A vegetation analysis of some woodlands in the Coniston basin Cumbria

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A Vegetation Analysis of
Some Woodlands in the
Coniston Basin
Cumbria.

By

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1. INTRODUCTION

The woodlands studied cover the west facing slopes of hills to the east of Coniston Water, Cumbria (Grid Refs. SD 290900 - SD 300930) and range in altitude from 45m to 210m; the hills themselves reaching a height of 300m.

The study area is probably one of the best remaining representatives of what has been regarded as the climax vegetation of the Lake District, that is:- mixed sessile oakwood. The mixed woods are composed mainly of Quercus petraea with Betula pubescens, Corylus avellana, Alnus glutinosa, Ulmus glabra, Fraxinus excelsior and Tilia cordata and include woodlands formerly exploited and treated for centuries as enclosed coppice but now allowed to grow up. There are also some planted areas of Larix decidua and Fagus sylvatica.

The study was planned as a primary phytosociological survey, to provide a preliminary description by identifying the major vegetation types within the woodlands and to establish whether the variation in vegetation could be related to variation in underlying rocks or to former working of the woodlands for charcoal or influence of other environmental factors.

The sampling was confined to those woodlands owned by the National Trust, partly to restrict the

Fig. 1. Coniston Woods

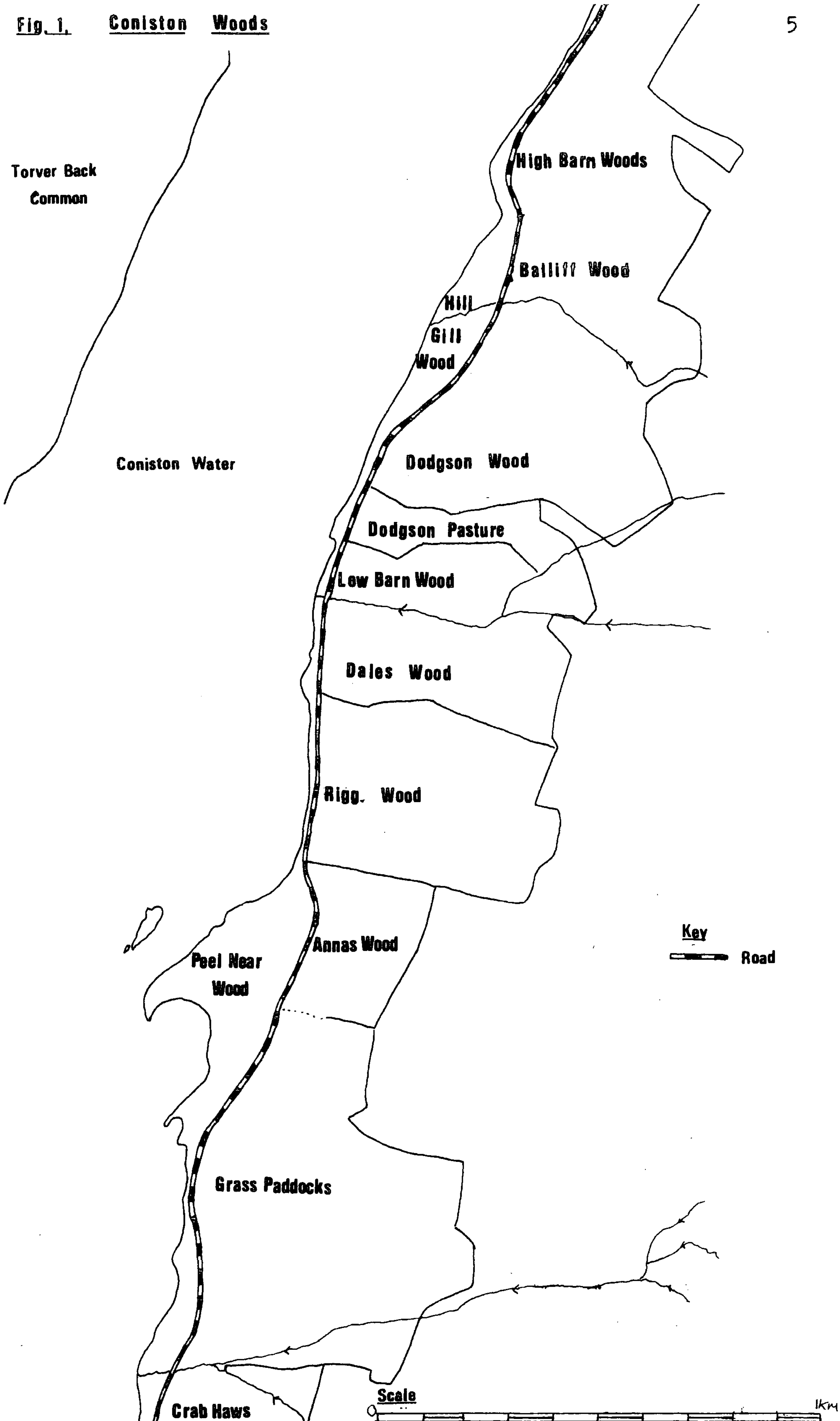
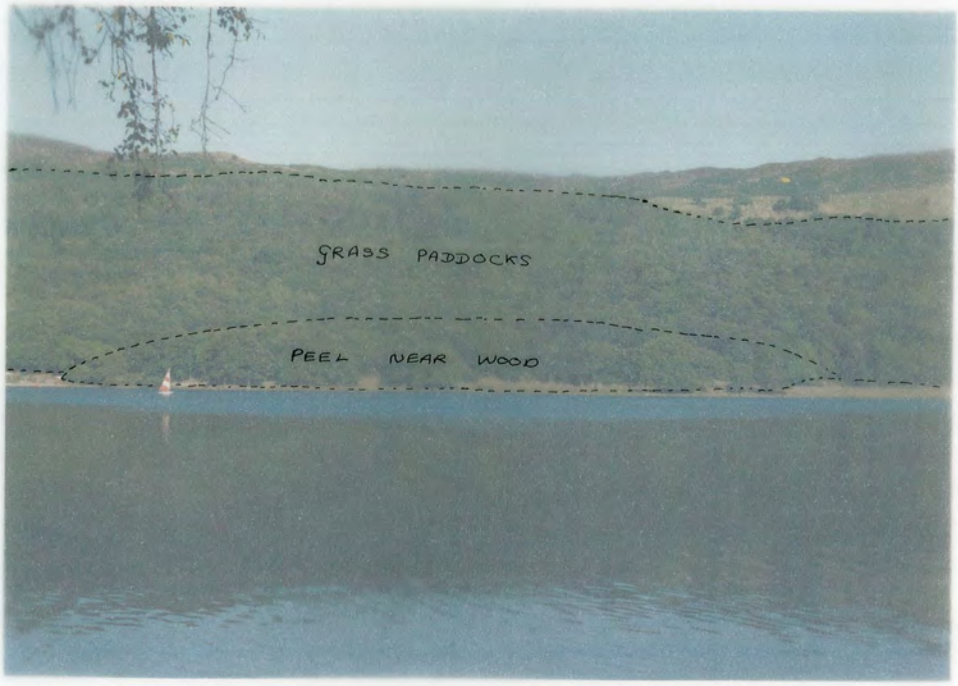


Fig.2.
(a)

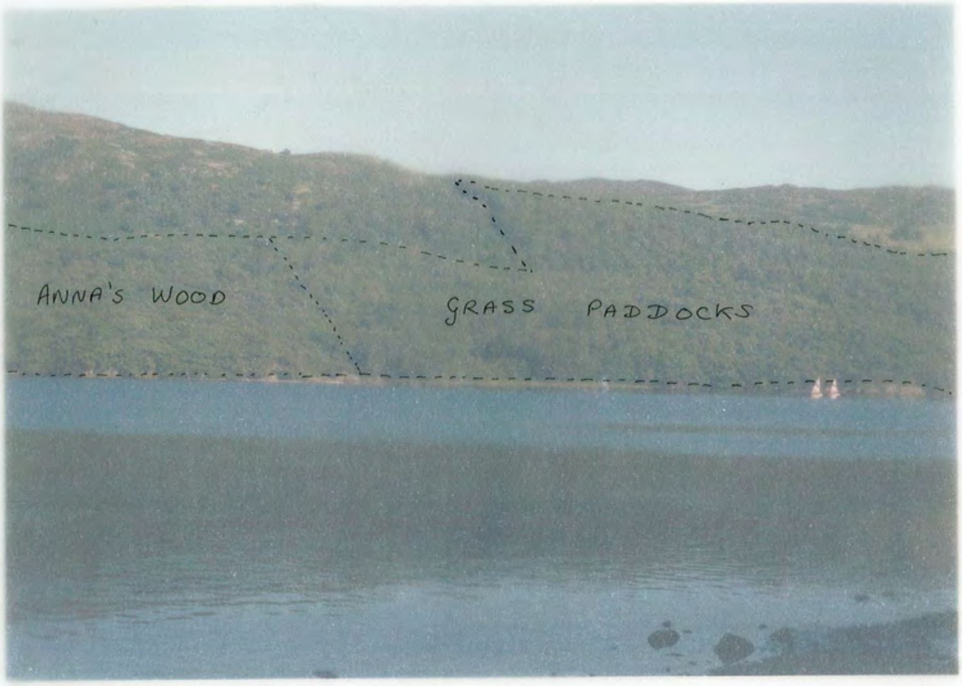
Crab Haws and Grass Paddocks.

Fig.2.
(b)



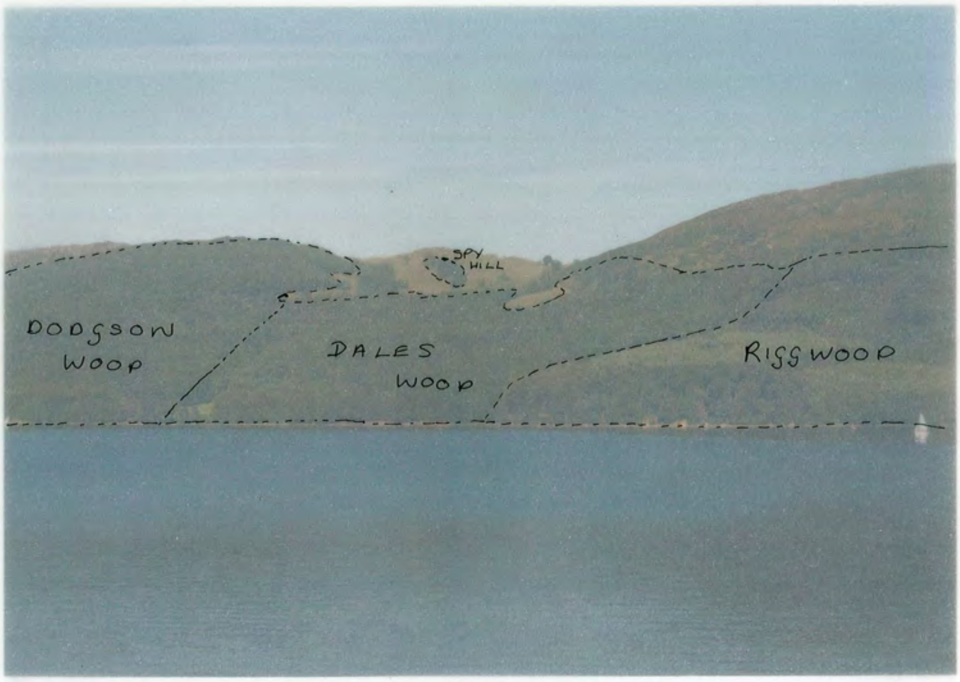
Grass Paddocks.

Fig.2.
(c)



Anna's Wood and Grass Paddocks.

Fig.2.
(d)



Dodgson Wood, Dales Wood and Rigg Wood.

extent of the study and also for easy access: the woodlands studied are namely:- Crab Hawes, Grass Paddocks, Anna's Wood, Dales Wood, Low Barn Wood, Dodgson Pasture, Dodgson Wood, Hill Gill Wood, Bailiff Wood and Coplands Barn (Fig.1 + 2). The woods grade upwards into Festuca/Agrostis grassland (Fig.3) and downwards directly onto the lake shore (Fig.4) and throughout the report they will be collectively referred to as Coniston Woods. The National Trust has conducted a more wide ranging study of their woodlands in the Lake District but this has not yet been published.

Nomenclature follows:- Clapham, Tutin, + Warburg (1962) for vascular plants, MacVicar (1964) for liverworts, James (1965) for lichens and Smith (1978) for mosses.

Fig. 3.

The woodlands merge upwards into Festuca/Agrostis grassland with bracken on the deeper soils; and this is periodically cut which accounts for the markings on the slopes.

Fig. 4.

The woodlands merge downwards directly onto Coniston Water.

2. ENVIRONMENTAL FACTORS

2(i) Geology

2(ii) Climate

2(iii) Soils

2(iv) Biotic Factors

2(i) GEOLOGY

The published geological data for the area is sparse and information is obtained from the old series geological maps (sheets 38 + 48) of which there is only one edition (1884). These use a geological terminology which is now superceded and must be interpreted with caution.

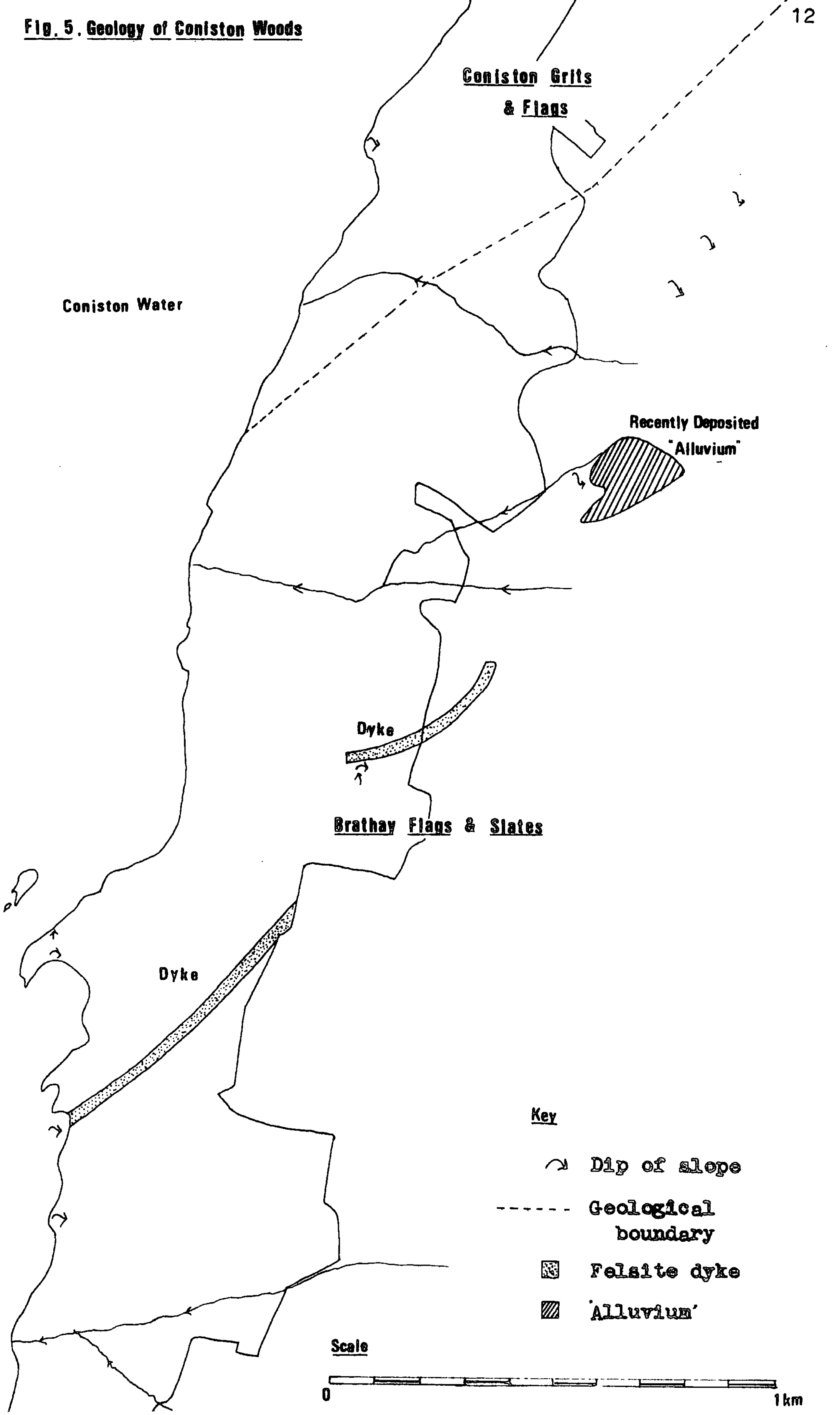
The Coniston Woods lie on the Coniston Grits, Upper Coniston Flags and Brathay Slates and Flags, which are sandy mudstones with bands and beds of sandstone. These formations are of Silurian age and being relatively soft tend to a scenery of hills with gentle rolling aspect in contrast to other regions of the Lake District of Ordovician age rocks which form the mountains.

The woods can be separated geologically, towards the north of Coniston Water the woods lie on the Coniston Grits and Flags and towards the south on the Brathay Flags and Slates, the junction of which starts at Grid Reference SD 300930 (Fig.5)

CONISTON GRITS AND FLAGS

This formation is about 1800 metres thick and represents the main onset of the greywacke turbidities. The greywacke grits and silt stones which may vary in coarseness are often interbedded with both green/grey and blue/grey mudstone. The grit bands give rise to

Fig. 5. Geology of Coniston Woods



minor but resistant ridges.

BRATHAY FLAGS

This formation consists of thinly laminated dark blue/grey mudstones that weather dull greenish brown and are in places pink tinged. Hard ovoid siliceous concretions are common and occasional calcareous nodules are present. Variations in hardness betwen successive strata and the effects of glaciation have resulted in a characteristically "knobbly" landscape.

In the Devonian geological period there was great upheaval of rocks and molten rock intruded in many places to form dykes, two of which, both of felsite, outcrop in the Coniston Woods.

To the top of the woods (Grid Ref. SD 308927) is an area of recently deposited "alluvium", probably glacial in origin, and although thin glacial drift covers a lot of the area it is relatively discontinuous and of unknown composition.

2 (ii) CLIMATE

The Lake District lies between 54° and 55° N latitudes and the climate is remarkably mild for its latitude, but is in common with most of the West coast of Britain.

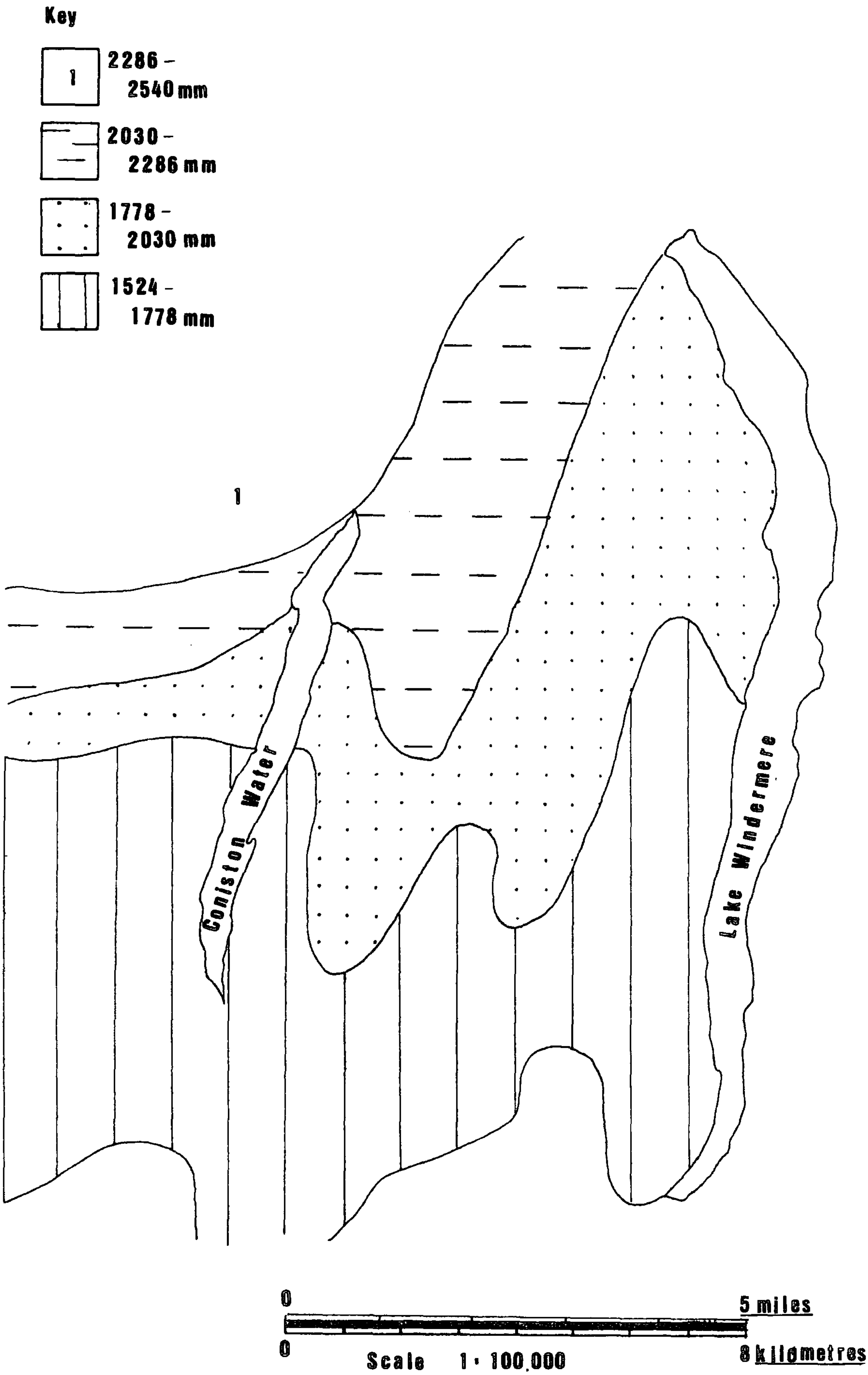
The Coniston Woods are moderately wet, the prevailing westerly winds bringing orographic rainfall. The annual average rainfall is 1524-1778 mm at the south end of Coniston Water, 1778-2030 mm in the middle and 2030-2286 mm at the north end (Fig.6) This is quite high in contrast to the south-west of Lancashire for example where rainfall averaged 889-1016 mm.

The annual average humidity for the area (1901-1930) was 80% (Meterological Office 1952) but depends upon the direction of the wind, the south-westerly winds being humid, whereas winds from the east are dry. In some of the summer months if easterly winds are prevalent there is sometimes a water deficit in the soil. The wind frequencies for the area are:-

55% south to west
25% north to east
10% west to north (Manley 1973)

Wind frequency and rainfall increase with altitude whereas temperature decreases with altitude. The temperature of the area as a whole is generally equable. Winters are mild with monthly means of daily minima normally above 0°C. (Table 1). Summers are cool with mean temperatures for July and August just over 15°C but

Fig. 6. Mean Annual Rainfall, Coniston



(Modified from Soil Survey 1970)

TABLE 1.

Monthly Means of Daily Maxima and Minima of Air Temperature at Two Sites in North-West Britain.

STATION	ALTITUDE	PERIOD		J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
AMBLESIDE	46m	1941-43	MAX	5.8	6.3	9.1	12.0	15.6	18.4	19.2	18.9	16.8	13.4	9.1	6.9
35/3704		45-46	MIN.	0.2	0.2	1.3	3.6	6.1	9.1	10.7	10.6	9.0	6.4	3.0	1.0
MORECAMBE.	7m	1941-70	MAX.	5.9	6.1	8.7	11.3	15.1	17.8	18.7	18.8	16.8	13.6	9.3	7.0
34/4364			MIN.	1.3	1.2	2.8	5.2	8.0	11.0	12.7	12.6	10.9	8.1	4.4	2.4

TABLE 2.

Monthly Means of Hours of Sunshine Per Day at Two Sites in North-West Britain.

STATION	ALTITUDE	PERIOD.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
AMBLESIDE.	46m	1941-43 45-46	1.18	2.14	3.21	4.43	5.48	5.66	4.39	4.20	3.07	2.29	1.56	1.10
MORECAMBE. 34/4364.	7m	1941-70	1.42	2.57	3.73	5.27	6.37	6.72	5.51	5.28	4.06	2.96	1.87	1.24

(Extracted from Meterological Office 1976).

because of the latitude there is great variation in intensity of radiation on slopes of different aspect therefore locally causing marked differences of temperature. Temperature differences are also related to altitude, the mean daily maximum of air temperature at a height of 200 m. is 1.4°C. lower than at the coast (Meterological Office 1976).

In spite of high rainfall the amount of sunshine compares well with other stations in similar latitudes. Mean averages per day for July and August are about 5½ hours (Table 2) (Meterological Office 1976). North-westerly winds tend to bring generally cloudless skies, but in the wetter seasons persistence of cloud will be more than other parts of the country.

2 (iii) SOILS

The main soil association of the area is the Brantwood association of brown earths, bare rock and rankers. This occurs on the valley sides and often intermingles with the Grizedale association on the plateaux.

The parent material of the Silurian rocks normally weathers to a fine earth dominated by silt sized particles, however many of the rocks are resistant to weathering and the bulk of the solum is of small angular fragments. The association normally occurs below 213 m. for above this the peaty gleyed podsols of the Grizedale association predominate due to increased rainfall and lower temperatures.

The valley sides have been glaciated and subjected to long periods of solifluction and hillwash so the upper parts are now the steepest. Although the annual rainfall varies from 1524 mm to 2286 mm (Fig.6) water is rapidly shed from the steep slopes via a network of deeply cut water courses. Thin deposits of alluvium are associated with flush sites adjacent to the streams.

The Brantwood association therefore varies with relief and is predominantly a sequence of rankers and brown earths, flush sites being occupied by shallow ground-water gleys.

(a) RANKERS + BARE ROCK

Rock and scree often occur on the upper slopes with rankers on narrow ledges. Rock also outcrops on the lower slopes forming small knolls with similar sporadic ranker development. The ranker profile consists of superficial accumulations of organic remains derived from leaf litter, lichens and mosses with well developed F and shallow greasy H horizons overlying rock.

(b) BROWN EARTHS

Brown earths with strong brown acid B horizons are widespread throughout the woods particularly on the slopes. Moder is the most common humus form consisting of leaf remains of deciduous trees or bracken, the H horizon being deepest under bracken. Brown earths with mull surface horizons, occur sporadically.

(c) GROUND-WATER GLEY SOILS

These occur on small terraces and flush sites adjacent to the narrow stream courses on steep valley sides. These sites are waterlogged following heavy rain and water moves laterally through the deposits. Typical profiles have a dark grey silt loam surface horizon, sometimes peaty or humose merging into a light grey and rust mottled horizon.

EFFECTS OF LEACHING

Climatic conditions of the area favour intense leaching and this has profound effects on the soil.

Leaching water dissolves soluble constituents and releases cations such as calcium, magnesium and potassium which are either removed from the profile altogether or redeposited in lower horizons. Brown earths are generally strongly leached; on the steeper slopes in the woods the brown earths are notably ochreous with strong B horizons, granular structure and friable consistencies. This development is probably due to intense leaching with removal of bases leaving sesquioxide - rich residues which have bright colours and friable consistencies (Crompton 1960) Rankers are also subject to leaching.

EFFECTS OF WATERLOGGING

Soils which are periodically waterlogged develop features which result from the reduction and mobilization and partial reoxidation of iron. Well drained soils are brown and red whilst poorly drained soils are grey or bluish grey. Waterlogging in soil is due either to slow percolation of water through fine textured parent materials to ground water held above a substratum less permeable than overlying layers, or to a generally high ground water level. In Coniston Woods both features occur, the former in hollows and the latter in the woods on the lake shore.

2 (iv) BIOTIC FACTORS

The two major biotic factors affecting the woods today are sheep grazing and man. Both have a long history of presence in the woodlands and this is discussed in Chapter Three.

GRAZING

(a) Sheep

Herdwick is the indigenous breed of sheep reared in the Lake District for their ability to tolerate the climate. They are found throughout the year in the Coniston Woods, during the summer months the numbers are few and have strayed down from the pasture to the top of the woods and in the winter the National Trust let out the woods to neighbouring farms as valuable winter grazing and the numbers increase tremendously. There is a profound difference in grazing intensity from summer to winter, tree seedlings being able to survive throughout the summer, but being rapidly destroyed in the winter. Access is available to most woods except some of the coppices and Hill Gill Wood (Grid Ref. SD 301930). The sheep tend to favour the gentle slopes with less rocks and even where access is available into the coppices the sheep tend not to graze there, due to a rocky substratum and general lack of forbs. Under severe grazing pressure, all areas of the wood will be grazed and it is only the completely inaccessible areas which remain ungrazed, e.g. gorge sides.

(b) Deer.

Roe deer (Capreolus capreolus) are occasionally seen in the woods, but are few in numbers and extensive damage has not been observed. Some Ilex aquifolium trees have a rounded appearance and are presumed to have been grazed by deer. Absence of well developed Rubus fruticosus agg shrubs may be the result of roe-browsing.

(c) Red Squirrel (Sciurus vulgaris leucorus)

This species is quite common in Coniston Woods and may influence the numbers of tree seedlings germinating.

MAN

Man today has comparatively little effect on the woods due to alternatives for wood in the fuel and construction industries. The largest impact is indirectly by the grazing of his sheep and directly by tourism. Coniston Water although one of the least popular lakes in the Lake District with tourists still has considerable numbers of visitors during the summer months. This has resulted in the trampling of vegetation along the shore line and damage to road verges and areas of woodland by haphazard parking of cars. This damage is totally confined to the areas within 50m on either side of the road and the rest of the woodlands tend to be preserved.

3. HISTORY

"Any attempt to consider British vegetation can only do so against a background of human history."

(Pearsall W.H. + Pennington W. 1947).

The Coniston Woods although thought to be semi-natural in the sense that they are composed of native species, bear the evidence of centuries of exploitation, and this is probably one of the major factors contributing to the present composition of the woods.

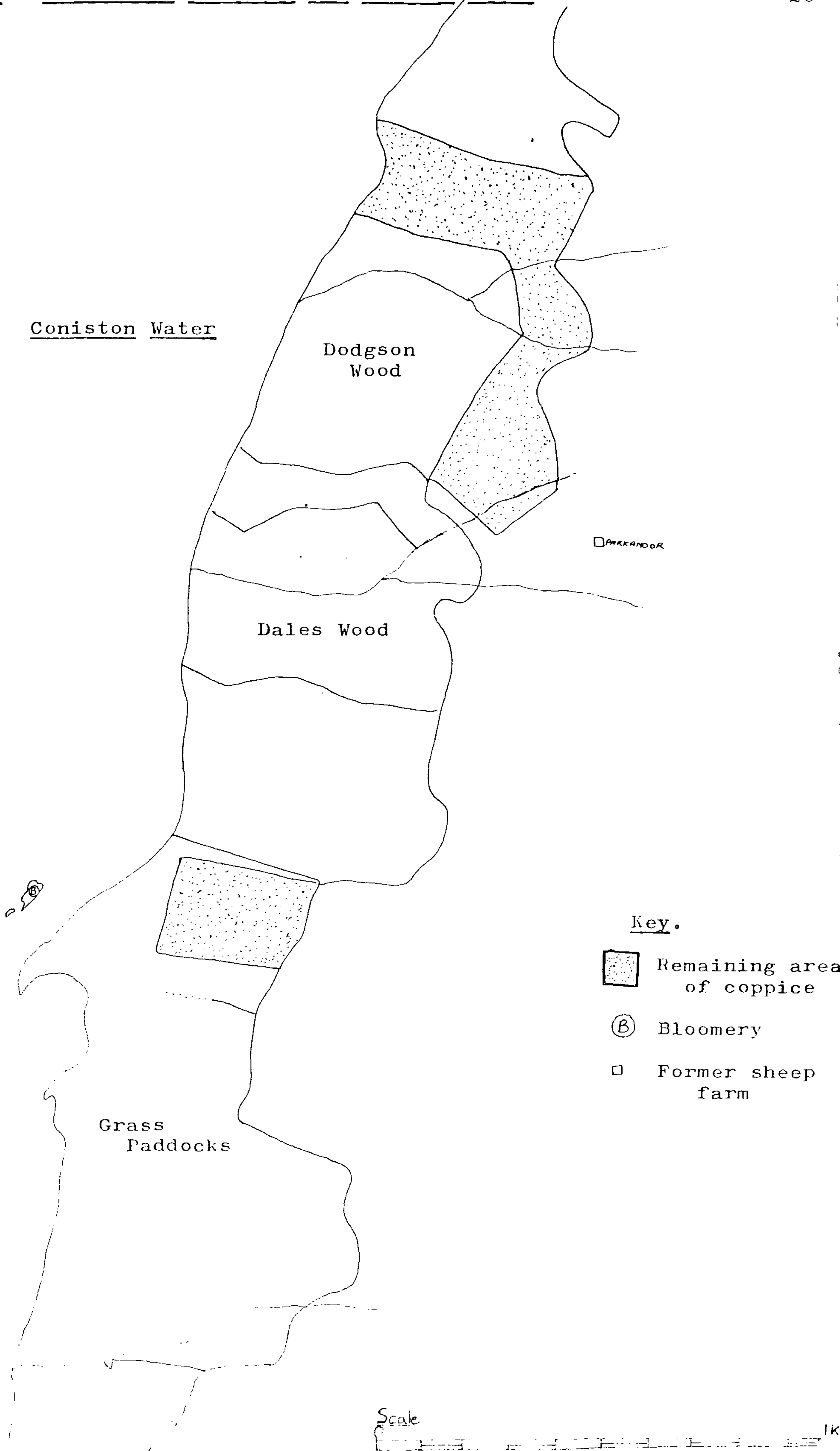
The first human colonists of the area were of 'megalithic' age and came from the south-west by sea about 7000 B.P. It is thought they lived in the woods making small clearances, but generally not affecting the landscape to any degree, but there is little evidence to confirm this.(Pearsall + Pennington 1947).

The Neolithic peoples about 2 millenia later tended to live further up the woods in more permanent settlements, giving them easy access to the grasslands for grazing their domestic animals. They used the leaves of various trees as fodder particularly the elm and also holly. This has been proposed as a possible cause of the 'Elm Decline' which in the Lake District is dated between 5300 and 5000B.P. (Pennington 1965). The effect of this primary attack on the woods was to reduce the distribution of the elm and to allow the expansion of the ash tree into the thinner lighter forests. The occupancy also intensified the proportion of grasses in the woodland flora and the destruction of the woods either by felling or intensive grazing accelerated soil erosion and deterioration resulting in larger areas becoming treeless. Such areas exist to the top of Coniston Woods and are now Festuca/Agrostis grasslands with bracken on the deeper soils (Fig.3). The former woods probably covered this area completely. Further attacks took place on the oak woods all over the Lake District in the second and third centuries A.D. as agriculture improved corresponding to the late and post Roman period.

Severe exploitation occurred in the 9th and 10th centuries A.D. with the Norse occupation. They intensified sheep grazing as a result of increased population. A Norse land-take existed on the lower woods in the sample area collectively known as Nibthwaite Woods, the element thwaite is of Norse origin indicating a clearing or land-take.

After the Norse the woods around Coniston Water were mostly owned by the Cistercian monks of Furness Abbey and they began the conversion of what remained of the natural vegetation on their land to sheepwalk and enclosed coppice woodlands. The Furness monks rented out large sheep farms at Lawson Park and Parkamoor to the top of Coniston Woods (Fig.7) and these farms existed until acquisition by the Forestry Commission and National Trust respectively. The sheep affected most of the woodlands except where they were of commercial value as coppice and these areas were

Fig. 7. Historical Evidence in Coniston Woods.



enclosed by dry stone walls.

After the dissolution of the monasteries in the sixteenth century A.D. the woodlands still provided grazing areas for sheep and cattle mainly as winter grazing, but their greatest source of wealth lay in the amount of wood available for timber, charcoal, and bark. The industries scarred the woods with permanent packhorse ways, charcoal pitsteads, stables, bark houses and dwellings. The packhorse ways and pitsteads are very much in evidence today (Fig.8) and remains of the dwellings can be seen occasionally (Fig.9) (Marshall and Davies-Shiel 1969).

The trees provided the raw material for housing, sailing vessels, barrels, staves, hoops and fuel for dozens of industries from iron manufacture to preparation of gun powder. Several bloomeries existed in the woods, the remains of one can be found on Peel Island (Grid Ref. SD 295918).

To ensure a regular supply of wood, most of the trees were coppiced and large areas of former coppice remains today. (Fig.7) The principle of coppicing is that when the standard is felled the cut is made a few centimetres above the ground and at an angle so that the bole will not rot. From this stool springs up a ring of shoots that compete fiercely for sunlight and grow tall and straight, 10-20 poles may grow from each stool and the stools are about 2-3 metres apart. The woods were coppiced every fourteen to sixteen years. The

Fig.8.

Charcoal pitstead and pathway, Coniston Woods.

Fig.9.

Remains of a charcoal burner's dwelling, Coniston Woods.

poles were sold directly to timber merchants, or the charcoal burners who burned the poles on pitsteads in the woods. The pitsteads today (Fig.8) are seen as flat circular terraces on otherwise steeper slopes usually colonized by bracken or birch and old trees facing into the pitstead may bear the scars of intense heating.

Due to different rates of demand for various trees and shrubs, some may have been planted, e.g.hazel coppices and others may be discouraged from growing e.g. Tilia cordata, which was regarded as a worthless tree by the charcoal burners because of its tendency to reignite. (Pigott and Huntley 1978). Oak was in great demand for support beams and hoops, the smaller branches for high-grade charcoal and the bark for tannin. Ash,too, was of great value particularly for oars, poles and axe handles, but later American imports reduced the demand for ash. There are incidences of coppiced oak and ash throughout Coniston Woods.

The woods today have not been coppiced since the Second World War when wood was in great demand, but selective felling has taken place in some of the plantation areas probably as thinning measures.

4. METHODS

4 (i) Field Survey

4 (ii) Methods of Field Survey

4 (iii) Soil Analysis

4 (iv) Data Processing.

4 (i) FIELD SURVEY

Prior to any sampling a preliminary investigation of the woods took place. This showed that the major variation in vegetation was between the relatively inaccessible gorge sites and the rest of the woods. To ensure a reasonable representation of these stream sites in the field survey it was decided to select sites for plots at random distances along the stream. By using random sampling other communities were, however, under or unrepresented altogether, these sites included high altitude lichen rich oakwood, alderwood on the lake shore, various Juncus and Sphagnum communities in hollows and also birch/oak coppice.

As the purpose of this preliminary survey was to characterize the major vegetation types within the woodlands, these communities of small extent were omitted from the survey.

4 (ii) METHODS OF FIELD SURVEY

The methods of field survey were the same as those used by the National Vegetational classification (N.V.C.) and set out in their field manual. (Rodwell 1978, unpublished)

For the purpose of sampling in a woodland, a fairly large quadrat is necessary, both in order to include a reasonable number of trees, and if the canopy is dense to accomodate an adequate sample of ground vegetation. The sixty-eight sites studied were randomly selected throughout the woods. The woodland ecosystem is composed of several layers, canopy, shrub, ground and bryophyte layer. To represent all layers two quadrats of different areas were employed at each site. The first quadrat was 50m. x 50m. and was used exclusively for estimating cover of the tree canopy and shrub layer. Square plots were taken at all but the gorge sites where a rectangle of the same area was used to keep the quadrat relatively homogenous. The second quadrat was 4m. x 4m. and was used for estimating cover of the ground and bryophyte communities, all of these smaller quadrats were square. Later during data classification both the large and small quadrats were combined under a single site heading.

At each site several environmental variables were noted:- grid reference, altitude (m.), slope (degrees), aspect (degrees), soil profile and pH.

Simple notes were made on:-

(i) Community structure

(ii) Spatial relationships with neighbouring communities.

(iii) Temporal relationships with other communities.

(iv) Biotic factors of possible importance.

(v) Environmental features not covered elsewhere.

Sketches of the sites were also made and together with the notes above appear under the heading 'Site and Vegetation Description', on the field record cards but were unable to be reproduced on the computer facsimiles.

The mean height of the canopy, shrub, ground and bryophyte layers were recorded (m,m,cm and mm respectively). Height variations within these layers were noted in 'Site and Vegetation Description'. The percentage cover of each layer was estimated using the Domin scale (sensu Dahl + Hadac 1941):

Domin Value	% Cover Abundance	
10	91-100%	
9	76- 90%	
8	51-75%	
7	34-50%	
6	26-33%	
5	11-25%	
4	4-10%	
3	frequent	< 4%
2	sparse	< 4%
1	rare	< 4%

Species List

All the vascular species, bryophytes, and macro lichens were listed. In accordance with continental practice bryophytes on rocks were ignored (c.f. Poore 1955) and only those growing on soil were included. The areas of bare rock, bare soil and litter were entered at the end of the complete list.

These methods produce a basic unit of phytosociological data:- the relevé, comprising a list of plant taxa present plus their cover abundance values and additional data describing the location of the plot and the structure of the vegetation.

4 (iii) SOIL ANALYSIS

The soil from each plot was examined, samples were taken using a 3.8cm diameter corer, and two or three cores were taken from different positions at each sample site. As soon as possible after collection the pH was measured in a 1:2.5 soil/water ratio by volume.

The soils were passed through a 2mm sieve and oven dried at a temperature of 120°C. prior to further analysis. Only readily exchangeable calcium was measured by the following method:- 2.5g. of dried soil was shaken for an hour with 25cm^3. of 1 mol/dm^3 ammonium acetate in water. The suspension was centrifuged for ten minutes then filtered and the residue was re-suspended three times in 25 cm^3 1 mol/dm^3 ammonium acetate and centrifuged and filtered each time to give 100 cm^3 of extract.

Preliminary readings of the extracts were taken using a Unicam SP 90 A Series 2 Atomic Absorption Spectrophotometer and dilutions were then made according to the reading. 1 cm^3 of strontium chloride was added to each 9 cm^3 of extract to prevent interference from other cations e.g. phosphorus.

After dilutions accurate readings were taken and the results adjusted accordingly.

Calcium concentrations in moles/kg were calculated from the readings by the following relationship:

$$(\text{Reading} \times \text{Dilution}) - \text{Blank} \times \frac{\text{standard concentration}}{\text{standard reading}} \times \frac{1000}{\text{wt. sample(g)}} \times \frac{\text{volume cm}^3}{1000}$$

The standard was 0.5 moles/dm^3 and when the stanard read 100 on the Atomic Absorption Spectrophotometer the blank had a reading of 3.

4 (iv) DATA PROCESSING

Data were handled using primarily the PHYTOPAK program package (Huntley, Huntley + Birks 1981) developed by Dr.B.Huntley at the University of Cambridge and implemented by him for use by the National Vegetational Classification team members working in the Universities of Lancaster and Manchester on the C.D.C. 3600 computer at the University of Manchester Regional Computer Centre. Phytopak is a series of computer programs that facilitate the handling and analysis of large sets of phytosociological data. The programs are written in FORTRAN IV and implement on both IBM and CDC computers.

Quantitative species and environmental records for the 68 samples were coded, in order to encode the data each relevé was assigned a unique code number and unique code numbers were assigned both to taxa encountered and to each of the non-biological features of the plot. The collective term 'species' is used for taxa and these special variables. The format used on the punched cards is called FORMAT - H which allows for 4 digit 'species' code numbers and 3 digit data variables. Having encoded the data and transferred to punched cards the data were then stored in the computer. A names file and primary data file containing all the data were generated.

Computer facsimiles of the record cards were printed using NVCREC program. NVCREC processes the primary data, relevé by relevé producing for each relevé a single sheet listing species and values. The primary function of the record sheet output by NVCREC is to allow easy checking of the data against the original data source. Coding and punching errors were corrected and the samples were subjected to a divisive polythetic classification using the INDICATOR SPECIES ANALYSIS (Hill et al 1975) program on the qualitative species scores.

Indicator Species Analysis is a divisive polythetic method of numerical classification applicable to large sets of qualitative or quantitative data. It generates a key which enables new data to be assigned to the classificatory framework. Each dichotomy is established in several steps. First, a one dimensional reciprocal averaging ordination is computed. The stands are then divided into those with higher and those with lower scores than the mean score for all stands. Indicator species are then identified which discriminate as well as possible between the two groups of stands. These are then used to construct a secondary ordination. The balance between the indicator species in the secondary ordination provides an objective and easily applied criterion for identifying the two groups of stands which can be used conveniently in the form of a key. The process was repeated several times and five hierarchical levels reached (Fig.11)

The program TABLE was then used to print a data table of sample/species records structured according to the results of Indicator Species Analysis but with quantitative species scores inserted. Ordering of species was carried out manually but it is recognised that the program TWINSPAN (Hill,1980) is now available which has a method incorporated in the program to do these.

Ecological groups were defined which, in most cases, were readily recognised and seem to have clear ecological meaning.New tables were then printed with environmental variables added.

5. RESULTS

5. RESULTS

Indicator Species Analysis defined thirty-two groups after five divisions, but it is only meaningful to distinguish eight groups which are formed after three divisions.

The groups defined are:-

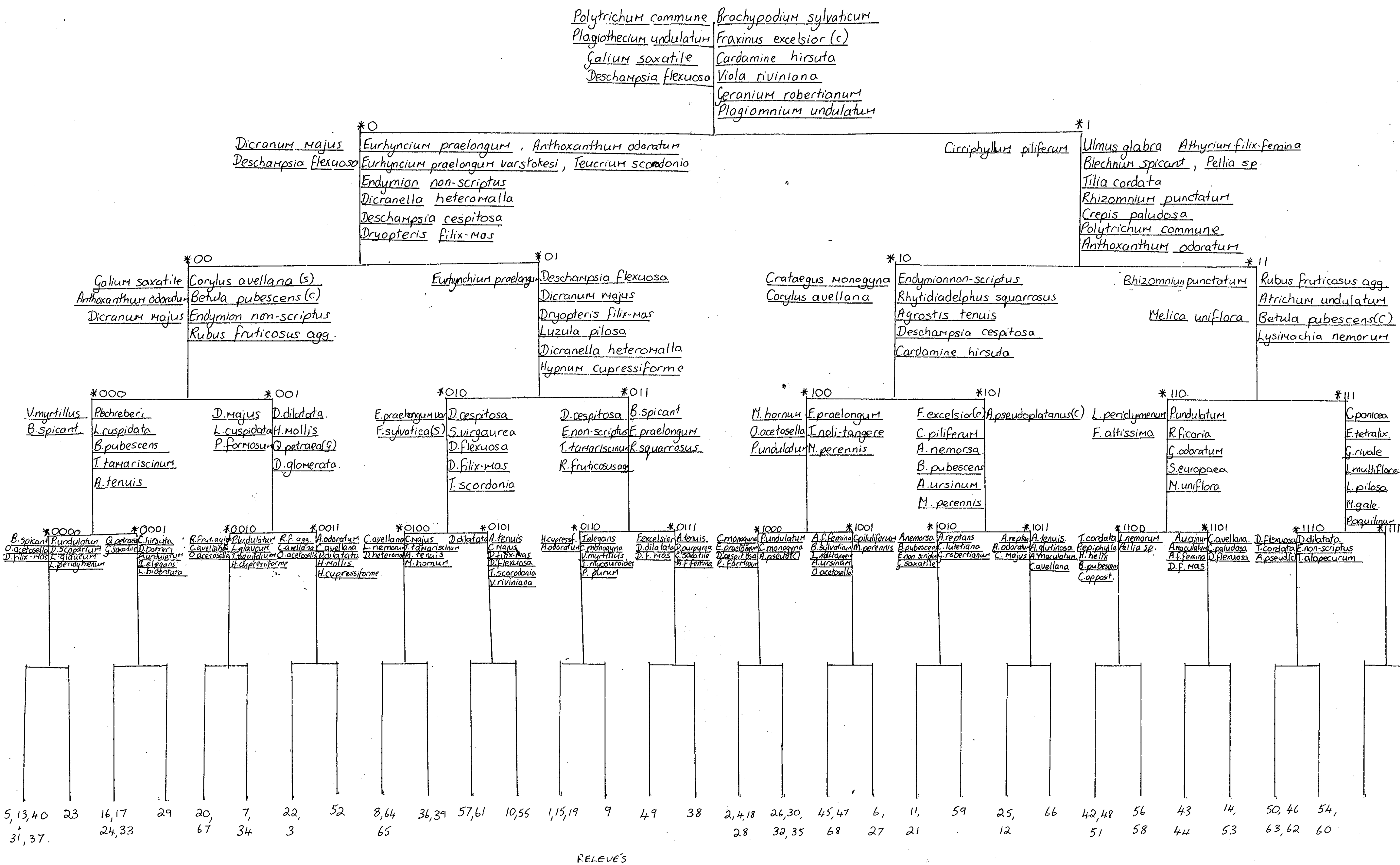
1a. Oak/Birch/Hazel Coppice.
1b. 'Heathy oakwood'
2a. Dry oakwood.
2b. Humus rich oakwood.
3a. Damp ash/oakwood with hazel coppice.
3b. Ash/oakwood
4a. Wet gorge sites, mixed deciduous.
4b. Drier streamside sites, mixed deciduous.

Synoptic constancy tables are constructed for each group: the constancy classes are determined by the following constancy percentages of a particular species in a group.

CONSTANCY CLASS	PERCENTAGE
I	1-20%
II	21-40%
III	41-60%
IV	61-80%
V	81-100%

Throughout the results the symbols (G), (S), and (C) accompany tree and shrub species. These symbols represent ground layer, shrub layer and canopy layer respectively.

Fig.11. Indicator Species Analysis of Coniston Woods Data.



GROUP ONE

This group is characterised by the constancy and abundance of Quercus petraea and Betula pubescens in the canopy, and Oxalis acetosella, Deschampsia flexuosa, Anthoxanthum odoratum and Pteridium aquilinum in the field layer with a bryophyte community of Dicranum majus, Mnium hornum and Polytrichum formosum (Tables 3 + 4)

Positive indicator species are Dicranum majus and Deschampsia flexuosa.

This community of oak/birch woods is found on the steeper rocky slopes of the woods at a range of altitudes (61-210m). The vegetation type is best described as 'heathy woods' as recognised by Moss et al (1910), Tansley (1939 pp314-315), Scurfield (1953), McVean and Ratcliffe (1962) and Tittensor and Steele (1971), based upon floristics of the field and ground layers, although one or two species suggest a better soil than the poorer heathy types found on podsols. Pearsall (1938) has described this community on the basis of soil properties; he outlines a Vaccinium/Deschampsia/Dicranum community on soils which are base deficient with a pH of less than 3.8 and earthworms absent.

'Heathy woods' are characteristic of dry acidic soils and in Coniston Woods although precipitation is high there is good drainage of these sites, vertically through the sandy brown earths, and laterally drainage is facilitated by the steep slopes which for Group 1 have a mean of 20° (Table 5).

TABLE 3 ISA GROUP ONE.

RELEVE NUMBER	39	137	13	67	43	5	107	9	24	81	61	73	45	31	33	47	65	57	CONSTANCY
Bare soil/litter	6		6		8	5	5	1	3		2	5		5	3	3	5	3	IV
Bare rock					2			3		2							2		II
Oxalis acetosella	3	4	2		2	6	6	1	4	4		4		4	3	5	3	3	V
Quercus petraea (G)	8	7	7	6	8	7	7	7	8	8	9	8	8	9	9	8	8	8	V
Mnium hornum	3	4	3	4	2	4	5	2	3	2		3	1	2	3	2	3	5	V
Thuidium tamariscinum	4	3	3		2	2						3			2		1	4	III
Betula pubescens	7	5	4	2	2	5	5		4	6		4	7				4	3	IV
Fraxinusexcelsior (G)		2									1			2			1	1	II
Pteridium aquilinum	8			4	9	2	3	2	6		6	5	3	4	4				IV
Rubus fruticosus agg.	2	2				1	1		2					2		3	2		III
Deschampsia flexuosa	6	3	5	4	1	3	3	8	8	7	6	4	8	5	7	5	5	8	V
Polytrichum formosum	4	4	3	5		4		4	5	2	5	4	4	5	5	3	6	5	V
Rhytidiadelphus loreus		3	3	3		4		3	4	6	3	2	4			4	4	4	IV
Plagiothecium undulatum			2	4		2	3				2	2	4	2		3	2		III
Dicranum majus	2	2	7	3				4	2*	4	4	4	3	3	3	3	2	3	V
Anthoxanthum odoratum		4					5	4	6	5	2	4	3	5	4	4	4	3	IV
Galium saxatile	4							4			3	3	5	3	3	3	2		IV
Agrostis tenuis		4							2	3		4		5	3		3	2	III
Lonicera periclymenum	6											2	4	3	4	3			II
Corylus avellana (S)	4	7		4		8	5												II
Quercus petraea (G)						1	2	1	1	2	2	2		2	2	2	2		IV
Pleurozium schreberi													4	4	3	4		3	II
Vaccinium myrtillus			3					5		4	4		6						II
Lophocolea cuspidata	4	3	3				3						5	6	4	4		2	III
Hypnum cupressiforme			1	3			3		3						2			2	II
Blechnum spicant						1		2	3	1									II
Dryopteris dilata						2	3		1								1		II
Luzula pilosa	1										3				3				II
Dicranum scoparium		2		2	2								3						II
Betula pubescens (S)					6											4	2	3	II
Endymion non-scriptus	2				3	3													I
Holcus mollis						2	6									8			I
Betula putescens (G)	1			2					3										I
Ilex aquifolium (G)			1				1								2				I
Crataegus monogyna (S)					2		4												I
Dryopteris borreri		2																2	I
Dryopteris filix-mas									1	4									I
Isopterygium elegans						2												3	I
Leucobryum glaucum				3									2						I
Lophocolea bidentata		2					2											4	I

The mean number of species per releve is 17.83 and the standard error of the mean is 0.648

Additional species with a constancy of I :-

Alnus glutinosa (G), Brachypodium sylvaticum, Cardamine flexuosa, Conopodium majus Deschampsia cespitosa, Festuca ovina, Fraxinus excelsior(C), Ilex aquifolium (S) Luzula campestris' Luzula multiflora Lysimachia nemorum, Prunus padus(S) Taxus baccata(C) Atrichum undulatum, Eurhyncium praelongum Isothecium myosuroides Rhizomnium punctatum, Plagiomnium undulatum, Polytrichum commune, Pseudoscleropodium purum, Bazzania trilobata, Cladonia coniocraea, Cladonia furcata, Parmelia saxatilis, Acer pseudoplatanus, Crataegus monogyna (G)

Table 4 Group 1 Synoptic Constancy Table

	1	1a	1b
Oxalis acetosella	V	V	V
Quercus petraea (c)	V	V	V
Deschampsia flexuosa	V	V	V
Mnium hornum	V	V	V
Polytrichum formosum	V	IV	V
Pteridium aquilinum	IV	IV	V
Betula pubescens (c)	V	V	IV
Dicranum majus	V	IV	V
Anthoxanthum adoratum	IV	I	V
Quercus petraea (G)	IV	II	V
Rhytidiadelphus loreus	IV	III	V
Galium saxatile	IV	I	V

Table 5 Group 1, Environmental Variables

Site Number	39	137	13	67	43	5	107	9	24	81	61	73	45	31	33	47	65	57	Mean A	Mean B	Overall Mean
pH	4.2	3.9	4.0	3.8	3.8	3.7	3.8	3.8	3.8	4.2	4.4		4.5	3.7	4.1	3.8	3.8	4.1	3.9	4.0	3.9
Ca mM/kg	7.9		9.1	3.5	3.4	16	4.0	4.8	4.2	13	3.6		4.0	4.3	2.4	6.9	15.3	9.6	7.8	7.1	7.3
Aspect		280	240		265	220	262	245	266	310		260	305	240	260	90	260	310	253	254	254
Altitude	86	91	91	62	93	62	160	210	61	78	187	69	78	86	62	86	93	164	92	106	101
Slope	0	25	30	0	20	22	17	35	20	35	0	20	15	8	17	2	9	25	14	16.9	16
Grid Reference	298 916	303 930	303 928	300 927	299 917	303 935	301 913	305 927	297 912	296 913	304 931	302 926	297 914	298 912	297 913	296 914	304 936	306 935			

There are three level sites in Group One:- 39, 67 and 61. Drainage, however, is not impeded, due to the positioning of the sites as terraces on otherwise steep slopes and they are examples of charcoal pitsteads(Fig. 8) With such an efficient drainage system the effects of leaching are particularly evident with a mean calcium content of the soil of 7.3 mM/kg and a mean pH of 3.8. This compares well with the description by Pearsall (1938). The soils are predominantly acidic brown earths, rather shallow in places and occasionally show signs of podsolization. The soils of sites 65, 57 and 5 have much higher calcium values due to their situation on the Coniston Flags. All the sites face west with the exception of site 47 with an aspect of 90°.

Group one is split into two by Indicator Species Analysis. The ecological interpretation of this division is into woods with a substantial proportion of coppice and those sites without coppice. A dominance of coppice in the relevés has a profound influence on the composition of the field and bryophyte layers and it is because of this that differences occur between la and lb even though they occur on similar soils.

The negative species for this division are <u>Corylus avellana (S)</u>, <u>Betula pubescens</u> (C), <u>Endymion non-scriptus</u> and <u>Rubus fruticosus agg</u>, all of which are indicators for Group 1. Positive indicator species for the division are <u>Galium saxatile</u>, <u>Anthoxanthum odoratum</u> and <u>Dicranum majus</u> which are all indicative of Group 1b.

Group 1a

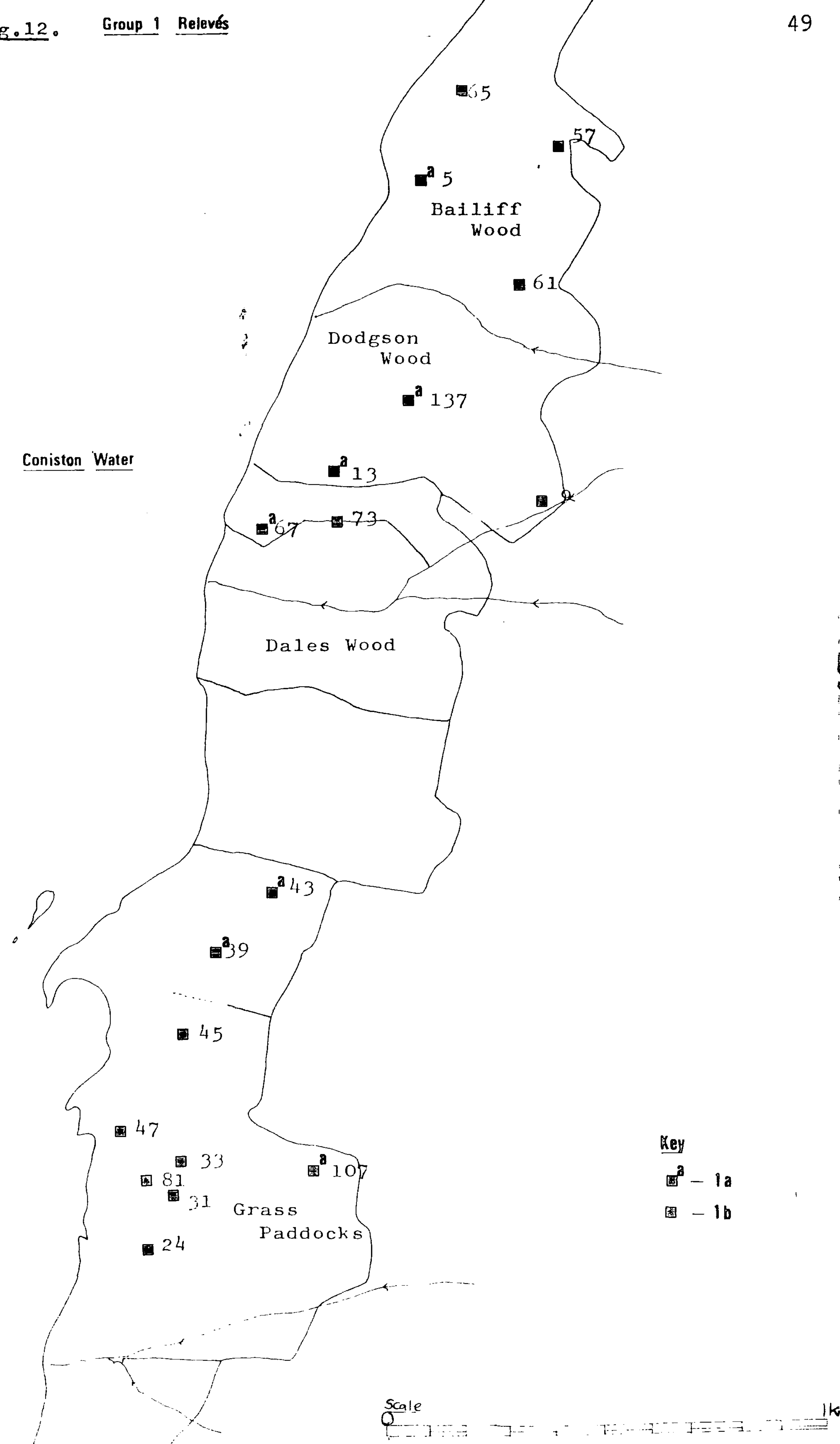
This group is atypical of 'heathy woods' due to the presence of a shrub layer, mainly hazel coppice. It is not certain if the hazel was planted, it is probable that the shrubs are principally relict with planting in the more suitable areas.

Drystone walls once effectively prevented the entry of sheep into the coppices, but these have since degenerated in places and sheep are now allowed access. The sheep tend not to graze in these areas due to unstable substratum and lack of young coppice shoots and forbs. This is partly a result of lack of management, since the coppices have now grown up. The last cutting was in the 1940's, therefore the vegetation is at the climax of the coppice 'cycle' and in the summer months casts a very deep shade which few plants can tolerate. Another factor contributing to lack of forbs is the unstable nature of the substratum. The substratum is very rocky and most of the boulders are loose although outcrops of rock occur. Surface soil is confined to crevices and around the bottom of boulders, therefore rooting places are limited.

Canopy and Shrub Layers

The canopy is composed of Quercus petraea and Betula pubescens. In the areas of hazel coppice they are standards, although in some relevés of Group 1a they too are coppiced. Betula reaches its highest abundance in this group; this may be the result of intense woodland

Fig.12. Group 1 Relevés



industries in these areas in the past, which created breaks in the canopy favouring the entry of birch which when allowed to grow up, was perhaps most effective at competing for space on the nutrient poor burnt areas. Crataegus monogyna and Ilex aquifolium are occasionally found as shrubs.

Field Layer

The field layer is generally poor, consisting of a few plants rooted around the bases of moss covered boulders. Most of the plants are perennials which are able to reproduce vegetatively; flowering is rare in such dense shade. Deschampsia flexuosa tends to dominate and Oxalis acetosella is common mainly due to its ability to grow directly on the humus. Endymion non-scriptus occurs sporadically due to its pre-vernal life-cycle. Pteridium aquilinum is sparse at most site, but dominates at two sites where light intensity allows.

Bryophyte Layer

Bryophytes form a rich community covering the boulders, due to a suitable substratum and the dark, moist environment within the coppice. The design of the sampling programme was to exclude bryophytes growing on rocks therefore these species were excluded from the relevés. Dominant mosses are Mnium hornum and Polytrichum formosum and these often form rooting areas for Deschampsia flexuosa.

These sites are typical of dry acidic coppiced woodlands, lacking in diversity of species. Diversity tends to decrease with the age of the coppice. (Ash and

Barkham 1964) and the dominants tend to be shade tolerant. The dominance of a single species in such areas is a direct result of the coppicing (Tansley 1939 p310) and in this group the dominant is Deschampsia flexuosa. The age of the Coniston coppices is approximately forty years and they have a mean number of species per relevé of 17.14 and a mean value of 10.4 vascular species, showing that bryophytes substantially contribute to the diversity.

Group 1b

This group represent the true 'heathy woods' which generally do not have a shrub layer. The woods are open with a predominantly grassy field layer with bryophytes growing within the turf and on the rocks. The substratum is rocky, but tends to be much deeper than 1a. These areas are favoured for grazing by sheep and the composition of the field layer is influenced by this.

Canopy and Shrub Layers

The canopy is composed of Quercus petraea and Betula pubescens standards and the shrub layer is unrepresented.

Field Layer

The field layer although dominated by Deschampsia flexuosa contains Galium saxatile, Agrostis tenuis and Lonicera periclymenum all of which are absent from 1a and are indicative of a long history of grazing.

Fig.13.
(a)

Dry hazel coppice - May.

Fig.13.
(b)

Dry hazel coppice- August.

The increased light intensity due to the paucity of the shrub layer allows *Pteridium aquilinum* to dominate at several sites, but it is not enough to allow *Calluna vulgaris* a sometimes important constituent of heathy woods to be present. *Vaccinium myrtillus* is well represented in the field layer and is only lightly grazed, but in the winter it will probably become closely cropped.

Bryophyte layer

The bryophytes are typical of grazed acidic heathy oakwoods:- *Dicranum majus*, *Plagiothecium undulatum*, *Pleurozium schreberi*, *Rhytidiadelphus loreus* and *Polytrichum formosum*.

Groups 1a and 1b have many floristic affinities due to both groups occurring on rocky acidic brown earths, and can conveniently be grouped together. Important differences arise due to the coppiced nature of the trees and shrubs in group 1a.

Most members of 1a and 1b are 'typical' of their assigned groups apart from relevés 5 and 9.

Relevé 5

This relevé from Group 1a is adjacent to a flush area and the soil from the site is damp. *Alnus glutinosa* forms an important part of the coppice and several base loving plants can be found in the field layer, e.g. *Brachypodium sylvaticum*. As this is a borderline community, representatives from both drier acidic coppice and damp, neutral to base rich coppice are present therefore this relevé probably does not represent a community type

Fig.14.
a.

A typical example of the heathy oakwoods of group 1b.

Fig.14.
b.

High altitude oakwood- relevé 9.

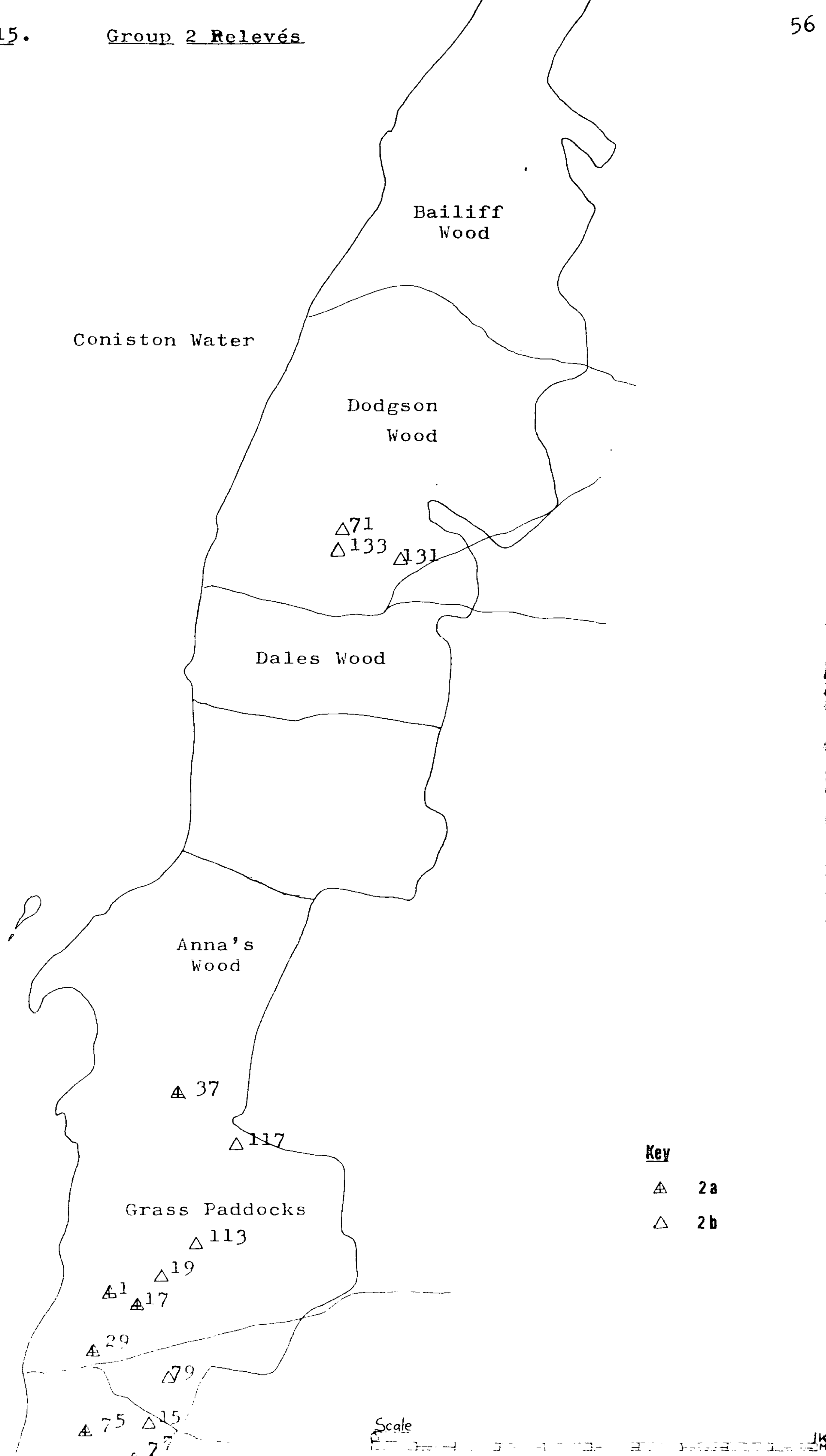
but a gradation between two.

Relevé 9 (Fig. 15)

This relevé from group 1b is a distinct community and is underrepresented in the survey. It is an example of high altitude oakwood where the oaks are stunted and the vegetation is dominated by lichens. The community is comparable to the Keskadale Oaks (Leach 1925). It is certain that this would form a distinct community type if more representative relevés were taken, but it would still be a facies of 'heathwood' with which it is classed in the survey.

A typical representative of Group 1a is relevé 67 and of 1b relevé 81 (Figs 12, 13 & 14)

Fig.15. Group 2 Relevés



Group 2

This community is characterised by the constancy and abundance of Quercus petraea and Betula pubescens in the canopy. Anthoxanthum odoratum, Oxalis acetosella, Pteridium aquilinium, Endymion non-scriptus, Holcus mollis, Agrostis tenuis and Galium saxatile form the field layer with a bryophyte layer of Mnium hornum and Polytrichum formosum (Tables 7 and 8).

Positive indicator species are Teucrium scorodonia, Endymion non-scriptus, Dicranella heteromalla, Deschampsia cespitosa, Dryopteris filix-mas, Anthoxanthum odoratum and Eurhynchium praelongum.

This group is characteristic of a dry sessile oakwood facies on sandy brown earths, with a shrub layer poor or absent. 'Dry oakwood' has been recognised by Woodhead (1906), Tansley (1939 p 315), Puri (1948) and Scurfield (1953). Tansley described it as one of the commonest communities of Quercetum sessiliflorae and relates it to the heathy woods of Group 1. It also has close affinity with the herb-rich birch and oakwood associations on degraded brown earth as described by McVean (1964) and Tittensor and Steele (1971).

The soils are similar to Group1, having predominantly brown forest soils with a mean pH of 3.9 and a mean calcium content of 6.0 mM/kg. This suggests similar drainage and leaching processes to Group1 although in this group the calcium values tend to be lower. This may be the result of increased rainfall reaching the

Table 6. Group 2. Environmental Variables.

Site Number	1	29	37	17	75	15	131	133	71	77	117	79	19	113	Mean G.A.	Mean G.B.	Overall Mean
	A					B.											
pH	3.9	4.4	3.8	3.9.	4.2	3.4	4.2	3.7	3.7	3.7	3.7	3.9	3.7	4.0	4.1	3.7	3.9
Ca mm/kg.	4.9	5.4	2.6	2.2	5.5	1.8	10.3	3.9	3.1	5.2	17.3	5.5	2.5	13.9	4.12	7.6	6.0
Aspect	310	282	280	284	200	262	260	303	280	310	270	240	280	262	271	274	273
Altitude	91	70	93	70	61	91	122	99	76	117	99	91	76	91	77	96	89
Slope	15	18	19	20	30	20	17	5	22	12	15	15	2	8	20	13	15.6
Grid Reference	287 912	297 908	298 914	297 909	296 906	297 907	304 927	302 926	302 927	297 906	299 914	298 908	298 911	298 911			

Key. G.A. - Group A.
G.B. - Group B.

Table 7 Group 2. Synoptic Constancy Table

	2	2a	2b
Anthoxanthum odoratum	V	IV	V
Quercus petraea (C)	V	V	V
Oxalis acetosella	V	V	V
Mnium hornum	V	V	V
Pteridium aquilinum	V	IV	V
Agrostis tenuis	IV	V	III
Galium saxatile	IV	III	V
Fraxinus excelsior (G)	IV	III	IV
Betula pubescens(C)	IV	III	IV
Eurhynchium praelongum	IV	I	V
Polytrichum formosum	IV	V	III
Thuidium tamariscinum	III	IV	II
Rubus fruticosus agg.	III	IV	II
Deschampsia flexuosa	III	V	II
Lonicera periclymenum	III	IV	II
Luzula pilosa	II	IV	I
Teucrium scorodonia	III	IV	II
Deschampsia cespitosa	III	IV	III
Dryopteris filix-mas	III	IV	II
Dicranella heteromalla	III	IV	II

TABLE 8 ISA GROUP TWO.

Releve Number	1	29	37	17	75	15	131	133	71	77	117	79	19	113	CONSTANCY
Bare soil/litter	5	3			2	3			3	4	9	6			III
Bare rock.	2								1						I
Oxalis acetosella	5	5	4	3	4	2	5	2	6	4	1	6	4	4	V
Quercus petraea (c)	8	8	8	8		3	6	2	8	7	6	7	9	8	v
Mnium hornum	4	2	4	4	2		5		3	2	3	3	2	3	V
Thuidium tamariscinum	3	5	4	5					5	4			3		III
Betula pubescens(c)	2	5		4		3	6	4	5	3		4		6	IV
Fraxinus excelsior (g)		2	2	1			2	1		2	1	1	1	2	IV
Pteridium aquilinum	3		5	7	2	1	3	9	2	5	2	7	7	4	V
Rubus fruticosus agg	2	4	3	4		2							3		III
Deschampsia flexuosa	3	5	4	4	4								4	3	III
Polytrichum formosum	5	3	2	3	3	3	3		3			2	2		IV
Anthoxanthum odoratum	4	6	5		7	7	4	3	4	4		2	5	5	V
Galium saxatile	2		3		3	4	4	5	5	4		4	2	2	IV
Agrostis tenuis	5	3	3	3	3			2	4	3			5	3	IV
Lonicera periclymenum		4	3	6	3					3		4		4	III
Rhytidiadelphus loreus			3	2					4				4		II
Plagiothecium undulatum	3				2		2		3	2					II
Dicranum majus	2			3	3										II
Luzula pilosa		4	2	3	3							3			II
Teucrium scorodonia	2		4	4	5								2	2	III
Digitalis purpurea	1		2		3					2					II
Hypericum pulchrum	2	3		3											II
Deschampsia cespitosa	5	5	4	4			3					4	4	3	III
Dryopteris filix-mas	1	2	1	1									1	2	III
Dryopteris dilatata	2	3					2			1		2			III
Hypnum cupressiforme	2	3	4				2				1	3			II
Dicranella heteromalla	2	4		2	2	2		2							III
Endymion non-scriptus	1	5	3	1		6		1		5	3	4	4	4	IV
Holcus mollis		3				4				3	3	4	3	4	II
Pseudoscleropodium purum				4	4		3	3	4				5	3	III
Eurhynchium praelongum					4	2	3	3	2	3	3	5	3	3	IV
Eurhynchium praelongum var stokesii			3		3	3	2		3	4			3		III
Conopodium majus		3	3						3	3			6	2	III
Quercus petraea (G)	1	2		2						2			2	2	III
Corylus avellana		5	4	4		5	8								II
Luzula multiflora	3		1		2							3	3		II
Viola riviniana	3		4				4						5	4	II
Rhytidiadelphus squarrosus					4	3	6						3	4	II
Blechnum spicant					4				3			4		3	II
Lysimachia nemorum			2			3	3						4		II
Lophocolea cuspidata		2	2										2		II
Betula pubescens (S)	4		5		4				3						II
Fagus sylvatica (S)					7					4	9	4			II
Ilex aquifolium (G)	1	2			2								4		II
Crataegus monogyna(S)				2		2			2						II
Solidago virgaurea											2		1	3	II
Plagiomnium undulatum		3				3			2						II
Lophocolea bidentata						4	3							3	II
Agrostis canina								3						2	I
Brachypodium sylvaticum			3										3		I
Fagus sylvatica (C)						6				4					I
Fraxinus excelsior (C)			2	2											I

The mean number of species per releve is 24.71 and the standard error of the mean is 1.882.

Additional species with a constancy of I are:-

Betula pubescens(G), Crataegus monogyna (G), Athyrium filix-femina, Carex pilulifera, Cerastium holosteoides, Dryopteris borreri, Ilex aquifolium(s), Juncus effusus, Larix decidua(C), Luzula campestris, Rumex acetosa, Thelypteris limbosperma, Vaccinium myrtillus, Viola reichenbachiana, Atrichum undulatum, Cirriphyllum piliferum, Dicranum scoparium, Isopterygium elegans, Isothecium myosuroides, Pleurozium schreberi, Polytrichum commune, Bazzania tricrenata Larix decidua(S), Quercus petraea(S), Prunus padus (C).

ground through lack of a shrub layer. The mean slope is 16^{o} which is only moderately steep for the topography of Consiston Woods. Pearsall (1938) recognises 'dry oakwood' on the basis of soil properties, on base deficient soils with a pH of above 3.8 and below 5 with nitrates and earthworms present. He labels it 'Holcus and general Lake District type'. This generally would be applicable to the present group, but Group 2b have deep litter horizons and their soil pH values, which could not be measured until a few days after collection tend to be much lower than expected at 3.7. This drop in expected pH could be due to this storage, and Romell (1935) confirms this phenomenon by stating that on storage a mor soil becomes more acid and mull soil becomes less acid. All the slopes are West facing and most of the sites tend to be at lower altitudes, but range from 61 to 120 metres.

Group 2 is split by Indicator Species Analysis. The ecological interpretation of this division on floristics is due to the presence of a litter layer in the group 2b as a result of the presence there of profuse litter producers e.g. Fagus sylvatica and Larix decidua. Both communities are facies of 'dry acidic oakwood'. The negative indicator species of this division are Deschampsia flexuosa, Dicranum majus, Dryopteris filix-mas, Luzula pilosa and Dicranella heteromalla all of which are indicators for Group 2a. The positive indicator species are Eurhynchium praelongum and Hypnum cupressiforme which are indicators for

Group 2b.

Group 2a

This group has some affinities with the heathy woods of Group 1, as demonstrated by the ordination diagram (Fig.22) and in floristic composition particularly by the presence of Deschampsia flexuosa. The slopes are relatively steep and there are very few rocks, therefore there is little chance of leaf litter accumulating, and this allows Deschampsia flexuosa to become significant in the community which in itself further inhibits leaf litter accumulations. The canopy layer is composed of Quercus petraea and Betula pubescens standards and there is a sparse shrub layer of Betula pubescens and Corylus avellana.

Teucrium scorodonia, Hypericum pulchrum, Dryopteris filix-mas, Digitalis purpurea, Luzula pilosa and Luzula multiflora are typical members of the field layer. Pteridium aquilinum grows where light intensity allows, but tends not to dominate.

Deschampsia cespitosa is constant throughout 2a where it has a refuge from intense competition. This is due to the fact that most of the sites are at low altitudes (60-90 metres) and are consequently under the most pressure from tourists. Deschampsia cespitosa withstands trampling and tends to line the charcoal pathways. It is able to flourish well on these well drained nutrient poor soils. (Davy and Taylor 1974). Most of the members of the field layer are characteristic of open habitats e.g. Deschampsia cespitosa, Digitalis purpurea, Teucrium scorodonia etc. and it is significant that many areas of the lower woods have been felled creating open spaces.

The bryophyte layer is composed of Mnium hornum, Polytrichum formosum, Thuidium tamariscinum and Dicranella heteromalla.

Group 2b

This group is another facies of dry oakwood, but includes even age plantations of Fagus sylvatica and Larix decidua, notable litter producers. Quercus petraea is still important in the canopy and Betula pubescens tends to be scattered.

The field layer is ultimately dependent at these sites on light intensity and depth of leaf litter. Where Fagus and Larix are planted closely together the field layer is sparse or absent altogether (Fig.17)

In felled and cleared areas there is an increased light intensity and the Pteridium/Holcus/Endymion complementary society is found, as so often described by Woodhead (1906), Tansley (1939 p315) and Scurfield (1953). There is a gradient of communities from the shaded sites with deep litter to the lighter sites. There is a distinct absence of Deschampsia flexuosa which is thought to be inhibited by a deep litter layer (Jarvis 1964) and this could also account for the absence of Teucrium scorodonia and Digitalis purpurea which are replaced by Endymion non-scriptus

Fig.16.
(a)

Dry acidic oakwood, with Pteridium aquilinum where light intensity allows.

Fig.16.
(b)

Fagus sylvatica plantation with sparse field and ground vegetation.

and grass species e.g. Holcus mollis which are better at penetration of the leaf litter (Sydes and Grime 1980). The increased number of Fraxinus excelsior seedlings may be due to this litter layer which conceals the ash keys from predators. (Sydea and Grime 1980). Further investigations of these seedlings later on in the summer showed most of the seedlings were dying probably as a result of lack of nitrates.

The bryophyte layer is almost exclusively Eurhynchium praelongum which is a shade loving species, shade being provided by the depth of leaf litter and the close spacing of trees in the plantations. The absence of other mosses e.g. Dicranum majus may be the result of lack of rocks as a suitable substratum and the unstable nature of the leaf litter. Mnium hornum is present at most sites and can adapt to such conditions.

Groups 2a and 2b can be conveniently grouped together as dry acidic oakwood. Plantations of Larix and Fagus cause two facies of this community to be distinguished:

(a) Open Deschampsia/Teucrium/Digitalis
(b) Pteridium/Endymion/Holcus

A typical example of Group 2a is relevé 38 and of Group 2b is relevé 10 (Fig.16).

Group 3

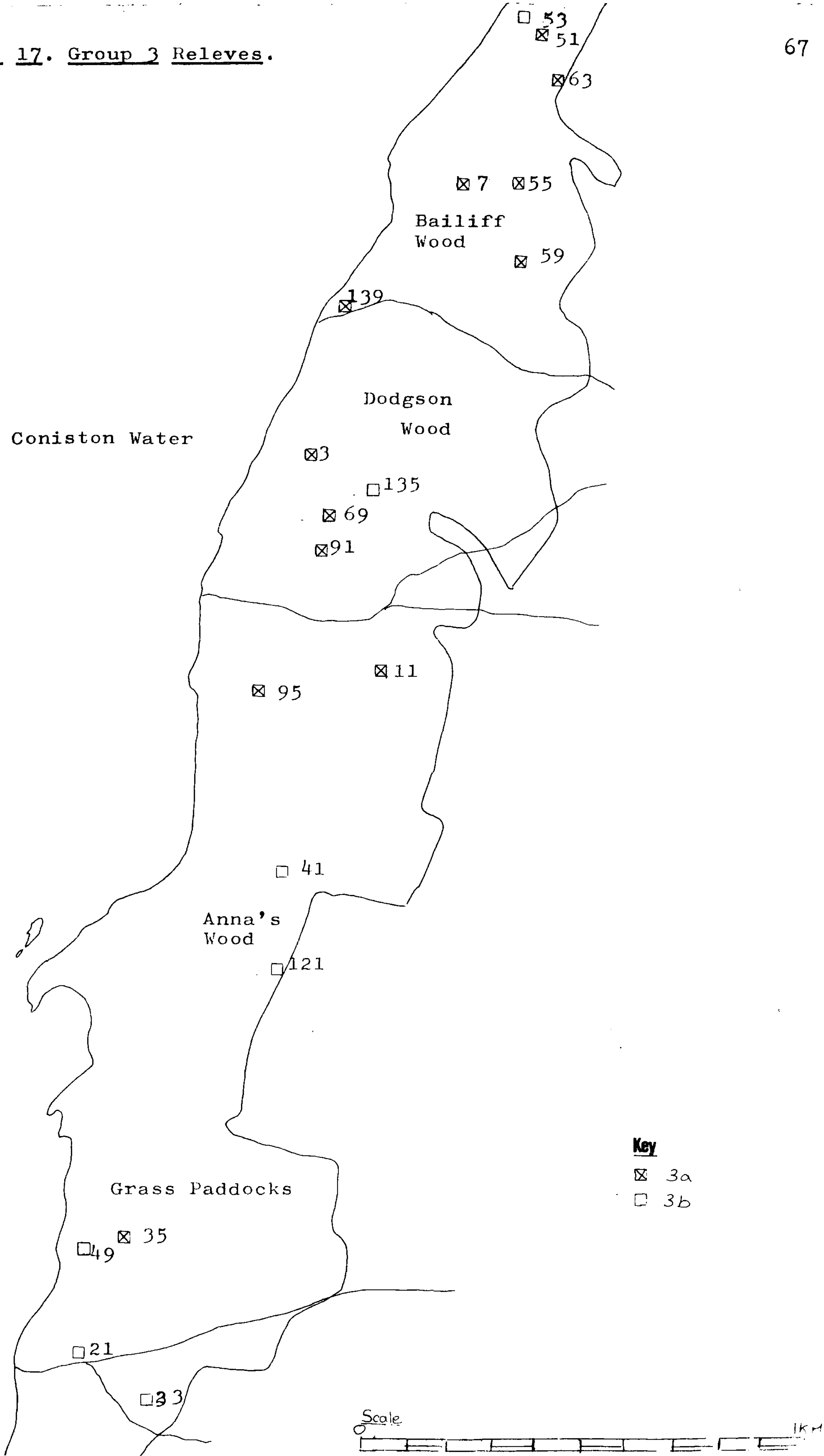
This community is characterised by the constancy and dominance of Quercus petraea and Fraxinus excelsior in the canopy and occasionally Betula pubescens. The field layer includes Brachypodium sylvaticum, Oxalis acetosella, Lysimachia nemorum, Viola riviniana, and Rubus fruticosus agg and there is regeneration by Fraxinus and Quercus. Bryophytes include Thuidium tamariscinum, Mnium hornum and Plagiomnium undulatum.

There is only one positive indicator for the group which is Cirriphyllum piliferum.

This community has been described as an ash-oak wood by Moss, Rankin and Tansley (1910) and Puri (1948), on a damp soil with mild humus (Tansley 1939 p315), on moist well drained sites (Wardle 1961) and as the Brachypodium sylvaticum rich ashwood association (McVean 1964). On the basis of soil properties Pearsall (1938) describes it as the Mercurialis/Brachypodium society on soils often calcareous at times, base deficient with nitrates and worms present. This community also has affinities with a 'Fern-rich mixed deciduous wood' as described by Tittensor and Steele (1971).

The presence of ash in the ash-oak woods of the Lake District has been associated by Tansley (1939 pp317-318) with high rainfall, but this has been disputed by Puri (1948) who states that under the same climatic conditions ash can be present in one area and not another

Fig. 17. Group 3 Releves.



and its distribution probably correlates with the calcareous more unstable soils.

The soils of Group 3 are quite different from the stable acidic brown earths of Groups 1 and 2. The soils are mainly stony loams, flushed brown earths and ground water gleys with correspondingly increased pH and calcium values. The mean pH is 4.3 and the mean calcium content of the soil is 36.9 mM/Kg.

There are several possible explanations:-

(i) The soils at flush sites are continually fed with bases leached from higher altitudes (Pearsall 1938) and at the sites in hollows the bases from these higher altitudes are only slowly leached away due to impeded drainage.

(ii) The hollows are often filled with glacial drift which may be richer in Ca^{++} than the surroundings. It is possible that glacial drift in the area contains fragments of the Coniston limestone which is found to the north of Coniston Water.

(iii) The soils are unstable and relatively immature; therefore leaching is less effective and there is continuous erosion releasing bases.

The sites vary in altitude, but none of the sites are above 179 metres and all the slopes face west.

Group 3 is divided by Indicator Species Analysis into two groups. The ecological interpretation of this division is into those sites which are coppiced and those which are not coppiced, the latter tending to be on the heavier soils. The negative indicator species for the division are *Crataegus monogyna* and *Corylus avellana* which are characteristic of Group 3a. The positive indicator species are *Endymion non-scriptus*, *Rhytidiadelphus squarrosus*, *Agrostis tenuis*, *Deschampsia cespitosa*, and *Cardamine flexuosa* which are all indicative of Group 3b.

Group 3a.

This group represents a mixed coppice on damp soils. These coppices differ from the coppices of 1a in the much wider variety of trees and shrubs, and the presence of *Acer pseudoplatanus* in the canopy suggests some areas of the coppices are of secondary nature. Pearsall (1946) states that the entry and rapid spread of a new or alien species in a wood is facilitated and ensured by disturbances in the original forest cover. In these coppices it is generally only the hazel which is coppiced and *Fraxinus excelsior* and *Quercus petraea* are usually standards.

The field layer is composed of *Oxalis acetosella*, *Viola riviniana* and *Brachypodium sylvaticum*. *Impatiens noli-tangere* a relatively rare plant, becomes locally dominant in these sites. This species is extremely sensitive to grazing and the rocky substratum in the coppices provides a refuge from sheep. Ferns are abundant in the coppices where the dark humid conditions are ideal for *Athyrium filix-femina* and *Dryopteris dilatata*. *Orchis mascula* is found occasionally and indicates a base-rich environment.

The bryophyte layer tends to be quite rich including Thuidium tamariscinum, Mnium hornum, Plagiomnium undulatum, Eurhynchium praelongum and Eurhynchium praelongum var stokesi. Mosses growing on rocks and dead wood were again ignored. The bryophytes in this group are indicative of shaded conditions and a fertile soil which is neutral to basic in reaction.

Group 3b

This group represents an open wood with a sparse shrub layer and is found mainly on the gentle lower slopes which tend to have a damp substratum. These sites are particularly favoured by sheep and grazing indicators in the field layer such as Agrostis tenuis, and Rhytidiadelphus squarrosus suggest a long history of grazing at these sites. Other members of the field layer are Brachypodium sylvaticum, Oxalis acetosella, Ajuga reptans, Mercurialis perennis and Allium ursinum. The vegetation of the field layer tends to form a mosaic. The drier areas are dominated by grasses e.g. Holcus mollis and Agrostis tenuis and the wetter areas are dominated by Mercurialis perennis communities or Brachypodium sylvaticum/ Ajuga reptans communities. The Mercurialis communities tend to be on the heavier damp soils in hollows. Tansley (1939 p282) describes this as one of the most clearly marked societies in woodlands which tends to avoid acidic soils unless there is an abundant supply of water (Salisbury 1916 p104)

In other areas, the field layer is composed of many

TABLE 9 ISA GROUP 3

RELEVE NUMBER	3	7	35	55	51	59	63	69	91	95	139	11	53	21	41	121	49	23	135	CONSTANCY
Bare soil/litter	6	3		3	4	3	4	3												
Bare rock.					2	4	2	1												
Oxalis acetosella	7	6	6	5	6	5	5	6	4	4					4	4	3	5	3	IV
Quercus petraea (C)	5	5	7	5	7	6		3		7	5	6			6	8	6		4	IV
Mnium hornum	3	4	3	4	2	3	3	3				4		4	2	2		3	3	IV
Thuidium tamariscinum	3	4	3	4	4	6		5	3			4	4	9	6	2		3	4	IV
Betula pubescens(C)	5	5		2	5	3		2	3	2	4	3	3	2	5					IV
Fraxinus excelsior(G)	1		2			3	3	3	2	3	4	1	1			3			3	IV
Pteridium aquilinum	2	1			5	1	3	2	1	4		3						1		III
Rubus fruticosus agg	2	2	5		3	3	2	2		3	2	1			4	2		5		IV
Brachypodium sylvaticum	2	2	6	4	4	7	4	6	5	4	3			4	6	4		4	3	V
Viola riviniana	4	3	5		4	5	4	4	2	2		5			3	1	4	4		IV
Fraxinus excelsior(C)	1			2		3	8	4	5	5		5	6	8	4	5				IV
Lysimachia nemorum	4	3	5	3	3	5	3	2	4	5	3	4			4			5		IV
Athyrium filix-femina		1	4	2		1			2	2	3			2				3		III
Cardamine flexuosa				3	2				3	2		3		2	2	2		2	2	III
Geranium robertianum	3		3			4			3	3	4	2				3			1	III
Deschampsia cespitosa	2		3							4		4		3		4	3	6	3	III
Plagiomnium undulatum				2	3	4	3	2			3			4	3	2	3	3	3	IV
Eurhyncium praelongum	4		6	2					3	4	3	2	6	2				7	6	III
Eurhyncium praelongum var stokesii			3		4	4		4	4					2	4	3	4			III
Acer pseudoplatanus(c)						4		8	8	1		2	2				6	8	6	III
Cirriphyllum piliferum			5		3			4				4	4	6	4	4				III
Conopodium majus	3	3			3		3			3					2	2	3	6		III
Potentilla sterilis	2		3	2	2							3								II
Impatiens noli-tangere									4	5	4									I
Corylus avellana(S)	6	8	6	8		6	7	6	6		8	4							5	III
Crataegus monogyna	2	1		2					2	2	2	2								II
Arum Maculatum	4	2					2	2	3			6							4	II
Dryopteris filix-mas			1	2	1			2		2					1					II
Ajuga reptans			6							2						2	3	2		II
Rhytidiadelphus squarrosus															3		3	3	4	II
Ranunculus repens										3				3		2	3		3	II
Polytrichum formosum	4	4		4			5					2			3				4	II
Rhytidiadelphus loreus	2	3		3	2							3			5				3	II
Agrostis tenuis					2			3							4	2		5	5	II
Anthoxanthum odoratum	2		3					3							7		8	4		II
Endymion non-scriptus	3		1											2	8		3	3		II
Holcus mollis	2	1										7			3		4	4		II
Atrichum undulatum		2	2		2					3		2				3				II
Allium ursinum		4							1		6			6		2				II
Dryopteris dilatata			1	1		1		2											4	II
Galium saxatile					3			3						2	3			3		II
Mercurialis perennis											8	3	10	8						II
Dryopteris borreri			2										2					2	2	II
Veronica chamaedrys	4				3									3	4					II
Veronica montana			5						3			3					2			II
Betula Pubescens(S)					4					2		2	2							II
Anemone nemorosa												1		2	3					I
Circaea lutetiana																3		3	3	I
Stachys sylvatica			2							3						3				I
Lophocolea cuspidata												3						4		I
Alnus glutinosa (S)			6															4		I
Ulmus glabra (S)										6						6				I

The mean number of species per releve is 24.53 and the standard error of the mean is 1.491.

Additional species with a constancy value of I are:- Acer pseudoplatanus (G), Crataegus monogyna (G), Dactylis glomerata, Deschampsia flexuosa, Digitalis purpurea, Fragaria vesca, Ilex aquifolium(S) Ranunculus ficaria, Lophocolea bidentata, Alnus glutinosa(C), Quercus petraea(G), Carex distans, Chrysosplenium oppositifolium, Cirsium palustre, Festuca rubra, Filipendula ulmaria, Galium uliginosum, Hypericum pulchrum, Juncus effusus, Larix decidua (C), Lonicera periclymenum, Malus sylvestris, Mentha aquatica, Milium effusum, Orchis mascula, Prunus spinosa (S), Rumex acetosa, Taxus baccata (C), Teucrium scorodonia, Thalictrum flavum, Urtica dioica, Dicranella heteromalla, Dicranum majus, Dicranum scoparium, Eurhynchium striatum, Hypnum cupressiforme, Isopterygium elegans, Isothecium myosuroides, Rhizomnium punctatum, Pseudoscleropodium purum, Bazzania tricrenata, Plagiochila asplenioides, Scapania nemorosa, Fagus sylvatica (S), Fraxinus excelsior (S), Prunus padus (C)

Table 10 Group 3 Synoptic Constancy Table

	3	3a	3b
Brachypodium sylvaticum	V	V	IV
Betula pubescens (c)	IV	V	III
Oxalis acetosella	IV	V	IV
Mnium hornum	IV	IV	V
Fraxinus excelsior (G)	IV	IV	III
Fraxinus excelsior (c)	IV	IV	III
Quercus petraea (c)	IV	V	III
Rubus fruticosus agg.	IV	V	III
Lysimachia nemorum	IV	V	II
Viola riviniana	IV	V	III
Thuidium tamariscimum	IV	IV	V
Plagiomnium undulatum	IV	III	V
Pteridium aquilinum	III	IV	I
Corylus avellana	III	V	I
Deschampsia cespitosa	III	II	IV

Table 11. Group 3. Environmental Variables.

	A												B									
Site No	3	7	35	55	51	59	63	69	91	95	139	11	53	21	41	121	49	23	135	Mean A	Mean B	Overall Mean
pH	4.6	4.6	4.0	5.1	3.8	4.0	4.5	4.5	5.1	4.5	4.5	4.7	4.9	5.1	4.1	5.0	4.0	3.9	4.8	4.24	4.5	4.5
Ca mm/Kg	65.7	[illegible]3.2	21.47	101.7			28.2	[illegible]3.7	88.7	56.7	19.7	25.7	51.7	42.7		56.5	5.9	4.6	102.7	36.9	37.7	37
Aspect	300	270	320	240	240	242	245	270	285	265	285	230	240	225	280	290		240	245	266	253	262
Alt.	101	91	78	125	86	179	156	62	68	76	46	91	62	91	78	91	70	86	99	96	82	91
Slope	15	11	12	24	12	20	21	7	9	5	2	3	12	5	20	7	0	19	9	12	10	11
Grid Ref.	301 928	304 934	297 912	305 9[illegible]5	306 937	305 933	305 935	301 927	301 926	301 925	[illegible]02 931	303 9[illegible]5	305 937	297 907	299 919	299 917	296 912	297 907	302 928			

species and the formation of well marked societies appears to be less common and may be due to the absence of coppicing. Moss in fact (1911, 1913) does not recognise definite field layer societies within this habitat.

Deschampsia cespitosa forms a well marked community dominating on a few of the 'ground-water gley' soils where the canopy has been reduced by felling (Fig. 18a)

The bryophyte layer is characterised by Cirriphyllum piliferum, Plagiomnium undulatum and Thuidium tamariscinum. These mosses indicate shady, moderately calcareous soils, shade being provided by the luxuriant field layer.

Although 3a and 3b are classed together as damp Ash/Oak woods they can conveniently be separated into ungrazed coppice and grazed open woods. A 'typical' example of 3a is releve 59., and a typical example of 3b is releve 41.

A Mercurialis perennis community with coppiced ash is shown in Fig. 18b.

Fig. 18.

(a)

Deschampsia cespitosa tends to dominate in the cleared areas which have wetter soils.

Fig. 18.

(b)

Coppiced ash and Mercurialis perennis community.

Group 4

This group is characterised by the constancy and abundance of Quercus petraea and Fraxinus excelsior in the canopy with Tilia cordata frequent. The shrub layer is mainly Ulmus glabra with Corylus avellana occasional.

The field layer is quite rich with a mean number of species per relevé of 29.82 and a mean number of vascular species of 16.3
Typical plants in the field layer are Athyrium filix-femina, Brachypodium sylvaticum, Dryopteris dilatata, Viola riviniana, Lysimachia nemorum and Oxalis acetosella with the regeneration of both ash and oak occurring. The bryophyte layer is again diverse with Thuidium tamariscinum and Mnium hornum dominant and Pellia sp. in the wetter areas.

These sites can be labelled 'gorge and streamside communities' and have not often been recognised as distinct woodland communities mainly because of the absence of gorges from many woodlands. Tansley (1939 pp316-317) recognises a community of streamside and flush habitats of sessile oakwoods but like Moss (1913) does not recognise societies within this division.

In Coniston Woods the gorges are common and have their own distinct communities.

The mean pH of these sites is 4.8 which is the highest in the survey and the actual range is the widest from 3.8 to 5.7 and includes the highest pH encountered. The calcium content of the soil has a mean of 47.1 mM/Kg but ranges from 13.7 to 134.7mM/Kg which is very high considering the strength of leaching at most sites within the woods. The major question is: 'under such conditions, how can pH values of above 5 and large calcium values be maintained?' The answers to this are similar to those given in Group 3, plus several extra possible explanations:-

(1) A lot of the soils in the group are ranker and are too shallow for efficient leaching.

(ii) Stream action is efficient at eroding any exposed rocks and depositing the freshly eroded material along the sides of the stream.

(iii) To the top of Coniston Woods (Grid Ref.SD308927) (Fig. 5) is an area of recently deposited material probably glacial in origin and this could be contributing to the high pH and calcium values at these stream sites at lower altitudes.

The soils are predominantly rankers and flushed brown earth with loams and acidic brown earths at the more stable sites. Occasionally there are deep layers of loose discontinuous soils which have slipped down the gullies from the intervening slopes.

The sites occur at a range of altitudes (76 to 206m) and vary in aspect, but are predominantly south-west facing, with the occasional north-west facing slope. Another perhaps more important reason for the diversity of species, particularly the presence of <u>Ulmus glabra</u>

TABLE. 12. ISA GROUP 4

RELEVÉ NUMBER	85	97	105	115	119	87	89	27	109	103	129	93	125	111	16	17	CONSTANCY.
Bare soil/litter		2	4		2		3		4	3							III
Bare rock	5	5	4					4		3					5	2	III
Oxalis acetosella	3	3	4	4	5	3	2	4	4	4	3	4	4	4	3	3	V
Quercus petraea(C)	4	3	5	5	5		2	2	5			4	4	4	7		IV
Mnium hornum	2	4	4	5		3		4	3	3	3		4	4	4		IV
Thuidium tamariscinum	2			4	4	3		5	4	4	4	4	2	3	4	3	IV
Betula pubescens (G)	2		2			4				4		4		3	4	5	III
Fraxinus excelsior (G)	2		2	2	5	2	2	3	2		2		2	2	2	2	IV
Rubus fruticosus agg				4						2	1	2	1	2	2		III
Brachypodium sylvaticum	4		3		3	4	4	3		4	4	4	3	4	3	3	IV
Viola riviniana	2		4	4		4	3	4			4	3	3	3	3	3	IV
Fraxinus excelsior(C)	8	2	3	6	5	7			4	4	4	5	5	7	4	6	V
Lysimachia nemorum				3	3	2	4	3		3	4	3	2	2		2	IV
Athyrium filix-femina	2	3	2	3		2	2			5	2		2	1	1	1	IV
Cardamine flexuosa		3	4		4	3	3	3	3				3		4	1	III
Geranium robertianum			3	2		4	3	3		3	3			2	3		III
Deschampsia cespitosa	2			5	6		3				5	3	4	5	4		III
Allium ursinum			6			5	4			4			2				II
Arum maculatum						3	3						3				I
Dryopteris filix-mas	3	2		2	2	2	1						3	3	5		III
Blechnum spicant		3	2	2	4	2		2	3			2		3		3	IV
Ulmus glabra(S)	6	4		5	6	6	5	5		5	6	5	5	5	5		V
Tilia cordata(G)	6	5	7				9	8	7	7		5	6				III
Chrysosplenium oppositifolium		3	3			3	4	6		3			2		3		III
Pellia sp.				3	3				3		3		3	3	3		III
Pellia epiphylla	3	2	4					3		3						5	II
Crepis paludosa	5		3		2			4	2	3		1		3			III
Dryopteris dilatata	2	2	2	1	3	2			2			2		5	3		IV
Circaea lutetiana			4	2		4					3		2				II
Festuca altissima		2	2							3							I
Polytrichum commune			2	3				1		2	3		1		3	3	III
Rhizomnium punctatum	4		3	3	3	3	3	3	2					3			III
Plagiomnium undulatum						4	3	3	3								II
Mellica uniflora	5			3		5	2	8	5					4			III
Ranunculus ficaria						4	6	3									I
Galium odoratum						3		5	4								I
Sanicula europaea						4		3	4								I
Hedera helix(G)	3	2				1								2			II
Veronica montana							3		2		4	3		3	2		II
Atrichum undulatum											5		2	2	3		II
Carex remota									2	2	2			3			II
Dicranella heteromalla												3	3	2			II
Agrostis canina											3	2				3	I
Rhytidiadelphus squarrosus											3		2			4	II
Anthoxanthum odoratum			3			2		3	3	2	3	2	3		2	6	IV
Deschampsia flexuosa	2				2			2	2	5	3	2				3	III
Corylus avellana(S)	2		4	4				4	4								II
Holcus mollis	3									2		2			4		II
Ilex aquifolium(S)	2					2				2					2	3	II
Lonicera periclymenum	3													2			II
Dicranum scoparium			2	2					3	1	2					3	II
Thalictrum flavum					2	2					1			1			II
Eurhyncium praelongum			4		4										1		II
																4	II

The mean number of species per releve is 29.82 and the standard error of the mean is 1.456.

Additional species with a constancy of I are:-

Pteridium aquilinum, Agrostis tenuis, Conopodium majus, Dryopteris borreri, Fragaria vesca, Primula vulgaris, Ranunculus repens, Plagiothecium denticulatum, Rhytidiadelphus loreus, Thamnobryum alopercum, Acer pseudoplatanus, Alnus glutinosa(C), Crataegus monogyna(S) Endymion non-scriptus, Filipendula ulmaria, Impatiens noli-tangere, Thelypteris dryopteris, Thelypteris phegopteris, Veronica chamaedrys, Hypnum cupressiforme, Isothecium myosuroides, Plagiothecium undulatum, Concephalum conicum, Fraxinus excelsior(S), Tilia cordata (S), Anemone nemorsa, Carexdistans, Carex panicea, Chenopodium rubrum, Chrysosplenium alternifolium, Erica tetralix, Galium palustre, Geum rivale, Hymenophyllum wilsonii, Hypericum pulchrum, Juncus effusus, Luzula multiflora, Luzula pilosa, Luzula sylvatica, Mentha aquatica, Mercurialis perennis, Moehringia trinervia, Myrica gale, Poa annua, Prunus padus(s), Stachys sylvatica Teucrium scorodonia, Thelypteris limbosperma, Ulmus glabra(C), Viburnum opulus, Cirriphyllum piliferum, Dichodontium pellucidum, Eurhyncium striatum, Pleurozium schreberi, Pseudoscleropodium purum, Plagiochila asplenioides, Acer pseudoplatanus (C), Acer pseudoplatanus (G), Alnus glutinosa (S), Alnus glutinosa(G) Betula pubescens (S), Betula pubescens (G), Crataegus monogyna, Ilex aquifolium (G), Quercus petrae(G) Sorbus aucuparia(G), Ulmus glabra (G), Scapania sp, Eurhyncium praelongum var stokesii

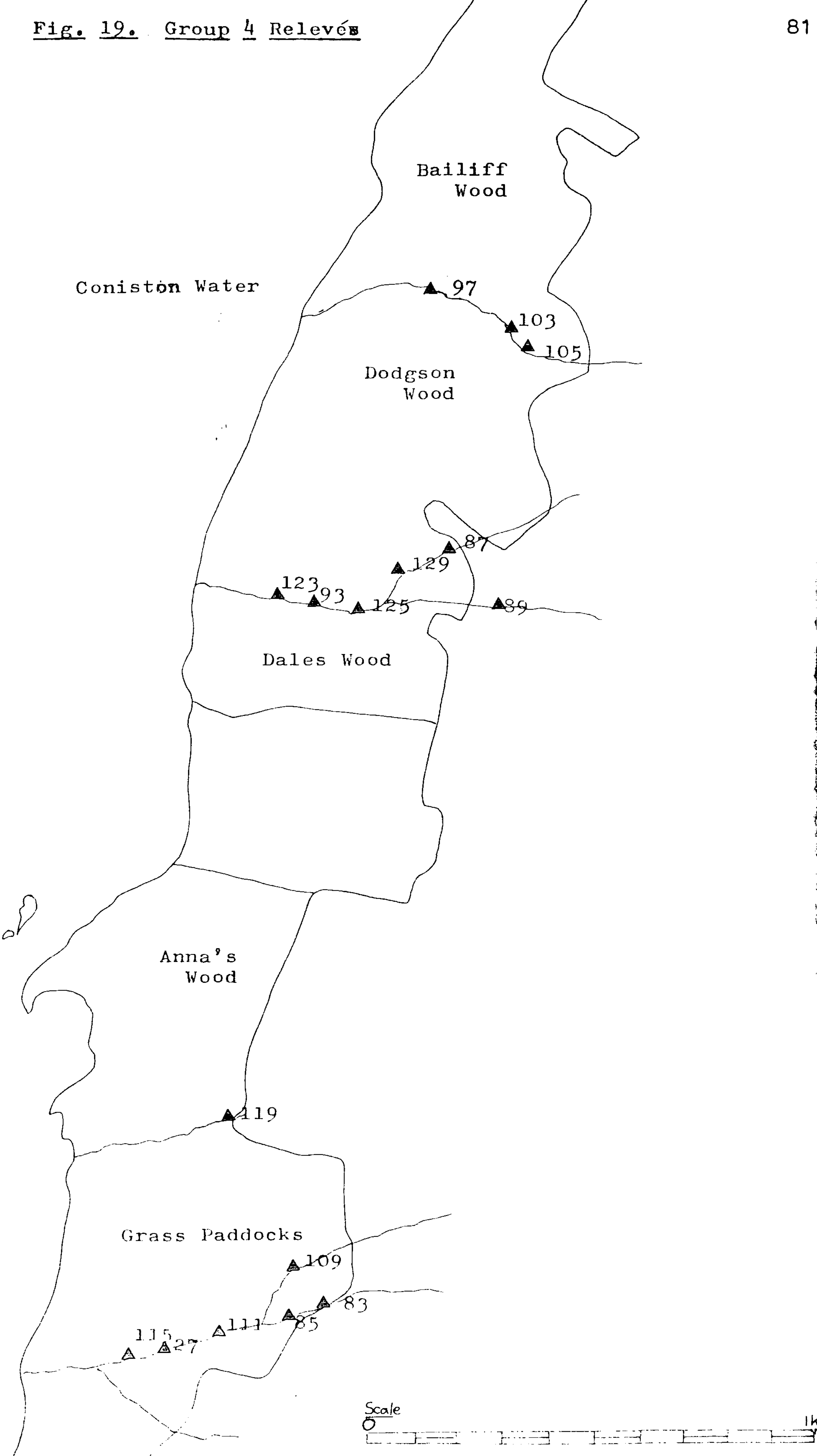
Table 13 Group 4. Synoptic Constancy Table

	4	4a	4b
Fraxinus excelsior	V	IV	V
Oxalis acetosella	V	V	V
Ulmus glabra (S.)	V	IV	V
Anthoxanthum odoratum	IV		V
Brachypodium sylvaticum	IV	IV	V
Quercus petraea	IV	V	IV
Thuidium tamariscinum	IV	IV	V
Athyrium filix-femina	IV	IV	V
Viola riviniana	IV	IV	V
Fraxinus excelsior (G)	IV	V	AIV
Mnium hornum	V	V	V
Lysimachia nemorum	IV	III	IV
Dryopteris dilatata	IV	IV	III
Blechnum spicant	IV	IV	III
Pellia sp.	V	V	V
Rhizomnium punctatum	III	V	I
Tilia cordata	III	IV	III
Cardamine flexuosa	III	IV	II
Dryopteris filix-mas	III	IV	III
Rubus fruticosus agg.	III	I	IV
Deschampsia cespitosa	III	III	IV
Atrichum undulatum	II	I	IV
Dicranella heteromalla	II	I	IV
Polytrichum commune	III	II	IV

Table 14. Group 4 Environmental Variables

Site No.	A									B								Mean A	Mean B	Over all Mean
	85	97	105	115	119	87	89	27	109	99	103	129	93	125	111	123	83			
pH.	5.3	5.7	5.7	4.4	3.6	4.6	3.4	5.3	5.6	3.7	4.5	4.7	5.2	4.7	4.3	4.3	5.0	5.0	4.5	4.8
Ca mm/kg	24.2	69.7	82.7	29.2	22.7	67.7	78.7	41.7	1[illegible]4.7	20.7	[illegible]7.7	24.7	42.2	48.7	17.2	45.2	13.7	61.2	31.26	47.1
Aspect.	280	342	240	302	270	260	255	0	310	25	240	300	273	250	300	262	190	282	230	241
Altitude	129	114	206	53	91	152	152	101	160	167	18[illegible]	114	76	91	91	76	121	128	115	122
Slope	35	87	20	7	9	22	20	45	25	85	20	12	5	10	20	15	30	30	25	27
Grid Ref.	299 910	303 932	305 931	297 909	298 915	304 926	304 925	297 309	301 912	304 932	304 931	303 926	301 924	302 925	298 910	301 925	301 901			

Fig. 19. Group 4 Relevés



and Tilia cordata, at these sites is that they have never been totally cleared by man. The majority of sites are relatively inaccessible and other areas were probably cleared for charcoal in preference to these. Tilia cordata was also regarded as a worthless tree by charcoal burners (Pigott and Huntley 1978). The sites are also inaccessible to sheep, therefore regeneration of trees and shrubs is able to take place, although regeneration of Tilia cordata from seed has not been observed for many years (Pigott and Huntley 1980). The composition of the field layer is also influenced by lack of grazing. Typical grazing indicators, e.g. Agrostis tenuis are absent and grazing sensitive species are found e.g. Festuca altissima, which is a relatively rare plant, and is usually devastated by even light grazing.

The substratum is extremely complex consisting of solid rock with loose boulders and thin patches of soil in the crevices. The rocks are covered by complex bryophyte societies, but again due to the sampling programme most were not recorded. It became difficult in places to decide whether the mosses were actually growing on soil or on the rocks and bryophyte data for this group must be interpreted with caution.
The mean slope is 30° and ranges from 5° to 87°.

Indicator Species Analysis divides the group into two. The negative indicators are Rhizomnium punctatum, Plagiomnium undulatum, Melica uniflora, Festuca altissima, and Ranunculus ficaria which are indicators of Group 4a.

The positive indicators are Rubus fruticosus agg, Atrichum undulatum, Betula pubescens (C) and Lysimachia nemorum.

The ecological interpretation of this division is into wetter sites, resulting from seepage and humidity and drier sites on the shallower gullies.

Group 4a

This group tends to be composed of sites at which the streams are well cut into the rocks. These gullies are very damp, spray from the stream creates a high air humidity and several seepage areas occur, draining into the stream. The wetness of these sites is reflected in the floristics.

The canopy is composed of Fraxinus excelsior, Quercus petraea and Tilia cordata with a shrub layer of Ulmus glabra. Alnus glutinosa is found at several sites. All are found as standards and Tilia cordata at most sites consists of a line of standards joined together with a tendancy for one or two to fall across the stream. This casts a deep shade on the field and bryophyte layers.

The field layer is composed of Brachypodium sylvaticum, Viola riviniana, Athyrium filix-femina, Cardamine flexuosa, and Geranium robertianum with Allium ursinum and Arum maculatum occuring where the soil is deeper. Hymenophyllum wilsoni is found at scattered sites, particularly beneath waterfalls. These dark humid areas are suitable for ferns, Thelypteris dryopteris, Thelypteris limbosperma and Thelypteris phegopteris being commonly found. These species are almost exclusive to these wetter gorge sites, but are occasionally found in Group 4b. Dryopteris dilatata, Dryopteris filix-mas and Athyrium filix-femina are also common, but are not restricted to this group. As stated previously these sites are relatively inaccessible to sheep and this allows Festuca altissima and Luzula sylvatica to grow. These two species are confined to this group.

The bryophyte community is very complex, but most species have not been recorded. Mnium hornum, Rhizomnium punctatum and Pellia sp are particularly dominant, but the list of species is varied. Thamnobryum alopecurum a species indicative of running water is significant at two of the sites.

Group 4b

This group represents the 'drier' stream sites, the streams tend to be slower flowing and over a gentler topography and generally not well cut. The canopy layer is mainly Quercus petraea and Fraxinus excelsior. Tilia cordata, although still important, is absent from a few sites and Acer pseudoplatanus is present. This alien intrusion and absence of Tilia cordata suggests that some of the sites in this group being more accessible have in fact at some time been cleared. The shrub layer is mainly Corylus avellana although this tends not to be very dense.

The field layer is varied with some species indicative of a streamside vegetation but with several grazing indicators present. This is not surprising as damp more accessible areas are often favoured by sheep for grazing. The result is that there are few well marked societies within the group.

Deschampsia cespitosa tends to dominate at a few sites where soils are deeper and heavier. Deschampsia cespitosa is able to withstand grazing as it is not very palatable to sheep (Davy 1980). The grazing indicators present are Anthoxanthum odoratum, Galium saxatile, Holcus mollis and Rhytidiadelphus squarrosus. These species plus the presence of Deschampsia flexuosa suggest that due to the topography there is not a sharp distinction between the actual streamside community and the other communities within the wood. Most of these sites, therefore, include borderline communities. (In Group 4a the border between the gorge communities and other communities was abrupt due to the topography and the sites tended to be isolated). Several other calcifuge plants occur, e.g. Blechnum spicant, but tend to be rooted in humus trapped between rocks. Most other members of the field layer are indicative of base rich, damp conditions which normally accompany streamside sites and include Brachypodium sylvaticum, Athyrium filix-femina, Viola riviniana and Lysimachia nemorum.

The bryophyte layer includes Atrichum undulatum, Dicranella heteromalla, Mnium hornum and Pellia sp. The mosses indicate that there is more surface soil in this group than group 4a and the soils tend to be ground water gleys or brown earths. Polytrichum commune is found particularly on the acidic brown earths indicating the borderline nature of this community

A few members of Group 4 show floristic variations due to minor topographical features. These relevés are 97, 99 and 83.

Relevé 97

This site occurs under a waterfall and the soil is very thin on an almost vertical rock face. Although typical of a gorge site it differs from other members of Group 4 due to its extremity and very humid conditions. The relevé is characterised by Hymenophyllum wilsoni, Dichodontium pellucidum and Luzula sylvatica. This relevé is one of the few sites where Luzula sylvatica is found in Coniston Woods due to the inaccessibility of the site to sheep.

Relevé 99

This relevé differs from other members of Group 4 by the presence of a bank of brown earth. This discontinuous soil has slipped over the gorge from the main slope of the woods and provides rooting places for many ferns. The species ordination characterises the relevé by Thelypteris dryopteris and a shrub layer of Tilia cordata. This shrub layer of Tilia cordata has formed by suckering. Other ferns present are Athyrium filix-femina, Thelypteris limbosperma and Dryopteris filix-mas.

Fig.20.
(a)

An example of a wet streamside community of group 4 a.

Fig.20.
(b)

A dry streamside site typical of group 4 b.

Relevé 83

This relevé is found on acidic brown earth, on the very edge of the wood where the wood merges into *Festuca/Agrostis* grassland. The relevé is a stream site and has corresponding characteristic species. In addition many heathland plants are present e.g. *Erica tetralix*, and *Myrica gale* is present which is rarely found elsewhere in the woods. The affinity of this relevé with the heathy woods of Group 1b is demonstrated by the ordination scatter diagram of axes 1 and 2 (Fig 22)

Groups 4a and 4b can conveniently be grouped together as 'gorge and streamside' communities as they have many floristic affinities due to the increased wetness, and base-status, as a result of flushing.

A typical member of 4a is relevé 89 and of 4b, relevé 125.

6. DISCUSSION AND CONCLUSIONS

DISCUSSION AND CONCLUSIONS

This primary analysis of Coniston Woods has enabled the identification of the major vegetation types within the woodlands. Most of the communities can be equated with previously described noda, but local variations in floristics do occur. The vegetation of Coniston Woods is essentially a continuum (Table 3) within which the delimitation of the groups is arbitrary.

Poore (1955) suggest that such groups should be regarded as convenient reference points within a field of continuous variation and not as discrete groups. Ordination of the data by Reciprocal Averaging (Hill 1973) was performed, followed by Indicator Species Analysis as another option in the program. The relevé ordination diagram of axes 1 and 2 (Fig.22) illustrates the most important vegetational gradients which should in turn reflect the most important gradients in environmental factors. Reciprocal Averaging generates simultaneous species ordinations and with knowledge of the ecology of some of the species these environmental gradients can be identified.

The main directions of ecological variation appear to be soil moisture, soil base status, biotic disturbance, humidity and altitude although there are complex

Fig.22. Position of Relevés on First and Second Principal Component Axes.

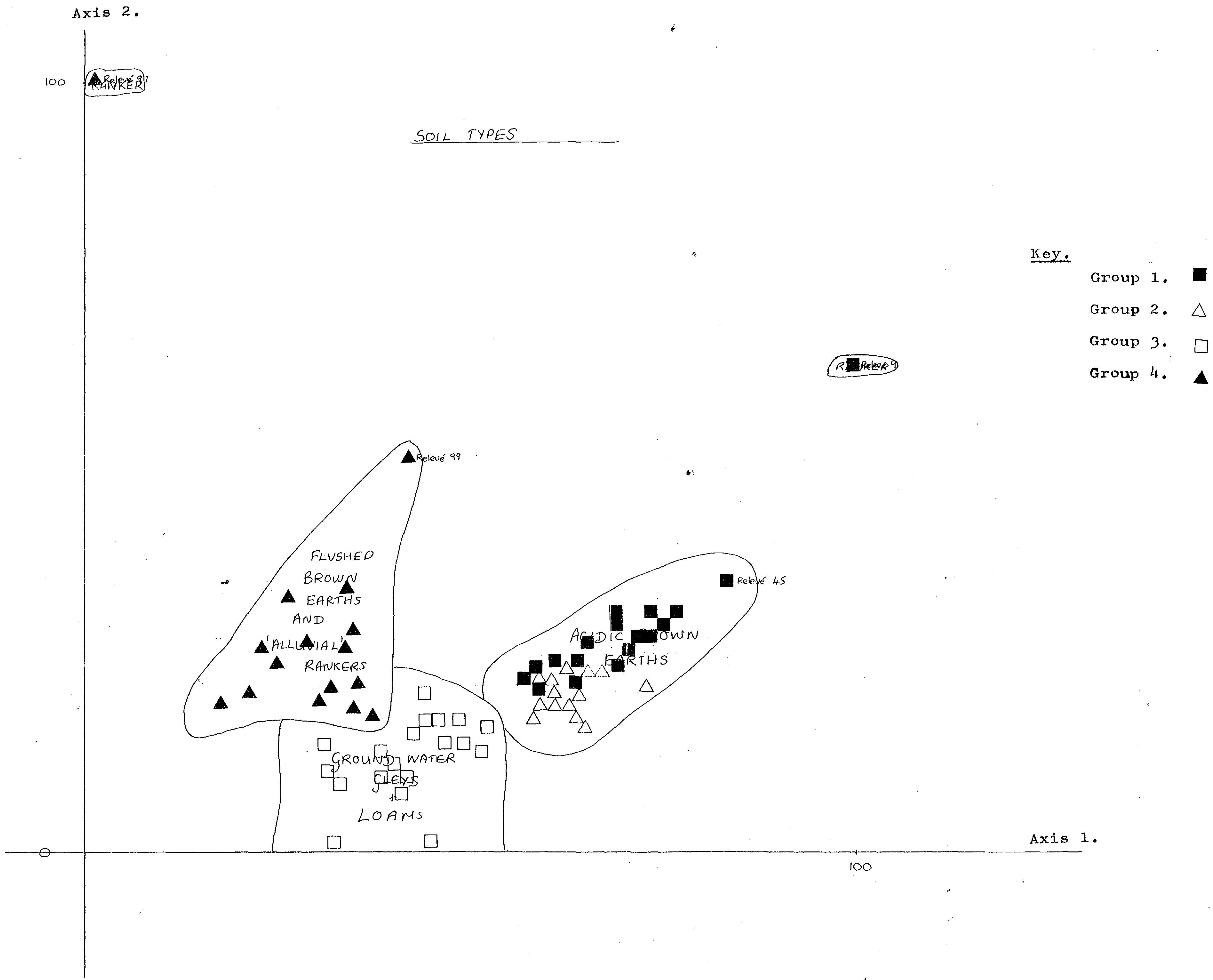
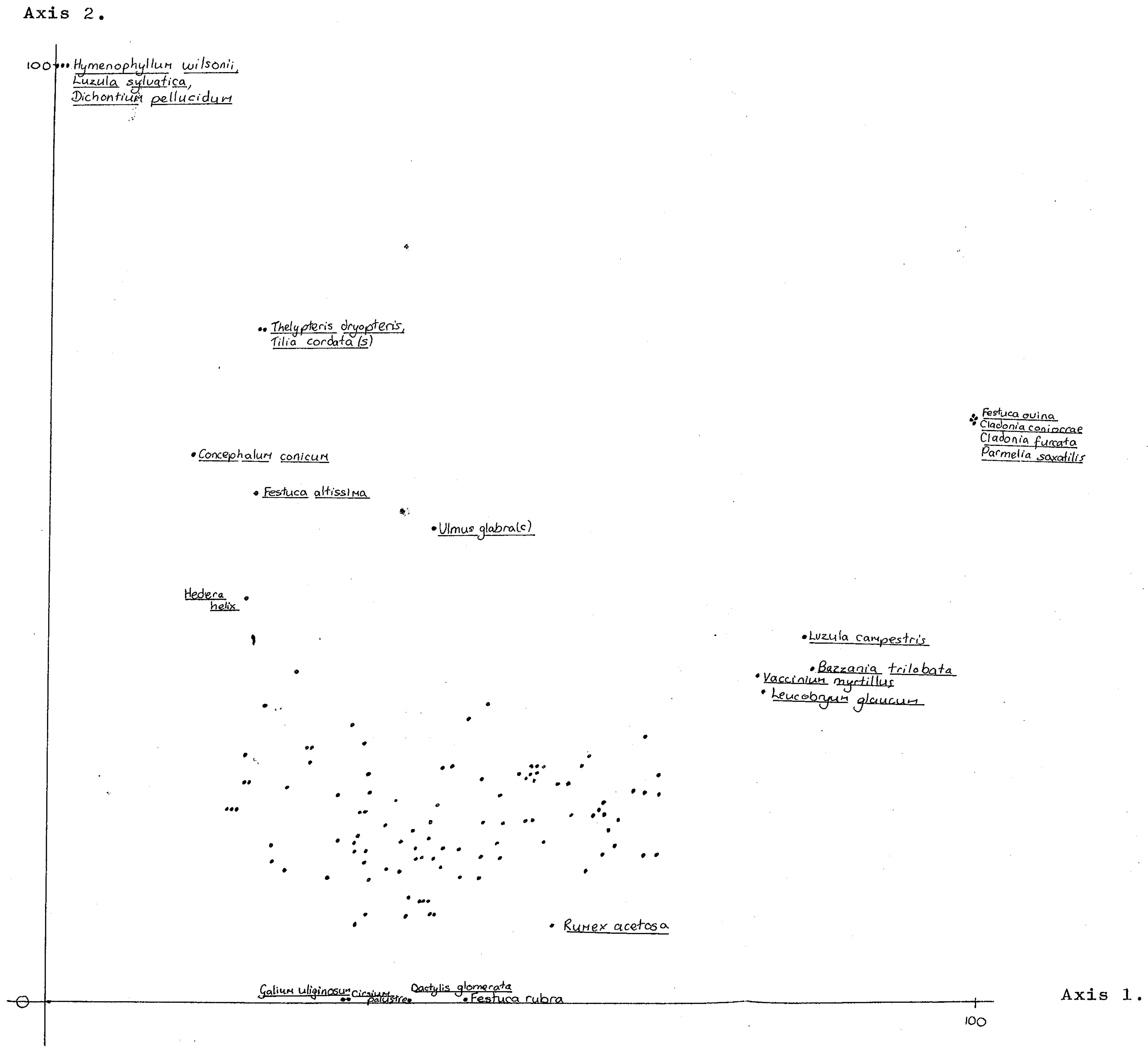


Fig.23. Position of Species on First and Second Principal Component Axes.



interactions. The most important overall factor influencing these gradients appears to be the topography.

The Coniston Woods are found on siliceous soils ranging from clays, loams and flushed brown earths to rankers and acidic brown earths. The soil type is known to be a major factor in determining the vegetation at a given locality and, as a result of this great variety of soils on all of which Quercus petraea is dominant, the associated trees and ground vegetation also show a wide range. The geology of Coniston Woods is only of limited importance; the soils on the Coniston Flags and Grits tend to produce a higher base status soil, whereas where igneous rocks penetrate the woods the flora tends to be calcifuge. Elsewhere the soils are so altered by leaching that the parent rock has very little influence. The status of glacial drift in the area is uncertain due to its discontinuity and unknown composition.

The relief is a major factor determining the composition of the soil, therefore influencing the vegetation. On the upper hills and knolls the bases are leached down the slopes, and are replaced by hydrogen ions, thus increasing the acidity and creating acidic brown earths and podsols. Some of the bases percolate down the hillsides and provide a flushing effect along drainage channels, creating mull brown earths, flushed brown earths and ground water gleys. The idea that topography influences plant distribution, through the effect of leaching and flushing on soil base status is expressed by Pearsall (1950) and Salisbury (1922).

The distribution of soils in Coniston Woods provides a major gradient upon which the vegetational gradient can be aligned. Since the distribution of soils is dependent upon the topography of the woods, a complex mosaic of different soils occurs as a result of the topographical irregularity, and this mosaic is reflected in turn by the vegetation.

The past management of the woods for timber has also had an important influence upon the vegetation in Coniston Woods. There are a few areas which, due to their inaccessibility have not been intensively exploited by man. This combined with a high soil base status and pH due to flushing, results in a floristically rich community. Many species find refuge from grazing at these sites. In other areas of the woods where exploitation has been severe the soil has deteriorated, the natural humus has been destroyed, and the base status has declined. These areas are characterised by the presence of old bloomeries, charcoal pitsteads, and pathways. This has destroyed the natural woodland ground vegetation, and allowed grass species to invade. Where tree regeneration has not taken place large gaps in the canopy occur below which the ground vegetation is dominated by Pteridium aquilinum, on the drier sites, or Deschampsia cespitosa, on the wetter sites. The presence of alien trees e.g. Acer pseudoplatanus in the vegetation also indicates that these areas were once cleared (Pearsall 1946). Although Rhododendron ponticum is absent it is encroaching in several other woods in the Coniston basin.

Coppicing of several areas has created distinct communities. Here the ground vegetation species are adapted to the dense shade cast in the summer, although pre-vernal species are also found. Two types of coppice ground flora result from the variations in soil base status and moisture.

Grazing also provides a gradient to which vegetation can be related. Winter grazing is particularly dense and prevents the natural regeneration of many trees and shrubs. Seedlings are observed to germinate and survive the first summer, but two year old seedlings are not observed and are therefore assumed to be grazed in the winter months. The predominance of grass species in many areas of the woods indicates a long history of grazing. These areas of intense grazing form the extremity of a gradient which has at the other end, the inaccessible areas or areas of unsuitable substrata where grazing is not apparent.

Aspect tends to be of little importance to the composition of the vegetation. This is mainly because most of the sites face west following the natural strike of the hills. It is only the gorge sites which show a slight variation in aspect, most of these sites facing south-west.

Altitude is an important environmental gradient. This is, however, mainly due to a correlation between the distribution of the soil types and altitude. Exposure at the higher altitudes nonetheless is also a significant factor. Rankers, and acidic brown earths with a tendency towards podsolization, are found at the higher altitudes. The deeper acidic brown earths are found on the medium to high parts of the woods and the flushed brown earths, and 'alluvial rankers' are found at the stream sides. (The term alluvial ranker is used to describe thin gravel type soils deposited directly upon streamside rocks). Loams and ground water gleys are found on the lower slopes or in hollows. At the higher altitudes e.g. relevé 9, the oaks tend to be wind-pruned and stunted, and the ground flora is composed mainly of lichens and mosses which are able to withstand the exposure (Fig. 14)

Ordination Diagrams

The first axis (Fig. 24) appears to be a gradient primarily of soil moisture and humidity. The wetter sites are found at the lower end of the scale, e.g. site 97 which is a waterfall site characterised by Hymenophyllum wilsoni, Dichodontium pellucidum and Luzula sylvatica. At the dry end of the gradient is site 9 which is characterised by Festuca ovina, Cladonia coniocraea, Parmelia saxatilis and Cladonia furcata.

There is also evidence that this axis is in part reflecting soil base status. Soil moisture and base status tend to be correlated in Coniston Woods; the wetter areas are usually flush areas with high base status and the drier areas are poor in bases due to leaching.

Another factor which may be involved is grazing, the ungrazed sites tend to be the wetter gorge sites, and the grazed areas tend to be drier. Similarly human disturbance is probably playing some part since it is least in gorge sites and greatest in the heathy woods.

The gradient formed by axis 1 is basically:-

Gorge sites →	Damp oakwood →	Dry oakwood →	Heathy Oakwood
Group 4	Group 3	Group 2	Group 1

On the Reciprocal Averaging scatter diagram for axes 1 and 2 the groups defined by Indicator Species Analysis tend to be reasonably distinct. There are, however, relevés which overlap with members of other groups. This is an expression at least in part of the continuity of the vegetation of Coniston Woods. Several relevés from Group 3 (Damp oakwood) overlap on this moisture/soil base-status gradient with members of Group 4b (Drier gorge-sites). The overlapping members of Group 3 tend to be those found in hollows which are subject to seepage. Groups 1 and 2 are not clearly separated on the basis of soil moisture and base status. Since both of these groups are found on acidic brown earths this is perhaps not unexpected, and similarities between dry oakwood and heathy woods are described by

Fig.25. Species Ordination on Second Principal Component Axis.

0 C.palustre,D.glomerata,F.rubra,G.uliginosum

M.effusum,R.acetosa.
A.reptans,N.sylvestris,M.perennis,O.mascula
A.nemorosa,P.spinosa,U.dioica,D.dilatata.
A.pseudoplatanus(C).

P.sterilis,R.repens,S.sylvatica,C.piliferum.
F.ulmaria,L.decidua(C),P.asplenoides,E.praelongum var stokesii
A.maculatum,C.holosteoides,F.sylvatica(C),J.effusus,M.aquatica,R.ficaria,P.padus(C)V.chamaedrys,M.undulatum,B.tricenata.L.bidentata.S.nemorsa.
C.distans,C.majus,C.monogyna(S)I.noli-tangere,V.montana,A.undulatum,E.striatum A.glutinosa(S),F.sylvatica(S).
A.ursinum,C.lutetiana,G.robertianum,D.cespitosa,D.purpurea,D.borreri E.non-scriptus,V.riviniana,E.praelongum.
B.sylvaticum,L.nemorum,T.scorodonia,R.squarrosus,P.purum,A.glutinosa(G) B.pubescens(S),C.monogyna(G).
A.glutinosa(C)C.avellana,F.vesca,S.virgaurea,T.oreopteris,T.tamariscinum F.excelsior(G)
A.canina,A.tenuis,B.pubescens(C), C. alternifolium,H.mollis,P.annua,H.pulchrum M.trinervia,V.reichenbachiana,L.elegans,I.myosuroides
C.hirsuta,G.palustre,P.aquilinum,L.decidua(C),L.cuspidata,Q.petrea(S). L.multiflora.
C.pilulifera,G.saxatile,F.excelsior(C),I.aquifolium(S),P.denticulatum,P.sp., O.acetosella,Q.petrea(C),S.europea,T.baccata,D.heteromalla,
A.odoratum,A.f.femina,C.panicea,E.tetralix,G.odoratum,G.rivale,M.uniflora,
L.pilosa,D.scoparium,P.commune,I.aquifolium,A.pseudoplatanus(S).
D.dilatata,D.f.mas,L.periclymenum,P.vulgaris,T.flavum,R.lorens.
C.remota,D.flexuosa,V.opulus,H.cupressiforme,P.undulatum,P.schreberi,B.pubescens T.alopecurum.
C.rubrum,C.paludosa.
D.majus,P.adianthiodes.
U.glabra(S).
B.spicant,P.sp.
C.oppositifolium,P.padus(S).
L.glaucum,F.excelsior(S).
B.trilobata,S.aucuparia(G).
T.cordata(C),V.myrtillus,U.glabra(G).

L.campestris.

P.epiphylla.

H.helix.

R.fruticosus agg.
U.glabra(C),S.sp.

M.gale.

F.altissima.

F.ovina,C.coniocraea,C.furcata,P.saxatilis.
C.conicum.
Q.petrea(G).

T.dryopteris,T.cordata(S).

100 H.wilsoni,L.sylvatica,D.pellucidum.

Tansley (1939 p314). Generally the heathy woods are drier, with a lower base status than the dry oakwoods and are also more heavily grazed.

The second axis appears to be related principally to altitude. The damp oakwoods of Group 3, which are found at lower altitudes in the woods, are found at the bottom of axis 2. The corresponding species for this group from the species ordination are Cirsium palustre, Dactylis glomerata, Festuca rubra and Galium uliginosum (Fig. 23)

At the other extreme of the axis is the waterfall site 97, characterised by Hymenophyllum wilsoni, Luzula sylvatica and Dichodontium pelludicum. It is closely followed by the high altitude oakwood site characterised by Festuca ovina, Cladonia coniocraea, Parmelia saxatilis and Cladonia furcata. The next site at a high altitude on axes 2 is site 99. This site differs from other members of Group 4 (gorge sites) due to a bank of discontinuous brown earth which has slipped down the gorge; most other members of Group 4 are predominantly rocky. The wet soil provides rooting places for many ferns and the species ordination characterises the site by Theylpteris dryopteris and a shrub layer of Tilia cordata which has regenerated from suckers (Fig. 22). Group 4 occur at a wide range of altitudes and are also well spread out along axis 2. Group 3 (damp oakwood) sites tend to be at lower altitudes and Groups 1 and 2 again show similarity by being grouped closely together. The dry oakwoods tend to be at lower altitudes than the heathy oakwoods of Group 1 and this is reflected by their relative positions on the axis.

Soil type quite closely corresponds with altitude. Where overlapping of relevés from different groups occurs, this is due to the diverse topography creating a mosaic of soil types. The general trend of soil types varying with altitude is nonetheless demonstrated by axis 2 (Fig.22)

No broad ecological interpretations could be found for axis 3 and subsequent axes. These axes appeared to reflect minor variations in the data resulting from the peculiarities of individual relevés.

The results of Reciprocal Averaging for the relevés were plotted for axes 1 and 2, and presented in the form of a scatter diagram (Fig. 22) The interrelations between the relevé groups defined by Indicator Species Analysis can be seen.

Groups 1 and 2 are very similar, and are close together in the ordination. This is due to similarities in floristics as a result of similar soil moisture, soil base status, soil type, altitude and grazing intensity. Groups 1 and 2 tend to be intermingled in the woods and gradations in floristics exist between the two.

The ordination also emphasizes the dissimilarity between relevé 9 and the rest of Group 1. The reasons for this have been mentioned previously. If further relevés of high altitude oakwood were taken it is expected that they would form a cluster of relevés around the position of relevé 9.

Group 3 (damp oakwood) is shown as a distinct group, and the ordination has emphasized the differences between the wetter and drier sites by placing them somewhat apart on both axes. These clusters do not correspond to 3a and 3b as the reason for this division was on the presence of coppice in Group 3a, and wet sites occur in both.

Group 4 is also seen as a distinct group, but with a few of the relevés showing similarities to the wetter sites of Group 3. Relevé 83, which is a stream site, has affinities with the heathy woods of Group 1. This relevé is found on acidic brown earth; near the Festuca/Agrostis grassland to the top of the woods, and is quite dry. Some of the species of the heathy woods are therefore found in this relevé with the typical streamside flora.

Site 97 is also distinct from other members of Group 4. This is because the site is under a waterfall on extremely thin soil and on an almost vertical rock face. This causes many elements in the flora to be exclusive to this relevé e.g. Hymenophyllum wilsoni. Site 99 has floristic differences to other relevés in Group 4 due to the presence of a bank of discontinuous brown earth which has fallen into the gorge.

The evidence presented in this survey suggests that the range of vegetation types observed within the Coniston Woods is related to variations in the topography, altitude, soil type (moisture and base status), grazing, light intensity and exploitation of the woods by man. There are several areas of *Fagus sylvatica* and *Larix decidua* plantations within the study area, but the field and ground vegetation are determined by the former variables.

The gorge sites represent areas which have never been totally cleared by man, and are distinct from the rest of the woods particularly in the variety of species in the canopy and shrub layers. These sites are probably remnants of a more mixed woodland which may have covered the whole of the 'Coniston Basin'.

Exploitation of these woods allowed *Fraxinus excelsior* and *Acer pseudoplatanus* to penetrate the canopy. As a result of coppicing and other management, the dominance of one or two tree or shrub species is common. The onset of soil leaching was facilitated by the initial clearance, although under the present humid oceanic climate it is the dominant pedogenic process.

The various woodland types in the Coniston Woods today can probably be related to a historical sequence of woodland types suffering successively greater degrees of anthropogenic disturbance as follows:

Mixed woodland→ ash- oak woodland→ oak woodland→ oak-birch woodland

This is also the ordering of the types along axis 1 of the ordination.

Grazing of the woods has enhanced this progressive deterioration resulting initially from woodland management practices. Only in the inaccessible wetter and base rich areas, where flushing overcomes the predominant influence of leaching are communities of mixed woodland, and even ash-oak woodland able to persist.

In conclusion; the vegetation of Coniston Woods today consists of a series of types believed to be representative of a progressive deterioration from mixed deciduous woodland ultimately to oak-birch woodlands as a result of the progressively increasing base-deficiency of the soils caused by a number of interacting environmental factors.

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