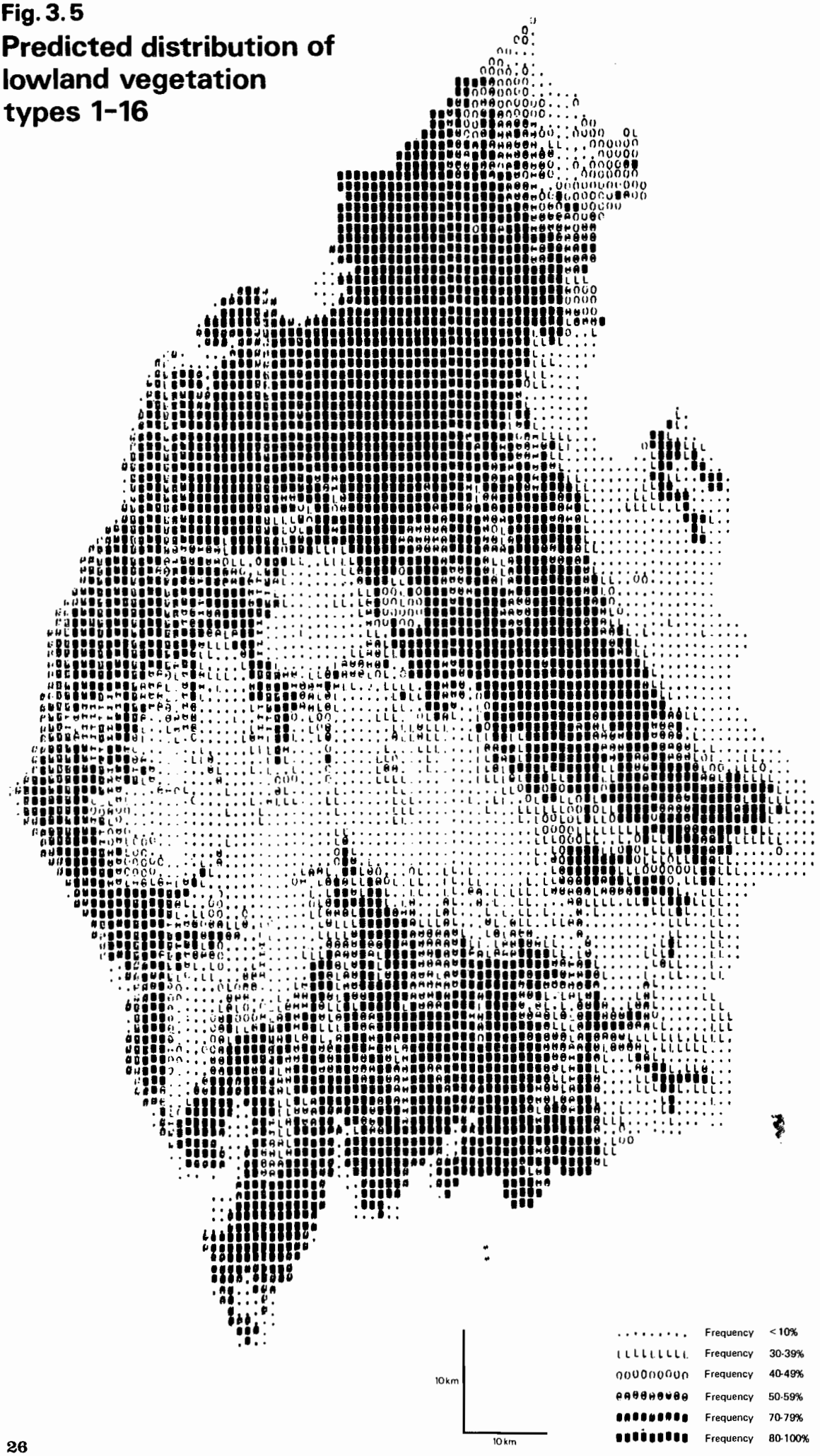


Fig. 3.6

Predicted distribution of upland vegetation types 17-32

Fig. 3.7

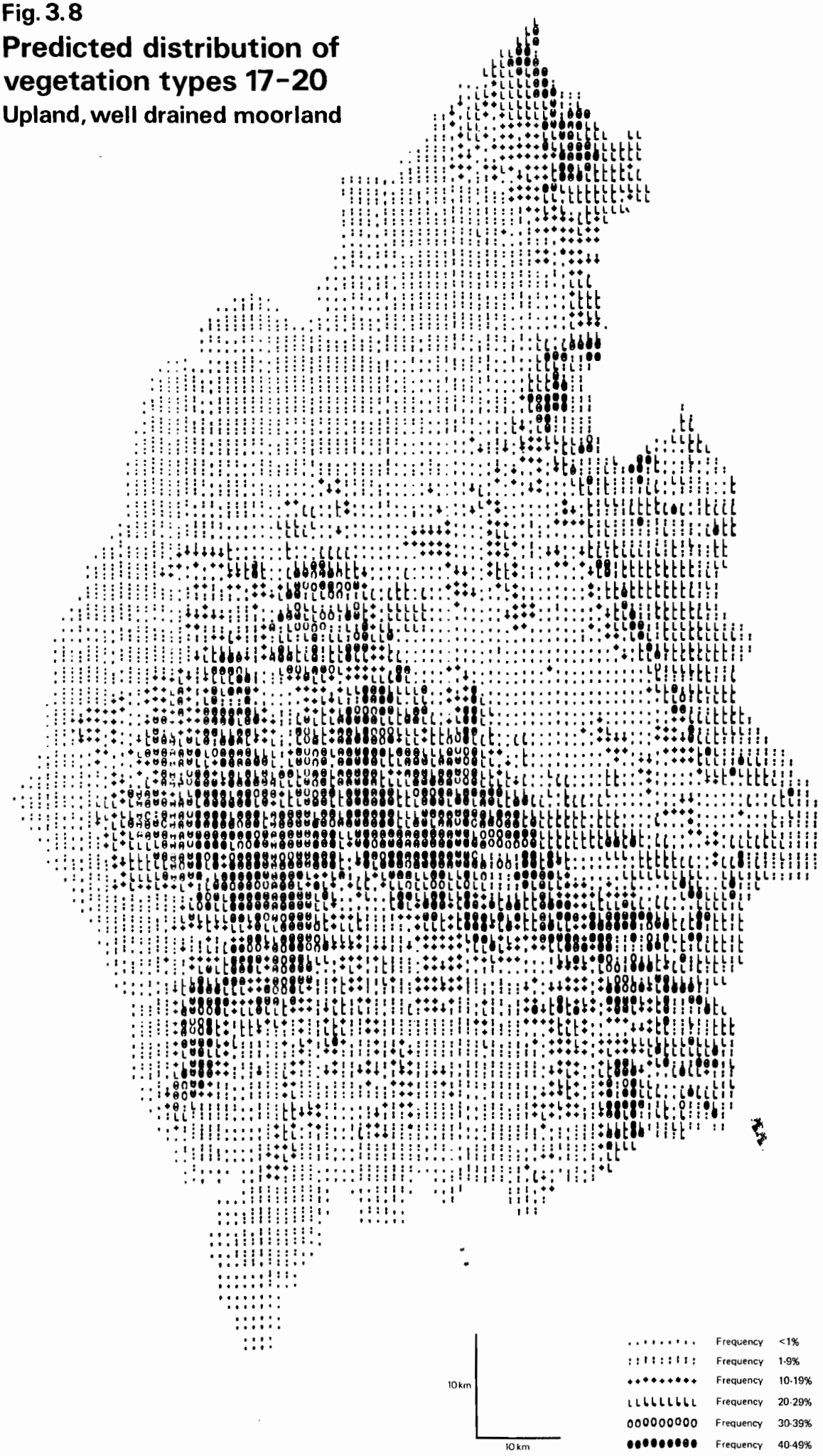
Predicted distribution of vegetation types 1-4

Lowland, cultivated leys

Fig. 3.8

Predicted distribution of vegetation types 17–20

Upland, well drained moorland



3.3.6 Table 3.4 gives the relative frequencies of the 8 main groups of vegetation types in each land class. The predicted distribution of lowland cultivated leys (vegetation types 1-4) shows that it is a fairly widespread group (Fig 3.7) with a complex pattern, as would be expected since leys can be created wherever the land is ploughable. There is, however, a greater concentration in the Eden Valley than elsewhere and, to a lesser extent, on the Solway Plain and the coastal and southern lowlands. Well drained upland moorland shows a greater concentration in the mountains of the central Lake District than in the Pennines (Fig 3.8), the latter having a preponderance of badly drained upland moorland (Table 3.4).

3.3.7 The patterns shown by these groups of vegetation types can be related to recognisable features of the land of the county. Rapid impressions can be gained of the probable patterns present in different areas. These patterns are at a high level in the analysis of the vegetation data and, to enable examinations to be made of particular areas in more detail, distributions can be predicted for each of the vegetation types. The relative frequencies of the vegetation types in each land class are shown in Table 3.5. The distributions, whether they be diffuse or discrete, reflect actual contrasts in the ecological characteristics of the vegetation types. They can provide interpretable information regarding special features, eg vegetation type 23 (high level peat) indicates areas where problems could arise from peat erosion.

3.4 THE VEGETATION RESOURCE

3.4.1 In assessing the total vegetation resource for the county, the proportions of the vegetation types, as estimated by their frequency in the vegetation analysis, need to be corrected for the relative abundance of the relevant land class (Table 3.8). In order to be an abundant vegetation type overall, a vegetation type needs not only to be common within a land class but also to be in a common land class. The overall estimates for the 8 groups of vegetation types show that badly drained moorland, whilst being the most common type in the vegetation analysis, gives way to leys and improved pastures when corrected for the frequency of the land classes. Such a conclusion fits better with general observations in that the majority of the county's area is lowland, although the mountains are an obvious feature, and lowland vegetation would be expected to be more common.

3.4.2 Of the individual vegetation types the following are the eight most common:

	% frequency
9 Recently improved pasture	7.1
10 Improved pasture	7.1
21 Acid seepages	6.9
1 Short term leys	6.7
22 Blanket peat	6.1
2 Long term leys	5.7
20 Rocky moorland	5.2
17 Moorland	4.0
	48.0

TABLE 3.7
THE VEGETATION CHARACTER OF THE LAND CLASSES

Land class	Constant species	Principal cover species	Most frequent vegetation type	Features of the main groups of vegetation types
7	-	-	-	Estuarine ecosystems comprising mud flats with some seaweed and Zostera species.
8	Cirsium arvense	Lolium perenne	9 Recently improved pastures	An almost equal proportion of improved pasture and leys but with an appreciable amount of maritime vegetation.
6	Rumex obtusifolius	Lolium perenne	1 Short term leys	Predominantly leys with a high proportion of improved pasture.
5	Plantago major	Hordeum vulgare	7 Arable fields	Mainly arable but with a high proportion of leys.
1	Achillea millefolium	Lolium perenne	3 Invaded leys	More variable than the above; improved pasture predominates but with a high proportion of leys.
2	Phleum pratense	Lolium perenne	1 Short term leys	Contains the highest proportion of arable but has a wide range of other groups.
4	Veronica chamaedrys	Pteridium aquilinum	10 Improved pasture	Marginal class with mainly improved pasture but also well drained moorland.
3	Cynosurus cristatus	Lolium perenne	14 Old permanent pasture	Mainly permanent pasture but with leys and improved pastures present.
11	Pteridium aquilinum	Agrostis tenuis	20 Rocky moorland	Mainly upland grassland but with permanent pasture and well drained moorland.
12	Potentilla erecta	Pteridium aquilinum	17 Moorland	Similar amounts of well drained moorland and permanent pasture.
10	Rumex acetosa	Agrostis tenuis	9 Recently improved pastures	Half is upland unwooded grassland and well drained moorland; but with improved pasture.
9	Juncus squarrosus	Calluna vulgaris	22 Blanket peat	Upland moorland similar to land classes 14 and 16 but at a lower altitude.
13	Luzula multiflora	Juncus effusus	21 Acid seepages	Parallel differences occur with land class 14 as between 15 & 16 Thus although mainly badly drained moorland there is much upland grassland.
14	Empetrum nigrum	Vaccinium myrtillus	22 Blanket peat	More badly drained moorland than 13 and well drained moorland replaces upland grassland.
15	Nardus stricta	Calluna vulgaris	23 High level peat	Mainly badly drained moorland with much well drained moorland and upland grassland.
16	Juncus squarrosus	Nardus stricta	17 Moorland	As with class 14, 16 is a more extreme version of, in this case, class 15 with a higher proportion of badly drained moorland and well drained moorland.

These give a further impression of the overall ecology of the county and, when compared with Table 3.7, again show the polarisation at either end of the vegetation trend emphasising the contrast between upland and lowland. Almost 50% of the county is covered by the eight most common vegetation types indicating the degree of uniformity present. There is something of a gap between the high frequency vegetation types and the remainder which have more uniform frequencies ie 10 types are between 0.1 and 1.9%, 14 between 2.0 and 3.9% and only 3 between 4.0 and 5.9% and 5 between 6.0 and 7.9% indicating that the less frequent types are superimposed on top of a more uniform background. An overall picture of the county has now been obtained that can be used as a basis for comparison not only with sub regions within the county but at a later date with other counties. The important principle involved here is that a baseline has been drawn from which standardised comparisons can be made. Although numerical analysis is involved as well as a sampling procedure, the ecological conclusions are straightforward.

TABLE 3.8
THE PROPORTIONS OF EACH VEGETATION TYPE IN CUMBRIA

Vegetation type:		Frequency in vegetation analysis (%)	Frequency in Cumbria (%)
5	Arable fields	1.8	2.1
8	" "	1.0	1.7
7	" "	1.6	2.7
6	" "	1.3	1.8
1	Short term leys	5.2	6.7
2	Long " "	4.8	5.7
3	Invaded leys	4.1	3.6
4	Arable hedgerow	2.3	2.9
9	Recently improved pasture	6.6	7.1
10	Improved pasture	5.7	7.1
11	Hedgerows associated with 9	2.0	1.8
12	" " " 10	1.8	2.5
13	Permanent pasture	3.0	3.3
14	Old " "	3.8	3.6
16	Complex marginal habitats	1.8	2.1
15	Upland permanent pasture	2.5	2.3
30	Basic woodland	0.7	1.0
29	Neutral/acid woodland	0.7	0.9
28	Mineral flushes	2.6	2.0
26	Rocky, damp slopes	2.1	2.5
32	Sitka spruce plantations	0.3	0.2
31	Acid woodland	0.8	0.8
27	Wet mineral flushes	2.5	1.9
25	Steep mountain slopes	3.3	2.5
24	Peat flushes	2.0	1.5
18	Rocky grassland	3.0	2.2
21	Acid seepages	7.7	6.9
20	Rocky moorland	4.4	5.2
17	Moorland	4.9	3.5
19	High level slopes	5.3	4.0
22	Blanket peat	6.9	6.1
23	High level peat	3.6	1.6
5-8	Lowland cultivated arable	5.7	8.3
1-4	" " leys	16.4	18.9
9-12	" uncultivated improved pasture	16.1	18.5
13-16	Lowland uncultivated permanent pasture	11.1	11.3
29-32	Upland grassland wooded	2.5	2.9
25-28	" " unwooded	10.5	8.9
17-20	" moorland, well drained	17.6	14.9
21-24	" " badly drained	20.2	16.1

3.5 ACCURACY

3.5.1 There are many sources of error in the prediction of the frequency of vegetation types from the land classes in an area. Such errors can arise through errors in the land classification or errors in the subsequent vegetation classification. Although errors can be made in recording map characteristics and punching the data these seem likely to be small in comparison with the ground survey phases. The main trend in the land classification is very dominant however, making the prediction of individual characteristics related to this trend fairly accurate. Complexes of characteristics will be even more accurately predicted. Isolated attributes unrelated to the main trend clearly cannot be predicted. Adjacent squares are likely to be in the same or closely similar land class as the range of characteristics does not change abruptly across the county. The land classes are segments of a continuum which has been divided for convenience into 16 parts and although it is difficult to attach a precise figure, 95% of squares are likely to be correctly classified.

3.5.2 Some likely errors in the vegetation classification are the same as for the land classification ie the errors involved in translating data into punched computer tape and errors in the analysis. Other arise through misidentification of species in the sample plots although this is not a serious error as not all the species are needed to fix a plot into its vegetation type. This error is particularly relevant to the taxonomically difficult species which in the present survey were grouped as aggregates such as Taraxacum, Hieracium and Betula. The identification of plots using the key generated will lead to errors if the vegetation type is outside the range of samples used to generate the key. This would happen with this key if the plot was from, say, a limestone pavement. Also different observers may have different criteria for a good fit. Some expect every last detail to fit whereas the norm for a given vegetation type may have a large or small range, ie some vegetation types are inherently more variable than others. This is particularly true of the cover species that occur in large amounts locally but not widely in the county.

3.5.3 The most important factor governing the accuracy of the predicted distributions for the vegetation types is the sampling intensity used to characterise the land classes. In this survey only three squares from each land class were sampled in the field. The range of sampling intensities for each land class is given in Table 3.9. Whether or not this is sufficient will depend upon the variability inherent in each land class. Diversity measures have been calculated for the land classes from the subsequent surveys based on them (Table 3.9). Those land classes with

the greatest variability will need a greater sampling intensity to describe that variability than the more uniform land classes. Prediction of the vegetation types in km squares from land classes 1 and 4 will be more liable to error than those for the more uniform km squares in land classes 6, 13, 14, 15 and 16, because the high diversity of land classes 1 and 4 is coupled with a low sampling intensity and vice versa for land classes 6, 13, 14, 15 and 16.

3.5.4 The magnitude of the error in predicting the vegetation types for a given region will therefore depend upon a range of factors of which the land class composition is particularly important. It is difficult, however, to separate errors from divergencies in the region from the norm for Cumbria, as will be shown from the examples below. The difference between observed frequencies measures in the field and the expected frequencies calculated from the land class composition have been examined in three areas in the county.

3.5.5 In the first example (Table 3.10), Outhred (unpublished) carried out a survey of the Howgill Fells examining the vegetation in 54 plots in 4 land classes. The affinities of the vegetation were established by running down the plots in the key to the vegetation types. Differences between the observed and expected frequencies therefore include errors not only from the original survey but also from the second series of recordings and from the identification of plots by the key. Nevertheless, the two major groups are closely comparable and the differences in the grassland frequencies correspond with an increase in the well drained moorland category, reflecting the high abundance of this habitat in the Howgills as compared with that expected in comparable areas throughout Cumbria.

3.5.6 In the second example a rapid survey was made in the Langdale Valley of the land under broad land use categories. The comparable categories within the vegetation types were then estimated from the land class composition in the valley. This enabled a general comparison to be made between observed and expected frequencies that tested the predictive ability of the survey in a general way and also the acceptability of the structural names applied to the vegetation categories. The results (Table 3.11) show that there is a very good general agreement between the predicted and the observed frequencies, particularly when taking into account the difference between the general nature of the field survey and the statistical derivation of the prediction.

3.5.7 The third example is taken from a survey in the parishes of Sedbergh, Dent and Garsdale, currently in progress. Four vegetation plots were completed in each of forty-eight 0.25 sq km squares within the region. The land class composition of these squares was then established. The frequency of vegetation types was predicted

TABLE 3.9
DIVERSITY OF THE LAND CLASSES AND THE SAMPLING INTENSITIES USED FOR THE VEGETATION CLASSIFICATION

Land class	Relative diversity	Frequency in county (%)	Sampling intensity (%)
1	0.52	12.6	0.34
2	0.10	11.0	0.38
3	0.37	7.6	0.56
4	1.00	12.0	0.35
5	0.41	10.9	0.39
6	0.28	4.0	1.06
7	0.00	2.1	2.04
8	0.00	3.3	1.27
9	0.11	8.7	0.48
10	0.61	5.1	0.84
11	0.73	4.8	0.88
12	0.74	3.9	1.08
13	0.23	5.4	0.79
14	0.00	2.9	1.44
15	0.25	1.7	2.48
16	0.06	3.9	1.06

TABLE 3.11
COMPARISON OF OBSERVED AND EXPECTED VEGETATION TYPES IN THE LANGDALE VALLEY

Vegetation type:	Frequency from rapid field estimates (%)	Predicted frequency from land classes (%)
Enclosed land	31	22
Unenclosed land	69	78
Arable	<1	<1
Haymeadows and improved pasture	6	10
Permanent pasture	4	4
Woodland	5	<1
Unwooded upland grassland	16	8
Upland moorland	69	78

TABLE 3.10
OBSERVED AND EXPECTED NUMBERS OF PLOTS IN VEGETATION TYPES FROM FOUR LAND CLASSES ON THE HOWGILL FELLS

	Land Class									
	9		13		14		15		Total	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
Lowland 1 - 16	0	0	0	0.0	0	0.0	0	0.0	0	0
Upland moorland well drained 17 - 20	10	14	6	0.5	3	1.5	3	0.8	22	17
Upland moorland badly drained 21 - 24	21	16	7	8.0	3	4.2	0	1.5	31	30
Upland grassland unwooded 25 - 28	1	2	0	4.3	0	0.3	0	0.7	1	7
Upland grassland wooded 29 - 32	0	0	0	0.0	0	0.0	0	0.0	0	0

and then corrected for the oversampling of some of the land classes, since the sample was at random. The species data from the plots were then run down using the vegetation key as in the first example. In this case some errors may be caused by unrepresentativeness of the 0.25 sq km of the entire sq km. The results are given in Table 3.12. If the frequencies are ranked, then 8 out of the top 10 of observed and expected are the same and the largest difference in percentage is 4.3% with 22 out of the 32 less than 1%. Considering the number of stages involved these figures are sufficiently close to support the methods used. Also the divergencies can be explained in terms of the differences between the region surveyed and the norm for Cumbria. The differences between observed and expected follow patterns, with groups of adjacent types either having too many or too few. Thus, in comparison with the norm for the Cumbrian land classes represented in the region, there is less old permanent pasture, permanent pasture and recently improved pasture than expected but more acid seepages, high level slopes and moorland. Such figures fit in well with local knowledge in that the region has exceptionally narrow valleys and would therefore be expected to have a deficiency of the lowland types. These trends are further demonstrated when the types are considered at a higher level with deficiencies being highlighted in the lowland as opposed to upland and moorland types rather than grassland. Originally the comparisons were made at an early stage in the survey and wide divergences were found between expected and observed which later were found to be due to a biased sample being surveyed initially. It is therefore essential to ensure that comparisons are based on a sound sampling basis and also that subsequent surveys should include sufficient numbers of plots.

3.5.8 It is therefore difficult to estimate how much of the differences between observed and expected frequencies is due to error and how much is due to the inherent characteristics of a region, although the above examples would suggest that the latter is probably accounting for most of the differences, since the patterns are so consistent. Such differences will probably vary from area to area and between land classes. For example class 2 is relatively uniform and tends to occur in quite large blocks, whereas class 11 is very diverse and tends to occur in small groups. A way to improve such differences would be to carry out additional survey in the more diverse squares to increase the definition of their characteristics; the first stage would still be needed to determine their variability. A further lesson from the present survey is that there is more variation between squares than within and

TABLE 3.12

OBSERVED AND EXPECTED FREQUENCIES IN 48 KM SQUARES IN SEDBERGH, DENT AND GARSDALE.

The expected frequencies are corrected for the relative numbers of different classes sampled

		Obs	Exp		Obs	Exp		Obs	Exp		Obs	Exp
1	Short term leys	2.7	3.1									
2	Long term leys	2.9	4.7	leys	7.7	10.5						
3	Invaded leys	1.5	2.1									
4	Arable hedgerows	0.6	0.6				cultivated	9.5	12.2			
5	Arable	1.2	1.1									
6	"	0.6	0.6	arable	1.8	1.7						
7	"	0.0	0.0									
8	"	0.0	0.0							Lowland	31.0	42.8
9	Recently improved pasture	5.8	7.0									
10	Improved pasture	4.7	4.9	improved pastures	12.0	12.6						
11	Hedgerows with 9	0.4	0.3									
12	" " 10	1.2	0.4				uncultivated	21.5	30.6			
13	Permanent pasture	2.1	4.2									
14	Old permanent pasture	3.2	7.5	permanent pastures	9.5	18.0						
15	Upland permanent pasture	3.1	4.2									
16	Complex marginal	1.2	2.1									
17	Grassland	3.0	1.2									
18	Rocky grassland	3.9	2.3	well drained								
19	High level slopes	6.8	4.4	moorland	19.9	13.3						
20	Rocky moorland	6.2	5.4									
21	Acid seepages	17.1	13.2				moorland	46.5	35.0			
22	Blanket peat	6.2	6.6	badly								
23	High level peat	1.1	0.6	drained moorland	26.5	21.7						
24	Peat flushes	2.1	1.3							Upland	69.0	57.5
25	Steep slopes	5.3	5.4									
26	Rocky damp slopes	3.3	3.6	upland	20.5	20.4						
27	Wet mineral flushes	5.5	4.5	grassland								
28	Mineral flushes	6.5	6.9				grassland	22.5	22.5			
29	Woodland	0.4	0.0									
30	"	0.1	0.4									
31	"	1.1	1.3	woodland	2.0	2.1						
32	"	0.3	0.4									

the sampling strategy should therefore concentrate on covering a wide range of squares, rather than detail within squares at the first stage. Later studies can concentrate on detail, once the primary characteristics of the types are determined.

3.6 SUMMARY AND CONCLUSIONS

3.6.1 32 vegetation types present in the land classes are identified and characterised. The relationship between these vegetation types and the land classes is examined and used to predict the distribution of the types. The total vegetation resource in Cumbria is estimated and described and the errors in such estimations are discussed. The main conclusion is that the range of variability of the common ecosystems in Cumbria has been described and classified. They cover the cultivated and permanent pastures, and arable land in the lowlands of the county together with the upland moorlands and grasslands. The predicted distributions of the vegetation types show well defined patterns and high correlations with subsequent surveys, although individual characteristics can diverge widely from the norm.

4 Further surveys based on the land classes

4.1 COMMON FEATURES OF OTHER SURVEYS

4.1.1 As planning or other problems arise, rapid surveys can be conducted which use the land classification as a sample framework. Information on a number of features in the land classes is, therefore, gradually built up. Woodlands are relatively infrequent in Cumbria, by far the greatest proportion of vegetation types being grassland of one sort or another. However, they are very important because of their visual contribution to the landscape. The variability within them and the tree cover characteristics of km squares is, therefore, not adequately assessed from the vegetation types. The same is true for linear features such as hedgerows and stone walls. Together with the vegetation types and associated land use characteristics, such as urban development, these features combine to form the landscape of an area. Separate surveys for these three features are needed to fill in the gaps left by the vegetation type survey, to provide a more complete picture of the ecological characteristics of Cumbria, and to increase its usefulness for planning purposes.

4.1.2 The same basic principles apply to these surveys as to the vegetation type survey. The land classes were used as strata from which sample km squares were chosen for detailed field surveys. Four squares from each stratum were sampled for their tree cover characteristics, three squares were sampled for their hedgerow and boundary characteristics, and eight squares were sampled from each stratum for their landscape characteristics. The data were analysed by RA and ISA to produce tree cover types, hedgerow types and landscape types in an analogous manner to the vegetation types. Correlation of these types with the land classes enables their distributions to be predicted and an evaluation of the countywide resource can be done.

4.2 THE TREE COVER SURVEY

4.2.1 Within each sample km square the woodland areas were marked onto 1/10,000 maps and the relative frequency of each of the canopy species in each wood was visually assessed on the ground. The total number of canopy trees in each wood was calculated from the relative frequencies using a density of 494 trees per hectare, obtained from random density measurements in ten woods within the sample km squares. All isolated trees, including those in hedgerows, were counted if they were estimated as being over 5m in height. All obvious forestry plantations were noted as such. The 59 species recorded were divided into woodland and non-woodland trees, giving effectively 118 'species'. These were reduced to 60 by excluding those 'species' which occurred in less than 1.0% of the squares. The occurrence of these 60 'species' in the sample km squares was used to group the squares into five tree cover types; excluding squares without any trees, which were placed in a sixth tree cover type.

4.2.2 The characteristics of each of the six tree cover types is given in Table 4.1. In type 1 nearly all the trees are found in hedgerows and there are occasional broadleaved woods along river banks, although the mean area of woodland is very low, as is the woodland/non-woodland tree ratio. Broadleaved trees are fairly common in type 2, both in small woods and in hedgerows, but many of the small woods are coniferous and appear to have been planted as shelter belts. It is very similar to tree cover type 1, differing from it mainly in the presence of small woods. Tree cover type 3 has twice as much woodland

TABLE 4.1
CHARACTERISTICS OF THE SIX TREE COVER TYPES

	Tree cover type					
	1	2	3	4	5	6
Total average number of trees	365	2 562	5 200	6 182	27 039	0
Total average woodland area (ha)	0.12	4.71	10.87	11.87	54.6	0
Total average number of woods	0.14	2.38	4.3	5.1	1	0
Woodland/non woodland tree ratio	0.56	8.06	15.85	14.3	2 008.9	0
Number of species	31	27	38	49	19	0
% of woodland under conifers	0	54.5	32.7	37.1	100.0	0
Constant species	Acerpseudoplantanus Fraxinus excelsior	-	Crataegus monogyna Fraxinus excelsior Sorbus aucuparia	Fagus sylvatica Fraxinus excelsior	-	-

as type 2, with a preponderance of broadleaved species. Non-woodland trees form an important component with Acer pseudoplatanus and Fraxinus excelsior being the commonest species both in woodland and outside it. Type 4 is the most species-rich tree cover type, with less non-woodland 'species' than type 3 but with a slightly greater woodland area. It contains the park-like areas around some large country houses and the high species number is due to the presence of unusual species in these parks. Tilia cordata, Fagus sylvatica and Aesculus hippocastanea are all common parkland trees which were indicator species for tree cover type 4 in the classification. Some of the woods are well managed for timber, whereas others, particularly the broadleaved ones, are nearer a semi-natural state. Oak is the most abundant common woodland species which is also important as a non-woodland tree. Tree cover type 5 consists of afforested upland moorland. Native species are absent apart from the occasional birch, holly or oak. The woods are dominated by spruce, larch and pine.

4.2.3 The frequency of each tree cover type in each land class is given in Table 4.2. With the exception of tree cover type 6 both land classes and tree cover types are ordered in their sequence on the first RA axes so that approximately similar classes and types are adjacent. Ignoring tree cover type 6, there is a marked diagonal across the table; with a correlation coefficient of 0.71 between the two axes being significant at less than 1%. The frequency of the tree cover types and the area they occupy throughout the county (Table 4.3) shows that a quarter of the county is treeless and 40% consists of the two most heavily wooded tree cover types. Areas where the trees are mainly non-woodland cover 27.9% of the county.

4.2.4 The accuracy of this predicted distribution has been tested against an independent count of the number of woods over 0.5 ha in the Lake District National Park (LDNP). The prediction was that there are 3,639 woods in the Park, occupying 16,323 ha. This is 16% greater than the figure of 3,248 woods greater than 0.5 ha measured by the Lake District Special Planning Board from aerial photographs but does include woods of less than 0.5 ha. The actual area of these woods is approximately 24,000 ha and this is half as much again as the predicted area. However, Forestry Commission type conifer plantations are not related to the main trend through the land classes in the LDNP because of planning restrictions. This is a contrast to land class 12 outside the Park which is highly correlated with coniferous forest. Therefore, the area estimates have not accounted for these woods. The actual area of such plantation in the LDNP is 9,600 ha; close to the difference in areas given by the estimated and actual figures.

4.3 THE HEDGEROW SURVEY

4.3.1 Within the randomly selected km squares the various types of hedgerow structure and other boundaries were mapped and four 25 sq m plots aligned at random along the hedgerows. Within these plots the species composition of one side of the hedgerow was recorded (Whitbread, 1976).

4.3.2 The classification of the plots resulted in eight hedgerow types the main features of which are summarised in Table 4.4. Types 1-4 contain species more frequent in woodland remnant situations whereas types 5-8 contain species more generally associated with lowland pasture. Within this latter group types 5 and 6 are separated from 7 and 8 on the basis of species associated with nitrogen rich habitats. Types 1 and 2 are associated with drier habitats than types 3 and 4.

4.3.3 The frequency of hedgerow types in the land classes does not produce a marked diagonal orientation in Table 4.5 where the land classes and hedgerow types are ordered according to their similarities. The upland/lowland trend shown by the land classes is, therefore, not mirrored in the hedgerow types, probably because

TABLE 4.3
FREQUENCY AND AREA OF TREE COVER TYPES IN THE WHOLE COUNTY

Tree cover type	Frequency in whole county (%)	Area of type in county (sq km)
1	13.6	965
2	14.3	1 015
3	22.8	1 618
4	17.4	1 235
5	5.7	404
6	26.1	1 853

TABLE 4.2
PERCENTAGE FREQUENCY OF TREE COVER TYPES IN THE LAND CLASSES

Tree cover type	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
1	0	25	25	0	25	25	25	25	0	25	0	0	0	0	0	0
2	0	25	50	0	0	25	25	75	0	0	0	0	0	0	0	0
3	0	0	0	75	0	50	0	0	25	0	50	0	0	0	0	0
4	0	0	25	0	75	0	50	0	50	25	50	0	0	0	25	0
5	0	0	0	0	0	0	0	0	25	25	0	25	25	0	0	0
6	100	50	0	25	0	0	0	0	0	25	0	75	75	100	75	100

TABLE 4.4
CHARACTERISTICS OF THE HEDGEROW TYPES

	Hedgerow type							
	1	2	3	4	5	6	7	8
Indicator species	Taraxacum officinale Lolium perenne	Corylus avellana Glechoma hederacea Prunus spinosa Rosa species Lonicera periclymenum	Ranunculus acris Stellaria holostea Cirsium arvense Juncus effusus	Veronica chamaedrys Carex pendula Fraxinus excelsior	Anthriscus sylvestris Heracleum sphondylium	Stellaria media Festuca rubra Poa annus Veronica chamaedrys Ranunculus acris	Ulex eurapaeus Plantago lanceolata Deschampsia caespitosa	Ranunculus acris Achillea millefolium Rumex obtusifolius Urtica dioica
Constant (100%) species	Arrhenatherum elatius Crataegus monogyna	Arrhenatherum elatius	Arrhenatherum elatius Dactylis glomerata Ranunculus acris Filipendula ulmaria	Carex pendula Dactylis glomerata	Arrhenatherum elatius Crataegus monogyna	Arrhenatherum elatius Crataegus monogyna Ranunculus acris	Arrhenatherum elatius	Arrhenatherum elattus Ranunculus acris Convolvulus arvensis
Main management features	On bank over 1 ft. tall, by roadside, stockproof	Short hedges by roadside, with gaps at bases.	Unmanaged hedges between grass fields	Stockproof, but unmanaged hedges, with uneven outline and >9 ft. spread of branches on each side	Machine trimmed with gaps in the base	Short, stock-proof, thin in the base, on a bank over 1 ft. tall, between grassed fields.	Tall, stock-proof but unmanaged between grass fields	Unmanaged, tall, on a bank over 1 ft high, between grass fields
Shrub species with greatest cover (>20%)	Crataegus monogyna Rubus species	Crataegus monogyna	Crataegus monogyna Rubus species	Crataegus monogyna	Crataegus monogyna	Crataegus monogyna	Crataegus monogyna Ulex europaeus	Crataegus monogyna Ulex europaeus

TABLE 4.5
PERCENTAGE FREQUENCY OF HEDGEROW TYPES IN THE LAND CLASSES

Land class	Hedgerow type 7	8	5	6	1	3	2	4
8	0	30	40	0	20	0	0	10
6	0	8	0	25	50	0	17	0
5	0	0	0	8	50	25	17	0
1	0	17	0	17	8	0	58	0
2	50	0	25	0	0	0	25	0
4	33	25	25	0	0	0	8	8
3	0	0	25	0	13	13	13	38
12	0	0	0	25	0	25	0	50
10	0	0	0	0	75	0	25	0

TABLE 4.6
FREQUENCY OF HEDGEROW TYPES IN CUMBRIA AND LENGTHS OF HEDGEROW IN EACH TYPE

Hedgerow type	Frequency in county (%)	Length (km)
1	19.8	4 494
2	22.5	51 075
3	6.7	1 521
4	8.7	1 975
5	12.7	2 883
6	7.1	1 612
7	13.4	3 042
8	9.2	2 088

TABLE 4.7
BOUNDARY FEATURES PER KILOMETRE SQUARE

Land class	Length of hedge (km)	Length of dry stone wall (km)	Length of wire fence (km)	Boundary removed (km)
1	3 058	7 377	1 826	703
2	5 457	0	6 885	207
3	3 473	1 280	6 127	972
4	4 607	937	8 153	152
5	7 482	2 510	4 867	110
6	9 703	210	4 667	233
7	0	0	0	0
8	4 608	10	4 067	383
9	0	1 065	250	0
10	170	5 763	1 477	200
11	0	7 123	1 643	83
12	750	1 640	1 587	0
13	0	2 557	0	0
14	0	0	0	0
15	0	1 413	90	0
16	0	682	0	0

the main factor influencing the hedgerows is the management of the hedges themselves and the adjacent land. However hedgerow types 1, 2, 4, 5 and 7 are associated more with one land class than with another.

4.3.4 The frequency of the hedgerow types in the whole county and the total length of each type are given in Table 4.6. Types 1 and 2 containing species from dry woodland remnant situations have the greatest lengths, those from the wetter woodland situations (types 3 and 4) having the shortest lengths.

4.3.5 The distribution of the boundary types (Table 4.7) shows that drystone walls occur mainly in the upland areas of Cumbria. There is a lower percentage of drystone walls in the more fertile areas of the Solway Plain and Eden Valley. The higher open moorland of the Pennines often contains no boundaries of any sort. The greatest lengths of hedgerow occur in the Solway Plain and the proportion of managed hedgerows is greatest in such agricultural areas. The Eden Valley contains larger fields in comparison to many areas. The size of fields correlates well with lengths of boundaries removed, illustrating the fact that such boundaries are being removed to increase field size in agriculturally productive areas. However, only about 10% of the boundaries have been removed.

4.4 THE LANDSCAPE SURVEY

4.4.1 Eight sample km squares were surveyed in each land class, with the exception of 7 and 8. A check list of 313 landscape features was recorded in the field and relate to land form, land use, enclosures, visible rock, communications, field boundaries, recreation facilities and buildings. Eight landscape types were produced by ISA and are readily interpretable (Benefield, 1977).

4.4.2 Landscape types 1 and 2 are similar lowland hedgerow landscapes. Type 1 is lowland with well drained, deep soils, with arable and grassland near towns and villages. The rectangular, medium sized fields have boundaries of wire fences and single-species hedges. There are good services and communications and 'unsympathetic' buildings are a feature. The boundary hedges in type 2 tend to have more shrub species and fields are smaller; they are further from urban centres but with good communications. Landscape types 3 and 4 consist of permanent or reseeded pastures as opposed to temporary leys, with buildings more in vernacular style than landscape types 1 and 2 and with field boundaries being mainly walls. Type 3 has good permanent pasture and goes up to an altitude of about 76m (250 ft). The scattered farms are in vernacular style of local materials. There are diverse boundaries to the rectangular fields, but hedgerows with more than three shrub species and standard trees are a feature. Landscape type 4 shows scrub woodland invasion where management is less intense and there is a conspicuous absence of buildings. Boundaries are invariably walls and these are well maintained.

4.4.3 Landscape types 5 and 6 are rough fells of moderate altitude and with very variable characteristics. Type 5 is undulating rough fell up to 488m (1600 ft) altitude with variable drainage. Bracken invasion of pastures, and woodland are features, as are footpaths and small, fast flowing becks. It is traditionally referred to as marginal land. Type 6 consists of poor grazing intake up to 488m (1600 ft) with variable drainage and bracken invaded pastures. Angular rock outcrops with walls, gates and stoops in a bad state of repair distinguish this from type 5. Landscape types 7 and 8 are the mountains of the Lake District and the Pennines. Type 7 is the fell tops of the central Lake District with steep crags and screes and small, fast flowing becks. There are many popular walking routes with shallow soils and sparse acidic grasslands. Type 8 shows gentle relief at a high altitude, with peat haggs and poor grazing on Calluna/Nardus grassland. There are few enclosures.

4.4.4 The diagonal element in Table 4.8, which shows the frequency of the landscape types in the land classes, illustrates the strength of the correlation between the two classifications. The correlation coefficient (r) between the two axes is significant at 0.1% (r = 0.98), this also being the correlation between the landscape and the vegetation axes. The relative frequency of the landscape types and the area they occupy in Cumbria is given in Table 4.9. Landscape type 2 covers the greatest area, although types 3 and 4 permanent or reseeded pastures, occupy the greatest area at the second division level in the analysis.

4.5 SUMMARY AND CONCLUSIONS

Tree cover, hedgerow and landscape surveys have been carried out using the land classes as strata for detailed sampling. Tree cover, hedgerow and landscape types are described and close relationships are shown with the land classes; particularly with the landscape survey.

TABLE 4.9
FREQUENCY AND AREA OF LANDSCAPE TYPES IN WHOLE COUNTY

Landscape type	Frequency %	Area (sq km)
1	6.1	433
2	23.5	1 668
3	19.8	1 406
4	13.6	966
5	6.7	476
6	5.3	376
7	17.1	1 214
8	8.0	568

TABLE 4.8
PERCENTAGE FREQUENCY OF THE LANDSCAPE TYPES IN THE LAND CLASSES

Landscape type	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
1	0	0	24	12	5	22	1	0	0	7	0	0	0	0	0	0
2	0	0	48	46	40	57	8	37	0	0	3	0	0	0	0	0
3	0	0	24	25	40	17	29	50	5	7	4	1	0	0	0	0
4	0	0	4	12	10	4	42	0	29	29	29	5	0	0	3	2
5	0	0	0	0	0	0	11	0	27	21	21	16	7	0	3	0
6	0	0	0	0	0	0	0	0	10	29	12	10	16	10	16	11
7	0	0	0	4	5	0	9	12	27	7	16	41	35	41	42	84
8	0	0	0	0	0	0	0	0	2	0	15	27	42	48	36	2

5 Further applications: regional comparisons

5.1 A COMPARISON OF THE LDNP WITH THE REST OF CUMBRIA

5.1.1 The land classification not only provides a basis for further surveys of the whole county but also a standard basis for comparing regions, because the land classes have been derived using objective criteria. Regions can be defined according to particular requirements and these can be openly related to personal choice. Typical comparisons might involve physical formations such as valleys or administrative areas such as parishes. The relative frequency of the land classes enable estimates of the relative frequency of the vegetation types and landscape types, for example, to be assessed. The accuracy of these assessments will depend upon the land classes present and the size of the regions; the smaller the area the less reliable will be the assessments of its composition. Therefore, the county wide survey enables the norm to be predicted for a region without a field survey, and this norm can be compared with that for another region. The predicted norm can be used to compare the results of a field survey of the region to find out whether or not it is typical of the whole county.

5.1.2 The Structure Plan is prepared jointly by Cumbria County Council and the Lake District Special Planning Board. A comparison of the LDNP with the region of Cumbria outside this Park is therefore useful in establishing whether unique features are present in the Park and in fitting it into the context of the whole county. Table 5.1 shows the predicted frequencies of

TABLE 5.1
COMPARISON OF THE VEGETATION TYPES IN THE LDNP WITH THE REST OF CUMBRIA

		Frequency (%)		Area (sq km)		Ratio outside Park to LDNP	
Vegetation type		Outside Park	LDNP	Outside Park	LDNP	Frequency	Area
1	Short term leys	7.7	3.5	397	70	2.2	5.6
2	Long " "	6.7	2.5.	346	50	2.7	6.9
3	Invaded leys	6.2	3.8	320	76	1.6	4.2
4	Arable hedgerows	3.2	1.7	165	34	1.9	4.8
5	Arable fields	2.3	1.1	118	22	2.1	5.4
6	" "	1.7	0.8	87	16	2.1	5.5
7	" "	3.1	1.4	160	28	2.2	5.7
8	" "	2.0	0.9	103	18	2.2	5.7
9	Recently improved pasture	7.6	5.4	392	108	1.4	3.6
10	Improved pasture	7.6	5.6	392	112	1.4	3.5
11	Hedgerow associated with 9	2.4	1.2	123	24	2.0	5.1
12	" " " 10	2.6	2.3	134	46	1.1	2.9
13	Permanent pasture	3.9	2.1	201	42	1.9	4.8
14	Old permanent pastures	4.3	3.2	222	64	1.3	3.4
15	Upland permanent pasture	2.3	2.2	118	44	1.0	2.7
16	Complex marginal habitats	2.2	2.4	113	48	0.9	2.3
17	Moorland	2.1	6.6	108	133	0.3	0.8
18	Rocky grassland	1.1	4.8	56	96	0.2	0.6
19	High level slopes	2.4	7.5	123	151	0.3	0.8
20	Rocky moorland	5.0	5.2	258	104	1.0	2.5
21	Acid seepages	5.6	8.1	289	163	0.7	1.8
22	Blanket peat	4.4	9.6	227	193	0.5	1.2
23	High level peat	0.5	3.9	25	78	0.1	0.3
24	Peat flushes	1.2	1.6	62	32	0.8	1.9
25	Steep mountain slopes	2.2	3.5	113	70	0.6	1.6
26	Rocky, damp slopes	2.4	3.1	123	62	0.8	2.0
27	Wet, mineral flushes	1.9	1.9	98	38	1.0	2.6
28	Mineral flushes	2.2	1.7	113	34	1.3	3.3
29	Neutral/acid woodland	0.9	0.7	46	14	1.3	3.3
30	Basic woodland	1.0	0.7	51	14	1.4	3.7
31	Acid woodland	1.1	1.5	56	30	0.7	1.9
32	Conifer plantation	0.4	0.3	20	6	1.3	3.4
1-4	Leys	23.7	11.4	1 223	231	2.1	5.3
5-8	Arable	9.0	4.1	464	84	2.2	5.5
9-12	Improved pasture	20.1	14.4	1 038	292	1.4	3.5
13-16	Permanent pasture	12.6	9.8	650	199	1.3	3.3
17-20	Well drained moor	10.5	24.0	542	485	0.4	1.1
21-24	Badly drained moor	11.6	23.1	599	467	0.5	1.3
25-28	Unwooded	8.6	10.1	444	205	0.9	2.2
29-32	Wooded	3.3	3.1	170	64	1.1	2.6
1-8	Cultivated	32.7	15.5	1 688	316	2.1	5.3
9-16	Uncultivated	32.7	24.2	1 688	492	1.4	3.4
17-24	Moorland	22.1	47.1	1 141	953	0.5	1.2
25-32	Grassland	11.9	13.2	614	270	0.9	2.3
1-16	Lowland	65.4	39.7	3 377	808	1.6	4.2
17-32	Upland	35.0	60.3	1 807	1 223	0.6	1.5

the vegetation types and the areas they are likely to occupy. The upland character of the Park's vegetation is a major feature, as is the dominance of lowland vegetation outside the Park. In the lowland vegetation types the main difference is the predominance of cultivated arable and ley vegetation types outside the Park, where it is twice as frequent as inside the Park. Upland moorland is twice as frequent in the Park as outside but occupies approximately the same total area of land. It is almost equally divided into badly drained and well drained moorland.

5.1.3 The vegetation types, which are virtually confined to the LDNP, are:

17	Polytrichum commune/Nardus stricta.	Moorland.
18	Pseudoscleropodium purum/Pteridium aquilinum.	Rocky grassland.
19	Hylocomium splendens/Nardus stricta.	High level slopes.
23	Trichophorum caespitosum/Calluna vulgaris.	High level peat.

These indicate that the Park has a larger proportion of well drained moorland than the rest of Cumbria. In fact it comprises 22.8% of the Park as against 6.1% of the rest of Cumbria.

5.1.4 The vegetation types which are virtually confined to the area of Cumbria outside the LDNP are:

2	Phleum pratense/Lolium perenne.	Long term leys.
1	Lolium multiflorum/Lolium perenne.	Short term leys.
7	Convolvulus arvensis/Hordeum vulgare.	Arable fields.
8	Polygonum lapathifolium/Hordeum vulgare.	" "
5	Matricaria matricoides/Hordeum vulgare.	" "
6	Polygonum persicaria/Hordeum vulgare.	" "
11	Crataegus monogyna/Lolium perenne.	Hedgerows with recently improved pasture.

These comprise 25.9% of the area outside the Park, as against 11.4% within the Park.

5.1.5 The predicted frequencies of the landscape types and the area they are likely to occupy are given in Table 5.2. Landscape type 7, with its high mountains, footpaths and screes is most characteristic of the LDNP. It is more than twice as frequent inside as outside the Park, although there is a similar area of such landscape outside as inside the Park. Lowland, hedgerowed landscapes with grass leys (landscape types 1 and 2) are most characteristic of the land outside the Park, where they are twice as frequent and cover ten times the area.

5.1.6 Tree cover type 6 (absence of trees) is most characteristic of the LDNP (Table 5.3); being twice as frequent as outside the Park, but occupying about the same area; it occupies about twice as much land as any of the other tree cover types. Tree cover type 4 is the opposite to type 6, being the most heavily wooded type with the greatest number of species. It is the most characteristic type of the area outside the Park, occupying almost five times as much land as inside the Park. It is, however, not the most abundant type outside the Park, covering as much land as type 6 (no trees) and only two-thirds the area of type 3, to which it is very similar.

5.1.7 The frequencies of the hedgerow types inside and outside the LDNP are very similar (Table 5.4); although there is a greater frequency of hedgerow type 1, which is characteristic of drier woodland remnants, outside the Park.

TABLE 5.2
COMPARISON OF THE LANDSCAPE TYPES IN THE LDNP WITH THE REST OF CUMBRIA

	Frequency (%)		Area (sq km)		Ratio outside Park to LDNP	
Landscape type	Outside Park	LDNP	Outside Park	LDNP	Frequency	Area
1 Lowland hedged leys.	7.1	3.1	366	62	2.3	5.9
2 Lowland hedged leys, unsympathetic buildings.	27.4	14.6	1 414	294	1.9	4.8
3 Permanent pasture, farms, hedges.	22.2	15.1	1 146	304	1.5	3.8
4 Permanent pasture, walls.	13.5	13.2	697	266	1.0	2.6
5 Foothills and woods.	6.0	8.9	309	179	0.7	1.7
6 Foothills.	4.4	7.1	227	143	0.6	1.6
7 Mountains, footpaths and screes.	12.2	28.8	630	580	0.4	1.1
8 Mountains, peat, heather.	7.1	9.9	366	199	0.7	1.8

TABLE 5.3
COMPARISON OF THE TREE COVER TYPES IN THE LDNP WITH THE REST OF CUMBRIA

	Frequency (%)		Area (sq km)		Ratio outside Park to LDNP	
Tree cover type	Outside Park	LDNP	Outside Park	LDNP	Frequency	Area
1	13.8	10.1	712	202	1.4	3.5
2	15.5	15.0	800	303	1.0	2.6
3	29.2	20.0	1 507	404	1.5	3.7
4	18.4	9.8	950	196	1.9	4.8
5	4.4	7.4	227	149	0.6	1.5
6	18.7	37.6	965	754	0.5	1.3

5.2 A COMPARISON OF VALLEY SYSTEMS.

5.2.1 The land class composition of 50 valleys in upland Cumbria was used to rank them into a series based on their comparative 'uplandness' or 'lowlandness', in order to assess their similarities. A primary ranking ordered the valleys on the frequency of the upland land classes (9-16). A secondary ranking then re-ordered them by comparing the intermediate upland classes (9-12) with the extreme ones (13-16). The valleys vary widely in the proportion of lowland classes present and the ranking emphasises that many of the upland valleys contain only a small proportion of land with lowland affinities (Table 5.5). The ranking provides a means whereby a standard series of valleys can be selected for further study to cover as wide a range of variation as possible within as few sites as possible. Vegetation and other characteristics can be predicted for these valleys and the valleys compared on the basis of these predictions. Such comparisons enable the representativeness of any particular valley to be assessed and fitted into an overall framework for the county.

5.3 SUMMARY AND CONCLUSIONS

5.3.1 The land classification provides a means whereby regions within Cumbria can be compared; both in terms of the relative frequencies of land classes and in terms of characteristics predicted from the county wide survey. The character of the LDNP is compared with that of the rest of Cumbria on the basis of its constituent land classes. A comparison of 50 valleys in upland Cumbria illustrates how the land classes can be used to rank areas in terms of their land class composition.

TABLE 5.5
THE RANKING OF 50 VALLEYS

		Classes 1-8 % total	Classes 9-12 % total	Classes 13-16 % total
1	Coniston Water	100	0	0
2	Elterwater	100	0	0
3	Windermere East	91	9	0
4	Claife Heights	88	13	0
5	Lorton Vale	71	21	8
6	Bassenthwaite	70	18	12
7	Tarn Hows and Coniston	65	35	0
8	Duddon Valley	49	35	16
9	Lickle Valley	45	56	0
10	Bannersdale	44	48	7
11	Dentdale	48	45	13
12	Ullswater West	38	53	10
13	Loweswater	36	58	6
14	Greta Valley	34	33	34
15	Ravenstonedale	32	50	18
16	Derwentwater	32	43	25
17	Kentmere	31	50	19
18	Eskdale and Upper Esk	27	50	23
19	Wasdale	22	33	44
20	Longsleddale	22	52	26
21	Little Langdale	21	57	21
22	Rawthay/Cautley	21	56	24
23	Caldew	20	24	56
24	Newlands	19	48	33
25	Barbondale	19	81	0
26	Troutbeck	17	57	26
27	Dufton	17	33	50
28	Grasmere	16	49	35
29	Blengdale	16	60	24
30	Crowdundle	16	32	53
31	Buttermere	16	53	31
32	Coledale Beck/Braithwaite	14	32	55
33	Great Langdale	13	40	47
34	Martindale	12	62	26
35	Mitredale	12	59	29
36	Ennerdale	10	39	51
37	Stockgill	9	64	27
38	Coniston Fells	8	38	54
39	High Cup Gill	7	21	71
40	Borrowbeck	6	66	28
41	Longstrath	6	35	59
42	Thirlmere	6	53	42
43	Grizedale Beck/Patterdale	5	26	68
44	Garsdale	5	90	5
45	Black Burn	4	19	77
46	Swindale/Mosedale	4	52	44
47	Haweswater	3	44	53
48	Wormgill	0	67	31
49	Wetsleddale	0	65	40
50	Hartsop	0	41	59

Note:
Rows may not always add exactly due to rounding

TABLE 5.4
COMPARISON OF THE HEDGEROW TYPES IN THE LDNP WITH THE REST OF CUMBRIA

	Frequency (%)		Area (sq km)		Ratio outside Park to LDNP	
Hedgerow type	Outside Park	LDNP	Outside Park	LDNP	Frequency	Area
1	20.8	16.5	1 074	332	1.3	3.3
2	22.5	21.1	1 161	425	1.1	2.7
3	7.0	6.3	361	127	1.1	2.8
4	7.7	9.2	397	185	0.8	2.1
5	13.1	14.8	676	298	0.9	2.3
6	6.9	7.4	356	149	0.9	2.4
7	13.4	13.4	692	270	1.0	2.6
8	8.6	11.3	444	227	0.8	1.9

6 The use of survey information in the Structure Plan

6.1 NATURE CONSERVATION

6.1.1 The reasons for the collection of ecological information and its use in the Structure Plan for Cumbria are outlined in Chapter 1. The first of such uses was for the formulation of policies which would protect the nature conservation interest of tracts of countryside. This is a three stage process involving an evaluation of the nature conservation interest, the identification of the reasons why some areas are highly valued, and the formulation of policies which maintain these high values. The survey information in Chapters 3 and 4 provides the basis for the evaluation. The processes involved in ecosystem functioning have already been described elsewhere in the broad sense, this level of detail being sufficient for the County Structure Plan at this stage. See, for example, the relationship between agriculture and nature conservation (NCC, 1977).

6.1.2 The criteria used depend on the survey information available but have been defined by Ratcliffe (1971) as diversity, extent, naturalness, rarity, fragility, representativeness, research and educational value, recorded history, potential and contiguity. They overlap to some extent and can even conflict with each other. Their application will depend upon the region surveyed and the type of information collected. They were first elucidated to aid in the selection of sites as nature reserves, and all will not be useful for other purposes.

6.1.3 The most appropriate criteria to apply to the survey data reported here are diversity, rarity and naturalness; with the greatest conservation values being attributed to uncommon land classes which have a high proportion of natural ecosystems, coupled with a high diversity. The rarity value of each land class is based on the assumption that each land class is unique in its combination of ecological characteristics. Each land class, therefore, has some conservation value but this is greatest in the most uncommon classes. The rarity value is one minus the relative area of the land class. A composite diversity index was derived from a number of measures of diversity of each land class by principal components analysis (Table 6.1). The composite diversity index for each land class is its score (ranged between zero and one) on the first principal component. The naturalness and degree of interference with natural and semi-natural ecosystems has been assumed to be related to the proportion of

TABLE 6.1
DIVERSITY VALUES FOR EACH LAND CLASS

	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
Total number of species	-	179	178	177	247	141	248	179	228	190	206	119	123	105	155	135
Average number of species groups	-	5.24	4.96	4.75	7.05	4.45	5.82	5.77	7.63	5.97	5.73	4.60	6.53	5.10	6.10	4.90
Number of species with cover over 1%	-	5	6	5	8	6	13	9	11	12	12	10	7	8	8	9
Variance on first axis of landscape analysis	-	-	53	144	122	40	521	146	241	360	76	103	96	61	142	48
Variance on first axis of vegetation analysis	-	72	79	353	384	160	831	172	414	733	695	34	160	41	165	48
Number of vegetation types	-	10	14	14	13	13	20	12	15	15	17	8	6	6	11	7
Composite index	-	-	0.28	0.41	0.52	0.10	1.00	0.37	0.73	0.74	0.61	0.11	0.23	0	0.25	0.06

Note:
Land classes are ordered according to their scores on the first ordination axis of the map analysis

reseeded pastures and arable land in each land class. These proportions were ranged between zero and one to put them on a par with those for diversity and rarity. Where the mean of these three values is less than 0.5 the conservation value is assumed to be minimal and is given a score of zero. If the mean value is greater than or equal to 0.5 it is given the highest conservation value of 3 if all values for rarity, diversity and naturalness are greater than 0.5. A conservation value of 2 is given if only two of these criteria have a score greater than 0.5 (Table 6.2).

6.1.4 The NCC have evaluated, on a site basis, the importance of parts of Cumbria for nature conservation. They have identified 148 SSSIs in Cumbria, 63 of which they consider to be of national significance. The two evaluations coincide quite well but show a marked difference in emphasis. The evaluation based upon the grid square survey indicates that the greatest importance should be attached to the foothills in the county, where upland and lowland ecosystems and land use practices meet. The evaluation based upon SSSIs emphasises the value of open water, woodland, grass and heathland, peatland and geological sites in the foothills. However, on an area basis it gives much more weight to the coastal and upland land classes. This is because of the extensive nature of the ecosystems in these land classes and their low diversity; together with the fact that SSSIs are evaluated nationally, not just in the context of Cumbria, and that factors other than rarity, naturalness and diversity are used in their evaluation.

6.2 THE DETERMINATION OF RURAL POLICIES

6.2.1 Present rural land use objectives are pursued by a variety of organisations, such as the Ministry of Agriculture, Fisheries and Food (MAFF), and the Forestry Commission, as well as private landowners, with usually only one use in mind with occasional secondary uses such as nature conservation. The land classes provide a framework within which these uses can be compared over the whole county and areas suggested within which specific objectives can be pursued. Policies for the integration of land uses and conservation objectives can be sought for the whole county and provide a backcloth against which the social and economic character of Cumbria can be viewed.

6.2.2 Extensive forestry is limited by physical and climatic factors which mean that tree growth is usually poor and relatively uneconomic at altitudes in excess of 457m (1500 ft). With national policy factors dictating that the better land should be used for agriculture, this means that the most suitable areas for large scale afforestation are in the land classes which have a high probability of containing extensive rough grazings and acid woodlands below 457m (1500 ft), ie vegetation types 17-32 (Table 6.3). The same constraints apply to integrated forestry/farming, although in this case the permanent pasture (vegetation types 13-16) may well be considered for planting in some cases. In order to fit into the landscape, small scale plantings would be the most appropriate in areas where there is already some form of woodland cover, ie tree cover types 2, 3 and 4. Lowland agriculture should be the main use on land in agricultural quality class 2 and better quality class 3. Such land is indicated by the current distribution of cultivated land and reseeded pasture (vegetation types 1-12) as well as by maps supplied by MAFF. Upland agriculture such as livestock rearing is the main land use in those areas not devoted to lowland agriculture. Therefore, the probability of finding such areas within the land classes is one minus the

TABLE 6.2
NATURE CONSERVATION VALUES OF THE LAND CLASSES

	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
Diversity (Component values)	-	-	0.28	0.41	0.52	0.10	1.00	0.37	0.73	0.74	0.61	0.11	0.23	0.00	0.25	0.06
Naturalness (Plots not reseeded)	1.0	-	0.03	0.05	0.33	0.15	0.45	0.73	0.90	0.81	0.75	1.00	1.00	1.00	1.00	1.00
Rarity	0.96	0.85	0.79	0.76	0.00	0.15	0.06	0.61	0.72	0.80	0.69	0.36	0.57	0.89	1.00	0.80
Mean of 3 classes	-	-	0.37	0.41	0.28	0.13	0.50	0.57	0.78	0.78	0.68	0.49	0.60	0.63	0.75	0.62
Conservation value	-	-	0	0	0	0	1	2	3	3	3	0	2	2	2	2

Note:
Land classes are ordered according to their scores on the first ordination axis of the map analysis

probability of the land class being suitable for lowland agriculture; with the exception of land classes 7 and 8, where the remaining probabilities are taken up by estuarine and sea shore ecosystems.

6.2.3 The landscape character of the lowland land classes is very much a function of the presence of woodland and hedgerow trees. Landscape policies aimed at maintaining this tree cover should be applied in areas where tree cover types 2, 3 and 4 are most likely to be found. The upland landscape types 5 to 8 have the open character which landscape conservation policies generally seek to maintain. Therefore, such policies should be pursued in land classes which have a high probability of containing these landscape types. Land classes with a high nature conservation value have been described in 6.1 and policies aimed at maintaining this value should be pursued in these land classes.

6.2.4 Pursuit of these land use and conservation objectives in the land classes which show a high probability for the given objectives is possible only when such objectives are compatible. In general, integrated forestry/farming, upland agriculture, lowland landscape conservation and nature conservation are likely to be compatible with each other, as are upland agriculture, upland landscape conservation and nature conservation. Extensive forestry is likely to be incompatible with all the other possible uses and conservation objectives. Allocation of a use or conservation policy to the land classes in which the probability of their suitability is greater than 0.6 results in compatible land uses and conservation policies in land classes 1, 3, 4, 8, 12, 13, 14, 15 and 16. Incompatible mixtures of lowland agriculture and lowland landscape conservation arise in land classes 2, 5 and 6. Land classes 9, 10 and 11 have incompatible mixtures because of the possibility of extensive forestry within them.

6.2.5 Comparing the distribution of compatible land uses and conservation policies enables four rural policy areas to be defined. It should be noted that the policy zones identified in the Preferred Strategy 'Tomorrows Cumbria' are based upon the following basic policy areas. Policy area I consists of land classes 9, 10 and 11. The main policy could be to encourage the development of an extensive forest industry both by the State (Forestry Commission) and by private foresters. The better agricultural land would continue to be farmed but this would not be expected to comprise a significant proportion of the land area (Fig 6.1).

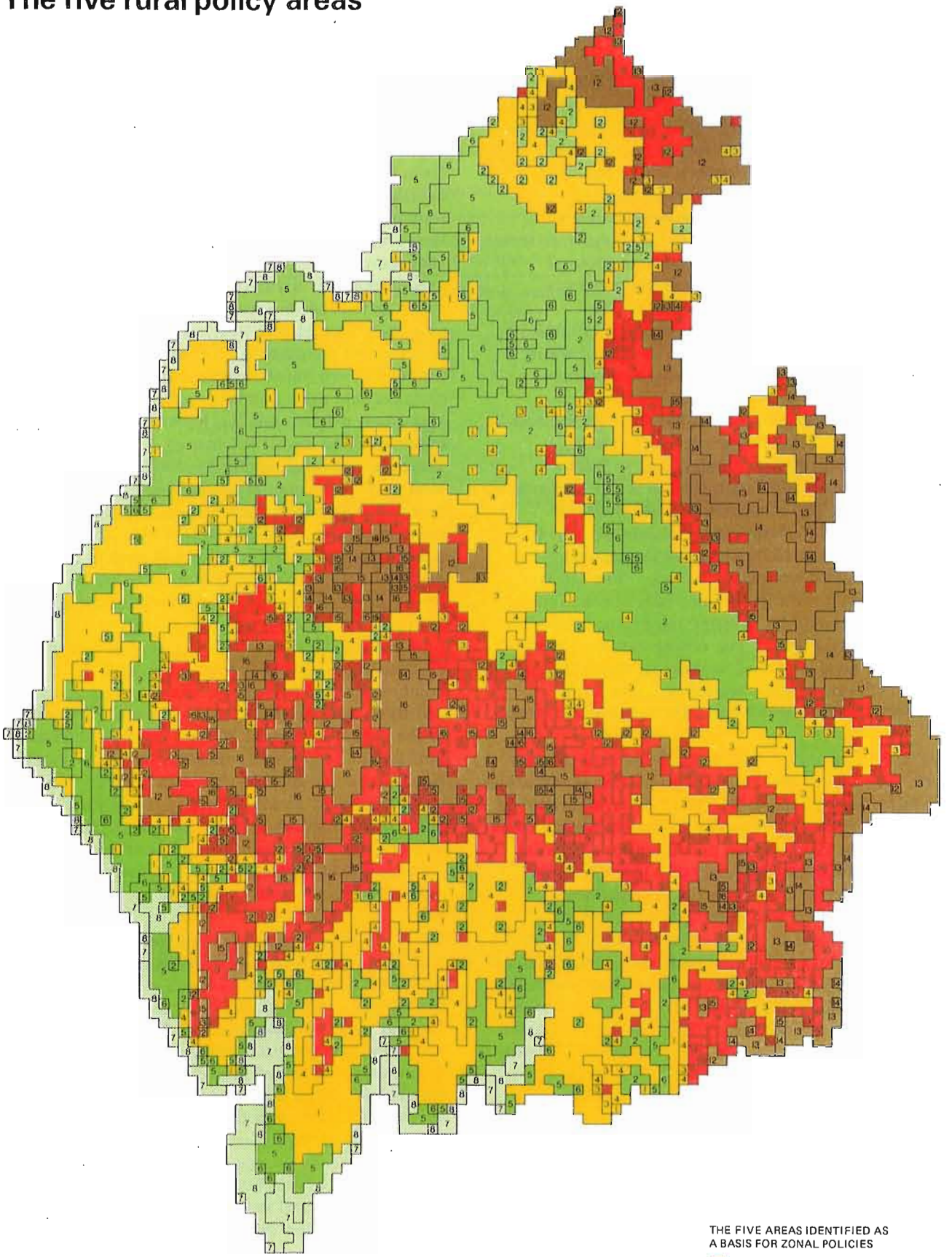
6.2.6 Policy area II consists of land classes 4, 3 and 1. Small scale forestry should be encouraged and a major consideration would be to ensure that the plantings are sympathetic to the landscape in which they are set. The existing wooded nature of the landscape should be maintained and plantings with native broadleaved species encouraged. The nature conservation interest of these foothills should be maintained by the conservation of diversity in the landscape. This would be assisted by the conservation of woodlands, peatlands, open waters and sites of geological interest. Agricultural uses should be integrated with forestry and the aim should be to try to achieve a balanced economy based on a number of land uses rather than a single one.

TABLE 6.3
PROBABILITIES THAT THE LAND CLASS IS SUITABLE FOR EACH LAND USE OR CONSERVATION POLICY

Land use/ conservation	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
Extensive forestry	0.00	0.00	0.30	0.10	0.20	0.05	0.41	0.06	0.67	0.52	0.61	1.00	0.00	0.00	0.00	0.00
Small scale forestry	0.00	0.14	0.41	0.44	0.54	0.45	0.60	0.67	0.83	0.53	0.87	0.50	0.00	0.00	0.00	0.00
Lowland agriculture	0.00	0.70	0.90	0.78	0.38	0.89	0.43	0.27	0.06	0.10	0.17	0.00	0.00	0.00	0.00	0.00
Upland agriculture	0.00	0.00	0.10	0.22	0.62	0.11	0.57	0.73	0.94	0.90	0.83	1.00	1.00	1.00	1.00	1.00
Lowland landscape conservation	0.00	0.25	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.25	1.00	0.00	0.00	0.00	0.25	0.00
Upland landscape conservation	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.50	0.68	0.88	1.00	1.00	1.00	1.00	1.00
Nature conservation	-	-	0.00	0.00	0.00	0.00	0.33	0.66	1.00	1.00	1.00	0.00	0.66	0.66	0.66	0.66

Fig. 6.1

The five rural policy areas



THE FIVE AREAS IDENTIFIED AS A BASIS FOR ZONAL POLICIES

- Area I (land classes 9, 10 and 11)
- Area II (land classes 1, 3 and 4)
- Area III (land classes 2, 5 and 6)
- Area IV (land classes, 12, 13, 14, 15 and 16)
- Area V (land classes 7 and 8)

6.2.7 Policy area III consists of land classes 2, 5 and 6. Intensive agricultural use of these lowland areas conflicts with the conservation of the wooded landscape characteristic of them. This conflict is inevitable in the drive to increase food production. Any loss of woodland and hedgerow trees in the rationalisation and intensification of farming should be ameliorated by the production of a new landscape, with replacement trees being planted in field corners and areas unsuited to agriculture. Old hedgerows should be retained as should old permanent pastures, where this does not conflict with the agricultural potential of the land. Within this matrix of intensive farming, sites which harbour rare plants and animals (as specified by the Protection of Wild Creatures and Wild Plants Act, 1975) should be protected as should SSSIs and nature reserves. Intensive agriculture should be the sole land use on land of agricultural class 2 and the better quality class 3. In the urban fringe areas around Carlisle, Penrith, Barrow and Kendal, and in West Cumbria generally, such land is under particular pressure. The structure and efficiency of farming in the urban fringes should be helped wherever possible by ensuring the minimum disturbance of agricultural land. The labour-saving and greater efficiency of modern farm buildings should be of more importance than the lowland landscape. The conservation of visual amenity need not be of overriding importance although every effort should be made to fit modern farm buildings into the lowland landscape.

6.2.8 Policy area IV consists of land classes 12, 13, 14, 15 and 16. These upland areas of the county correspond to the 'less favoured areas' of the EEC directive (75/268/EEC) which authorises member states to make provision for a special system of assistance in certain less favoured areas in order to 'ensure the continuance of farming thereby maintaining a minimum population level or conserving the countryside'. The provisions bring into existence compensatory allowances which are basically headage payments similar to those being paid under the hill cow and sheep subsidy schemes. There are two reasons for assisting agriculture in the uplands. Firstly, it is the primary land use and is essential if healthy rural communities are to be maintained and depopulation prevented. Secondly, the open nature of upland landscapes and their associated characteristics such as stone walls, depend to a large degree on their use as grazing lands. Therefore, assistance to agriculture in 'less favoured areas' helps to conserve the landscape as well as maintaining the nature conservation interest of these areas. The conservation of the upland landscape is one of the prime reasons for the existence of the Lake District and Yorkshire Dales National Parks, and for the proposal to designate the North Pennines as an Area of Outstanding Natural Beauty (AONB). Policies aimed at conserving the upland landscape should, therefore, have priority in these areas; also in areas of similar character outside the national parks and AONB.

6.2.9 Coastal land classes 7 and 8 comprise a fifth policy area, separated from the rest by the special character of these land classes.

6.2.10 These policy areas have been derived from present land use objectives. More detailed farming objectives need specific information concerning the productivity of the land classes. Bishop (1977, unpublished) has characterised the land classes in terms of their productivity for a variety of uses, and investigated the implications for the land use pattern of changing objectives. He has generalised the outputs from the classes as timber (cu m), meat (tonnes), food energy (terajoules), milk (tonnes), recreation and ecological values, and the inputs as labour (standard man days) and energy (terajoules). These outputs and inputs have been related to six land uses viz: coniferous forestry; broadleaved forestry; livestock rearing (cattle); livestock rearing (sheep), with and without improved pasture management; dairy farming, and arable farming. A mathematical modelling technique known as linear programming has been used to calculate the land use patterns which most efficiently produce any desired mix of commodity outputs. The model developed has been run under combinations of objectives, management options and fixed land use patterns. The most relevant to the County Structure Plan at present are fixed land use patterns in the national parks, proposed North Pennines AONB and common land. It was considered that no major change from what is taken to be the present uses of land in these categories will be permitted within the current structure plan period, because of the need to conserve their visual landscape.

6.2.11 Three policy options have been explored with these fixed land use constraints. A land use pattern was produced which maximised the production of timber and kept other outputs at least at their present levels. Similarly the land use pattern which maximised meat production and that which maximised food energy was produced. The outputs from these three analyses are given in Table 6.4 and show that each analysis gives an increase over present outputs of milk. Maximising food energy in particular gives a very high milk yield but requires 7% more labour than at present and twice as much extra energy as maximising the timber and meat outputs.

6.2.12 The change in land use patterns necessary to realise the increase in productivity is shown in Table 6.5. In each analysis there are increases in the area of coniferous forestry in classes 4 and 9, intensive sheep farming in classes 10, 11 and 12, and dairy farming in classes 1, 8, 2, 5 and 6. Maximising timber

and meat production entails increases in the area of livestock rearing (cattle) farming in classes 3 and 4, and sheep farming in classes 1 and 8. The sensitivity of these analyses to small changes in the productivity of the land classes is such that the major changes, ie an increase in forestry at the expense of livestock rearing land, require large changes in the productivity if the proposed land use pattern is to be altered. Dairy farming, with associated beef production, is the first choice for land classes 2, 5 and 6. Livestock rearing (cattle) is first choice for class 3 and sheep farming for class 4. Classes 1 and 8 can go into any one of these three uses depending upon the product being maximised. The distribution of land

TABLE 6.4
OUTPUTS AND INPUTS FROM CUMBRIA UNDER PRESENT AND PROPOSED LAND USE CONFIGURATIONS

	Present land use pattern	Optimum patterns: maximising timber		Optimum patterns: maximising meat		Optimum patterns: maximising food energy	
	Totals	Totals	% of present totals	Totals	% of present totals	Totals	% of present totals
Timber (tonnes)	331 000	450 510	36	331 000	0	331 320	1
Meat (tonnes)	81 800	81 800	0	83 904	3	81 800	0
Food energy (terajoules)	3 470	3 470	0	3 470	0	4 143	19
Milk (tonnes)	843 000	918 471	9	910 390	8	1 144 910	36
Wool (tonnes)	2 700	2 700	0	2 700	0	2 700	0
Recreation	332 000	332 063	0	332 130	0	332 048	0
Ecological value	287 000	287 050	0	287 096	0	287 081	0
Labour input (millions SMD)	3.60	3.61	0	3.60	0	3.86	7
Energy input (terajoules)	9 600	9 951	3	10 006	4	10 379	8

TABLE 6.5
CHANGE OF USE OF LAND CLASSES UNDER PROPOSED FUTURE LAND USE PATTERNS

Percentage of each land class that changes use under the proposed future land use patterns when maximising the outputs of timber, meat, and food energy successively whilst maintaining the outputs of other products at their present levels.

	Coniferous forestry	Broadleaves forestry	Cattle rearing	Dairy farming	Arable farming	Sheep farming	Intensive beef	Intensive sheep
Timber maximised:								
Land class								
1, 8	-1	-1	-12	17	-3	0	0	0
2	6	-2	-25	-21	0	41	0	0
3	-2	-1	31	-16	-2	-10	0	0
4	9	-1	23	-6	0	-27	0	0
5, 6	0	-2	-14	27	-3	-9	0	0
9	11	0	-5	-3	0	-2	0	0
10, 11, 12	-2	-1	-4	-2	0	-11	0	20
13	1	0	0	0	0	-1	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	1	0	0
16	0	0	0	0	0	0	0	0
Meat maximised:								
Land class								
1, 8	-1	-1	-2	-35	-3	42	0	0
2	-2	-2	-25	41	0	-13	0	0
3	-2	-1	45	-16	2	-24	0	0
4	9	-1	14	-6	0	-19	0	0
5, 6	0	-2	-14	27	3	-9	0	0
9	11	0	-5	-3	0	-2	0	0
10, 11, 12	-9	-1	-4	-2	0	-9	0	24
13	1	0	0	0	0	-1	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	-1	0	0
16	0	0	0	0	0	0	0	0
Food energy maximised:								
Land class								
1, 8	-1	-1	-12	17	-3	0	0	0
2	0	-2	-25	38	1	-13	0	0
3	-2	-1	-6	-16	-2	27	0	0
4	8	-1	-14	-1	0	5	0	0
5, 6	0	-2	-14	27	-3	-9	0	0
9	10	0	-5	-3	0	-2	0	0
10, 11, 12,	-8	-1	-4	-2	0	-11	0	26
13	-1	2	0	0	0	-1	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0

TABLE 6.6
PROBABILITY OF LAND CLASSES BEING SENSITIVE TO CARAVAN SITE DEVELOPMENT

	Land class															
	7	8	6	5	1	2	4	3	11	12	10	9	13	14	15	16
Nature conservation value	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.66	1.00	1.00	1.00	0.00	0.66	0.66	0.66	0.66
Tree cover types 1, 2 and 6	1.00	1.00	0.75	0.25	0.25	0.50	0.50	1.00	0.00	0.50	0.00	0.75	0.75	1.00	0.75	1.00
Landscape types 5, 6, 7 and 8	0.00	0.00	0.00	0.13	0.13	0.00	0.75	0.83	0.83	0.83	1.00	1.00	1.00	1.00	1.00	1.00
Summed probabilities	1.00	1.00	0.75	0.38	0.38	0.50	1.58	2.49	1.83	2.33	2.00	1.75	2.41	2.66	2.41	2.66
Ranged probabilities	1	1	1	1	1	1	2	3	2	3	2	2	3	3	3	3

Note:
Land classes are ordered according to their scores on the first ordination axis of the map analysis

classes which require an increase in the proportion of land under these uses is given for the land use pattern which maximised food energy production (Fig 6.2). Such maps can provide a basis for the derivation of rural policy areas when the social and economic factors not used in the modelling are considered against the priorities for planned change in the way land is used.

6.3 LOCAL PLANS

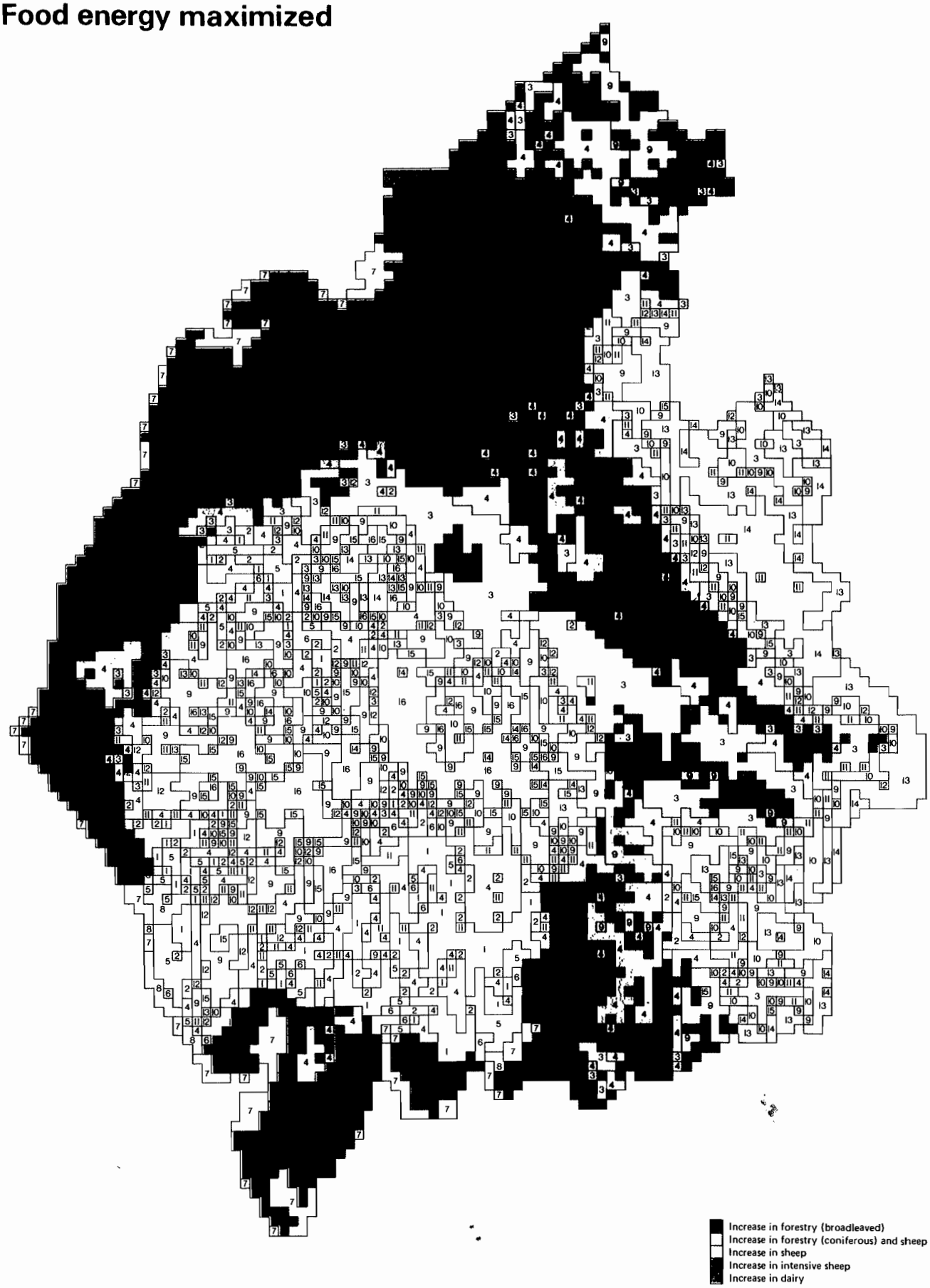
6.3.1 Local plans differ from the Structure Plan in that they are, as their name suggests, produced for smaller areas of the county and for specific subjects. The ecological characteristics of a local plan area can be predicted from its land class composition, as was done for the Lake District National Park (cf Chapter 5). A local survey on the same lines as the county wide survey, with its own land classification from map characteristics of grid squares, can be carried out and compared with the norm predicted for the area. Such surveys for future local plans are currently being done for the Arnside/Silverdale AONB and for that portion of the Yorkshire Dales National Park in Cumbria.

6.3.2 The county wide survey information has been used in a local subject plan for caravan development throughout the county. The definition of areas likely to be sensitive to caravan development on landscape and nature conservation grounds can be carried out by consideration of the factors affected by caravan sites. The nature conservation value of the land classes is important here. Of the six tree cover types defined, the probability of finding types 1, 2 and 6 in a land class was used as measure of sensitivity. The assumption underlying this choice was that areas where there was a minimum of tree cover were likely to be more sensitive to caravan development than densely wooded areas. Of the eight landscape types defined, the probability of finding types 5-8 in a land class was used as a measure of sensitivity. The assumption underlying this choice was that upland open landscapes were likely to be more sensitive to caravan development than the lowland landscapes. The probabilities for each of these three criteria were summed and placed into three ranges; the highest range showing the land classes which were likely to be most sensitive to the development of caravan sites (Table 6.6). Translating these values onto a map shows that the central Lake District, Pennines and the western edge of the Eden Valley are likely to be sensitive to caravan development. This does not preclude finding suitable caravan sites within them. It means that the chances of finding a suitable site are much lower in these areas. As with other applications of the land classification, a framework has been provided for estimating the extent of a particular attribute throughout the county.

6.4 SUMMARY AND CONCLUSIONS

6.4.1 The survey data collected from the land classes has been used to assess the nature conservation value of each land class. These values have been compared with those derived from an analysis of SSSIs and the two evaluations are shown to be similar but with their emphasis slightly different. In the first case the greatest values are attached to the intermediate land classes where the uplands and lowlands meet. In the second case the greatest significance is attached to the high upland and coastal land classes. The productivity of each land class has been assessed for a number of products and the land use patterns, which maximise certain products such as food energy, derived by computer modelling.

Fig. 6.2
Food energy maximized



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