Phytosociological studies of relict woodlands in the North East of England

Graham, George Gordon

PHYTOSOCIOLOGICAL STUDIES OF RELICT WOODLANDS IN THE NORTH EAST OF ENGLAND

by

George Gordon Graham (B.A. Dunelm)

being

a thesis

submitted for the degree of Master of Science

in the University of Durham.

April 1971.

The content of this thesis is, apart from any text references to published works, entirely the product of my own research, and has not previously been submitted in candidature for any other degree or diploma.

G. Gordon Graham

G. GORDON GRAHAM

April 1971.

ABSTRACT

This thesis attempts within a more limited area, and by a more exhaustive analysis than is usual, a phytosociological investigation of some relic woodlands in the North of England.

In and around the woodlands some 226 Aufnahmen were made and nine Associations recognised. A further six partial Associations or noda are considered.

Epiphytic communities are studied in detail in some 257 Aufnahmen and a number of epilithic communities also are examined. From these, ten epiphytic Associations or parts of Associations are described and a number of epilithic Associations indicated.

The Associations of the ground flora are related to the system advanced by Lohmeyer *et al* (1962) and emended by Westhoff and Den Held (1969), and some phytogeographic relationships of the kindred Alliances are considered.

The epiphytic Associations are fitted as far as possible into the framework advocated by Barkman (1958) and some relationships are noted between the epilithic Associations and those of Klement (1955).

The thesis is divided into six parts:-

Part I reviews the previous work done in the area; introduces the problems of application of phytosociological methods within a restricted area; and outlines the geology, topography, climate, and other factors, as they bear on the ecology of that area.

Part II summarises the history of woodland vegetation in the North of England; examines the general structure and composition of the woods in question; and considers them from a general ecological standpoint as they compare or contrast with those woodlands previously mentioned in traditional British ecological literature.

Part III describes the methods used in the investigation.

Part IV presents the results of the survey with enumeration and descriptions of the Associations encountered. The epigeic, epiphytic and epilithic Associations are considered in separate chapters. In this part some evidence is adduced through the Association *Sorbo-Brachypodietum* for the classification of the N.W. Atlantic woodlands within the Alliance *Fraxino-Brachypodion* of the Order *Fagetalia-Sylvaticae* and Class *Querco-Fagetea*.

Part V discusses (a) the problems, limitations and possibilities of the Z.-M. technique in the examination of a small area and (b) some special problems connected with epiphytic and epilithic communities.

Part VI comprises 21 Association tables and is to be found in the folio volume.

References

LOHMEYER, W. *et al*. (1962). Contribution a l'unification du systeme phytosociologique pour l'Europe moyenne et nord-occidentale. *Melhoramento*, 15, 137-151.

WESTHOFF, V. & DEN HELD, A.J. (1969). *Planten Gemeenschappen in Nederland*. Thieme & Cie, Zutphen.

BARKMAN, J.J. (1958). *Phytosociology & Ecology of Cryptogamic Epiphytes*. Van Gorcum, Assen.

KLEMENT, O. (1955). Prodromus der mitteleuropaischen Flechtengesellschaften. *Feddes Rep. Spec. nov. Reg. veg.* Beih. 135.

Foreword

In the text, all Latin species names and all other names in italics are underlined with a continuous line. The names of Orders, Alliances, Associations, Noda, etc., are underlined with a broken line.

Species Nomenclature

LICHENS:- JAMES, P.W. (1965). A new check-list of British lichens. *The Lichenologist*, 3 (1), 95-153.

——————— (1966). Additions and Corrections - 1. *The Lichenologist*, 3 (2), 242-247.

BRYOPHYTES:- WARBURG, E.F. (1963). *Census Catalogue of British Mosses*, (3rd ed.) Brit. Bryol. Soc., Ipswich.

PATON, J.A. (1965). *Census Catalogue of British Hepatics*, (4th ed.) Brit. Bryol. Soc., Ipswich.

FLOWERING PLANTS AND FERNS :- TUTIN, T.G., HEYWOOD, V.H., BURGES, N.A., VALENTINE, D.H., WALTERS, S.M., & WEBB, D.A., ed. (1964). *Flora Europaea*, vol. 1. Cambridge.

TUTIN, T.G., *et al*. ed. (1968). *Flora Europaea*, vol. 2. Cambridge.

DANDY, J.E. (1969). Nomenclatural Changes in the List of British Vascular Plants. *Watsonia*, (7) 3. London.

Species names not yet dealt with in these works are taken from:-

CLAPHAM, A.R., TUTIN, T.G. & WARBURG, E.F. (1962). Flora of the British Isles, 2nd ed. Cambridge.

British roses are named from:-

WOLLEY-DOD, A.H. (1930-1). A Revision of the British Roses. Journ. Bot. Suppl. 68-69.

Synsystematics

In presenting the results of the survey the set format followed by most recent phytosociological papers has been followed; the Zürich-Montpellier system of classification as advocated by Lohmeyer *et al.* (1962) and slightly modified by Westhoff & Den Held (1969) is used as the framework, and brief descriptions are given for each of the levels of classification within which the Associations fall. Within each Alliance the Associations are described in the following manner:- 1. Synonymy; 2. Habitat details; 3. Characteristics of the Association; 4. where possible, Zonation and Succession - the relationship of the Association to other plant communities.

A similar, though simplified, presentation is used for the epiphytic and epilithic communities, the framework of reference being taken from Barkman (1958) and Klement (1955) respectively.

Bibliography

Synsystematic reviews and literature on the original naming of Alliances, Orders, etc., are not included.

ACKNOWLEDGEMENTS

My thanks are due in the first instance to my supervisor, Dr. D.J. Bellamy, for his guidance and continual support, for suggesting the topic and criticising the manuscript. I am grateful also to Professors D.H. Valentine and D. Boulter for permission to use the facilities of the University Botany Department; to the owners of the Strathmore Estates for permission to work on their land; to the Nature Conservancy for access to the N. Yorkshire nature reserve and some transport expenses whilst surveying the Juniper Wood, and to successive officers of the Conservancy for general guidance and help, especially J. Peters, B. Ducker and C. Hadley.

In the preparation of the text a number of phytosociologists have rendered valuable aid both by their advice and suggestions as to relevant literature. In this context I should like to thank Professor R. Tüxen who pointed out many continental parallels in the Association tables, and Dr. P.D. Coker who advised me on the problems of epiphytic vegetation.

Above all I am indebted to Dr. D.W. Shimwell for advice, discussion, literature and help in disentangling phytosociological problems and for suggesting many improvements to the Association tables, especially where the British scene is manifestly different from that of the continent.

I am grateful to those who determined, or confirmed my opinion of, critical material. Of these, Dr. S.W. Greene kindly vetted my specimens of the Plagiothecium complex, and P.W. James, Esq., and J.R. Laundon, Esq., determined the more difficult crustose and sterile crustose lichens for me.

For climatic data I am indebted to the Meteorological Office and for permission to reproduce the map (Fig. I/1) to the Director General of the Ordnance Survey.

Finally I wish to thank my wife for help in preparing the phytosociological tables and her general understanding and forbearance; Mrs. M. Burnip for deciphering my writing and making a copy of the text, and Miss N. Clayton for typing the thesis and dealing so efficiently with and laboriously copying the final Association tables.

LIST OF FIGURES AND TABLES

FOLIO VOLUME

CONTENTS

Page

PART I

THE TEESDALE AREA

(a) Introduction

Chapter 1

Previous work in the area.

The vegetation of the Teesdale area and in particular that of Upper Teesdale has engaged the attentions of botanists, amateur and professional, continuously since the first plant records were made by John Binks, a lead miner, at the end of the 18th century.

One or two of the rarer species are mentioned in the older 'herbals', Potentilla fruticosa for instance being mentioned from the Tees valley by Ray (1689). But it was left to the Backhouses, father and son, following on from Binks, to put on record the riches of the area. Rarities had a peculiar significance for nineteenth century botanists so that Teesdale, with a fair proportion of plants that could justifiably be described as 'rare' or of a limited distribution, was thoroughly explored, as regards the higher plants, by the end of the nineteenth century. No doubt there are a few species left for the 20th century botanist to add - one notes Alopecurus alpinus confirmed in 1959 and Betula nana in or around 1966. Bryophytes and lichens have received less attention and present researches are proving that Teesdale's riches are not confined to angiosperms and vascular cryptogams.

Following on from interest in the local flora of Teesdale was a consideration of the geographical distribution of species and an attempt to classify plants in groups according to their climatic and geographical range - arctic, sub-arctic, continental, and so on. Watson's Cybele Britannica (1847) and all his later researches and publications gave an enormous impetus to the study of plant geography and Hooker and other Kew botanists were in the forefront in the delimitation of range types.

There is a fair summary, and a good bibliography of works dealing specifically with the importance of Teesdale in these researches, in the Ph.D. thesis by T.T. Elkington (1962). Elkington says (in loc. c.) "The interest of the Teesdale flora is primarily connected with the geographical distribution of the species that grow there and nearly all the numerous accounts of the plants of the area have stressed this feature."

In spite of the fact that plant lists from the Teesdale area enter into many discussions and theses on the geography and history of the British flora, little work has been done on the community aspect of these plants. So Pigott (1956) can say "there exists no easily accessible account of the communities in which the rare species (of Teesdale) find congenial conditions". And he goes on to describe the vegetation of the area in broad ecological community types. His thesis mentions, among others, sugar limestone, dolerite cliffs, hay meadows, gravel flushes, juniper heath, heathy birchwood and herb-rich birchwood.

Chapter 2

The phytosociological approach.

The last ten years has seen a desire amongst some British ecologists to align their findings with those of the continental schools. Applications of the Zurich - Montpellier system (sensu stricto) to British vegetation were stimulated by, and indeed for a time confined to, the work of Braun-Blanquet and Tüxen in Ireland (1952). But after their methods had been thoroughly investigated by Moore (1962) a steady trickle of articles began, resulting in theses by O'Sullivan (1965) on the Irish lowland grasslands, Shimwell (1968) on the calcareous grasslands of Britain, and Bridgewater (1970) on the British Heath formation.

Mention should of course be made of the classic work on the vegetation of the Scottish Highlands by McVean & Ratcliffe (1962) where the methods used were partly phytosociological (Z.-M. school) partly physiognomic (Nordhagen & Dahl, 1936, 1954, 1956).

As yet very little phytosociological work has been attempted in British woodlands and, of the vegetation units mentioned by Pigott in his paper (1956), woodlands have received the least attention in Teesdale. An attempt therefore to study some of the 'relict' woodlands of the Teesdale area on a phytosociological basis seemed a useful project.

Chapter 3

Problems of application.

When the first Irish and British phytosociological papers were written it was necessary to explain the methods and aims of the Z.-M. School - O'Sullivan (1965), and in some cases to present a defence of the system Moore (1962). A historical account of the British scene and the present state of phytosociological studies in the British Isles is given by Shimwell (1968) who discusses Poore's (1955 a. b. c.) evaluation and criticisms of the Z.-M. school.

Although the tensions between the continental and what might be called the traditional British approach have not been completely resolved it is now widely recognised that the methods of the Z.-M. school do form a reasonable working schedule and that the results obtained do give a valid basis for a comparison of the continental and British vegetation. The present paper makes no attempt to go over the ground already covered but is written with an open mind on the many problems of synecology hoping that the end product is in some measure a justification of the methods used.

One special problem of application was that the survey was to be conducted in a relatively small area. A caveat of Shimwell (1969) that "the description of all communities within a small geographical region often leads to erroneous creation of Associations etc., which, when compared with a broad overall view, may appear only as minor variations in a widespread Association", had to be borne in mind throughout. But again it was felt that it would be better to carry out the project before anticipating the answer. The problems likely to arise would be in the interpretation of results rather than the collecting of data. Whatever our conception of vegetation - as a continuum or as a pattern of more discrete units - any analysis must begin with some kind of floristic list, so lists were taken and analysed.

(b) Some regional considerations

Chapter 4

Topography.

The Upper Tees divides the counties of Durham and Yorkshire, with higher reaches and tributaries stretching into Cumberland and Westmorland. The complete river system drains the Eastern Pennines which reach a maximum altitude of nearly 3,000' (915 m.) in this region (latitude 54°40' N.)

Much of the area is now covered with blanket bog in its many stages of degeneration, with communities belonging to the classes Nardo-Callunetea and Oxycocco-Sphagnetea predominating.

The few remaining woodland relics are confined to the more sheltered valley areas often in fairly steep ravines. At High Force, for instance, the Tees descends in a cascade over the Whin Sill and passes through a wooded gorge below, (the Birch wood of the present study) and then flows beside low lying meadows to a further and smaller series of falls at Wynch Bridge.

Above these meadows on the northern slopes are two other woodlands of the study. Mill Beck is really a steep wooded ravine and Park End a dolerite hummock bounded by a road from the upper fells and by a steep boulder scree fall from the meadows of the Tees valley.

The last remaining woodland under study is of Juniper. Of a more scrubby nature it covers the north slopes of Keedholm Scar directly above the Birch wood mentioned previously and to the south of High Force.

The four woodlands are all to be found on the accompanying map (Fig. I/1). Grid references are as follows:-

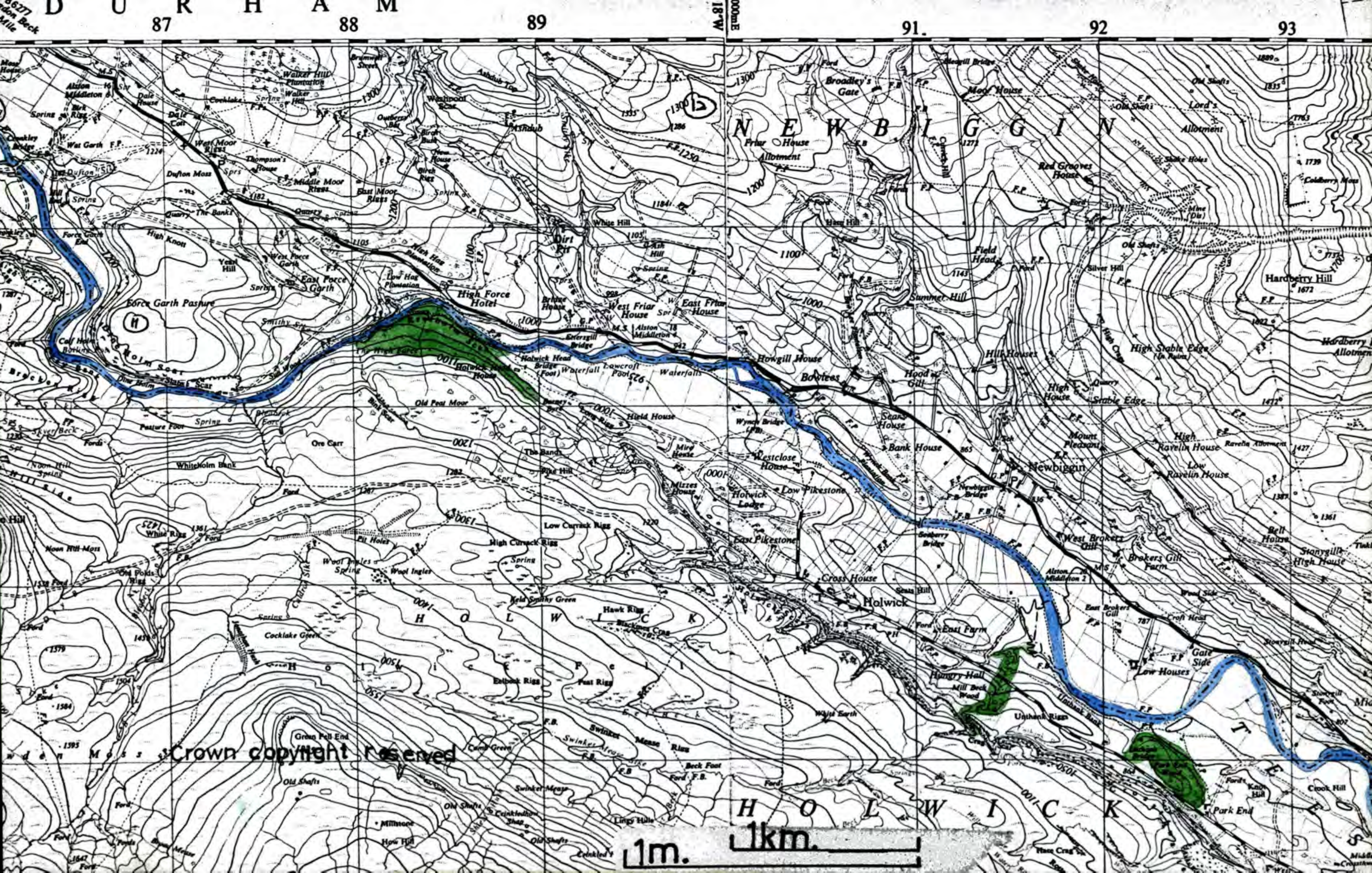
Juniper wood	35/88 28
Birch wood	35/88 28
Mill Beck wood	35/91 26
Park End wood	35/92 25 and 35/92 26

From High Force to Park End is 3 miles in an E.S.E. direction. This line extended to Middleton in Teesdale could be considered the hypoteneuse of a triangle with base running W. from Middleton to Bink Moss (4 miles) and a vertical to High Force (3 miles). Bink Moss at 2,028 ft. is the highest point of Holwick Fell and at the rightangle of our triangle. Crosthwaite Common which slopes gently at first and then more steeply in a series of scars down to the Tees valley forms the hypoteneuse of our triangle.

The four woodlands are all situated at the base of these north facing scars on the Yorkshire side of the river, the Durham or south facing fells rising to equivalent heights on Middleton and Newbiggin Commons.

FIGURE I/1 Map of the area surveyed.

(1:2,500)



D U R H A M
87
88
89
91
92
93
NEWBIGGIN
HOLWICK
HOLWICK FELL
TEES
High Force Hotel
Force Garth Pasture
Newbiggin
Holwick
Bowlees
Howgill House
East Friar House
West Friar House
Low Force
Hield House
Westclose House
Low Pikestone
East Pikestone
Cross House
Hungry Hall
Bank House
Summer Hill
Hardberry Hill
High Stable Edge
Stable Edge
High Ravelin House
Low Ravelin House
Mount Pleasant
West Brokers Gill
Brokers Gill Farm
Low Houses
Park End
Crook Hill
Uthank Riggs
Friar House Allotment
Broadley's Gate
Moor House
Red Grooves House
High Knott
Dufton Moss
Wat Garth
Walker Hill
West Moor Riggs
Middle Moor Riggs
East Moor Riggs
Old Peat Moor
Ore Carr
Whiteholm Bank
Low Currack Rigg
High Currack Rigg
Hawk Rigg
Blackmea Crag
Cocklake Green
Green Fell End
Swinkel Mease
Crown copyright reserved
1m.
1km.

Chapter 5

Geology.

Although over much of the region glacial drift obscures the underlying rock formations the area under consideration is particularly uniform in its underlying rock stratifications. Each of the woodlands in question lies on the dolerite intrusion known as the Great Whin Sill. This large intrusion outcrops at a number of places and in several of the slopes overlooking the Tees, block boulder scree is left, the boulders being anything from $^1/_8$ to 8 cubic metres in size. The scree slopes have only very shallow soil layers between the boulders where ferns and bryophytes thrive but flowering plants are very restricted in number and kind.

The Juniper Wood lies on a dolerite slope between the more gently sloping peat moor and the steeper gorge of the Tees. The surface 'soil' consists of a layer of peat and raw humus over which is a dense mat of undecomposed vegetation. The actual soil is only a few cm. thick and the junipers appear to be anchored in crevices in the underlying rock. Depths of the profile ranged mostly from 8-20 cm. with a few peaty hollows where the thick humus added another 10 cm. to the total depth. A representative profile was:-

0 - 4 cm.	decaying vegetation
4 - 12 cm.	raw humus
12 - 15 cm.	grey-brown sandy soil
15 - 18 cm.	orange to red brown iron pan
18 -	underlying rocks

pH averaged 4·1.

The Birch Wood is situated on the steeper banks of the river immediately below the juniper scrub. Here there was very little peat, some raw humus and a little drift soil at the eastern end of the wood. On the other hand towards the steeper western part of the gorge the soil tended to be very shallow indeed, with numerous boulder outcrops. Along the river margin was a periodically inundated strip of a very different composition ranging from a couple of metres of bare rock to 20 m. of sandy alluvium often very calcareous.

Mill Beck is a cleft in the Dolerite where water from Holwick Scars drains into the Tees. Most of the woodland is confined to the rocky banks of the stream where soil is very shallow often only 5 - 10 cm. in depth. A few hollows in the general drainage area are very waterlogged and have accumulated a thicker layer of acid silt overlaid by undecomposed humus, total depth 1.5 m. Where the ravine opens out, just above the Tees meadows, the stream has followed a number of courses encircling small areas or flood plains about 20 m. in diameter with up to 30 cm. depth of alluvium.

Park End Wood clothes a dolerite hummock, which is partly encircled by a stream, again draining the higher screes of Holwick. The banks of this stream are quite waterlogged and small patches of deeper silt and even sphagnum support a very characteristic ground vegetation. The main area of woodland has the same shallow profile as Mill Beck but its northern margin is a steep boulder scree similar to that in parts of the Birch Wood. At the S.E. corner the wood is divided from the road by a narrow meadow through which passes a narrow drainage channel, here the alluvium is at its greatest depth, 6 dm.

Drainage problems have been mentioned and will be considered in more detail in the discussion on woodland types, Chapter II. In general it would be correct to say that the Birch Wood is the best drained of all the areas in question. It is again the only wood that receives any periodic inundation from calcareous water or where there is any clear evidence of calcareous springs. The Juniper Scrub receives a higher proportion of run-off water than any of the other three woods. This water is often highly acidic and after the snow melt the small stream dividing the scrub becomes for a few hours a solid sheet of water perhaps 50 m. wide.

In Mill Beck and Park End the main areas are well drained but there are patches of more waterlogged alluvial soils.

Chapter 6

Climate.

The climate of the north-eastern area of England has been discussed in detail in a series of papers by Manley (1935, 1936, 1943), who was one of the pioneers in advocating high altitude meteorological stations. He was instrumental in installing equipment at Moor House, a lonely cottage in the Pennines, which has since developed into a research station and an important meteorological centre. Since 1968 readings have been available also from Widdybank Fell.

As these stations are respectively 10 miles WNW and 6 miles W approximately from the woodlands being studied it is possible to extrapolate reasonable data and to gain an overall picture of the climatic conditions of the area.

Manley (1936) speaks of the north Pennine moorlands as the coldest part of England, with bleak, damp and windy days. The climate of Moor House he likens to southern Iceland which island has perhaps more sun and less rain. He sketches for us the picture of a broad moorland basin bounded on three sides by hills from 2,000' to 3,000' in height but open to the sea on the east. The basin acts as a drainage area to the S.E. so far as air is concerned and it is important to realise that it is often cold polar air which rolls over the rim of the basin and down the valley, lowering the temperature until late spring.

Table (I/3) gives some statistics from the Moor House station. Rainfall is spread throughout the year, being least in spring but high throughout the summer, autumn and winter. Although the climate diagram (Fig. I/2) shows a reasonably smooth average curve for rainfall, the yearly pattern for the area is seen better in the Widdybank curve. This latter diagram is a summary of only two years' readings but its high peaks show the occurrence of the violent storms mentioned by Manley as prevalent throughout the year. Similar one-year rainfall curves for Moor House show even greater fluctuations with peaks of 300 mm. and 270 mm. respectively in the years 1959 and 1965. When these storms occur the Tees rises very rapidly bringing down not only peat but much limestone sediment which produces the silty calcareous margin of the Birch Wood bordering the river with its characteristic strand vegetation.

The average precipitation over 35 years at Moor House is 81.2 inches (2,062 mm.), and at Widdybank 63.2 inches (1,602 mm.) for a period of two years. As the average for Middleton at 750' is 35-40 inches it is reasonable to estimate an average of 40-50 inches for the area under consideration.

Manley suggests a notable increase in snow lie above High Force but even so there are often long spells of snow cover above Middleton between December and March with low April temperatures and all in all quite a short growing period. The approximate numbers of days with temperatures above 7^{o} C are 150, 200, 220 (estimate), respectively for Moor House, Widdybank and below High Force.

A comparison of the climate diagrams for Widdybank and Moor House shows how conditions ameliorate as lower ground to the east is reached. As Glasspool (1932) computed certain climatic data for the Western Pennines, before meteorological stations were set up on higher ground, it has seemed reasonable to extrapolate certain figures for the area in which the four woodlands lie, especially as much more data is available than in Glasspool's time.

The Juniper Wood 1,250' and only 5 miles west from Widdybank has certainly the bleakest outlook, and no doubt, being fully exposed, comes nearest in climate details to Widdybank. The Birch Wood at similar altitudes 1,000' - 850' is perhaps more sheltered unless the wind direction is immediately down the valley. But the general averages for temperature, rainfall and growing period must be almost the same as those for the Juniper Wood.

Mill Beck and Park End being one or two miles further west probably have a slightly lower rainfall and more shelter, but other factors can only be slightly better than those affecting the Juniper and Birch Woods.

FIGURE I/2 Climate diagrams

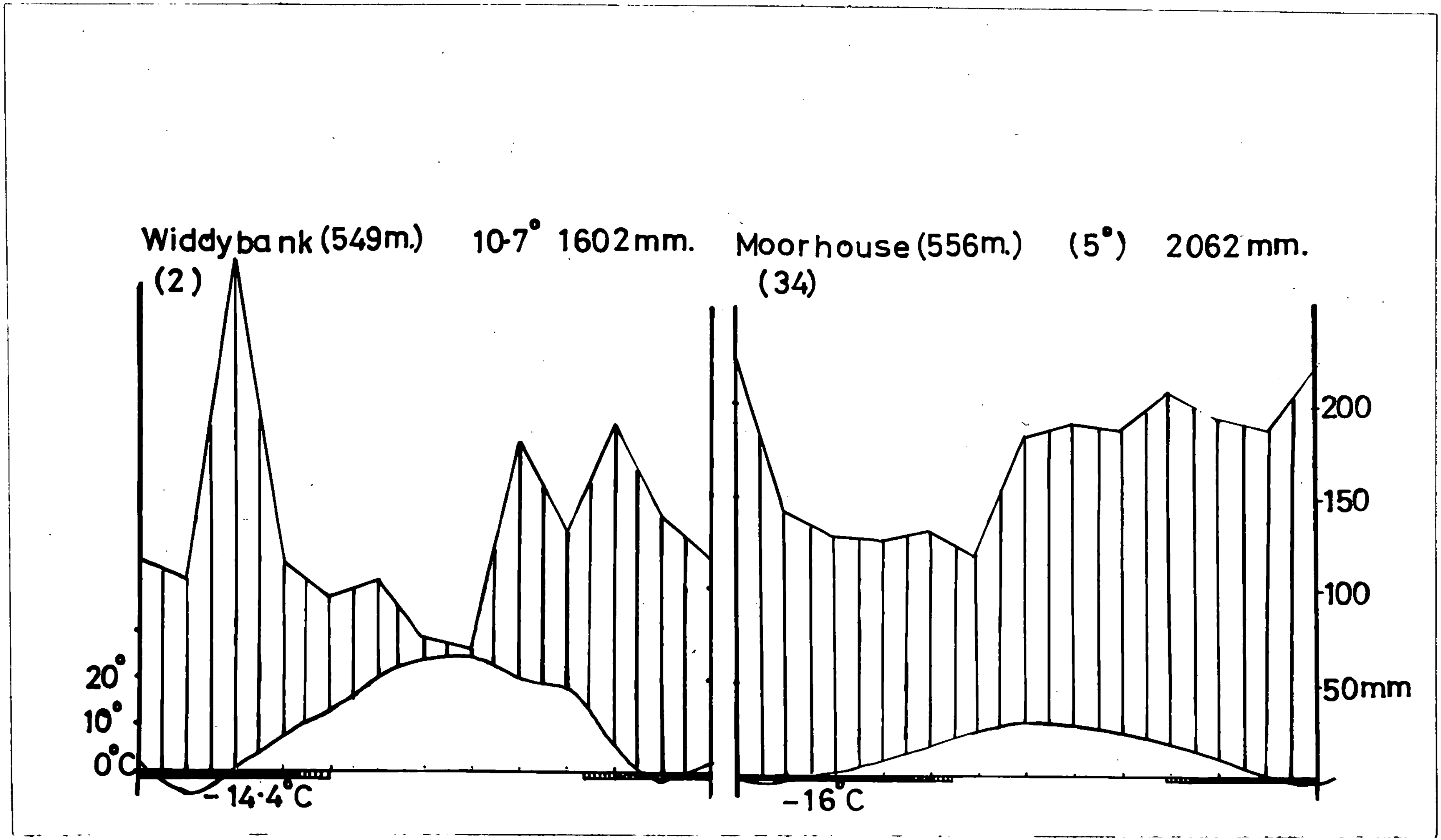

Widdybank (549m.)
10·7° 1602mm.
(2)
Moorhouse (556m.)
(5°)
2062 mm.
(34)
200
150
100
50mm
20°
10°
0°C
−14·4°C
−16°C

TABLE I/3 Climatological data

CLIMATOLOGICAL DATA at MOOR HOUSE, 1825'

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature (^{o}C) 1954-68													
Mean maximum	1.9	1.7	4.0	7.4	10.7	13.9	14.5	14.2	12.6	9.5	5.1	3.1	8.2
Mean minimum	-3.1	-3.6	-1.5	0.2	2.4	5.6	7.1	7.2	5.9	3.9	0.1	-2.1	1.8
Mean	-0.6	-0.9	1.3	3.8	6.5	9.7	10.8	10.7	9.3	6.7	2.6	0.5	5.0
Rainfall (inches) 1916-50													
Total	8.93	5.68	5.20	5.11	5.28	4.79	7.31	7.63	7.55	8.36	7.79	7.55	81.18
Sunshine (hours) 1954-68													
Total	35	47	82	120	163	173	135	126	102	79	42	31	1135
Daily mean	1.12	1.69	2.65	4.01	5.26	5.75	4.37	4.06	3.40	2.55	1.41	1.01	3.11
Number of days of:-													
Rain ($\geqslant$0.01 ins.)	21.7	20.8	20.5	19.6	19.0	18.6	20.9	22.1	20.0	21.5	21.9	23.7	250.3
Snow and sleet													
Snow lying (0900 hrs.)	18.5	15.5	11.6	2.3	0.7					0.1	4.4	11.5	64.6
Air frost	25.3	21.8	20.3	14.7	6.0	1.7	0.6	0.7	2.0	3.9	13.2	22.3	132.5
Ground frost	26.1	24.7	23.1	18.8	12.7	5.3	3.3	3.7	5.5	8.3	17.7	22.1	171.3

Chapter 7

Biotic.

Juniper Scrub

Historical evidence shows that juniper was at one time gathered here for firewood. Grazing by sheep has certainly been the pattern for many years although a portion has now been fenced against grazing in order to see what the new pattern will be.

Birch Wood

The steep banks of the Tees with shallow soils produce very poor pasture and show little evidence of grazing.

Mill Beck has patches of dense Corylus scrub and, for the most part, slopes, too steep for grazing by cattle, which seem to pasture the surrounding slopes during most seasons of the year. The transition from woodland through to poor pasture is very marked here.

Park End has marshy areas, unpalatable fern cover on the boulder slopes and the most dense tree cover of any of the woods considered. A small area in the centre is Bent-Fescue turf and between the wood, and the road on the southern limit, is a very small Juncus meadow poorly drained. These grazing areas seem to be occupied mostly by horses.

PART II

WOODLAND TYPES:

GENERAL ECOLOGY AND FLORISTICS

Chapter 8

Form, extent, and nature of forest.

During the last sixty years there has been a tremendous advance in our knowledge of the history of vegetation in the British Isles. In his first edition of "Studies in Fossil Botany" Scott (1900) could say "only twelve years ago it was said that fossil botany had contributed little to our knowledge of the affinities of plants". For the study of vegetational history there was thought to be little remaining evidence. With the then available facts this was a perfectly reasonable assumption.

For the most part vegetation decays unless preserved en masse and transformed out of all recognition into metamorphosed layers such as the familiar coal strata. Even the plant skeleton decays unless imprinted and embalmed in an almost unique way in Mesozoic mud, only to be baked hard and left as a fossil, identifiable thousands of years later as the frond of some prehistoric Pteridophyte. It was not until the last half of the nineteenth century that extensive mining, excavations for canals and railways, and other large scale soil disturbances brought to light a sufficient quantity of fossil plants to be of any significance.

However, with these fossil plants it was possible in the early years of this century to build up some kind of world picture of the flora of the past. So Scott can say in later editions of his book that "our whole conception of two at least of the great divisions of the Vegetable Kingdom, the Pteridophytes and Gymnosperms and of their mutual relations, is already profoundly influenced by the study of ancient forms."

It was the realisation (a) that the pollen grains of many plant species could be identified and (b) that pollen has been preserved in large quantities in peat and other similar stratified layers of wet vegetation, which led to spectacular advances in man's knowledge of the plant life of previous eras of earth's history.

Indeed it has been possible to identify sufficient species and in sufficient quantities so as to produce some kind of vegetational, as distinct from floristic, history of the Quaternary period. The palaeobotanist now has methods parallel to those of the archaeologist with pollen grains as his scarabs and potsherds.

It can thus be stated with near certainty that a large part of the British Isles was in the past covered with great forests; at least, land up to the 2,000' contour. Most of the forests have been very much modified either directly or indirectly by human activity during the last 3,000 years. Now only fragments or relics of these great woods remain. The fragments are of fundamental importance because they represent the units from which much of the existing vegetation has been derived.

Pearsall (1950) divides the woodland relics into five categories and he distinguishes between mixed woodlands and those predominantly of one species, oak, pine, birch and alder. These woodland types will be discussed insofar as they are related to the four specific woodland fragments studies in this thesis. First, however, it will be instructive to survey very briefly the arboreal history of the whole area in question as summarized by Turner (1970).

(i) <u>The Boreal period 7,000 - 5,000 B.C.</u>

In this period a relatively stable mixture of tree species was established, mainly elm, oak and hazel with birch and pine. Pollen diagrams have shown that the boreal forest pattern varied appreciably and although we can talk of a stable mixture of species over the whole country the composition of the woods varied considerably from place to place.

The lowlands seem to have been dominated by a broad-leaved deciduous forest whilst in upland areas pine was much more abundant.

Even in the upland areas there was a considerable difference in pollen percentages. Turner (1970) notes a 40% difference in pine pollen within one mile in the Widdybank area. She gives a description of the boreal forest as follows:-

"One must not therefore envisage the uplands as covered with a uniform pine forest rather like our modern pine plantations, but see them as covered with stands of trees changing in species composition over relatively short distances on the rich variety of available habitats".

(ii) The Atlantic period 5,000 - 3,000 B.C.

The resulting wetter atlantic climate brought in new species notably *Alnus* and the resulting woodlands seem to have varied greatly in accordance with the more widespread pattern of wet and dry habitat.

The picture in the Teesdale area seems to have been *Pinus* on the higher slopes, heathy birchwood with abundant *Betula* and possibly *Quercus* on well drained slopes with rushy *Alnus* woods in the wetter hollows. On the more fertile soils the better type of woodland remained.

The real turning point came at the end of this period. Over the whole of Europe such a striking change in the pollen spectrum then becomes apparent that this fluctuation has received a name - "the elm decline". Successful efforts have been made to date this period of the elm's decline to within a few hundred years of 3,000 B.C.

(iii) The age of man's influence, 3,000 B.C. onwards.

The last phase of vegetational history is closely linked with the era of man's development known as the Neolithic Age. There is a steady decline in woodland over the whole period down to the present day.

The beginning of this decline can be seen on the higher fells with the formation of blanket peat and the resulting displacement of

Boreal forest, not by Atlantic forest but by peat forming communities. The lower slopes however still retained their forests until the direct or indirect influence of man.

Degeneration of woodland seems to have been caused by several factors including the primary influence of man. These are:-

(i) leaching and soil degeneration

(ii) waterlogging of soil

(iii) grazing and draining

(iv) felling.

The four factors of course operate either singly or in some degree of combination, the first two resulting in the formation of blanket peat at higher levels with the total disappearance of woodland.

In some of these peat formations, particularly those at the heads of valleys or in corries, buried timber has been found, particularly the stumps of birch and pine. Alder, oak, rowan, aspen and willow have also been found but in much smaller quantities - Pearsall (1950).

Pigott (1956) notes Pinus and Betula under peat in the Teesdale area, particularly on Widdybank, Cronkley and Dufton fells. Thus we have evidence, in addition to the pollen layers, which points to the existence of high level forest in fairly recent times.

At lower levels too, waterlogged soils in hollows have led to woodland degeneration, the forest communities being replaced by communities of Leucobryum, Molinia and Sphagnum.

On the more free draining soils leaching has resulted in the disappearance of, or change in, the original forest layer. This leaching may have been natural or the result of clearing and heavy draining by man.

The other major factor of change has been of course intense grazing by domestic animals since Neolithic times. This has resulted in the denudation of thousands of acres of downs and lower hill slopes of their natural woodland and the formation of the familiar grassy pastures of Britain's foothills.

The importance of the remaining relics of natural or semi-natural woodland has already been pointed out. The general ecology and floristics of four of these relic woodlands will now be considered with reference to Tansley's pioneer studies (1939) and in relation to Pearsall's types already mentioned.

Chapter 9

Juniper Wood.

(A) In general

The distribution of juniper in Northern Britain since 10,000 B.C. is interesting since it shows periods of abundance and decline. During the warmer period (late Devensian) at the end of the full glaciation juniper was a first coloniser becoming widespread and accounting for 20% of the dry land pollen. By the end of the Devensian period juniper has almost completely disappeared (Turner (1970)).

In more recent history juniper again became common. Pearsall (1950) notes it in three characteristic habitats in the North of England and South of Scotland.

(i) abundant at one time on what might be called the knoll and hollow type of semi-moorland, where heather crowns the knolls and damp grassland (usually now with bracken) fills the hollows. Here juniper occupied an intermediate position on the upper flushed slopes below the heather.

(ii) now, juniper is often abundant along the flushed margins of damper and degenerating areas of vestigial pine forests. Here it can persist long after the conditions under which it established itself have passed away.

(iii) juniper is at times equally abundant in N. England and S. Scotland along the margins of vestigial grassy woodlands of oaks or birch especially those of the damper kind. Here it can form dense thickets especially on north-facing slopes.

In the South of England juniper is established on chalk downs and heaths.

Tansley summarized the picture saying "it has a wide distribution but with many gaps".

(B) The Juniper area under investigation

The map (Fig. II/1) shows the specific area included in the present survey.

Juniper clothes the hillside on the Yorkshire side of the Tees for almost 1,000 m. along the scar east to west (B.C.F.). It is north facing and agrees very well with (iii) of Pearsall's summary, outlined above. The scrub varies in depth but is about 250 m. in a north to south line at its central section (C.D.).

Over some areas the juniper forms extremely dense thickets. The bushes in this area are from 1.5 - 3 m. in height and their cover is extremely dense. Scattered among the shrubby forms are some taller more columnar trees up to 4 m. in height with others not quite as tall but contorted and looking almost as if they had been trimmed into various shapes.

There is little evidence of recent regeneration. For the most part only the resistant old trees survive although there are some younger bushes. Certainly in the denser parts of the scrub no seedlings were found. It has been noted that seeds do not mature on the extremely acid soil and litter beneath such a canopy but must be carried to more open habitats where there is soil of a satisfactory base status.

The area is grazed by sheep and although some authorities have maintained that juniper can persist and even regenerate when subjected to grazing, direct evidence is hard to come by. The Nature Conservancy have therefore erected a stout wire fence around section A.B.C.D. of the area and it will be interesting to compare this section of the Juniper Scrub with the grazed section C.D.E.F. in years to come.

Holwick scar on which the wood is situated outcrops at the 1,025' contour mark producing small steps, two or three metres in height.

Where these are clothed with juniper and also where the steps have broken down into scrub covered scree the interesting Juniperus - Thelypteris nodum occurs which will be discussed in the Phyto-sociological chapter. Most stands in the rest of the area had slopes varying from 5° to 20°.

Juniper passes over quickly into blanket peat and Calluna moor in the south at the 1,150' contour. The northern boundary of the juniper area is formed by the steep southern bank of the River Tees on which is situated the Birch Wood also under study. The Tees banks are precipitous at A. near High Force but slope more gently as Holwick Head Bridge (beyond E.) is approached.

In table II/1 a complete list of species occurring in the ground flora of all four woodlands under study is presented. The figures refer to the number of Aufnahmen in which the species occurred. The total number of Aufnahmen studied in each area is placed at the head of each column. From these figures we can extract some interesting information on the general floristics and ecology of each woodland as a preliminary to the more exact delineation of associations in Part IV.

For the Juniper Wood the following categories are important:-

Dominant or frequently occurring species

Agrostis canina ssp. montana
Agrostis tenuis
Anthoxanthum odoratum
Blechnum spicant
Calluna vulgaris
Deschampsia flexuosa
Festuca ovina ssp. ovina
Festuca ovina ssp. tenuifolia
Juniperus communis
Luzula pilosa
Potentilla erecta
Pteridium aquilinum
Vaccinium myrtillus
Hypnum cupressiforme var. ericetorum
Hylocomium splendens
Lophocolea bidentata
Pleurozium schreberi
Pseudoscleropodium purum
Rhytidiadelphus loreus
Rhytidiadelphus squarrosus

Species found only or mostly in the Juniper Wood

Aira praecox
*Carex binervis
*C. pilulifera
*C. echinata
=Drosera rotundifolia
*Empetrum nigrum
*Huperzia selago
*Juncus squarrosus
Listera cordata
Luzula campestris
*Luzula multiflora
Molinia caerulea
*Nardus stricta
*Polygala serpyllifolia
=Trichophorum cespitosum
*Vaccinium vitis-idaea
=Viola palustris

=Acrocladium sarmentosum
Campylopus flexuosus
Drepanocladus revolvens
*Hookeria lucens
*Leucobryum glaucum
*Mnium stellare
Polytrichum commune
=Sphagnum fuscum
=S. papillosum
=S. plumulosum
S. recurvum
=S. rubellum
=S. subsecundum
Cephalozia sp.
*Lophozia ventricosa
*Ptilidium ciliare

Species found only or mainly in the Juniper and Birch Woods

*Calluna vulgaris
Empetrum nigrum
Festuca ovina ssp. ovina
Festuca ovina ssp. tenuifolia
Juniperus communis
*Luzula pilosa
Polytrichum formosum

Sphagnum quinquefarium
S. girgensohnii
Scapania gracilis
Thelypteris limbosperma
T. phegopteris
Thymus drucei

The dominant and most frequently occurring plants are all good acidiphilous species characteristic of upland base-deficient soils. Species such as Listera cordata show affinities with wet heath vegetation and woodlands in the pine zone. Others (marked =) are characteristic of wet peaty heaths and show the transition from juniper to peat moor. In the present area they were noted mostly in wet hollows and small pockets with restricted drainage.

On the more open, well drained slopes where the soil was still very acid, the dry heath/heathy woodland species (marked *) were much more in evidence, relating the associations to the continental Nardo-Callunetea.

Species not found at all or very sparse in the Juniper Wood

Acer pseudoplatanus
Achillea millefolium
Ajuga reptans
Alchemilla xanthochlora
Allium ursinum
Alnus glutinosa
Angelica sylvestris
Betonia officinalis
Betula pubescens
Brachypodium sylvaticum
Briza media
Caltha palustris
Campanula latifolia
Carex nigra
C. pallescens
C. sylvatica
Centaurea nigra
Crepis paludosa
Coryllus avellana
Cruciata laevipes
Dactylis glomerata
Dactylorrhiza species
Digitalis purpurea
Dryopteris filix-mas
Dryopteris pseudomas
Endymion nonscriptus
Epilobium palustre
Filipendula ulmaria
Fragaria vesca
Fraxinus excelsior
Galium odoratum
G. uliginosum

Geranium sylvaticum

G. robertianum

Geum rivale

G. urbanum

Glyceria fluitans

Hieracium species

Hypericum pulchrum

Lathyrus montanus

Lonicera periclymenum

Luzula sylvatica

Melica uniflora

Mentha aquatica

Mercurialis perennis

Myosotis secunda

Plantago lanceolata

Potentilla sterilis

Primula vulgaris

Prunella vulgaris

Prunus spinosa

Ranunculus acris

R. ficaria

Rosa species

Rubus species

Sanguisorba officinalis

Sanicula europaea

Sorbus aucuparia

Stachys sylvatica

Stellaria holostea

Succisa pratensis

Teucrium scorodonia

Tussilago farfara

Ulmus glabra

Urtica dioica

Veronica chamaedrys

Vicia sepium

Acrocladium cuspidatum

Atrichum undulatum

Bartramia pomiformis

Cirriphyllum piliferum

Eurhynchium praelongum

E. striatum

Fissidens species

Mnium undulatum

Plagiothecium succulentum

Rhytidiadelphus triquetrus

Pellia epiphylla

As can be seen from the foregoing list there is a complete absence of species characteristic of woodlands on better soils. Indeed the dissimilarities between the Juniper and Birch Woods on the one hand and Mill Beck and Park End on the other appear to be related to the soil types of each pair. The first two woodlands are situated on acid mor deficient in the nutrients required by more exacting species such as Mercurialis perennis and Allium ursinum.

The latter pair share a soil much more akin to a good lowland mull where, provided the canopy cover is not too dense, a woodland can exhibit quite a rich ground flora.

One very similar area which has been studied from a general ecological standpoint is Boghall Glen in the Midlothians. Wyllie Fenton (1933) notes a number of points which compare very favourably with the foregoing account of the Teesdale Juniper Wood. Indeed he notes the close similarity himself saying, "Only recently the writer visited this area" (the High Force Juniper Wood) "and found a striking similarity of conditions to Boghall Glen, fully bearing out the conclusions reached."

Some of his findings and conclusions are as follows:-

(i) The dominant species of Boghall Glen are Juniperus communis, Calluna, Vaccinium myrtillus and Pteridium with Agrostis species and Festuca ovina in the open areas.

(ii) No seedling of juniper was noted and there was an absence of tree species.

(iii) Under dense juniper there were few species growing save Oxalis and some bryophytes.

(iv) Juniper was noted as growing only on the side of the glen where the sub-soil was derived from basic rocks even though the upper part of the soil profile might be highly acidic. This observation is borne out by Lewis (1904) for the valley of the River Tees, who notes juniper chiefly on limestone, basalt, and dolerite formations.

(v) Fenton suggests that juniper may be a retrogression from birch wood noting that it is found in Scotland both in open birch wood or mixed birch and pine.

FIGURE II/1 The Juniper Scrub (J) and Birch Wood (B) (1:25,000 approx.)

Legend:

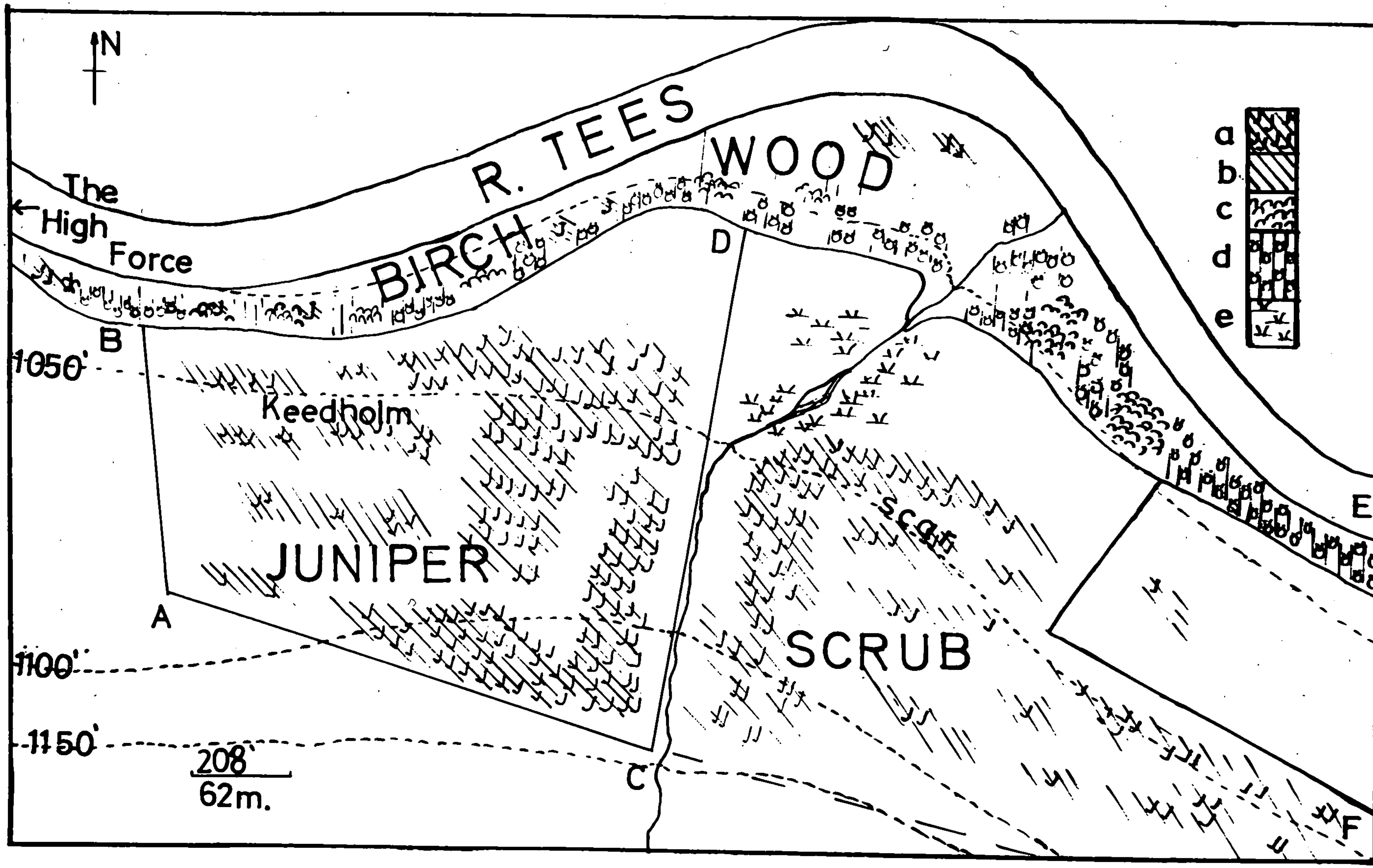
a. Dense *Juniperus communis*

b. Main juniper area

c. Boulder scree with ferns

d. *Betula pubescens*

e. *Juncus acutiflorus* etc.


N
R. TEES
The
High
Force
BIRCH
WOOD
JUNIPER
SCRUB
scar
Keedholm
A
B
C
D
E
F
a
b
c
d
e
1050'
1100'
1150'
208'
62m.

Chapter 10

The Birch Wood.

In Britain the chief Boreal tree invaders were birch and pine. Tansley noting that the requirements of their dominants are so closely similar considers birch and pine woods together suggesting that these woods belong to the zone north of the Deciduous Summer Forest. They are, in other words, the Eurasian form of the Northern Coniferous Forest. This statement will be seen to have a great deal of foresight and truth in it when the phytosociology of the Birch Wood is considered.

With improving climatic conditions oak forest tended to replace the birch and pine but this was of course mainly in the south. In the Scottish Highlands pine and birch remained as the chief dominants. When in direct competition birch gives way to pine so long as soil conditions are good but in adverse conditions of soil and climate birch can maintain itself.

The wood under consideration lies on the steep southern banks of the River Tees, i.e. on a north-facing slope. It forms an extension of the Juniper Wood (see Fig. II/1) and indeed has seral connections with it. The distance from High Force to Holwick Head Bridge is about 1 km. (A.E.) giving the total length of the wood. For the most part the trees form an open canopy only 50 m. or less across from river bank to the wall dividing the Birch Wood from the Juniper Scrub. The spur of the river at D. is open ground with some juniper on the flood plain and rocky scree on the higher slopes. There are more of these block boulder screes down the river towards E. whilst as A. is approached the banks become much steeper, consolidated in steep dolerite cliffs. There are flushes at various points on this cliff which bear some indication of lime enrichment from the underlying limestone. The level of the Tees tends to rise rapidly after rain and a characteristic strand vegetation clothes the sandy lime-enriched alluvium bordering the river. These are the main instances of calcareous conditions in the four woods studied. The soil in which the birches are rooted is a dark humus with pH ranging from 4.8 - 6.0. Owing to the open nature of the canopy parts of the ground layer support ericaceous vegetation and a nice sequence is formed between the more acid communities of the Juniper Wood and the Agrostis-Festuca communities of the main birch area.

In many places the banks rise steeply to 50° or 60° and it is here that large dolerite boulders support a characteristic fern community of the Northern Dryopteris pseudomas with Dryopteris filix-mas and very vigorous intermediates and hybrids. These boulders lie in heavy shade from the tall ferns and so support no luxurious bryophyte communities. The crevices between the boulders are filled with litter and very shallow acid humus so again bryophytes are notably absent or confined to one or two species.

An interesting comparison with the Scottish birch woods, noted both by Tansley (1939) and Pearsall (1950), is that the Teesdale birches belong also to a northern race Betula pubescens ssp. carpatica. Here, too, although not as old and contorted as the Caithness birches, the trees are often misshapen and many spring horizontally from the steep banks before assuming an upright habit. As many are 3 dm. in diameter they must be of considerable age.

Again as in the Highland birchwoods there are very few associated trees and shrubs.

A consideration of the dominant and frequently occurring plants shows the close relationship between this wood and the one just described. Although better drained, the soil too is, apart from the river-side alluvium, still an acid mor. So the main species are again acidiphilous but with a greater increase in those which prefer woodlands, especially woodland scree and moist shaded boulders. One might instance Thelypteris limbosperma, T. phegopteris, Dryopteris pseudomas, Sphagnum quinquefarium, S. girgensohnii, and other bryophytes.

An interesting habitat was noted in the Birch Wood where trees had been uprooted. Here were bryophytes of acid soil exposures and peaty banks such as Polytrichum urnigerum and Diplophyllum albicans.

Birch Wood: dominant or frequently occurring species

Agrostis canina ssp. montana
Agrostis tenuis
Anthoxanthum odoratum
Athyrium filix-femina
Betula pubescens
Blechnum spicant
Conopodium majus
Deschampsia flexuosa
Dryopteris dilatata
Dryopteris pseudomas
Luzula pilosa
Oxalis acetosella

Pteridium aquilinum
Thelypteris limbosperma
Vaccinium myrtillus
Viola riviniana

Dicranum majus
D. scoparium
Mnium hornum
Rhytidiadelphus squarrosus
Diplophyllum albicans
Lophocolea bidentata
Plagiochila asplenioides

Found only or mostly in the Birch Wood

Briza media
Cystopteris fragilis
Equisetum arvense
Helictotrichon pratense
Leontodon hispidus
Mimulus guttatus

Amphidium mougeotii
Breutelia chrysocoma
Cratoneuron commutatum

Ctenidium molluscum
Dichodontium pellucidum
Distichium capillaceum
Ditrichum heteromallum
Drepanocladus fluitans
Fissidens species
Polytrichum urnigerum
Rhacomitrium species
Solenostoma species
Nardia scalaris

In general many more bryophytes than in the other woods.

Not found or only very sparse in the Birch Wood

Allium ursinum
Alnus glutinosa
Anemone nemorosa
Arrhenatherum elatius
Betonica officinalis
Caltha palustris
Carex sylvatica
C. pilulifera
Cirsium heterophyllum
Crepis paludosa
Crataegus monogyna
Cruciata laevipes
Digitalis purpurea
Galium saxatile
Geranium sylvaticum
Geum urbanum
Juncus acutiflorus
Molinia caerulea
Nardus stricta
Myosotis species
Polygala serpyllifolia
Ranunculus ficaria
Rumex acetosa
Rubus species

Very sparse

Sorbus aucuparia
Stachys sylvatica
Stellaria graminea
S. holostea
Teucrium scorodonia
Ulmus glabra
Vicia sepium

The species restricted to the Birch Wood are for the most part not typical woodland plants. Either they occurred on wet acid rock exposures, e.g. Amphidium mongeotii or on the eutrophic, base-rich alluvial soils of the river terrace. Bryophytes such as Cratoneuron commutatum, Ctenidium molluscum, and Dichodontium pellucidum were found along this terrace in the inundation zone of the Tees.

The species absent from this wood are again, as in the case of the Juniper Wood, indicative of different edaphic conditions from those prevalent in Mill Beck and Park End. Although some common woodland species are present most of those demanding mull soils are absent.

FIGURE II/2 Section through Juniper Scrub and Birch Wood

Legend:

ca. *Calluna* & blanket peat

c. *Calluna*

v. *Vaccinium*

j. *Juniperus*

s. *Sphagnum*

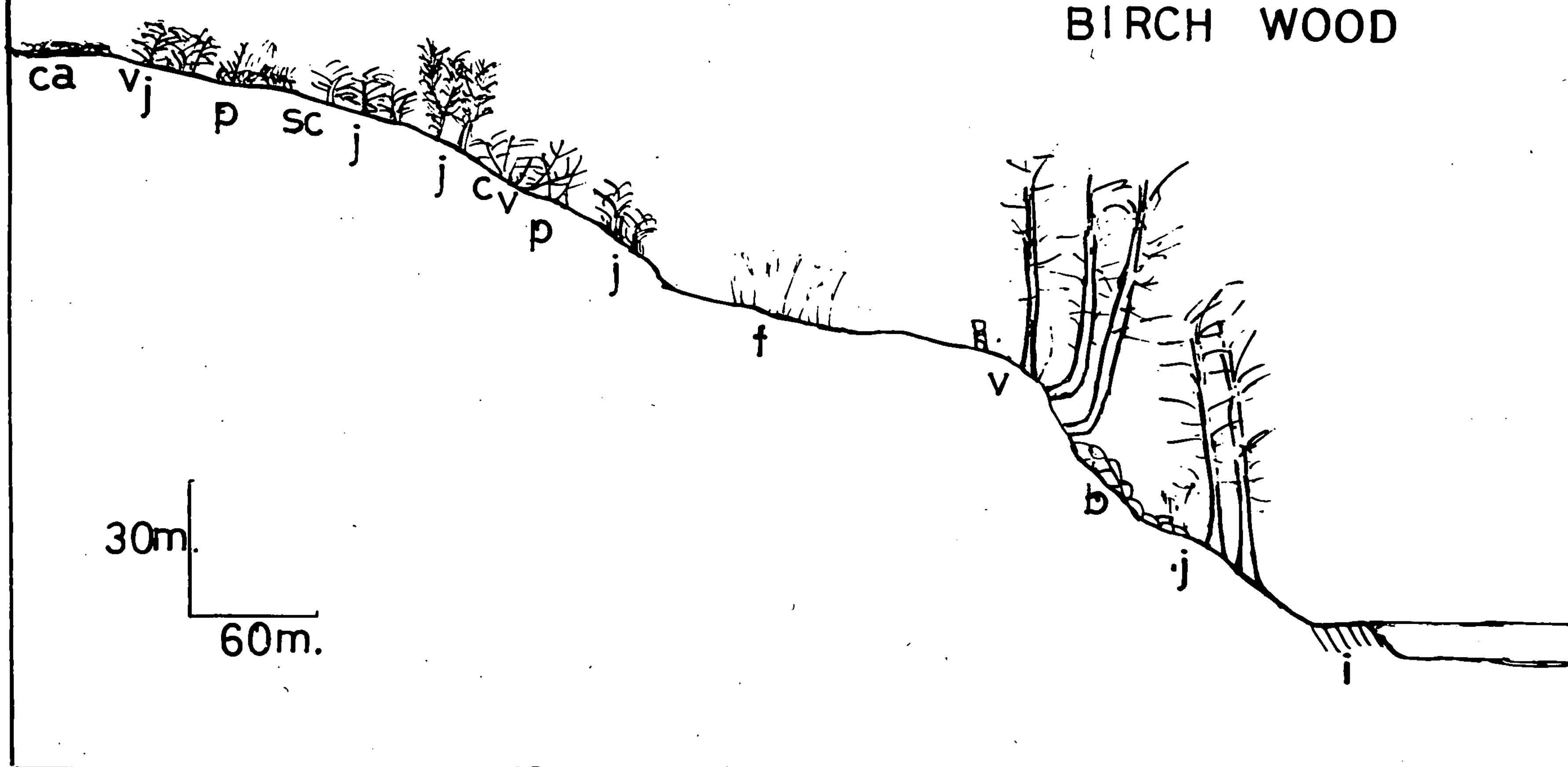
p. *Pteridium* & grasses

f. Flushed area with *Juncus* spp.

b. Boulder scree & ferns

i. Inundated area

SECTION THROUGH JUNIPER SCRUB & BIRCH WOOD



Chapter 11

Park End Wood.

Park End (Fig. II/3) is the most dense and compact of all the woods considered. Betula pubescens is again predominant, but there is also a high proportion of Sorbus aucuparia and a large area of Corylus scrub. The tree and shrub cover is denser than in Mill Beck or in the Birch Wood and the ground flora includes many more typical woodland species such as Endymion, Galium odoratum, and Lonicera periclymenum.

Situated on a hummock of dolerite the wood reveals a varied physiognomy. The northern boundary (B.C.) is a steep 50° block boulder slope with rich, tall fern communities. To the west the slope becomes more gradual but impeded drainage has resulted in an interesting flush community with Sphagna and Dactylorchids and an over storey of Alnus glutinosa. Pearsall (1950) notes that Alder at one time occupied every damp flush in upland woods and most of the alluvial plain. Three reasons are given for its disappearance:

(i) drainage and clearance by the Norseman,

(ii) lying on the best alluvial soils it was always in danger whenever there was more demand for grassland and hay meadow,

(iii) Alder is one of the best trees for charcoal production.

To the south Park End is bounded by a road. There is a portion of scrubby grassland (A.F.E.) supporting Rosa-Prunus spinosa communities. Towards E. there is a considerable depth of alluvium with a shallow drainage channel bordered by marshy meadow species, Glyceria fluitans, Ranunculus flammula, Viola palustris, Juncus articulatus and Acrocladium cuspidatum.

Between E. and D. there is an interesting belt of Corylus scrub about 20 m. wide fully exposed to the south and on a 10° - 20° slope.

Park End Wood: dominant or frequently occurring species

Agrostis stolonifera

A. tenuis

Betula pubescens

Corylus avellana

Alnus glutinosa

Anthoxanthum odoratum

Endymion nonscriptus

Oxalis acetosella

Holcus lanatus

H. mollis

Pteridium aquilinum

Sorbus aucuparia

Succisa pratensis

Found only or mainly in Park End

+Caltha palustris

+Equisetum sylvaticum

Euphrasia species

+Dactylorrhiza species

Lonicera periclymenum

Melampyrum pratense

+Pedicularis palustris

Prunus padus

+Senecio aquaticus

+Trollius europaeus

Found only in Park End and Mill Beck

+*Carex pallescens*
++*Chrysosplenium oppositifolium*
++*Crepis paludosa*
-*Cruciata laevipes*
Dactylis glomerata
Digitalis purpurea
Dryopteris filix-mas
Endymion nonscriptus
+*Epilobium palustre*
++*Filipendula ulmaria*
Fragaria vesca
++*Fraxinus excelsior*
++*Galium odoratum*
+*Galium uliginosum*
++*Geranium sylvaticum*
++*Geum urbanum*
+*Glyceria fluitans*
Hieracium perpropinquum
+*Juncus effusus*
-*Lapsana communis*
Lathyrus montanus
++*Lysimachia nemorum*
+*Myosotis caespitosa*
Poa species
Polypodium vulgare
-*Primula vulgaris*
+*Prunella vulgaris*
Prunus spinosa
++*Ranunculus ficaria*
+*R. flammula*
Rosa species
-*Rubus species*
+*Sanguisorba officinalis*
Sorbus aucuparia
-*Stellaria holostea*
Sieglingia decumbens
-*Succisa pratensis*
Teucrium scorodonia
-*Trifolium repens*
-*Urtica dioica*
++*Valeriana officinalis*
-*Veronica chamaedrys*
-*Zerna ramosa*
-*Atrichum undulatum*
-*Cirriphyllum piliferum*
Eurhynchium praelongum
-*Mnium undulatum*
-*M. longirostrum*
Rhytidiadelphus triquetrus

Not found or very sparse in Park End

Allium ursinum

Alchemilla xanthochlora

Angelica sylvestris

Blechnum spicant

Briza media

Carex binervis

Calluna vulgaris

Carex sylvatica

Circaea lutetiana

Empetrum nigrum

Erica tetralix

Festuca ovina ssp. *ovina*

F. ovina ssp. *tenuifolia*

Melica uniflora

Polygala serpyllifolia

Salix pentandra

Vaccinium myrtillus

Fissidens species

Polytrichum aloides

Much less frequent than in Mill Beck

Deschampsia cespitosa

Fraxinus excelsior

Filipendula ulmaria

Geum urbanum

Mercurialis perennis

Primula vulgaris

Ranunculus acris

and meadow species

Trifolium species

Ulmus glabra

Eurynchium striatum

Sanguisorba officinalis

Senecio jacobaea

Stachys sylvatica

Vicia sepium

Potentilla sterilis

FIGURE II/3 Park End Wood (P) (1:25,000)

Legend:

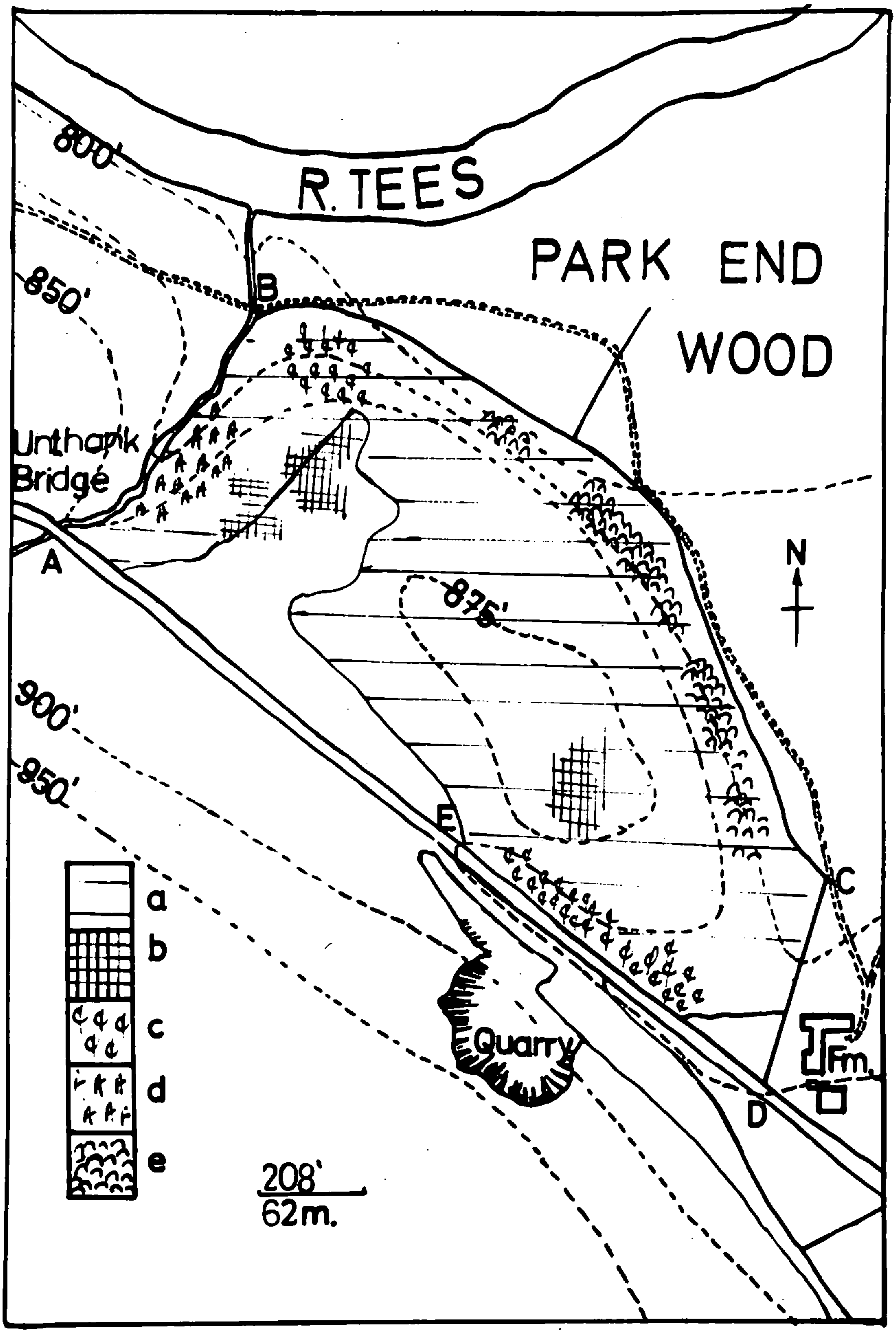
a. Extent of woodland

b. *Rosa* *Prunus* & *Rubus* scrub

c. *Corylus* scrub

d. *Alnus glutinosa*

e. Boulder scree & ferns


R. TEES
PARK END
WOOD
800'
850'
875'
900'
950'
B
A
C
D
E
Unthank
Bridge
N
Quarry
Fm.
a
b
c
d
e
208'
62m.

Chapter 12

Mill Beck Wood.

Mill Beck Wood (Fig. II/4) is situated on the banks of a mountain stream which drains the upper slopes of Crossthwaite Fell. There are no natural or artificial boundaries to the wood which shades over very quickly into pasture. It is possible to see here the effects of such close proximity of agricultural land. The natural spread of the wood is restricted to the steep banks of the stream: often its total width is only 20 metres although to the north of the road it reaches 40 or 50 metres.

Grassland species invade the tree zone and species such as Cynosurus and Dactylis are found in open Corylus scrub. The total fall from the upper tree line (A. at 1100') to (G.) is 300'. Between (A.) and (D.) the stream banks are very steep and eroded. It is here that fern communities and Brachypodium sylvaticum with Sorbus aucuparia are at their best. Four hollows with impeded drainage have a tree cover of Salix pentandra with marshy species such as Myosotis secunda, Caltha palustris, Ranunculus flammula and Cardamine pratensis.

In the northern, lower part of the wood where the mountain stream has at times followed various courses (and still does so in the snow melt or at other flood periods) there are a number of flatter alluvial terraces with a more dense tree cover. The remarks on Park End Wood apply here equally, as can be seen from the species which the two woods have in common over and against the Birch and Juniper Woods. Acidiphilous species, common to mor-humus and raw-humus rich soils of heathy woodlands (All. Quercion robori-petraeae and Class Nardo-Callunetea) are completely absent. On the other hand species of the Querco-Fagetea are present though not in large quantity. Evidently there are patches of more eutophic soils probably due to flushes from the limestone underlying the dolerite. These species are marked (X) in the lists from Mill Beck.

The higher proportion of species found here reflects (a) the greater variety of habitat, (b) the proximity of pasture and agricultural land, (c) the more open nature of the mature canopy. Although the wooded area is so small there is a greater mixture of trees here than in any of the other three woods, especially of trees with wind borne or bird-sown seeds and fruits, Fraxinus, Betula, Ulmus, Salices together with Alnus, Fraximus, Sorbus, Corylus, Prunus and Rosa species. If the surrounding terrain were as suitable, with a number of ravines, and restricted grazing and pasture, one could envisage here, from this fragment, a really mature example of Sorbo-Brachypodietum as delineated in Part IV.

Perhaps the greatest difference between Mill Beck and Park End lies in the preponderance in the former of more open and unstable scree slopes where Brachypodium sylvaticum and Melica nutans achieve higher cover. In Park End the steeper slopes seem to be either more stable and therefore covered with a more mature turf and herb mixture or very shaded and moist with a corresponding increase in bryophytes, ferns and undecomposed litter.

Mill Beck Wood: dominant or important species

Agrostis stolonifera
A. tenuis
Betula pubescens
Brachypodium sylvaticum
Corylus avellana
Dactylis glomerata
Holcus lanatus
H. mollis
Oxalis acetosella

Found only or mainly in Mill Beck

x*Allium ursinum*

Alchemilla xanthochlora

Brachypodium sylvaticum

Angelica sylvestris

x*Campanula latifolia*

Carex nigra

x*C. sylvatica*

x*Circaea lutetiana*

Cryptogramma crispa

Melica uniflora

Petasites hybridus

Salix pentandra

Not found or very sparse in Mill Beck (acidiphilous)

Agrostis canina

Briza media

Carex binervis

C. pilulifera

Dactylorrhiza species

Deschampsia flexuosa

Equisetum sylvaticum

Euphrasia species

Empetrum nigrum

Festuca ovina ssp. *ovina*

F. ovina ssp. *tenuifolia*

Gymnocarpium dryopteris

Juniperus communis

Luzula campestris

L. multiflora

L. sylvatica

Melampyrum pratense

Polygala serpyllifolia

Prunus padus

Senecio aquaticus

Thelypteris species

Sphagnum species

Vaccinium myrtillus

The species lists serve to underline the general remarks on this wood and above all to indicate the fundamental difference between the first two woodlands considered and the last two woodlands of this survey. As has been already pointed out the Juniper and Birch Woods are rich in species indicative of an acid mor soil. Here and also in Park End many acid loving species are absent, whilst in complete contrast both woods contain a variety of species found mainly on richer mull soils. These are marked (-) in the species lists.

A further series of plants marked (+) is characteristic of stream silt soils with some nutrient enrichment, and finally, on deeper alluvial silt with calcareous enrichment, are those marked (++).

Tansley (1939) has a chapter on Highland birchwoods and it is evident that they parallel the Teesdale woods extremely closely. Comparisons can be made between the two as every fresh paragraph in Tansley's account is perused.

Of the trees he mentions as dominant or even occasional only Populus tremula is missing in the four woods considered here, whilst Salix aurita is not a very common willow in the region as a whole. Tansley's field layer species list (compiled from Crampton's account of the Caithness birchwoods (1911)) is remarkably similar, only characteristically northern species such as Trientalis europaea and Ajuga pyramidalis being absent from the Teesdale list. Even the birch wood variants of Anderson (1932), e.g. "alder-birch" and "birch-rowan" have many points in common with the four woodlands of this thesis and some of these points will be brought out in Part IV of this work.

FIGURE II/4 Mill Beck Wood (M) (1:25,000)

Legend:

a. Extent of wood & scrub

b. *Pteridium* etc.

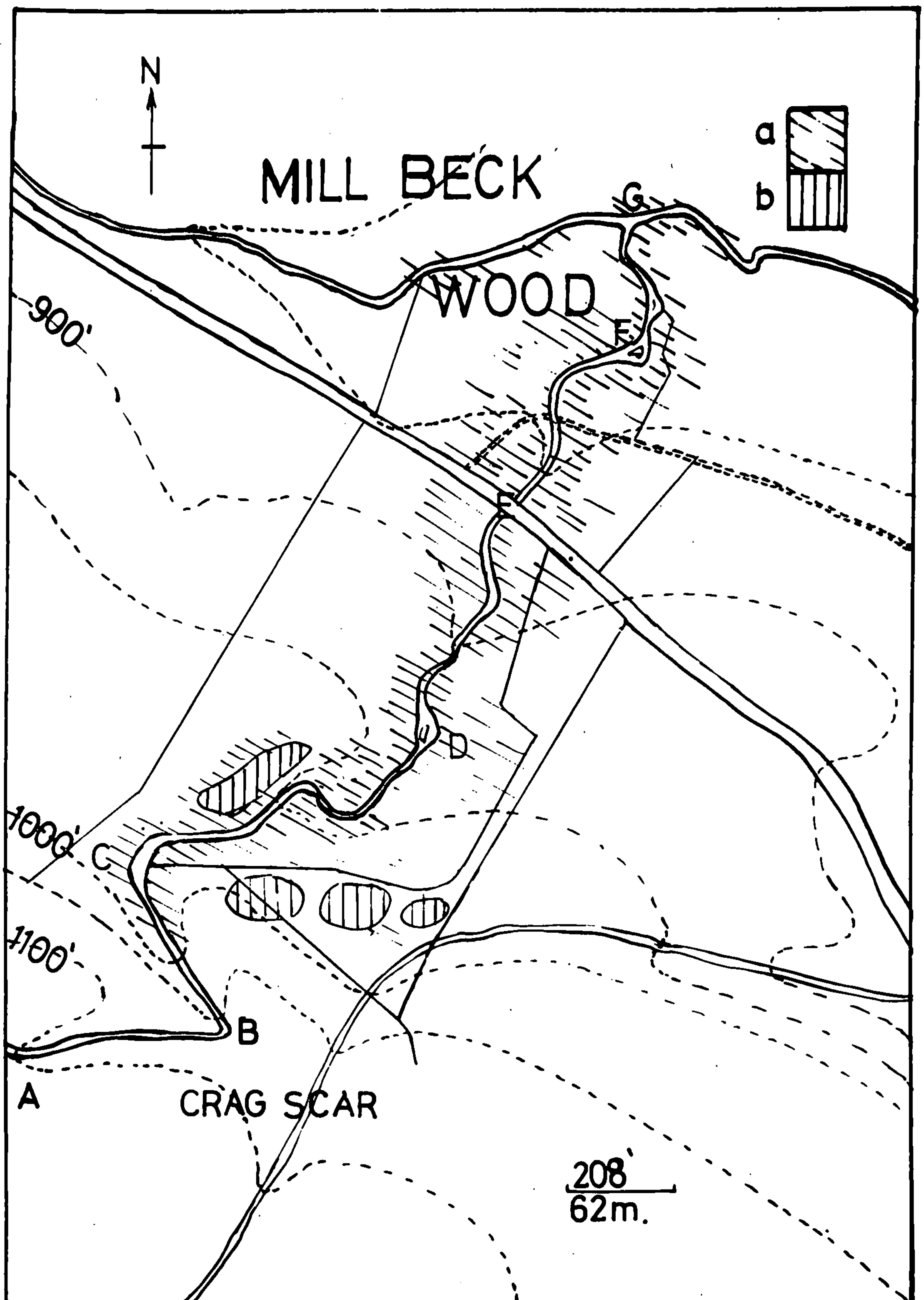

N
MILL BECK
WOOD
a
b
G
F
E
D
C
B
A
900'
1000'
1100'
CRAG SCAR
208'
62m.

TABLE II/1

GENERAL FLORISTICS

TERRICOLOUS SPECIES

Woodland symbol	B	P	J	M
Total aufnahmen studied	48	48	69	61
	Total aufnahmen in which species appeared			
Flowering plants and ferns				
Acer pseudoplatanus	2	2	-	3
Achillea millefolium	4	2	-	6
A. ptarmica	-	5	1	4
Aesculus hippocastanum	-	-	(+)	-
Agrostis canina ssp. montana	25	16	52	5
A. stolonifera	9	26	7	30
A. tenuis	37	39	60	39
Aira praecox	-	-	1	-
Ajuga reptans	-	(+)	(+)	13
Alchemilla glabra	7	4	(+)	10
A. xanthochlora	-	-	-	9
Allium ursinum	-	-	-	14
Alnus glutinosa	-	11	-	7
Anemone nemorosa	-	6	2	15
Angelica sylvestris	3	-	-	5
Anthoxanthum odoratum	29	30	45	34
Anthriscus sylvestris	1	-	-	2
Arrhenatherum elatius	-	9	1	25
Athyrium filix-femina	18	12	3	28
Bellis perennis	2	(+)	(+)	2
Betonica officinalis	-	7	(+)	3
Betula pubescens	32	25	-	20
Blechnum spicant	17	-	24	2
Brachypodium sylvaticum	-	(+)	-	22
Briza media	5	-	-	-
Callitriche stagnalis s.s.	-	(+)	-	-
Calluna vulgaris	13	-	63	(+)
Caltha palustris	-	7	-	7
Campanula latifolia	-	-	-	2
C. rotundifolia	10	12	21	11
Cardamine amara	-	1	-	-
C. flexuosa	2	2	6	11
C. pratensis	1	2	(+)	8
Carex binervis	-	-	20	-
C. demissa	2	(+)	2	-
C. echinata	-	1	6	-
C. flacca	3	(+)	1	-
C. nigra	-	1	-	5
C. otrubae	-	-	-	1
C. ovalis	-	(+)	-	-
C. pallescens	-	3	1	5
C. panicea	-	1	4	-
C. pilulifera	-	-	17	-
C. pulicaris	-	-	1	2
C. remota	-	1	-	-
C. sylvatica	-	-	-	7
Centaurea nigra	5	9	-	8

Cerastium fontanum	6	5	13	10
Chrysosplenium oppositifolium	-	1	-	3
Circaea lutetiana	-	-	-	5
Cirsium heterophyllum	-	(+)	(+)	16
C. palustre	9	5	1	11
Crepis capillaris	-	-	-	1
C. paludosa	-	7	-	19
Conopodium majus	29	9	2	42
Corylus avellana	14	20	-	42
Crataegus monogyna	-	7	2	17
Cruciata laevipes	-	4	-	11
Cryptogramma crispa	-	-	-	1
Cynosurus cristatus	1	2	-	4
Cystopteris fragilis	1	-	-	-
Dactylis glomerata	4	18	-	37
Dactylorhiza fuchsii	-	7	-	(+)
D. maculata ssp. ericetorum	-	2	-	-
D. purpurella	-	2	-	-
Deschampsia cespitosa	8	-	4	19
D. flexuosa	39	26	46	14
Digitalis purpurea	-	10	-	16
Drosera rotundifolia	-	-	1	-
Dryopteris dilatata	21	13	21	7
D. filix-mas	6	12	-	16
D. pseudomas	21	5	(+)	7
D. ? pseudomas x filix-mas	8	-	-	3
Empetrum nigrum	1	-	16	-
Endymion nonscriptus	1	27	-	33
Epilobium angustifolium	3	-	1	2
E. montanum	-	4	2	16
E. nerterioides	1	-	-	-
E. palustre	-	6	-	5
Equisetum arvense	1	(+)	-	-
E. sylvaticum	-	2	-	-
Erica tetralix	-	-	15	-
Eriophorum angustifolium	-	(+)	1	-
Euphrasia nemoralis	-	1	-	-
E. montana	-	2	-	-
Fagus sylvatica	-	-	1	-
Festuca arundinacea	-	-	-	1
F. ovina ssp. ovina	7	-	62	1
F. ovina ssp. tenuifolia	17	2	40	8
F. pratensis	-	(+)	-	(+)
F. rubra	13	4	34	27
F. vivipara	2	-	2	1
Filipendula ulmaria	1	7	-	27
Fragaria vesca	1	4	-	9
Fraxinus excelsior	-	3	-	16
Galium aparine	2	1	-	3
G. odoratum	-	6	-	12
G. palustre ssp. palustre	-	(+)	-	-
G. saxatile	-	13	67	14
G. uliginosum	-	5	-	5
G. verum	1	1	-	-
Geranium sylvaticum	-	13	-	26
G. robertianum	2	5	-	12
Geum rivale	8	3	-	1
G. urbanum	-	3	-	31

Glechoma hederacea	-	(+)	-	-
Glyceria declinata	-	(+)	-	-
G. fluitans	-	8	-	4
Gymnadenia conopsea	-	1	-	-
Gymnocarpium dryopteris	9	4	10	-
Hedera helix	-	(+)	-	-
Helictotrichon pratense	4	-	-	1
H. pubescens	-	-	-	1
Heracleum sphondylium	1	1	-	3
Hieracium perpropinquum	-	7	-	7
H. ? vulgatum agg.	1	-	-	3
Holcus lanatus	14	35	6	31
H. mollis	15	33	17	37
Huperzia selago	-	-	1	-
Hypericum pulchrum	2	3	-	5
H. tetrapterum	-	(+)	-	-
Hypochoeris radicata	-	3	(+)	1
Isolepis setaceus	-	(+)	-	-
Juncus articulatus	2	6	-	8
J. acutiflorus	-	5	5	4
J. effusus	1	5	(+)	10
J. kochii	-	4	1	-
J. squarrosus	-	-	7	-
J. subuliflorus	-	4	3	-
Juniperus communis	16	-	34	-
Lapsana communis	-	1	-	1
Lathraea squamaria	-	-	-	-
Lathyrus montanus	-	7	-	2
L. pratensis	-	-	-	3
Leontodon autumnalis	-	-	(+)	1
L. hispidus	5	1	(+)	1
Listera cordata	-	-	5	-
Lolium perenne ssp. perenne	-	(+)	-	1
Lonicera periclymenum	-	6	-	-
Lotus corniculatus	3	1	-	1
Luzula campestris	-	-	6	-
L. multiflora	2	2	39	-
L. pilosa	27	5	45	2
L. sylvatica	6	2	-	-
Lychnis flos-cuculi	-	2	-	5
Lysimachia nemorum	1	5	(+)	12
Malus domestica	-	(+)	-	-
Melica uniflora	-	-	-	13
Melampyrum pratense	-	8	1	-
Mentha aquatica	-	3	-	2
M. x verticillata	-	1	-	-
Menyanthes trifoliata	-	(+)	-	-
Mercurialis perennis	2	4	-	23
Mimulus ? luteus	1	-	-	-
Molinia caerulea	-	1	22	-
Montia fontana ssp. amporitana	-	(+)	-	-
Myosotis discolor	-	2	-	-
M. caespitosa	-	4	-	5
M. scorpioides	-	2	-	-
Nardus stricta	-	-	17	-
Narthecium ossifragum	-	1	3	-
Odontites verna	-	(+)	-	-
Oxalis acetosella	36	36	39	48

Parnassia palustris	4	-	-	-
Pedicularis palustris	-	2	-	-
Petasites hybridus	-	-	-	3
Plantago lanceolata	7	-	-	6
P. major	-	(+)	-	1
P. maritima	1	-	-	-
Poa annua	-	1	-	1
P. pratensis ssp. pratensis	-	-	1	2
P. pratensis ssp. irrigata	-	-	-	1
P. trivialis	1	8	(+)	15
Polygala serpyllifolia	-	-	15	1
Polypodium vulgare ssp. vulgare	1	2	-	3
P. vulgare ssp. prionodes	-	1	-	-
Potamogeton polygonifolius	-	(+)	(+)	-
Potentilla erecta	17	21	61	18
P. sterilis	1	6	-	26
P. fruticosa	2	-	(+)	-
Primula vulgaris	1	2	-	16
Prunella vulgaris	8	11	1	30
Prunus spinosa	-	2	-	5
P. padus	(+)	2	(+)	-
Pteridium aquilinum	20	30	64	14
Ranunculus acris	4	2	-	11
R. bulbosus	-	(+)	-	-
R. ficaria	-	12	-	17
R. flammula	-	8	(+)	5
R. hederaceus				
R. repens	13	13	2	39
Rosa afzeliana agg.	-	2	(+)	8
R. canina agg.	1	-	-	-
R. coriifolia agg.	-	-	-	3
R. dumetorum agg.	-	4	-	-
R. sherardii agg.	2	2	-	6
R. villosa agg.	-	-	-	1
Rubus caesius	-	3	-	-
R. chamaemorus	-	-	(+)	-
R. idaeus	2	12	-	17
R. saxatilis	-	2	-	3
Rumex acetosa	1	13	6	21
R. acetosella agg.	-	-	1	-
Sagina apetala ssp. erecta	-	(+)	-	-
Salix aurita	1	(+)	-	(+)
S. pentandra	-	-	-	4
Sanguisorba officinalis	-	3	-	11
Sanicula europaea	-	-	-	9
Scrophularia nodosa	-	-	-	2
Selaginella selaginoides	2	-	(+)	-
Senecio aquaticus	-	3	-	-
S. x ostenfeldii	-	1	-	-
Senecio jacobaea	6	5	1	30
Sieglingia decumbens	-	-	2	2
Solidago virgaurea	1	1	-	1
Sorbus aucuparia	2	25	1	39
Stachys sylvatica	-	2	-	21
Stellaria alsine	2	-	3	-
S. graminea	-	3	5	4
S. holostea	1	14	-	16
S. media	-	(+)	-	1
S. neglecta	-	3	-	1

Succisa pratensis	9	28	1	18
Taraxacum officinale agg.	5	2	3	9
Teucrium scorodonia	-	11	-	8
Taxus baccata	1	-	(+)	-
Thelypteris limbosperma	12	-	7	-
T. phegopteris	5	3	7	-
Thymus drucei	1	-	2	-
Trichophorum cespitosum	-	-	4	-
Trifolium medium	-	-	-	4
T. pratense	4	-	-	5
T. repens	-	3	-	5
Triglochin palustris	-	(+)	-	-
Trollius europaeus	-	1	-	-
Trisetum flavescens	-	-	-	1
Tussilago farfara	5	-	1	7
Ulmus glabra	-	1	-	12
Urtica dioica	2	4	1	5
Vaccinium myrtillus	20	3	50	1
V. vitis-idaea	-	-	1	-
Valeriana officinalis	-	2	-	2
Veronica beccabunga	-	-	-	3
Veronica chamaedrys	3	11	1	23
V. officinalis	2	2	8	8
V. serpyllifolia	-	1	-	-
V. scutellata	-	(+)	-	-
Vicia cracca	-	-	-	1
V. sepium	-	1	-	14
Viola lutea	(+)	-	(+)	(+)
V. riviniana	24	20	23	49
V. palustris	-	-	9	-
Zerna ramosa	-	1	-	5

<u>Bryophytes (mosses)</u>

Acrocladium cordifolium	-	(+)	-	-
A. cuspidatum	6	4	-	14
A. sarmentosum	-	-	1	-
Amphidium mougeotii	2	-	-	-
Atrichum undulatum	6	10	1	38
Aulacomnium palustre	-	1	3	-
Bartramia pomiformis	5	2	-	-
Brachythecium albicans	-	-	1	-
B. rivulare	-	-	-	3
Breutelia chrysocoma	2	-	-	-
Bryum capillare	-	-	4	-
B. pseudotriquetrum	2	-	-	1
Campylopus flexuosus	-	-	6	1
Cirriphyllum piliferum	8	10	1	25
Climacium dendroides	2	-	-	2
Cratoneuron commutatum	2	-	-	-
Ctenidium molluscum	1	(+)	-	-
Dicranella heteromalla	6	3	5	6
D. palustris	-	(+)	-	1
Dicranum majus	14	9	16	5
D. bonjeanii	-	1	-	1
D. scoparium	13	10	24	10

Dichodontium pellucidum	3	-	-	-
Distichium capillaceum	1	-	-	-
Ditrichum heteromallum	3	-	-	-
Drepanocladus fluitans	1	-	-	-
D. revolvens	-	-	1	-
D. uncinatus	3	-	-	2
Eurhynchium praelongum	11	25	3	39
E. striatum	1	4	-	16
Fissidens adianthoides	2	-	-	1
F. bryoides	1	-	-	14
F. taxifolius	2	-	-	4
Fontinalis antipyretica	1	-	-	-
Grimmia apocarpa	-	-	1r	-
Heterocladium heteropterum	-	1	-	-
Hookeria lucens	-	-	1	-
Hylocomium splendens	17	6	28	9
Hypnum cupressiforme	18	9	63	27
Isopterygium depressum	-	1	-	-
I. elegans	2	1	2	-
Isothecium myosuroides	1	8	3r	2
I. myurum	-	-	-	3
Leucobryum glaucum	1	1	5	-
Mnium hornum	28	24	29	38
M. longirostrum	5	16	5	13
M. punctatum	13	3	1	12
M. stellare	-	-	1	-
M. undulatum	7	18	-	29
Plagiothecium curvifolium	-	2	3	-
P. denticulatum s.s.	14	12	22	22
P. succulentum	7	5	-	6
Pleurozium schreberi	18	9	51	11
Pseudoscleropodium purum	19	12	48	17
Pohlia nutans	4	1	4	1
P. cruda	1	-	-	-
Polytrichum aloides	5	-	-	5
P. commune	5	2	20	6
P. formosum	19	8	24	6
P. juniperinum	-	1	2	-
P. piliferum	-	-	1	-
P. urnigerum	2	-	-	-
Rhacomitrium aciculare	2	-	-	-
R. canescens	1	-	-	-
R. fasciculare	1r	-	2r	-
R. heterostichum	1r	-	1r	-
Rhodobryum roseum	1	1	-	-
Rhytidiadelphus loreus	13	14	26	14
R. squarrosus	26	28	60	31
R. triquetrus	2	7	-	17
Sphagnum fuscum	-	-	1	-
S. girgensohnii	2	-	1	-
S. palustre	-	5	9	-
S. papillosum	-	-	5	-
S. plumulosum	-	-	6	-
S. quinquefarium	2	-	1	-
S. recurvum	-	-	4	-
S. rubellum	-	-	1	-
S. squarrosum	-	1	-	-
S. subsecundum	-	1	4	-

Tetraphis pellucida	1	1	2	5
Thamnium alopecurum	-	1	-	-
Thuidium tamariscinum	14	21	27	30

Bryophytes (liverworts)

Barbilophozia attenuata	2	-	6	2
B. barbata	-	1	2	2
B. floerkeana	7	2	14	1
Calypogeia fissa	5	4	13	9
Cephalozia bicuspidata	2	4	12	-
Cephaloziella sp.	-	-	4	-
Conocephallum conicum	1	-	-	3
Diplophyllum albicans	20	4	16	13
Leiocolea ? muelleri	1	-	-	-
Lejeunea cavifolia	-	-	-	4
Lepidozia reptans	1	-	2	-
Lophocolea bidentata	37	29	50	54
L. cuspidata	2	6	5	3
Lophozia ventricosa	6	4	17	-
L. obtusa	4	-	-	-
Marsupella emarginata	-	1	2	-
Metzgeria furcata	le	-	-	-
Nardia scalaris	7	-	1	1
Pellia epiphylla	5	12	1	16
P. neesiana	-	-	-	5
Plagiochila asplenioides	23	21	10	37
Preissia quadrata	3	-	-	-
Ptilidium ciliare	-	-	3	-
Riccardia pinguis	-	-	1	-
R. multifida	-	1	-	-
Scapania gracilis	4	1	6	1
S. irrigua	-	1	-	-
S. nemorea	-	1	-	-
S. undulata	5	-	-	-
Solenostoma triste	1	-	-	-
S. cordifolium	1	-	-	-
Tritomaria quinquedentata	-	1	1	-

Lichens

Baeomyces rufus	3	1	1	(+)
Cladonia chlorophaea	2	2	3	(+)
C. coccifera	-	-	2	2
C. coniocraea	2	1	-	-
C. furcata	-	-	1	-
Cladonia impexa	1	1	2	-
C. macilenta	4	2	2	(+)
C. ochrochlora	-	1	2	-
C. pyxidata	1	1	2	(+)
C. squamosa	3	1	-	-
Lepraria incana	6	-	(+)	-
Peltigera canina	1	-	-	-
P. polydactyla	1	2	-	-
P. praetextata	-	(+)	-	-

PART III

METHODOLOGY

Chapter 13

The Zürich-Montpellier system.

The methods of collecting, arranging and analysing data employed in this thesis follow in the main those of the Z.-M. school. Some of the modifications suggested by Poore (1955a) have been used.

Field technique has been fully discussed by Poore and the scene has been further illuminated by Shimwell (1968) who reviewed the British scene as it then stood. Barkman (1958) gives an exhaustive summary of phytosociological problems, both practical and theoretical, as they apply to epiphytic and epilithic vegetation, and Coker (1967) has enlarged upon this. No attempt is made therefore in this paper to present any further evaluation although in the discussion (Part VI) certain aspects of the controversy are touched upon if it is thought that the present work justifies or invalidates the methods used.

Chapter 14

Phanerogam dominated communities.

The Z.-M. system is applied in two stages:

A. The collection of field data, called by some authors "vegetation analysis".

B. Analysis of the collected data, synthesis of the vegetation tables and comparison with similar tables (if available) from other regions. This is called by the same authors "vegetation synthesis".

A. Collection of field data (Vegetation Analysis)

(i) A preliminary inspection of the woodlands in question was made before plots were chosen for analysis. These 'plots' were selected within "stands"* of reasonably homogeneous vegetation, an attempt being made to cover the total range of vegetation within each wood. Uniformity was assessed visually.

Tests for "minimum area"+ were carried out in each wood among differing stands of vegetation by the method advocated by Poore (1955a).

This minimum area was found to vary between 4 and 16 square metres. Plots were laid down accordingly. Normally a square plot was used but occasionally the sampling was better carried out within a rectangular area. In the Juniper Wood permanent standard plots of 4 sq. m. had already been laid down for the Nature Conservancy by the then warden, Mr. J. Peters, and by kind permission I was allowed to make use of these plots with the addition of a few more of my own

---

* Stand:- "the concrete unit of vegetation which is described in the field."

\+ Minimum area:- that area which contains "the normal characteristic species combination of a community" (von Glahn & Tüxen 1963), or "that area which contains 80% of the total number of species of the community" (Poore 1955).

choosing. In the other three woodlands there were a few larger units of very homogeneous vegetation, notably the fern communities on block scree, where a 10 m. square plot was found to be the most valuable unit.

(ii) Every sample area was given a plot number and the following field notes were taken for each plot. Precise location, altitude, aspect, slope and dimensions (see Appendix for symbols used in tables). A short description was made of the salient features of each stand particularly the type of drainage and the depth of the soil layer. A sample record sheet is shown in Fig. III/1.

(iii) A complete species list was then drawn up for each sample area and the cover and abundance of the individual species in each estimated by eye on the ten-point Domin scale.

10	cover about	100%
9	" more than	75%
8	"	50 - 75%
7	"	33 - 50%
6	"	25 - 33%
5	abundant, cover about	20%
4	" cover about	5%
3	scattered, cover small	
2	sparsely distributed, cover small	
1	one or two individuals	

a further value of (+) was used for isolated species belonging to the stand but situated just outside the sample plot area.

Cover was taken as the projection on the soil of all living parts of the plants.

Next the species were grouped according to layers. Height and cover values were estimated for each of the separate layers, tree, shrub, herb, bryophyte.

B. Analysis of the Collected data (Vegetation Synthesis)

(i) Tables were constructed showing the whole of the vegetation data for each woodland. Then by horizontal and vertical comparison and "a process of progressive approximation" (Poore 1955a) the tables were sorted and analysed. Diagnostic species were sought, groups were formed, and the four sets of data were compared to see if there were any noda in common.

(ii) Finally search was made in the relevant literature so that a comparison might be made between the tables thus produced and the continental vegetation already analysed.

Fig. III/1 EXAMPLE OF VEGETATION RECORD SHEET

Field No. 7

Grid. 35/883284 Loc. Juniper Scrub.

Aufnahme No. J 47

Solid and Drift Geology

Dolerite

General description of stand

V. sheltered. Just below a rocky slope. Rocks covered with a thin layer of detritus and good covering of bryophytes. Many branches close to ground and buried under it giving dense patches of shade.

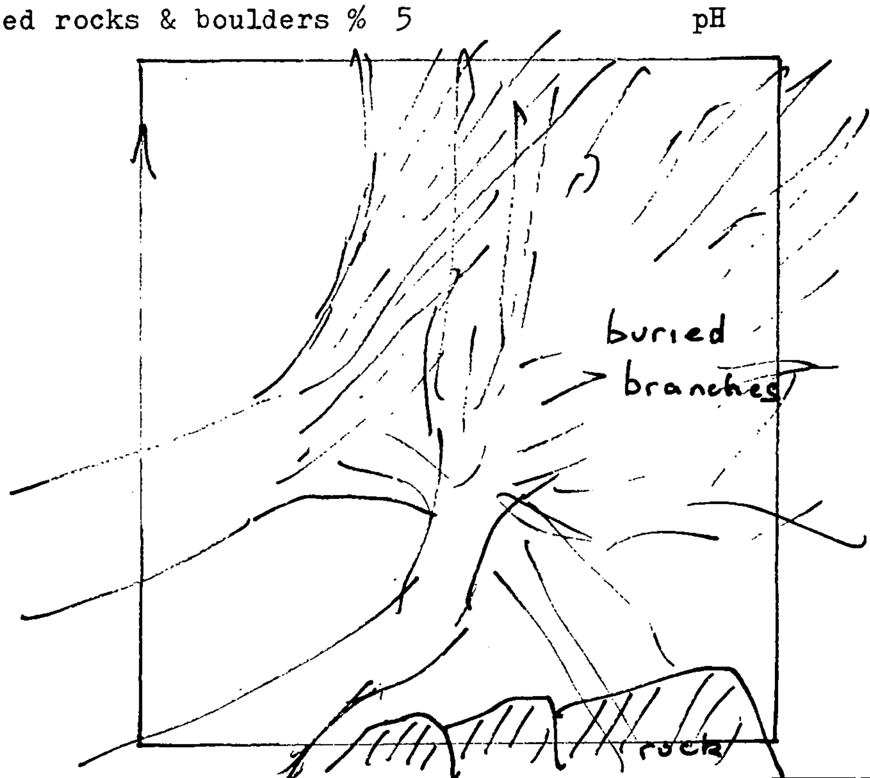
Altitude 1070'

Aspect NNE

Slope 20°

Area (m²) 2

Cover (Domin)		Height (dm.)	-
Tree layer	-	Tree	-
Shrub "	9	Shrub	24
Herb "	9	Herb	9
Moss "	9	Moss	0.8
Lichen "	-	Soil	
Bare earth and litter %	10	Depth (dm.)	1.4
Logs or branches %	5	Drainage	f. good
Exposed rocks & boulders %	5	pH	4.1



Chapter 15

Epiphytic communities.

The methods used in analysing and synthesising the data from epiphytic communities are in principle the same as those used for the ground flora in any area. However, owing to the different physiognomy of both vegetation and habitat, slight modifications were needed in practice.

A. Vegetation Analysis

(i) Choice of plot

In each vegetation stand studied a sample plot was chosen. Usually the plots chosen were rectangular but bark irregularities and fissures sometimes made this impossible. Homogeneous plots, in the main, were sampled though, with a restricted area to work, it was possible to attempt a complete coverage of all the epiphytic communities present, partial or otherwise. This resulted in a number of fragmentary though recognisable associations and some mixed combinations which were omitted from the final tables.

Some trees showed more than one vegetation type and where possible these were sampled separately.

With trees on the steep slopes encountered in the survey it was often possible to sample higher up the trunk than is normally the case, and of course in both the Juniper and Corylus scrub it was possible to examine bushes to the summit and branches to the extremity.

Coker (1967) notes the paucity of epiphytic bryophytes at higher tree levels, listing Ulota, Orthotrichum and Frullania species in fragmentary associations. In the present study Bryophytes were found to be very sparse indeed on higher branches owing to the nature of the woodlands studied. Indeed the four lichens, Lecanora conizaeoides, Parmelia saxatilis, Parmelia physodes and Cetraria glauca were by far the most common epiphytes on all the smaller branches.

(ii) Size of plot

The minimum area for a plot was found by Hilitzer (1925), fide Barkman, to be 4 sq. dm., though he used plots of 25 sq. dm. Barkman (1958) used plots of varying sizes and gives a table of minimum areas for various communities which he calculated during the course of his massive epiphytic studies.

Among others he lists:-

Pleurococcetum vulgaris	0.01	sq.dm.
Caloplacetum phloginae	0.25	" "
Physcietum elaeinae	5-10	" "
Parmelietum caperatae	20-40	" "
Ulotetum bruchii	1-2	" "
Tetraphido-Aulacomnion	4-8	" "
Cryphaeetum arboreae	50-100	" "
Anomodonteto-Isothecietum	100-400	" "

Coker (1968) in his work on bryophyte phytosociology calculates a minimal area of normally less than 2 x 2 dms. Like Barkman he too concludes that for some communities (he lists the maritime Cryphaeetum arboreae Barkm. as an example) the minimal area includes more than one tree. Lippman (1935b) also claims that the minimum area of Association Anomodonteto-Isothecietum is 3-5 trunks in Estonia. This is evident if one has a minimal area of more than 30 sq. dm. and host tree such as a Betula pubescens or a Corylus sp. In the present work the problem was most apparent when sampling the smaller branches of any species or its basal system of bosses and larger roots. In such instances records from the requisite number of branches or roots sufficient to form a minimal area were combined and recorded as one Aufnahme. Barkman's work shows that, provided the plots exceed the minimal area of the vegetation unit in question, they can be united in one table despite variation in size. In other instances in the present survey a plot of minimal area or slightly larger was chosen.

(iii) Zonation of the Phorophyte

Various methods have been used for recording epiphytic vegetation. Doignon (1954) used the whole tree as a sample plot, producing extremely heterogeneous lists. Others have standardised their sampling by taking records at fixed intervals over the tree surface or examining the whole circumference of the trunk in a kind of collar succession. Again, records have been taken from various trees at a fixed (say 1.5 m.) height.

Barkman concludes, rightly I feel, that, "for the delineation of vegetation types sample plots including all sides of the trunk are of necessity heterogeneous".

Ochsner (1928), who termed the host plant (usually a tree or a shrub) the Phorophyte, was aware of the problem of sampling, but Van Oye (1924) had already shown that a tree (phorophyte) could be divided into five zones each with typical epiphytic associations.

So quoting Barkman again - "owing to the differentiation of microhabits various vegetation types are often present on a single tree. ... Different heights, levels, and exposures, and such peculiar sites as upper and lower side of branches, branch axils, rain tracks, bark wounds and fissures often had to be recorded separately."

In this study many, though not all, of the phorophyte habitats noted by Barkman were examined and vegetation records made from them. The accompanying diagram shows the five zones of host plant described by Van Oye. It can be correlated with, indeed it is a diagrammatic representation of, Barkman's "specialised habitats". (Fig. III/2).

FIGURE III/2 Division of the Phorophyte

Legend:

1 Lower bole & roots

2 (a,b) Middle bole

r Rain track

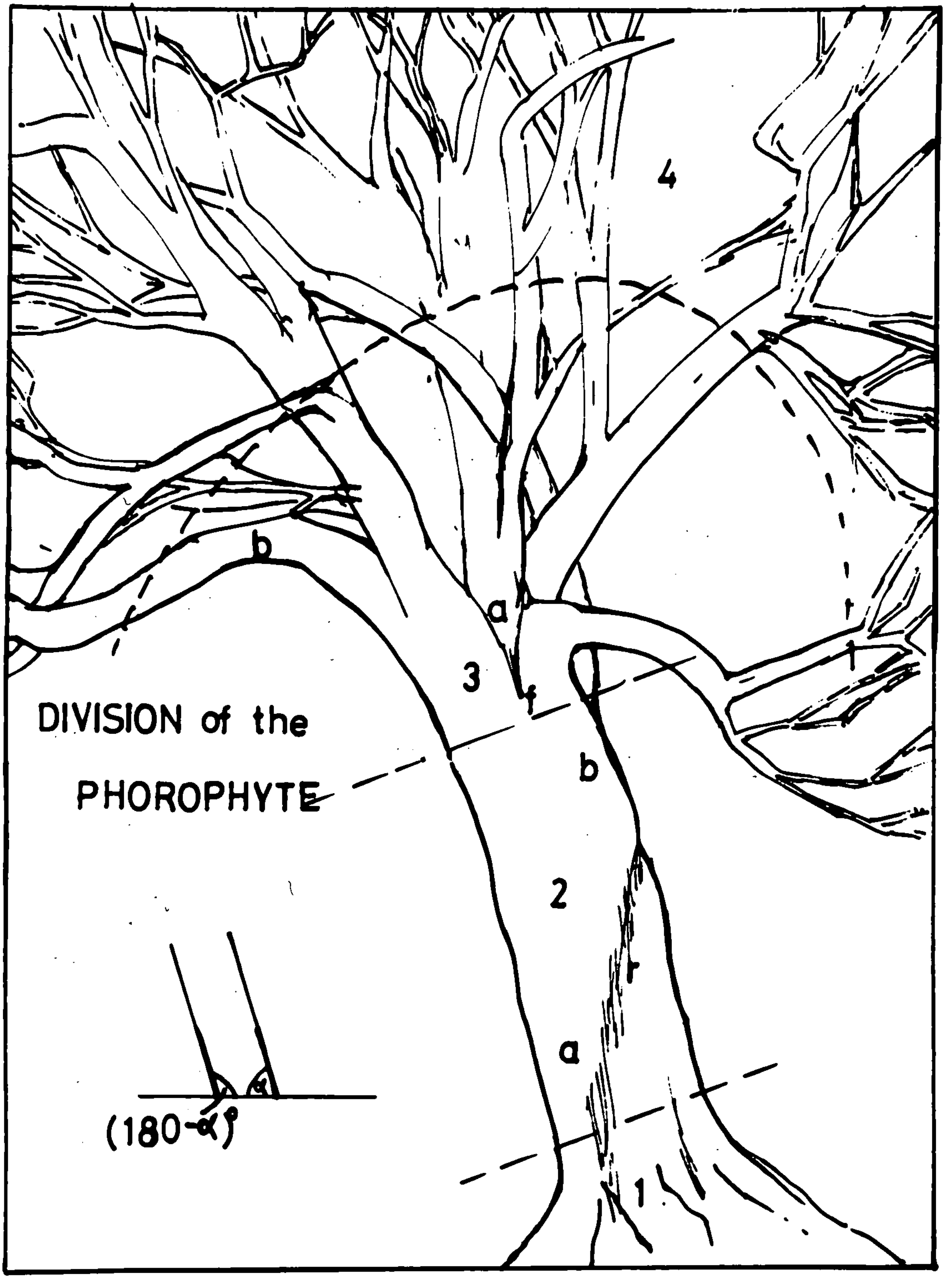
3 Crown base

(a) axils

(b) large branches

(f) fissures

4 Crown (upper branches)


DIVISION of the
PHOROPHYTE
4
a
3
f
b
b
2
a
1
(180-α)°
α

	Van Oye		Barkman
(a)	crown		upper and lower branches
(b)	crown base		branch axils
(c)	middle trunk	)	various heights and exposures,
		)	
(d)	below middle trunk	)	fissures, rain tracks
(e)	tree base		roots

(iv) Ecological field notes

These were made in accordance with the epiphytic vegetation sheet appended (Fig. III/3). A list of abbreviations used in the tables is given in the Appendix.

Measurements of the stand and tree girth were taken with a flexible metric steel tape. Height of tree and crown was estimated by eye in feet and converted to dm. on the reasonable approximation:- 1 ft. = 3 dm. Aspect and slope were read off directly in the field using (1) a prismatic compass, (2) a ball bearing clinometer. In the tables only 16 compass points were noted, i.e. at $22\frac{1}{2}^{\circ}$ intervals, and slopes were taken to the nearest 5 degrees.

Where a tree was leaning from the vertical, the angle between the tree and the horizontal (x°) was taken as the slope of the upper surface of the bole and the lower side of the bole was given the supplementary angle $(180-x)^{\circ}$.

Measurements such as illumination, degree of exposure, humidity, could only be subjectively estimated but with the same observer there should be some degree of correlation between the values for all the plots sampled. In the description of the stand, note was taken of any unusual features such as proximity of rivers, roads and farms, position of tree in wood, presence of tall herbs around the bole, and so on.

(v) Recording the vegetation cover

This was done on exactly the same principle and by the same scales as that used in recording the ground vegetation. Layering of the community was noted and cover values estimated for bryophyte, lichen and crustose lichen layers.

B. Vegetation Synthesis

Tables were constructed, sorted and compared in the manner previously described, para. 14B.

In compiling the associations the main works compared were Barkman's classic work (1958) and Coker's thesis (1967).

Fig. III/3 EXAMPLE OF SHEET USED IN RECORDING EPIPHYTIC VEGETATION

Field No. P81

Aufnahme No. P81

Altitude 850'

Aspect E

Slope 120°

Area (dm^2) 15

Height from ground 8-12 dm.

Illumination ms

Degree of exposure mp

Humidity d

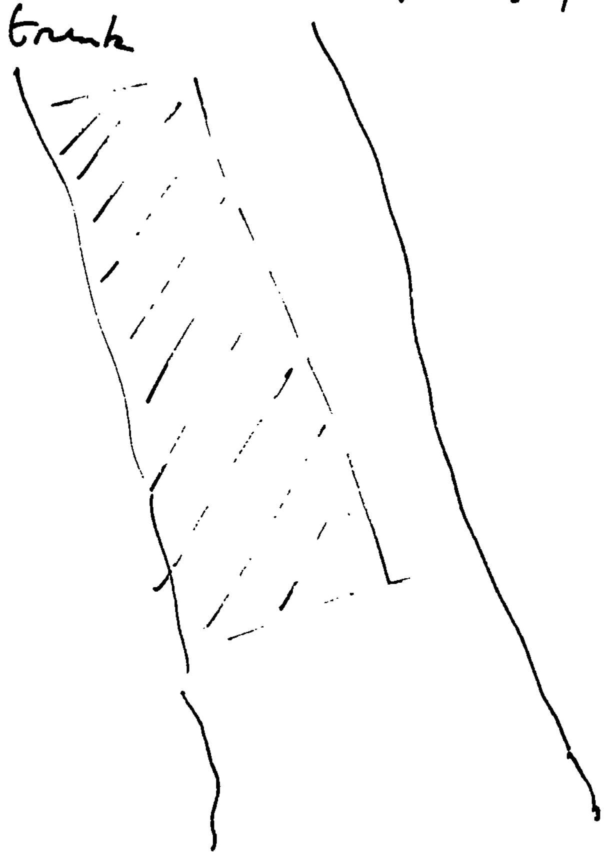
Nature of bark smooth but flaking badly

Environmental factors

on margin of wood

Description or rough sketch of stand

underside of trunk



Nat. Grid Ref. 35/923 260

Location Park End Wood

Cover % : total 80

bryophyte 5

lichen 75

crustose layer 75

Tree species Bet. pubescens

Height (dm.) 90

Height to crown -

Circumference (at height of 1m.) 32

Wood assn. and type

mainly Betula with Sorbus, Corylus & Alnus; fairly open canopy.

Chapter 16

Epilithic communities.

As far as is known epilithic communities have never been studied in Britain by the methods of the Z.-M. school sensu stricto. Indeed very few phytosociological studies of any kind have been made on rock communities in the British Isles. Laundon (1956), using Scandinavian nomenclature, mentions a few saxicolous federations occurring in Northamptonshire. In the Lichenologist (1967), as part of his lichen flora of London, he enumerates three rock federations of polluted areas in more detail. But again his approach is that of the Danish school of Almborn and Du Rietz.

Yarranton (1962) studied Bryophytic communities of Breidden Hill and in 1967 he made a quantitative study of the Bryophytic and Macrolichen vegetation of the Dartmoor Granite. However in neither of these studies did he view the communities from the phytosociological angle though his results can be correlated in some degree with continental work.

Perhaps the main reason why so little work has been attempted in epilithic communities is the difficulty and time consuming process of identifying the crustose genera of microlichens. Lichen studies in Britain were at a very low ebb during the first half of the 20th century. Leighton (1879) and Lorrain Smith (1911, 1918) produced their monographs largely as a result of intensive work in the latter half of the 19th century. Then for fifty years lichen studies were restricted in the British Isles to a few individuals, notably W. Watson. The formation of the British Lichen Society in February 1968 has done much to remedy the situation and already the macrolichens and epiphytic genera are becoming much better known so that phytosociological studies have begun on these communities.

The epilithic crustose lichens nevertheless still pose difficult problems that are absent from, or present only in a minor degree with the groups mentioned above.

(a) Pollution affects the majority of lichens but whereas macrolichens are still recognisable, microlichens are often damaged beyond recognition.

(b) Crustose lichens are often found sterile. In such instances much practice, and above all a sound knowledge of local lichens, is absolutely essential for a correct determination.

(c) The genus Lecidea and of course the Pyrenocarpous lichens are often impossible of determination in the field even when fruiting and must be checked microscopically or submitted to an expert for confirmation of identity.

With these warnings in mind it was felt that to tackle the problem of epilithic communities in any detail would be quite beyond the scope of this thesis. A further deterrent was provided by the title of this work:- "The phytosociology of woodlands ... ". The epilithic communities examined were for the most part unrelated to the woodlands because of the very nature of the four areas chosen. Here were no large rocks festooned with bryophytes and lichens such as have been described by Richards (1938) in the Killarney oakwoods or by Krusenstjerna (1965) on the boulders of Swedish woodlands. Rather were the communities on the woodland boulders and walls very similar to those in similar habitats on open moorland in the Teesdale area. Yarranton (1967) observes about the Dartmoor area:- "the main discontinuity in saxicolous bryophyte and lichen vegetation is brought about by deciduous woodland". The woodlands surveyed in this study had for the most part an open canopy and the microclimate was not suitable for either a rich epilithic or epiphytic vegetation. In other words there was no great discontinuity in saxicolous bryophyte and lichen communities! Where large block scree, both in Park End and in the Birch Wood, might have given rise to some interesting communities it was found that intense fern cover shaded out all but a very few species.

However some releves were taken in the hope that a pattern would emerge which could be compared with the available continental literature. The standard pattern of sampling was in the main the same as that used for epiphytic communities but owing to the varied morphology of the substratum there had to be some modifications.

A sample recording sheet is appended (Fig. III/4) which shows the various factors which were taken into consideration. The measurement of many of these variables posed problems and in the discussion (Part V) these problems will be assessed rather than those of pure synecology which has not been attempted.

Fig. III/4 EXAMPLE OF SHEET USED IN RECORDING EPILITHIC VEGETATION

Field No. Jo2

Aufnahme No. Jo2

Altitude 1,050

Aspect E.N.E.

Slope (average) 90°

Slopes (local) 85°–110°

Area (dm^2) 500

Height from ground 3-10 dm.

Illumination good

Degree of exposure e

Wetness d.

Depth of crevice soil 0.5
(if any) cm.

Biological influences —

Nat. Grid Ref. 35/888282

Location Juniper Scrub
Knedholm Scar

Cover % : total 100

bryophyte 3

lichen 90

crustose layer 90

tree -

shrub -

ground -

5-10% immature, indet.

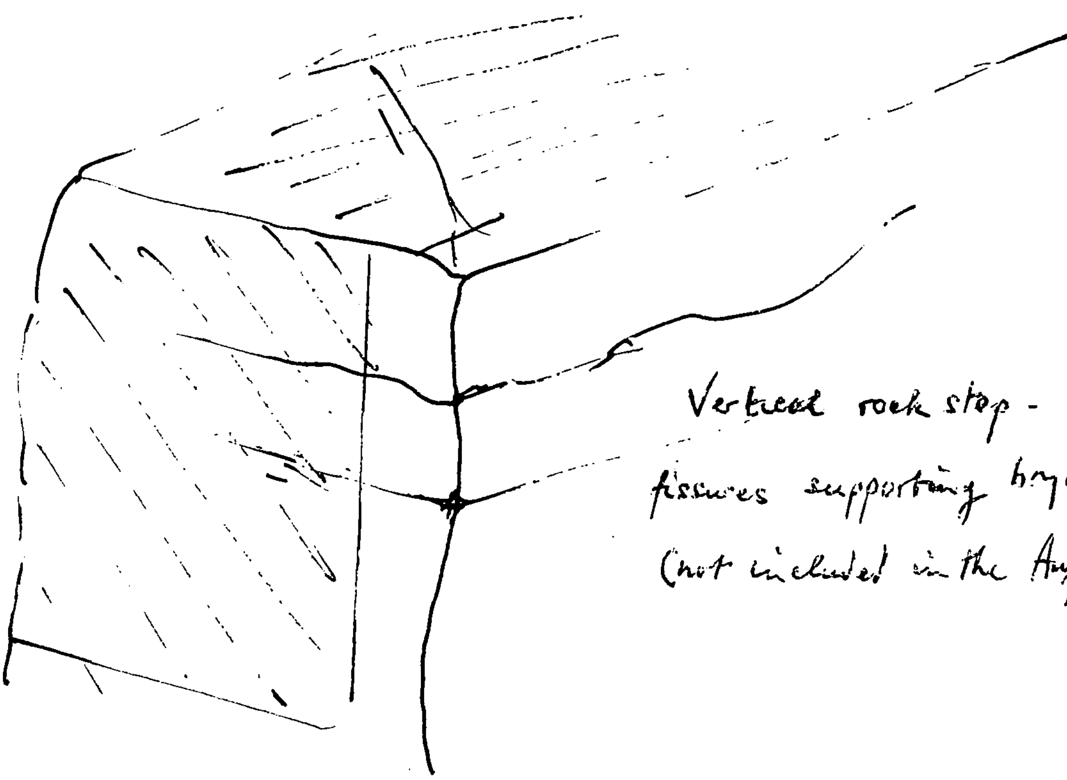
Nature of rock

type dolerite

size rock step 1 x 3 m

condition of surface f. smooth

Description and rough sketch of stand (note hardness and weathering of rock, influence of surrounding vegetation, etc.)



Vertical rock step - with two fissures supporting bryophytes (not included in the Aufnahme)

PART IV

SOCIOLOGY

Introduction

Using the methods described in the previous part of this work, the four woodlands were visited at different times of the year and 226 Aufnahmen made of the terrestrial vegetation.

At the same time epiphytic vegetation was studied and 257 Aufnahmen were made.

Epilithic communities were studied later and thirty to forty lists compiled. These proved to be too heterogeneous and further visits were made with a view to delimiting the communities more exactly. It was felt that a classification of the epilithic communities was beyond the scope of this thesis, nevertheless many fruitful avenues of discussion were opened up by this work.

The Associations recognised for the ground flora have, so far as is possible, been related to the system of vegetation classification for central and north west Europe advocated by Lohmeyer *et al*. (1962). Where this was not possible, tentative suggestions as to the place of the various noda in the European hierarchical system have been made.

For the delineation and description of epiphytic Associations Barkman's treatise (1958) was found to be an ideal guide. Most of the Associations, fragmentary or completed, fitted reasonably well into his scheme of hierarchical units.

For reference purposes, a brief synopsis of those Classes of terrestrial and epiphytic vegetation which appear likely to serve as a framework of discussion for the Associations and noda now considered, is appended to each of the following chapters.

Chapter 17

Terrestrial Communities.

The delimitation of the Association and the placing of it in a hierarchical system may have an effect on the system itself, since the formation of an artificial scheme and the recognition of its basic units are in themselves complementary operations. Within the well studied areas of Europe the higher units of vegetational classification are well worked out and for the most part valid. But in areas where phytosociological studies are in the early stages every nodum recognised is a challenge to the system itself and it says much for the existing framework that a great many British vegetation types can be fitted into it.

However, if the Z.-M. system is to be comprehensive, as its authors intended, and as its exponents still intend, certain revisions must be made from time to time. Shimwell (1968) has recently shown, for example, that after studying the calcareous grasslands of the British Isles, some revision can be made of the Syntaxonomy within the Class *Elyno-Seslerietea*.

A similar problem is to be found in the *Quercetea robori-petraeae* and although the present work is not of sufficiently large scope to resolve any such problems it is felt that some evidence is gained towards a solution. Hence the Class *Quercetea* is discussed more fully than other parts of the system, which act only as it were a backcloth against which the findings of this thesis are displayed.

CLASS **QUERCETEA ROBORI-PETRAEAE** Br.-Bl. & R.Tx. 1943

Synonymy: *Betuleto-Pinetea* Knapp 1942 p.p.

Querceto-Ulicetea Br.-Bl. 1947 p.p.

Querceto-Piceetea Doing, Kraft et Westhoff 1959 p.p.

(For the evaluation of this Class I am greatly indebted to Dr. D.W. Shimwell - discussion and personal comm.)

This Class is comprised of species-poor, poorly stratified deciduous oak-birch woodlands of the sub-atlantic and atlantic region of western Europe from southern Norway, north west Germany and Scotland to north west Spain. The woodlands are dominated by species of Quercus, Betula pubescens Ehrh., and B. pendula Roth. Although Tansley (1939) makes much of the differences between Pedunculate Oakwood (Quercetum roboris) and Quercetum petraeae he recognised the existence of hybrids and recently workers including Couzens (1965) have contended that there has been such extensive hybridisation and introgression between these two species that separation into two clear cut taxa is now virtually impossible in most parts of Britain, especially in the north. Soil types for this class of woodlands mentioned by various authors vary from acidic podsolised, humus rich brown forest soils to rocky siliceous mull rankers.

In central Europe the geographical floristic and ecological distinctions between Quercetea and Vaccinio-Piceetea Br.-Bl.1939 are quite distinct, but in north west Europe there is a line of continuous variation between the two Classes. This has been recognised by Doing and Westhoff (1959) who place the two classes into a single unit, the Querco-Piceetea. More extensive data from related communities in western Europe and especially in the British Isles is needed to test the validity of this suggestion of Doing and Westhoff and it is a contention of this thesis that the communities studied here do throw some light on the matter.

One Order and one Alliance are usually recognised in the Quercetea (although fresh work may lead to suggestions for a revision of this opinion).

O. QUERCETALIA ROBORI-PETRAEAE R.Tx. (1931) 1937 em. 1955

Synonymy: Pteridio-Quercetalia Scamoni et Passarge 1959

All. Quercion robori-petraeae (Malcuit 1929) Br.-Bl. 1932

Synonymy: Agrostido-Quercion + Molinio Quercion Scamoni et Passarge 1959

Character species of the Order and Alliance:

Quercus spp. Betula spp. Populus tremula, Melampyrum pratense, Lonicera periclymenum,

and a group of species, which, because of widespread woodland destruction are quite widespread in heaths and upland grasslands. This group nevertheless still characterise and differentiate Quercion woodlands from other woodland types:-

Holcus mollis	Carex pilulifera
Hypericum pulchrum	Deschampsia flexuosa
Blechnum spicant	Trientalis europaea
Vaccinium myrtillus	Luzula sylvatica
V. vitis-idaea	L. pilosa
Oxalis acetosella	Leucobryum glaucum
Thelypteris limbosperma	Pleurozium schreberi
T. phegopteris	Dicranum majus
Gymnocarpium dryopteris	Polytrichum formosum
Lathyrus montanus	Plagiothecium undulatum
Hieracium (Sect. Umbellata)	P. denticulatum
Hieracium (Sect. Sabauda) (most frequently H. umbellatum and H. perpropinquum.)	P. succulentum
	Sphagnum fimbriatum
Veronica officinalis	S. girgensohnii

In Britain, Associations of the Quercion fall into four broad series: (a) The continental Querco-Betuletum type of the sandy or humus-rich brown earths of the southern and eastern British lowlands.

(b) A western Quercus petraea - Q. robur woodland type on the siliceous soils and rocks of south west England, Wales, the Lake District and southern Ireland. Tansley (1949) divides the oak woodlands according to the species of Quercus which dominates the woodland, but as his summary (1949, p. 273) shows, both species can occupy similar situations and the types of ground flora societies can occur under both types of species canopy. This can be seen by comparing the ground flora of two woods cited - Devil's Bridge, Cardiganshire, and Wistman's Wood, Devon. Although dominated by different Quercus species the remaining plant species do not differ greatly. As far as can be ascertained, these types of western woodland on shallow, well-drained siliceous soils or damp shale soils fall within a series of Associations or vicariants which come under the general title of Vaccinio-Quercetum, named for the abundance of Vaccinium myrtillus in the field layer.

(c) Upland Betula woodland on siliceous soils in the north west of England and in Scotland, possesses much the same character species in the field and moss layers as does the Vaccinio-Quercetum type, and probably represents a regional zonal form of the latter. This has been described from numerous parts of the Scottish Highlands by McVean and Ratcliffe and occurs in other parts of Scotland, Northern England and the Peak District. The woods are often rich in ferns, particularly Dryopteris and Thelypteris species. The Teesdale counterpart will be described at length.

(d) Juniperus communis woodland on similar soils and in similar localities to the latter two types, also discussed at length below.

ASSOCIATION OXALIDO-BETULETUM (McVean & Ratcl. 1962) emend.

TABLE VI/3

Synonymy: Birchwoods and related communities McV. & Ratc. 1962
Highland birchwoods Tansley 1949 pro parte
Heathy birchwood Pigott 1956

Habitat details

This Association with its Sub-associations and variants is virtually the same as that described by McVean & Ratcliffe (1962) under the general heading "Birchwoods and related communities". From the lists supplied by Tansley (1949) it is evident also that the Association forms a part of the Highland birchwood complex and shows the same distribution pattern in the British Isles. These birchwoods are still widely distributed but for the most part scantily developed, mostly as fragments on valley sides. Most authorities seem to agree that at one time these woods must have been much more extensive and well developed but that widespread sheep grazing has arrested their development and in many areas caused their complete disappearance. A few rich areas remain, notably along the R. Spey and in other parts of the Rothiemurchus Forest area. In more outlying parts of Scotland such as Caithness, birchwoods can still be said to be widespread. McVean & Ratcliffe (1962) have found the birchwood noda from sea level to 2000' (610m.) throughout the Highlands and note a treeless facies of their Association Betuletum Oxaleto-Vaccinetum (Table 6, lists 21-26) on many corrie slopes and siliceous rock ledges both above and below the tree line. In the Teesdale area the birchwoods are found from 800-1000' (c. 300m.) on steep river banks and other ground unfit for agriculture which has not degenerated to blanket bog.

Soils

A "typical leached brown earth profile" would be the best overall soil description in the majority of stands. The fuller details given by McVean and Ratcliffe (op.cit.) serve to differentiate the Sub-associations encountered. For instance they differentiate:-

(i) Betuletum Oxaleto-Vaccinetum stands on black mildly acid humus lying directly on block scree.

(ii) The Betula-herb nodum on brown mineral soil with mull humus.

(iii) Stands rich in basiphilous herbs on periodically irrigated fertile brown loam, with pH and lime status greater than the soils of the grass dominated examples.

These all find a counterpart in the divisions of the Association Oxalido-Betuletum described below.

Characteristics of the Association

The Association is characterised by the dominance of *Betula pubescens* and the high constancy of *Oxalis acetosella*, with *Holcus mollis* preponderant in the herb layer of the typical Sub-association, though not as constant in Sub-association Vaccinietosum. In the tree layer *Sorbus aucuparia* may often be co-dominant with *Betula*, but apart from *Ulmus* few other tree species are found in the nodum. Other character species present of the Class Quercetea robori-petraeae are: *Luzula pilosa*, *Pleurozium schreberi*, *Plagiothecium denticulatum*, *Polytrichum formosum*, *Plagiothecium undulatum*, *Dicranum majus*, *Blechnum spicant*, *Thelypteris* species, *Gymnocarpium dryopteris*, *Plagiothecium succulentum*, and *Hieracium perpropinquum*, etc..

The Betula canopy is often quite open, with trees from 6-9 m. in height. There may also be quite dense patches of Juniperus or Corylus scrub with mature bushes up to 5m. high. A noticeable feature of these woodlands is their uniformity of structure. The grass layer, mainly Agrostis tenuis, Anthoxanthum odoratum, and Deschampsia flexuosa, dominates the more open parts in conjunction with Pteridium. Other important companion species which make up the structure are Lophocolea bidentata, Rhytidiadelphus squarrosus and Mnium hornum.

Two Sub-associations of the Oxalido-Betuletum can be clearly discerned, Sub-association Typicum with a Dryopteris variant and Sub-association Vaccinietosum with both a Dryopteris and a Juniper variant. This latter is intimately linked with, and indeed grades into, the Association Thelypterido-Juniperetum.

(i) Sub-association Typicum

Synonymy: Betula-herb nodum McVean & Ratcliffe 1962 (Table 6, lists 12-20)

Differential species: Endymion nonscriptus and Conopodium majus.

The Sub-association is also differentiated by the preponderance of Holcus mollis and the absence of Calluna, Vaccinium, Hylocomium splendens and Rhytidiadelphus loreus. There are also higher cover values for Holcus lanatus, Dactylis glomerata, Anemone nemorosa, Viola riviniana, Ranunculus ficaria and Mnium hornum.

The species lists are remarkably similar to those of the Betula herb nodum of McVean & Ratcl. (1962) and, of the constants they mention, Betula pubescens, Anthoxanthum, Galium saxatile, Oxalis, Potentilla erecta and Viola riviniana are identical. Dominants too are very close, the only difference between the Teesdale and the Scottish lists being the much greater abundance of Thuidium tamariscinum and Hylocomium splendens in the latter.

The soils which support the Sub-association are for the most part rather shallow brown earths. The average depth in the stands surveyed is 1.8 dm. Where there is even slight improvement in the depth and richness of soil, stands can be reasonably herb rich and, as McVean & Ratcliffe say, "similar to the ground flora of mixed deciduous woodland". Usually, shallow slopes favour this Sub-association but, if there is a sufficient depth of drift, it can be seen on moderately steep slopes.

(a) Dryopteris variant

This variant is not shown in the Scottish lists but is well characterised by the dominance of Dryopteris species with a consequent shading out of many other herbs and bryophytes; for example, Potentilla erecta and Polytrichum formosum. The variant is found in its maximum expression on very steep scree slopes particularly those where there is block boulder scree with little depth of good soil, often, indeed, between the boulders, there may be only a few cms. of acid humus and fern litter.

A number of bryophytes (of only very low cover, on well drained slopes dominated by grasses) find better expression in the more humid, less crowded conditions, between individual fern stocks. Amongst these are Plagiothecium undulatum, Dicranum majus and Polytrichum formosum.

(ii) Sub-association Vaccinietosum

(a) typical variant.

Synonymy: Betuleto Oxaleto-Vaccinetum McVean & Ratcliffe 1962 (Table 6, lists 5, 7-11)

This Sub-association is found where rock reaches surface level, often in flat or domed slabs. Soil is minimal, indeed there is often nothing on the slabs but a shallow layer of very acid humus and plant debris in which seedlings can mature and survive. In the present survey the Sub-association was found only in the Birch Wood, typically on the flat rim of the river gorge. Here large dolerite masses formed a stable unbroken edge, uncovered by drift, and without large crevices in which soil could accumulate. Stands were found on the lower slopes of the gorge but again only where the rock formations were of such a nature that soil was virtually non-existent.

Sub-association Vaccinietosum is accordingly characterised by acid-loving species, the differentials being Vaccinium myrtillus, Calluna vulgaris, Rhytidiadelphus loreus and Hylocomium splendens. Species having a higher performance than in the typical Sub-association are Deschampsia flexuosa, Lophocolea bidentata, Pleurozium schreberi, Blechnum spicant and Polytrichum formosum.

Those species notable by their absence have already been mentioned under the typical Sub-association.

(b) Dryopteris variant.

This is again found on scree and places where the bedding rock is broken into crevices. Here ferns can find a footing and a constant facies of tall Dryopteris species dominates the community, easily recognizable in the field.

The Birch Wood includes a number of stands of 100-200 sq.m. in area, with ferns 1.5 m. in height. These shade into the Dryopteris variant of the typical Sub-association where the dense fern cover shades out the typical heathy layer.

(c) Juniperus variant.

Synonymy: Betuletum Oxaleto-Vaccinetum McVean & Ratcliffe 1962 (Table 6, list 6)

The presence of Juniperus communis forms an interesting variant of which McVean and Ratcliffe have only one list (but two extremely good photographs op. cit. pl. 4 & 5). This variant is an edge effect on the main birchwood association, closely linked with, and indeed grading into the Association Thelypterido-Juniperetum which will be described next. The only difference between this facies of the Association, and its full expression in the Juniper Scrub, seems to be one of soil conditions. In the Birch Wood, for the most part, there has not been the same development of mor humus and consequently some of the characteristic bryophytes are missing there. Of the stand at Carrbridge, Invernessshire, McV. & Rat. (1962) say, "This fern rich stand is associated with Junipers and so is referable also to the Juniperus-Thelypteris nodum. The vegetation contains Blechnum spicant, Thelypteris dryopteris, T. phegopteris and Polystichum aculeatum, grading into Vaccinium myrtillus dominated ground." Affinities are found by these authors in Nordhagen's Vaccinium myrtillus-rich birchwood (Nordhagen 1927) and also in the Vaccinietum lapponicum (Braun-Blanquet, Sissingh and Vlieger 1939 p.57). No doubt because of these similarities and because of the presence in Scottish communities of Ptilium crista-castrensis, Empetrum hermaphroditum, Pyrola media, Trientalis and other northern species these authors find that the Betuletum Oxaleto-Vaccinetum transgresses the borders of the whole Order Vaccinio Piceetalia.

But this Order is essentially Sub-alpine, in which zone Picea and Pinus mugo dominate. The broad spectrum seems to be that of the Class Quercetea robori-petraeae as pointed out in the early part of this chapter.

A further interesting solution is the uniting of the Quercetea and the Vaccinio-Piceetea as proposed by Doing and Westhoff (1959) into a single Class the Querco-Piceetea. More evidence is needed, but it does seem that there would be little difficulty in fitting such Associations as Oxalido-Betuletum and Thelypterido-Juniperetum into an overall Querco-Piceetea.

If the two classes are to remain separate it would appear that the north western Atlantic birch woodlands have most affinities with the

Quercetea than the Vaccinio-Piceetalia. A last comparison is made with lists taken from K. Horst's monograph "Klima und Bodenfactoren ... des Naturschutzparks Lüneburger Heide" (1964).

The summary is taken from 5 Aufnahmen made within an area of 1000 m^2. It can be seen that the Association Oxalido-Betuletum is essentially a vicariant of this fragment, minus the Quercus species, and that the Thelypterido-Juniperetum is a seral stage in its development.

Querceto roboris-Betuletum fragm.

Quercus petraea	V	Betula verrucosa	I

Charakterarten (Quercetea robori-petraeae)

Sorbus aucuparia	V	Campylopus flexuosus	V
Vaccinium myrtillus	V	Hypnum cupressiforme	V
Deschampsia flexuosa	III	Pohlia nutans	IV
Quercus petraea	II	Dicranella heteromalla	IV
Polypodium vulgare	I	Polytrichum attenuatum	III

Charakterarten (Nardo-Callunetea)

Festuca ovina ssp. capillata	V	Hypnum cupressiforme var. ericetorum	III
Agrostis tenuis	V	Dicranum spurium	II
Carex pilulifera	V	Cladonia chlorophaea	II
Calluna vulgaris	IV	Cladonia squamosa	II
Sieglingia decumbens	IV	Ptilidium ciliare	I
Luzula campestris	I	Cornicularia aculeata	I
Galium saxatile	I	Cladonia pleurota	I

Companions

Juniperus communis	V	Entodon schreberi	V
Parmelia physodes	V	Dicranum scoparium	V
Polytrichum piliferum	IV	Ceratodon purpureus	IV
Agrostis canina ssp. arida	III	Polytrichum juniperinum	III
Agrostis alba	II	Isothecium myurum	II
Juncus effusus	II	Cladonia gracilis	I
Rumex acetosella	I	C. impexa	I
Leucobryum glaucum	V		

ASSOCIATION THELYPTERIDO-JUNIPERETUM (McVean & Ratcl.) emend
TABLE VI/2

Synonymy: Juniperus-Thelypteris nodum McV. & Ratcl. 1962
(Fern-rich juniper scrub)
Heather-Juniper-Blaeberry vegetation E.W. Fenton 1933

The Cairngorm juniper scrub at 2,000' is considered by McVean & Ratcliffe (1962) to be the best example of Sub-alpine scrub in Scotland. It is evident from their lists that the Association Thelypterido-Juniperetum is identical - of 65 species mentioned from the Cairngorms only eleven are missing from the Teesdale lists. If so it seems that the Association is widespread in the East-central Highlands in fairly small stands though the distribution map of Juniperus communis Perring & Walters (1962) shows that the Association must at one time have been much more abundant. Evidently there are many more isolated stands in Scotland and Northern England and the general ecological pattern of these has been discussed in the paper by Wyllie Fenton (1933) on the Boghall Glen area of the Midlothians mentioned in Chapter 9.

The altitudinal range in Highland Scotland is from 1000'-2500', and stands can be found in tall dense juniper thickets in pinewood clearings. In the Southern Uplands the Association occurs at 800' (in the Tynron National Nature Reserve) and the Teesdale Juniper Scrub lies between 900' and 1200'. Nordhagen (1928) estimates that Juniper scrub is widespread in the Norwegian mountains and although it is evidently a related community the (at times) co-dominance of Betula nana seems to differentiate it as a more northern facies. This observation probably holds good also for the corresponding Hylocomieto-Betuletum nana Juniperetosum Sub-association of Dahl (1956) in Rondane. At any rate McVean & Ratcliffe (1962) consider that these last two types of juniper scrub are related to the Scottish stands.

Characteristics of the Association

The Association is typified by the dominance of Juniperus communis in its shrubby form, about 1.5 metres in height. In well developed scrub, as for example in the Teesdale area, older junipers may be present up to 3m. in height. In the more open stands, particularly where there is scree or an agglomeration of small boulders, co-dominance may be shared by Thelypteris species and Gymnocarpium dryopteris. Other species of the class Quercetea and regional character species are Oxalis acetosella, Mnium hornum, Plagiothecium denticulatum, Dryopteris dilatata, etc..

The field layer shows the high constancy and abundance of Pteridium aquilinum, Agrostis tenuis, Festuca ovina, Agrostis canina ssp. montana, Vaccinium myrtillus, Rhytidiadelphus squarrosus and Hypnum cupressiforme var. ericetorum.

The seral nature of the Association is shown by the presence of Class character species of the Quercetea robori-petraeae, along with a group of character species of the Class Nardo-Callunetea which run right across the spectrum. The more important of these are of course Calluna, Potentilla erecta, Galium saxatile, Luzula multiflora and Carex binervis.

Two Sub-associations were separated:

(i) Sub-association Typicum

Here juniper is associated with woodland herbs and bryophytes in more open stands. Species of the Agrosto-Festucetum are encountered - Campanula rotundifolia, Cerastium fontanum, Holcus mollis, and Viola riviniana - which also act as differentials against the Sub-association with Lophozia and Campylopus. This is probably due to the effect of taller and more mature junipers which act as sheep cover. The consequent enrichment of the soil in these stands and higher grazing pressure bring in the rather untypical species.

(ii) Sub-association of Lophozia & Campylopus

Stands of this Sub-association are found where the majority of the junipers are only 1m. or so in height. Nevertheless there is a dense low cover, a tangle of branches and a lot of buried litter. The litter is mostly woody, dead branches and quite often living ones. Drainage seems to be rather poor as well. Consequently there is an increase in raw humus of woody origin in such places, and a notable increase in hepatics, particularly those which can act as epiphytes. Although ferns may still flourish, growing through the low juniper, grasses are decreased in vitality, and bryophytes of wet rocks or shallow soil on such rocks reach a higher performance. The Sub-association is thus characterised by the differential species - Lophozia ventricosa, Barbilophozia floerkei, Dicranum scoparium, Campylopus flexuosus, Scapania gracilis and others.

A tentative comparison has already been made between British and Norwegian juniper scrub. Sweden seems to show even more clearly affinities with British north western vegetation, in contradistinction to that of Central Europe. Du Rietz (1925) claimed that "Sweden south of the oak line phytogeographically forms a transitional area between Western and Central Europe on one side and the continental and northern parts on the other". It is the south-western area, particularly the dwarf shrub heaths, that offer links with northern Britain. So in the description by N. Malmer (1965) of these heaths many interesting links can be found between the communities there described, and those of Highland Scotland. There appears to be a very close connection between the Calluna-Vaccinium Community of S.W. Sweden and the Association Thelypterido-Juniperetum. Of the common species listed for Sweden, *Juniperus communis*, *Calluna*, *Vaccinium myrtillus*, *Carex pilulifera*, *Potentilla erecta*, *Dicranum scoparium*, *Deschampsia flexuosa*, *Festuca ovina*, *Luzula* spp., *Hylocomium splendens*, *Hypnum ericetorum* and *Pleurozium schreberi* are just those which typify the Association in N. England and Scotland.

Zonation and succession too appear to be very similar. The photographs and description of the Juniper-Calluna-Vaccinium community on northern slopes are very strong evidence of a similar zonation in Teesdale. The contact communities (shown in Table VI/2) have not yet been described, but the Agrosto-Festucetum, Molinieto-Callunetum and wet, *Sphagnum*-dominated facies of the latter, together with the Erica-Trichophorum communities and blanket peat all appear to be reflected in the Swedish scene.

The two main differences appear to be:

(a) Sweden has a number of species such as *Trientalis*, *Vaccinium vitis-idaea*, *Lycopodium clavatum*, *Dicranum undulatum* and so on which are common in Scotland and Norway but not common in northern Britain. These appear to act as local and regional vicariants of identical communities rather than as indicative of different ones.

(b) The heath formations of the continent appear to be much more aligned with those of Central and Southern England and so great care has to be taken in delimiting Juniperus associations. The good dry Nardo-Galion heath of Lüneberg with its Juniper seral stages has no evident counterpart in Northern Britain. So one would link the

Dicrano-Juniperetum Barkmann (see Westhoff & Den Held (1969) p.220) with south British and continental communities rather than with the Thelypterido-Juniperetum.

CLASS NARDO-CALLUNETEA Preising 1949

This is a class of species-poor, grass-heath, communities on acidic soils throughout the Atlantic and Sub-atlantic regions of western Europe reaching as far as the Sub-alpine regions of Central Europe and Boreal Scandinavia. Much of this land is derived from woodland and therefore many of the character species of the class Quercetea can still be found - Potentilla erecta, Sieglingia decumbens, Calluna, etc..

There are two Orders of this Class but only one need be considered here:

ORDER NARDETALIA (Oberdorfer) Preising 1949

In contrast with the Order comprising Associations of dwarf ericaceous shrubs, Ulex, Sarothamnus, and Genista species, the O. Nardetalia comprises all the rough grass noda. Here are such species as Nardus, Anthoxanthum, Luzula multiflora and other rushes of high constancy.

These are again divided into (a) The lowland Nardo-Galion Alliance, on more or less sandy soils, with a reasonable proportion of herbs in its constituent Associations; (b) The Eu-Nardion comprising the Alpine Nardus-dominated communities with fewer herbs than the lowland Alliance.

With these notes in mind we consider now an Association, which has evidently some affinities with the Nardo-Galion (Violion caninae), but which McVean & Ratcliffe were unable to classify and which of course cannot be classified satisfactorily until more data is available.

ASSOCIATION MOLINIETO-CALLUNETUM McVean & Ratcliffe 1962

TABLE VI/2

Synonymy: Molinia-Calluna bog McV. & Rat. 1962

Characteristics of the Association

Molinia caerulea, Nardus stricta, Empetrum nigrum and Erica tetralix serve as regional character species of the Association with Calluna, Hypnum, Pleurozium schreberi and Plagiothecium undulatum constant and of high cover. Of the other species given for Scotland a high proportion can be found in the Teesdale lists. Some of these serve to typify a Sub-association Sphagnetosum of wetter areas, e.g. Narthecium, Carex echinata, Trichophorum cespitosum and five mesotrophic Sphagna which are for the most part indicative of a higher water table.

It is evident that although the Association is related in some way to the Alliance Nardo-Galion, there are regional differences which pose difficult problems of classification.

Appended below is a list of K. Horst (1964) from the Lüneberg heath which at once reveals the similarities and poses the difficulties of comparison.

Nardus-Festuca capillata-Ges Preising 1959

7 Aufnahmen; area from 18-30 qm.; Av. no of species 17.

Local Character Species		Companion species	
Nardus stricta	V	Deschampsia flexuosa	III
Festuca ovina ssp. capillata	IV	Rumex acetosella	III
Agrostis tenuis	IV	Pohlia nutans	III
Juncus squarrosus	II	Pleurozium schreberi	III
		Cornicularia aculeata	II
		Ceratodon purpureus	II
		Parmelia physodes	II

Differential species of wetter areas		Companion species (continued)	
Carex fusca	IV	Vaccinium myrtillus	II
Erica tetralix	IV	Leucobryum glaucum	II
Molinia caerulea	IV	Agrostis canina var. arida	II
Juncus effusus	III	and other Lichens	

All., O., and Class character species

Calluna vulgaris	IV	Hypnum cupressiforme	II
Carex pilulifera	IV	Potentilla erecta	II
Galium saxatile	III		

The similarities can be seen at a glance. Missing species are just those which appear to link the British and Scottish associations with Trichophoreto-Callunetum communities.

Of the Molinia grasslands of the Western Highlands, McV. & Ratcl. (1962) see three types:-

(i) areas completely dominated by Molinia, usually associated with periodic flooding and sedimentation along the edges of sluggish streams on boggy ground.

(ii) herb-rich types of Molinia grassland on damp basic soils at low levels, having some affinities with Juncus acutiflorus mires.

(iii) Sphagnum rich Molinia communities which are related to the oligotrophic mires or even to the Trichophoreto-Eriophoretum.

It is interesting with this in mind to note that the Teesdale community gives way to blanket bog at higher levels and where drainage waters converge to form a permanently wet area below the Molinieto-Callunetum there is a small Juncus acutiflorus mire as indicated in (ii) above.

Perhaps one can only at this moment say that the Association is on the fringe of the Nardo-Galion but in no way typical of it, as Molinia is not very often a part of such Continental heath Associations.

Again relationships can be found with the Alliance *Calthion palustris* Tx. (= *Molinio-Juncion acutiflori* Duvign.) via the mesotrophic *Sphagna*. The widespread occurrence of *Molinia* grasslands in Scotland supports this contention.

But floristically there is definitely a leaning towards the *Trichophoreto-Eriophoretum*. Perhaps further research may separate a lowland and an upland nodum.

Geographical distribution

The Association as at present understood appears to be widespread in the Cairngorms, E. Central and Western Highlands of Scotland from 1500' to 2000'. McVean & Ratcliffe (1962) state that it covers many square kilometres of gently sloping lower hillsides in the Western Highlands. They adduce four points which seem to be borne out by the present study.

(a) *Molinieto-Callunetum* appears to be connected with water movement rather than stagnant conditions.

(b) It often occupies slight hollows or flats where the surface convexivities are covered by *Trichophoreto-Callunetum*.

(c) Underlying soils tend to be peaty - acid and base deficient - but still aerated by water movement.

(d) The Association is indifferent to the underlying rock type.

These conditions are all fulfilled in the stands.

CLASS MOLINIO-ARRHENATHERETEA R.Tx. 1937

This class includes many of the west European cultivated lowland communities of anthropogenic origin. The communities are stabilised by mowing, grazing and manuring. They are dominated by grasses and rushes and include pastures, hay-meadows and most of the enclosed land in the lowlands.

There are two Orders within the Class.

(A) O. Molinietalia coeruleae W. Koch 1926

This is the Alliance least affected by man and considered to be semi-natural by O'Sullivan (1965). Some of the more low-lying Molinia communities referred to under the Association Molinieto-Callunetum no doubt have affinities here.

(B) O. Arrhenatheretalia elatioris Pawlowski 1928

Synonymy: Arrhenatheretalia Br.-Bl. 1947

This order contains the majority of lowland, permanent pastures, meadows and rough grasslands. The Order is mentioned here as it serves as evidence, through its various Alliance character species, of contact communities fringing the woodlands described.

Again there is a problem of classification where upland areas of the Northern parts of the British Isles are concerned. Shimwell (1968) has tackled the problem in his survey of the calcareous grasslands of the British Isles by adopting a Scandinavian Alliance the Ranunculo-Anthoxanthion as a convenient reference point for the maritime, sub-alpine, limestone grasslands. These grasslands are not easily accommodated in the lowland Alliances already described by continental phytosociologists and it appears that a similar problem also awaits those who would classify the montane acidic pastures.

McVean & Ratcliffe (1962 p.138) say of the Agrosto-Festuceta (i.e. both species-poor and species-rich facies) that they are "virtually unclassifiable since they are almost entirely anthropogenic and range from oligotrophic to eutrophic. They may belong to the Nardeto-Agrostion tenuis Nordhagen 1943 of the Arrhenatheretalis elatioris Br.-Bl."

We shall therefore give a shortened account of Shimwell's approach to the problem before describing the Association Agrosto-Festucetum.

All. RANUNCULO-ANTHOXANTHION (Gjaervoll 1956) em. Shimwell 1968

Synonymy: Nardeto-Agrostion tenuis Sillinger 1933 p.p.

Ranunculeto-Oxyrion digynae Nordhagen 1943, emend Dahl 1956

The Alliance of Gjaervoll which differs only in dominant from the Alliances in synonymy above is emended in Britain to include damp montane and sub-alpine meadows and pastures dominated by Deschampsia cespitosa, Festuca ovina, F. rubra, Agrostis tenuis, A. canina or Anthoxanthum odoratum, since these Agrosto-Festuceta grasslands have also, basically, the same physiognomic and floristic structure. Shimwell (op. cit.) then gives the basic differences between his emended Alliance and other Arrhenatheretalia Alliances and contends that it fills a regional lacuna in the Z.-M. system of classification. He sees a parallel situation in Britain to that in continental Europe where species of the montane Alliance Polygono-Trisetion gradually replace the Arrhenatherion species at higher altitudes within the broad geographical range of the Arrhenatherion Alliance, which is the same as that of Fagus sylvatica woodland.

The situation in Britain,(where the geographical range of the oat-grass meadows coincides with that of natural Fraxinus woodland), is for these meadows to be replaced by Agrostis-Anthoxanthum-Festuca pastures at altitudes over 1000'.

ASSOCIATION AGROSTO-FESTUCETUM McVean & Ratcliffe 1962 TABLE VI/2

Synonymy: Species-poor/species-rich Agrosto-Festucetum McV. & R. 1962

Agrostis-Festuca (Bent-Fescue) grassland Tansley 1939

Anthropogenic grass heaths McV. & Ratcl. 1962

Siliceous grassland auct. Brit. p.p.

The few Aufnahmen comprising this Association in the present survey were mainly incidental, serving to show zonation within juniper scrub which has been grazed. However the main facies of the Association are evident even in such a small sample. The dominants are five grasses Festuca ovina ssp. ovina and ssp. tenuifolia, Agrostis tenuis, Anthoxanthum and Festuca rubra. Above these is a high core of Pteridium and in a third lower layer a few herbs and bryophytes such as Potentilla erecta, Galium saxatile, Rhytidiadelphus squarrosus and Pleurozium schreberi.

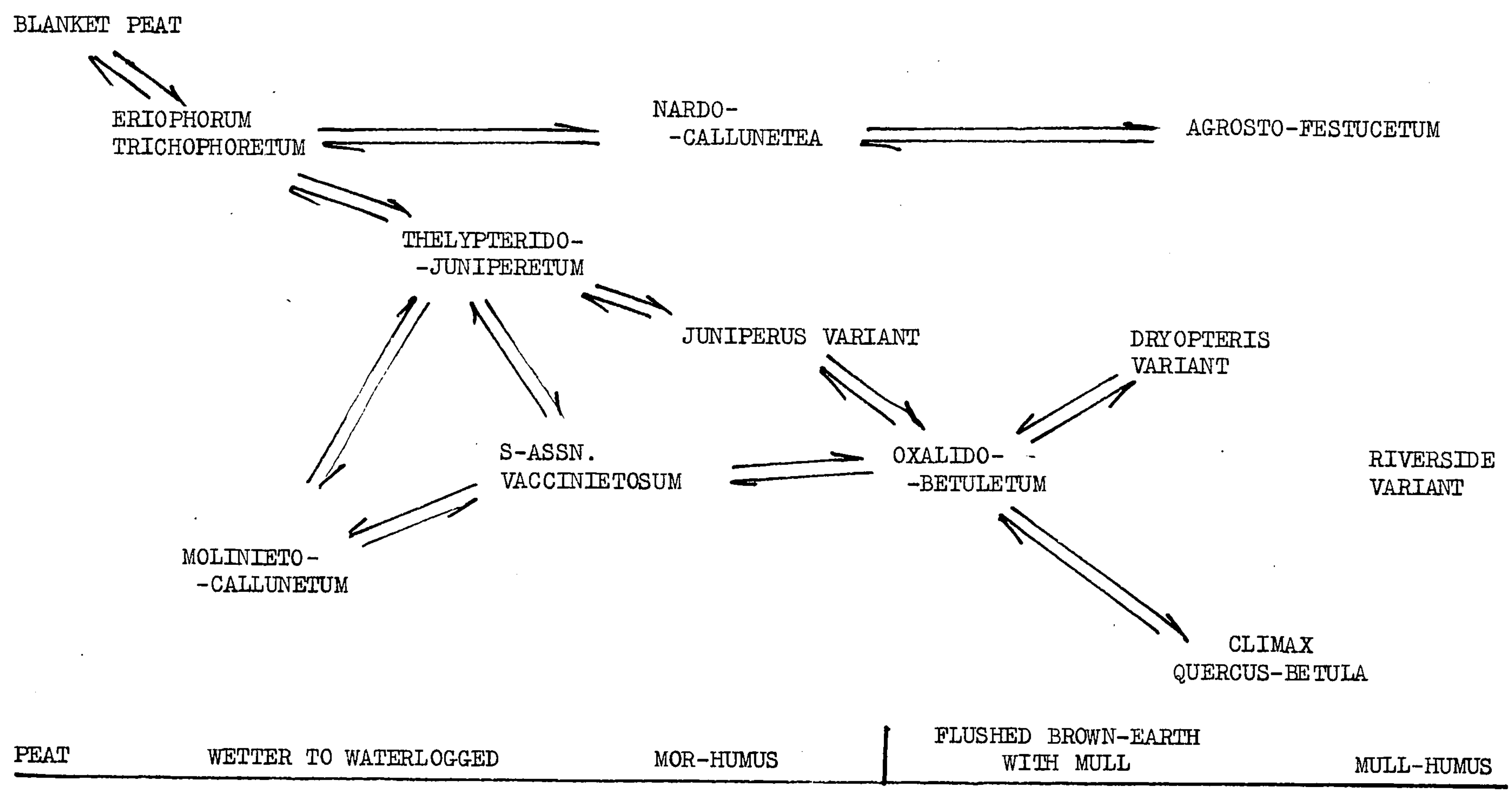
Nine differential species or grazing indicators are present and serve to delimit the Association in tabular form but apart from a few stands of Holcus mollis the physiognomy and field characteristics are fully represented by the companion species outlined above. The important differentials are Carex pilulifera, Veronica officinalis, Campanula rotundifolia, Viola riviniana and Stellaria graminea.

The nodum in question comes within the category "species-poor", the average number of species present being only 22. As grazing is now restricted in the area from which the Aufnahmen were taken, its full expression can be seen, whereas its usual appearance is, as McVean and Ratcliffe put it, "a close cropped sward less than 10cm. high". Altitudinal range in Scotland is given as from 100'-2700' (30-824m.) and Tansley says of this grassland type that, in Britain, it is not determined by altitude.

Underlying soils tend to be dry, well drained and base deficient. In the area surveyed the average pH was 4.5 and the soils were podsolic in nature immediately overlying dolerite intrusive rocks and between 1.5 and 2.4 dm. in depth.

Many pages and even books have been written on Bent-Fescue grasslands but their full elucidation and phytosociological presentation and status remain to be established. As they are so extensive, a survey of these upland acidic grasslands is needed on the lines of O'Sullivan's thesis describing the Irish lowland pastures.

ZONATION AND SUCCESSION



RIVERSIDE ALLUVIUM/ROCK MOSAIC COMMUNITIES TABLE VI/8

It has already been noted that the Birch Wood in question is bounded along the whole length of its north side by the River Tees. As the Tees is the main drainage channel for an area of some 300 sq. miles (Baker & Tate 1868 p.106) with its source in a basin of high moorland whose semicircular rim varies from 2000'-3000' in height, it will be appreciated that the river carries away a large volume of water from these slopes. It will also be understood why the river is subject to periods of great fluctuation, not only in the snow melt, but every time there are a few hours of rain. Indeed, as the Tees falls 430' between Cauldron Snout, some six miles upstream, and High Force (the western limit of the Birch Wood), along a fairly narrow channel, it is subject to spectacular rises and falls along the whole margin of the wood.

(A) We are left therefore with a strip of periodically irrigated river bank, which bears a mosaic of herb-rich communities, not strictly related to any of the woodland Classes, but rather to meadow Associations of the Class *Molinio-Arrhenatheretea*. Where the river gorge widens, the inundated area with its characteristic meadow community may extend some 10 metres into the woodland. This area is enriched with highly calcareous water only at the higher levels of the river, and consequently there is time for stabilisation and formation of ten or twenty cms. of rich compacted silt.

(B) There is also a narrow strip along the immediate river margin which is irrigated very frequently and where the underlying rock is washed free from soil or where the thin layer of silt is very unstable. Here the communities change rapidly to the Class *Montio-Cardaminetea*.

(C) Finally on the river spur (north of D. in Fig. II/1) there is a flat triangle of land, rather like a very small alluvial plain where sandy sedimentation has built up to a depth of 3 dm., dominated by large junipers and unlike any other community either in the Birch Wood or the Juniper Scrub.

The riverside communities fall into two more or less distinct community groups:-

(a) an Alchemilla-Festuca rubra group, (A) and (B) above,

(b) Juniperus alluvial stands, (C) above.

(a) Alchemilla-Festuca rubra community group

In the riverside stands within this group of communities there is a constancy of Alchemilla glabra, Geum rivale and a constancy and partial dominance of Festuca rubra, which species are not found elsewhere in the Birch Wood. The name therefore forms a convenient label for a heterogeneous group comprising fragments of four vegetation types.

(i) Bryophyte-rich streamside Community of the

Cl. MONTIO-CARDAMINETEA Br.-Bl. et R.Tx. 1943

O. Montio-Cardaminetalia Pawlowski 1928

This Order, with its Class, comprises stream, lakeside and flush communities in more or less oligotrophic habitats. The differential species of group (i) - Brachythecium rivulare, Bryum pseudotriquetrum, Philonotis fontana, Cratoneuron commutatum, Solenostoma cordifolium and so on are characteristic species of this type of vegetation.

Aufnahmen B5 and B19 are no doubt too extensive and contain evidences of more than one association. In the latter for example we have (α) fragments of a wet rock-crevice Association with Amphidium mougeotii, Rhacomitrium aciculare, R. heterostichum and Solenostoma spp.

(β) through Pellia epiphylla and Conocephalum conicum, affinities with the Association Pellio-Conocephaletum Maas 1959 in the Sub-alliance Cardaminion

(γ) an upland streamside community of the Alliance Cratoneurion.

As well as the differential species mentioned at (i) above there are two interesting plants: firstly, the New Zealand Epilobium which has spread to many upland gravelly stream and lake margins; secondly, a high proportion of Dichodontium pellucidum which is highly characteristic of loose sand or gravel, and other unstable habitats beside mountain streams.

All the fragmentary Associations of this group are found along the narrow strip of river bank (B), which is inundated at the slightest change in river level and subject to a certain amount of splash at all seasons.

(ii) Alchemilla-Festuca rubra typical Community

This, perhaps the most typical riverside community, is inundated and enriched only in winter and at flood level. It is very rich in Molinio-Arrhenatheretea character species; some, such as Centaurea nigra, Plantago lanceolata, Holcus lanatus and Prunella vulgaris, of quite high cover. At flowering time this community stands out well from the rather dull graminaceous cover of the typical Oxalido-Betuletum.

(iii) Potentilla fruticosa stands (Aufnahmen B3, B47)

Ass. Potentilletum fruticosae Shimwell 1968

Synonymy: Potentilla fruticosa associated species Elkington & Woodell 1963

Potentilla fruticosa stands Ivimey-Cook & Proctor 1966

It is interesting to note that Ivimey-Cook and Proctor (1966) report many Molinio-Arrhenatheretea species in the Potentilla stands of the Burren and actually place their communities in that Class. Shimwell (1968) has collected lists from most of the Potentilla fruticosa localities in Britain and suggests that there is in fact a new Alliance of the Order Prunetalia into which these communities fall, evidencing both the general physiognomy and the "Saum-Mantel" relationship to the Alno-Padion. The Association occurs (Shimwell 1968) "on damp alluvial soils and pebbly banks which are periodically irrigated with flood water and is in Teesdale a predominantly river-side community". The Irish localities are (Ivimey-Cook & Proctor 1966) "around small turloughs a few metres above the summer water level". In the Aufnahmen studied, conditions are exactly as Shimwell describes, one stand of 10 sq.m. being dominated by Potentilla fruticosa and situated on 15 cm. of calcareous silt which was deposited directly on the underlying rock along the river's edge. The constants mentioned by Shimwell are absent but there is a variety of Molinio-Arrhenatheretea species present, including Achillea millefolium, Centaurea nigra, Succisa pratensis, Holcus lanatus, Festuca rubra and Plantago lanceolata.

Dichodontium pellucidum is again a dominant species of the moss layer, evidently pioneering the fresh silt as it is laid down.

(iv) Rosa woodland-edge community Aufnahme B7.

The Birch Wood being literally an elongated ellipse has only two "edges". The river forms a natural boundary to the north and on the south a stone wall comprises the other boundary. Consequently edge-communities are practically non-existent, the only one studied having a fairly high proportion of Molinio-Arrhenatheretea species, yet belonging clearly to the Cl. PRUNETALIA and related to the boundary communities described later in this chapter. An interesting bryophyte encountered here was Breutelia chrysocoma, an upland photophilous moss of moist rock ledges.

(b) Juniperus riverside alluvial stands (Aufnahmen B39, B41)

Association Squarroso-Juniperetum Barkman in lit. 1968

These stands of dense tall Juniper on sandy alluvium are clearly differentiated from the other riverside communities:

1. by the lack of Molinio-Arrhenatheretea species;

2. by the species (4a of Table VI/8) *Galium saxatile*, *Plagiothecium denticulatum*, *Pteridium aquilinum*, *Luzula pilosa*.

But again they are differentiated from the *Thelypterido-Juniperetum* by the species (4b of Table VI/8) *Mercurialis perennis*, *Rubus idaeus*, *Urtica dioica*, *Stellaria alsine*, and *Cardamine flexuosa*.

The Aufnahmen have already been presented (though not discussed) in Table VI/3. From that Table it is clear that the character species of the *Quercetea-robori-petraeae* and the differentials of both Sub-associations of the *Oxalido-Betuletum* are absent from these two stands, so that the noda cannot be classed as a Juniperus variant of the latter Association.

An examination of the Association *Squarroso-Juniperetum* Barkm. as presented in Westhoff & Den Held (1969) points strongly to the conclusion that we have in these stands a large fragment of that Association. The dominants *Juniperus* and *Rhytidiadelphus squarrosus* are the same and many of Barkman's differentials are present. Habitat is almost identical,the German stands being along the "langs de rivieren Ems".

CLASS **QUERCO-FAGETEA** Br.-Bl. et Vlieger 1937

Order *Fagetalia sylvaticae* Pawl. 1928

This Class comprises the species-rich Quercus, Fagus, Fraxinus, Carpinus dominated woodlands throughout Central Europe to S. Sweden, Britain, and N.W. Scotland. They are developed on calcareous rendzina soils often on scree slopes.

The Order includes most of the Beech woodlands on calcareous soils.

All British Beech woodlands fall into the Alliance *Fagion sylvatici* but north of the beech line, as Tansley (1939) realised, and as a journey through England from North to South makes clear, woodland is dominated by Fraxinus. Thus the northern woods are related to the All. Fraxino-Carpinion. But because of the absence of Carpinus over the whole area it is suggested that the Alliance name be modified to Fraxino-Brachypodion (Shimwell mscr. and personal comm. 1968). Much of the data for this contention comes from a survey of the Derbyshire Ashwoods (Shimwell 1968) and some from the Aufnahmen prepared for this thesis in the same year. Certainly some new Alliance is needed to take account of the British ashwoods "which appear to have no exact parallel on the continent" Tansley (1939).

Association Sorbo-Brachypodietum nov. ass. Table VI/4.

Synonymy: Rowan-birchwood Anderson 1932

Fraxinus-Brachypodium sylvaticum nodum McVean & Ratcl. 1962 p.p.

Brachypodium-rich ashwood McV. & Ratcl. 1962 p.p.

The Association is essentially the same as that on the Durness dolomite of north-west Scotland, the main difference being that of tree canopy, which in limestone areas can be pure ash or mixed ash and birch. Evidently ash has been selectively removed in many parts of Scotland but the Association can still be recognised from the character species even when only birch remains in the tree layer. McVean & Ratcliffe (1962) think it quite likely that ashwood constitutes the climax vegetation on shallow limestone soil and pavements south of Sutherland, and that with such a restricted habitat, ashwood can never have been widespread in Scotland. In Britain the picture is different and, although many limestone areas have been depleted of natural woodland, quite considerable fragments remain in the dales from Derbyshire northwards.

Characteristics of the Association

The Association is characterised first by the canopy and shrub cover. Sorbus aucuparia is regionally constant with Fraxinus and some Ulmus and Betula. It may be that Fraxinus replaces Sorbus on limestone pavement and scree or that the two communities are altitudinal or edaphic variants but more work needs to be done to establish this. Possibly Sorbus aucuparia with Prunus padus and Ulmus are the dominants on less rich upland drift soils such as that found in Mill Beck Wood. Here there is a better soil profile, with appreciable drift, and evidences of soil enrichment that are absent from the other three woodlands considered. The underlying dolerite too weathers to a slightly alkaline rather than an acidic soil.

The understorey of tall Corylus scrub is very characteristic as well as the canopy layer and there appear to be stands of Corylus on basic soils that have the characteristic herb flora of the nodum.

The important Fagetalia and continental Alliance Fraxino-Carpinion character species are listed below:-

Brachypodium sylvaticum	Melica uniflora
Mercurialis perennis	Allium ursinum
Endymion nonscriptus	Stachys sylvatica
Atrichum undulatum	Primula vulgaris
Potentilla sterilis	Eurhynchium striatum
Dryopteris filix-mas	Galium odoratum
Sanicula europaea	Ranunculus ficaria

A species which seems to be a good regional differential is Cirriphyllum piliferum which is sometimes abundant under scrub on level ground. One important factor in the constitution of these woodlands is the fairly unstable nature of the soil. Where there is more or less unstable soil on scrubby slopes Cirriphyllum is replaced by Atrichum and Mnium species.

The ground flora is very rich with many constants notably Viola riviniana, Oxalis acetosella, Conopodium majus, Agrostis tenuis, Ranunculus repens, Lophocolea bidentata, Mnium hornum, Eurhynchium praelongum, Dactylis glomerata and so on. The list is very long and the table will repay careful study.

Of those species which give colour to the Association, and make up its characteristic floristic structure, might be listed the following:-

Geum urbanum	Ranunculus repens
Crepis paludosa	Tussilago farfara
Prunella vulgaris	Athyrium filix-femina
Veronica chamaedrys	Endymion nonscriptus

and others already mentioned among the constants and character species.

As this is a community of rather unstable ground and steep banks, very characteristic patches of Brachypodium sylvaticum, Sanicula europaea and Melica uniflora are often to be seen, with Campanula latifolia and Circaea lutetiana amongst the scree.

Bare patches of soil are soon colonised by pioneer bryophytes - Atrichum undulatum, Pellia and Fissidens species along with Mnium and Eurhynchium striatum which soon appear.

Alnus and Acer variant

The high core of the more alluvial, flatter, streamside areas has often a preponderance of Alnus, thus linking the community with the Alno-Padion Alliance which is characteristic of more base-rich mud. The stands are still very rich, and evidently belong to a different community from certain more oligotrophic stands in Park End Wood, also with Alnus cover.

Association Caltho-Alnetum nov. ass. pro. TABLE VI/5

The new and provisional Associations which have appeared under the Alliance Calthion palustris (see p. 181 Westhoff & Den Held 1969) show that there are a number of oligotrophic streamside, flush, and wet meadow communities, which cannot be classified in the existing Associations. The creation of a provisional Association *Caltho-Alnetum* is an attempt to delimit a sedge-poor marshy group of communities which appear related both to Alnus glutinosa stands and rather puddled wet meadows, or deep muddy flushes entering rivers and streams.

Characteristics of the Association

A number of *Molinietalia* Order species, and others of the Alliance *Calthion* occur with high constancy, some being dominants of the community. The following are the more important:-

Caltha palustris	Galium uliginosum
Glyceria fluitans	Myosotis caespitosa
Ranunculus flammula	Achillea ptarmica
Juncus articulatus	Epilobium palustre
J. effusus	Pellia epiphylla
J. acutiflorus	

Taller herbs such as Filipendula ulmaria, Crepis paludosa, Cirsium palustre, Senecio aquaticus, S. jacobaea and Dactylorchids give tone to the Association in summer and below these is a colourful carpet of Caltha, Ranunculus flammula, Viola palustris and Myosotis species.

Two Sub-associations have been distinguished which differ both in canopy cover and in a further group of herbs and bryophytes

(i) *Sub-Association typicum*

Alnus is here the canopy cover with differentials of Dactylorhiza fuchsii and Mentha aquatica. The community is developed on deep alluvial mud along the borders of drainage channels, the alluvium varying from 2, to as much as 8 dm. in depth. Herb cover is denser but bryophytes not as abundant as in the other Sub-association.

(ii) Sub-association Salico-Betuletosum

This Sub-association is well differentiated by the constancy and dominance of the moss Acrocladium cuspidatum and the canopy cover Salix pentandra, birch being possibly incidental. Cardamine pratensis and Ajuga reptans are also constant. Of the companion species another dozen appear only in this sub-association, Mnium punctatum and Pellia neesiana being abundant in four Aufhahmen.

Water movement in this sub-association appeared to be connected with springs, underlying drift soil rather than stream alluvium, and the depth varied from 1.5 - 3 dm.

NITROPHILOUS GRAZED EDGE COMMUNITIES — TABLE VI/10

CLASS RHAMNO-PRUNETEA Rivas Goday & Borja Carbonell 1961

Order Prunetalia spinosae R.Tx. 1952

The scrubby woodland edge communities with Rubus, Rosa, Berberis, Crataegus, Viburnum and other shrubs of the Order Prunetalia were previously placed in the Class QUERCO-FAGETEA, see Max Moor (1960). Recently this large Class has been divided and RHAMNO-PRUNETEA becomes the overall Class for these communities with the Order name unchanged.

The communities here studied include a group of nitrophilous, partially grazed, woodland margin Associations. Many of these are heterogeneous by nature, and classification and recognition of new noda seems to have the attentions of phytosociologists at the moment. It is therefore difficult to position the communities of Table VI/10 with any certainty although if the old Alliance Prunion fruticosae R.Tx. 1952 is superseded Rubion subatlanticum R.Tx 1952 or Berberidion Br.-Bl. (1947) 1950 appear likely classificatory positions for what is a heterogeneous mixture of Prunus, Corylus, and Rosa scrub.

(i) A roughly threefold division can be made according to shrub cover and grazing indicators. These latter separate off communities which are adjacent to, or situate within, pasture or rough grazing land. A good example is the Corylus scrub of stand M12. Situated on level ground and fairly open to grazing cattle, these small islands of Corylus lose their identity as natural edge communities, which they retain when lying on steep slopes and scree (see Table VI/9 and comment). Species of the Cynosurion Alliance creep in, and woodland herbs and bryophytes are lost through trampling and manuring.

(ii) Dense stands of Rubus fruticosus agg. appear more resistant to Arrhenatheretalia species, even when the stands are isolated and separated from hedgerow or wood. In the area studied there is a surprising lack of Rubus scrub, the main constituent being Rubus idaeus and a little R. caesius, neither of which afford dense cover or competition. The single stand (P36) studied may be called an edge community, but is isolated from grazing pressures, so no inferences can be drawn.

(iii) The rest of the stands are best left as examples of mixed Rosa-Prunus spinosa scrub until more detailed studies on a wider geographical basis have been attempted. For those who compare the literature it is worth noting that Rosa glauca is synonymous with R. afzeliana and R. dumalis is a blanket name which includes both R. afzeliana and R. coriifolia. Another point to remember when comparing Association tables is that Rosa sherardii and R. villosa are northern downy roses, and that Rosa afzeliana (rather than R. canina) is the Scottish 'dog-rose'.

NATURAL/SEMI-NATURAL EDGE COMMUNITIES TABLE VI/9

1. Sorbus-Dryopteris nodum
2. Corylus-Thelypteris nodum
3. Species-poor Corylus scrub

1. Aufn. P (43, 44, 28, 29, 30) M (18, 23, 47)

This appears to be a natural edge community of northern hill woodland especially when the woodland is bounded by, or broken by, scree slopes. The nodum is poor in herbs and rich in numbers of bryophytes which are often of small cover. Sorbus aucuparia and Dryopteris are differential species of high cover. Examples of very similar stands can be seen in the Dryopteris variant of the Oxalido-Betuletum (Table VI/3) where Sorbus aucuparia reaches high cover.

N.B. In all stands containing boulders, outcrops of rock, branches and undecayed wood, only the ground flora was noted, in accordance with standard procedure. Where stands were made on boulder scree this should be taken into account, otherwise cover values would give a wrong impression.

In stands P43 and P44, for example, exposed rock occupied 70-80% of the total area (see comprehensive data in the Appendix). So when bryophyte cover is noted as low the reference is of course to the cover between boulders and not on the boulders themselves.

2. Aufn. P (46, 47, 21)

This community is well developed on natural edges in fairly humid conditions and forms a species-rich Corylus facies. Differentials of high cover are Thelypteris species and Dicranum majus. The stands were made on steep, mountain-stream banks, where the stream formed a natural boundary to the wood in question. The interesting differential species Cirriphyllum piliferum with its companions Lophocolea bidentata, Plagiochila asplenioides and Mnium undulatum should be noted.

It seems that these species prefer the rather protected, fairly moist, habitat which moderately dense Rosa-Prunus and dwarf Crataegus scrub provide. As long as there is a reasonable amount of filtered light, no trampling, and a protective, not too dense, humidifying grass cover, these species and especially Cirriphyllum appear to thrive.

Of the shrubs connected with edge communities it appears that Crataegus spreads more easily to, and is the commonest pioneer community on open ground. Crataegus is not found as often in the shade of trees,which fact is clear from the woodland Aufnahmen made in this study.

Prunus is not as important in woodland understorey, though it spreads rapidly from woodland margins by suckering and is an important edge coloniser. Prunus and Crataegus both form dense scrub in which little else will grow. A good example of this is seen in stand M37.

Corylus is a main constituent of natural edge communities and often an important dominant.

3. Aufn. M (14, 16)

This nodum is fairly common where Corylus forms dense natural edge communities on drier habitats than the Corylus-Thelypteris nodum.

Both cover and habitat tend to produce a species-poor Corylus scrub.

CLASS. No acceptable Class yet erected.

Order Dicranelletalia heteromallae Philippi 1956

The terrestrial moss communities have not yet been fully classified nor the literature co-ordinated. However Philippi (1956, 1963) erects an Order as above and an Alliance Dicranellion heteromallae of light loving communities on sunny, acid, earth-banks and sandy to sandy-clay earth exposures.

Association Nardietum scalaris Philippi 1956 TABLE VI/7

The Association is very well typified by the following pioneer bryophytes:- Nardia scalaris, Dicranella heteromalla, Ditrichum heteromallum, Polytrichum aloides, P. urnigerum. Baeomyces rufus is also an important constituent in certain early stages of the nodum and Pellia epiphylla tends to have a higher cover at the base of steep banks where there is a continual moisture supply.

The constant high cover of Diplophyllum albicans links the nodum with Philippi's Sub-association Diplophylletosum.

Aufnahmen B (44, 43, 42) are very typical of the Association and come from soil exposed after the uprooting of trees in birch wood.

Aufnahmen B (21, 32, 33) are less typical, both in habitat and species, and probably represent a successional step in recolonisation of landslip - a fragment say of some Association of Mnium hornum, Polytrichum formosum, and Dicranum scoparium. The community was found on a landslip at the base of a woodland bank. The habitat was a mixture of rather fine rock scree and soil. The higher cover of herbs points to a longer established community and bryophytes present seem to indicate a higher humus content in the soil.

A summary of two groups of Aufnahmen (Philippi 1963) is given for comparison:

Total of Aufnahmen	14	11
Assn. Character species		
Nardia scalaris	III	V
Ditrichum heteromallum	III	V
Polytrichum urnigerum	I	IV
Diplophyllum obtusifolium		III
Nardia geoscyphus	III	I
Oligotrichum hercynicum		III
Solenostoma caespiticium	I	

Differentials of Sub-assn.

Pohlia nutans	IV	I
Diplophyllum albicans	IV	I
Dicranella heteromalla	III	

Alliance & Order character species

Polytrichum aloides	II	I
Solenostoma crenulatum	I	I
Calypogeia muelleriana	II	I
Cephalozia bicuspidata	I	I
Pellia epiphylla	I	I
Lophozia wenzelii		II

Philippi reports the Association from the mountain areas of Weser, Harz and Rhön in Germany: Shimwell (pers. comm.) reports it from a shady exposed peaty stream bank in Galloway. It is probably widespread on shady upland acidic soils throughout Britain.

CLASS No class erected

Order *Diplophylletalia albicantis* Philippi 1956

All. *Diplophyllion* Philippi 1956

On the continent *Diplophyllum* seems to be more or less restricted to rocks, whereas in the more westerly climate of Britain it appears on any damp, more or less acidic, exposed surface, so it is doubtful whether the two orders are valid when applied to N.W. Atlantic vegetation.

Philippi erects the Order for most moss communities of shaded damp acidic rocks and rock crevices.

DIPLOPHYLLUM-BARTRAMIA community TABLE VI/6

The community is described from moist dolerite rock ledges and is characterised by the two bryophytes Bartramia pomiformis and Pohlia nutans. Other dominant cryptogams are Diplophyllum albicans, Mnium hornum and Dicranum majus with Cladonia species invading drier soil or decaying bryophytes. The community is probably represented in some lowland areas, as both Bartramia and Pohlia nutans grow as well on acid sandy banks. It is reported from mountain regions of Germany.

TABLE V/2

REFERENCE FRAMEWORK FOR TERRESTRIAL COMMUNITIES

(From Lohmeyer et al. (1962) as emended in Westhoff, Den Held et al. (1969).)

Cl. VACCINIO-PICEETEA Br.-Bl. apud Br.-Bl., Siss. et Vl. 1939

O. Vaccinio-Piceetalia Br.-Bl. apud Br.-Bl., Siss et Vl. 1939

All. Dicrano-Pinion (Libbert 1933) Matuszkiewicz 1962

Ass. Dicrano-Juniperetum Barkm. in litt. 1968

All. Betulion-pubescentis Lohm. et R.Tx. apud R.Tx. 1955 em. Scamoni et Passarge 1959

Ass. Betuletum pubescentis (Hueck 1929) R.Tx. 1937 em. R.Tx. 1955

Cl. QUERCETEA ROBORI-PETRAEAE Br.-Bl. et R.Tx. 1943

O. Quercetalia robori-petraeae R.Tx. (1931) 1937 em 1955

All. Quercion robori-petraeae (Malcuit 1929) Br.-Bl. 1932

Ass. Querco roboris-Betuletum R.Tx. (1930) 1937

Ass. Oxalido-Betuletum (McV. et Ratcl. 1962) emend

Ass. Thelypterido-Juniperetum (McV. et Ratcl. 1962) emend

Cl. QUERCO FAGETEA Br.-Bl. et Vl. 1937

O. Fagetalia sylvaticae Pawlowski 1928

All. Fagion sylvaticae Pawlowski 1928

All. Fraxino-Brachypodion Shimwell mscr. 1968

Ass. Sorbo-Brachypodietum nov. ass.

(Sorbus-Dryopteris nodum)

(Corylus-Thelypteris nodum)

(Westhoff & Den Held place the O. Prunetalia spinosae in a new Class as below)

Cl. RHAMNO-PRUNETEA Rivas Goday et Borja Carbonell 1961

O. Prunetalia spinosae R.Tx. 1952

All. Prunion fruticosae R.Tx. 1952
(nitrophilous grazed-edge communities)

(Rosa-Prunus spinosa nodum)

(Rubus scrub community)

All. Potentillion fruticosae Shimwell 1968

Ass. Potentilletum fruticosae Shimwell 1968

All. Rubion subatlanticum R.Tx. 1952

All. Salicion arenariae R.Tx. 1952 em. Boerboom 1960

Ass. Squarroso-Juniperetum Barkman in litt. 1968

Cl. NARDO-CALLUNETEA Preising 1949

O. Nardetalia (Oberd. 1949) Preising 1949

All. Eu-Nardion

All. Violion caninae Schwick (1941) 1944 em. Preising 1949

(syn. Nardo-Galion saxatilis Preising 1949)

Ass. Molinieto-Callunetum McV. & Ratcl. 1962

Cl. MOLINIO-ARRHENATHERETEA R.Tx. 1937

O. Molinietalia W.Koch 1926

All. Calthion palustris R.Tx. 1937 em. 1951

Ass. Caltho-Alnetum nov. ass. prov.

O. Arrhenatheretalia Pawlowski 1928

All. Arrhenatherion elatioris Br.-Bl. 1925

All. Cynosurion R.Tx. 1937

All. Ranunculo-Anthoxanthion (Gjaervoll 1956) emend.
Shimwell 1968

Ass. Agrosto-Festucetum McV. & Ratcl. 1962

Cl. MONTIO-CARDAMINETEA Br.-Bl. et R.Tx. 1943

O. Montio-Cardaminetalia Pawlowski 1928

All. Cardamino-Montion Br.-Bl. 1925

Sub-All. Cardaminion (Maas 1959 prov. all.) Den Held & Westhoff 1969

All. Cratoneurion W. Koch 1928

Cl. No Class erected yet

O. Dicranelletalia heteromallae Philippi 1956

All. Dicranellion heteromallae Philippi 1963

Ass. Nardietum scalaris Philippi 1956

O. Diplophyllietalia albicantis Philippi 1956

All. Diplophyllion Philippi

Chapter 18

Epiphytic Communities.

The epiphytic communities were analysed in the same way as the ground flora, certain modifications being made as the work proceeded.

(a) The area under discussion was selected as a representative type of Northern relic woodland rather than as a source of rich epiphytic communities. Very few large, old, deciduous trees (apart from Betula) were present and consequently typical stands of more than one or two epiphytic Associations were hard to find. Nevertheless the comprehensive tables reveal the presence of a number of fragmentary Associations and stands which may belong to communities as yet undescribed. It was thought best to present these fragmentary and unresolved Associations in a number of comprehensive tables rather than try and force them all into the classification outlined in Barkman's classic work (1958). In this way the individual Aufnahmen may be of more use to future British workers who are studying a larger geographical area.

(b) The first epiphytic survey revealed a large proportion of evidently mixed stands. Some of these were rejected but many were re-surveyed and divided in the field. This proved relatively easy in the light of experience, as a preliminary analysis of the data showed that often too large an area had been chosen for each sample plot. The birches in particular presented a much smaller surface area than the oaks, hornbeams, elms and beeches mentioned in continental literature and many of the preliminary Aufnahmen proved to be a mixture of two closely allied Associations.

This was especially noticeable on lower tree boles where an analysis of the data showed the presence of both Isothecion and Dicrano-Hypnion Alliances along with the Association Leucobryo-Tetraphidetum.

A closer inspection of the individual trees revealed very often a mosaic, large enough in pattern to be separated into its constituent units by microhabitat. By a judicious movement, and sharper focussing as it were, of the sample plot areas, the individual units of the mosaic were discernible. A shift of 1 or 2 decimetres vertically for example was often sufficient to delimit the Isothecion from the Dicrano-Hypnion communities, whereas the Leucobryo-Tetraphidetum could be separated on areas of the lower bole and roots where humus and old or rotting bark were present.

In the following summary Barkman's monograph (1958) is referred to many times but, as it is the only work of that author referred to in the text, the date is not cited on every occasion.

Epiphytic Algal Associations

These were not studied in detail but a number of stands of Pleurococcetum vulgaris were encountered in the survey and a few are included in Table VI/11. The best stands were seen on the bole and roots of a very large, luxuriant yew. Here there was intense shade and evidence of sheltering birds and sheep with consequent nitrogen enrichment of the bark.

Other examples of the Association were noted in dense Juniper thickets. Here there was a fairly clear cut transition between the upper branches which supported Lecanora conizaeoides or Parmelia physodes communities and the deeply shaded boles on which nothing but a green algal layer was apparent.

Epiphytic lichen communities

Order LEPRARIETALIA Barkman 1958 TABLE VI/11

Continental character species

Lepraria chlorina, L. candelaris, L. incana.

Ecology

The Order is one-layered, consisting of crustose, often serediate, or purely leprose lichens. The constituent species appear all to dislike direct precipitation (ombrophobous), and nitrogen enrichment (nitrophobous), and can withstand a fair degree of shade. Opinions vary as to whether the Order is photophobous as some of the constituent Associations seem to frequent and even to thrive in areas where there is plenty of diffused light but no direct sunlight. Typical habitats are rock overhangs, the undersides of inclined trees, bark fissures and partly shaded tree boles.

Alliance Calicion hyperelli Hadač 1944 emend Barkm. 1958

(Calicion viridis) TABLE VI/11

Synonymy: Leprarion Almborn 1948, Klement 1955, Laundon 1956

Character species

Those of the Order plus Calicium viride (= C. hyperellum).

Ecology

The Alliance is differentiated from related epilithic communities of leprose lichens by the presence of many purely corticolous species i.e. most of the family Caliciaceae, which includes the genera Coniocybe, Calicium and Chaenotheca. The ecology is the same as that of the Order, with an additional factor, that most communities thrive best where atmospheric humidity is reasonably high (i.e. they are aerohygrophilous).

Association Leprarietum Almborn 1955

Barkman does not distinguish a species-poor association of Lepraria incana though he mentions the fact that the Calicion hyperelli is very fragmentary in the Netherlands, often being represented only by sociations of Lepraria candelaris and L. aeruginosa (= L. incana).

Laundon in his enumeration of the corticolous lichen federations of Northamptonshire (1956) and in his lichen flora of London (1967) recognises the fact that, in urban areas and other parts of the "lichen desert", many communities are extremely species-poor, and he gives these communities Union (= Association) status, using the names of Almborn (1955).

This seems quite reasonable and points supporting the practice will be enumerated in the following discussion (Part V).

Certainly, in the field, these species-poor communities have a recognisable ecological niche. Table VI/11 contains plots B50 to J 35 inclusive, also M98, J30 and J16 which consist almost entirely of one species Lepraria incana. Host trees include Taxus baccata, Juniperus communis, Betula pubescens, Corylus avellana, Ulmus glabra, Prunus padus, Fraxinus excelsior and Sorbus aucuparia. It will be seen that the undersides of inclined tree boles and even of the larger branches are a common habitat. Aufn. J30 was recorded at 180° i.e. on the undersides of the larger, very shaded, horizontal branches of an isolated Prunus padus. M98 was situated on the underside of a large elm bole with a slope of 120°. Such sites are quite free from direct precipitation, which is either absorbed by mosses on the upper side of such boles and branches, or deflected by rough bark to other areas.

Distribution

The Association is widespread in the British Isles, particularly in the Eastern region, and often in the vicinity of towns where most other epiphytes have been destroyed by pollution. Hawksworth & Rose (1970) have produced a "Qualitative scale for the estimation of air pollution .... using lichens epiphytic on non-eutrophiated bark". Zone 3 of this scale with 125 milligrams of SO_2 per cubic metre of air is recognised in the field by "having Lecanora conizaeoides extending up the trunk and Lepraria incana frequent on tree bases."

The very species-poor facies of the community is noted in Derbyshire by Hawksworth (1969) on shaded walls and at the bases of trees (esp. rough barked Quercus). Lepraria incana is always dominant in such situations and often the only species present.

Barkman recognises an exactly similar situation throughout the Netherlands though he calls the community a "Calicion fragment". Here Lepraria incana is found on all kinds of trees, particularly Quercus, Fagus, Betula, Ilex and conifers in shady and dry habitats. In marshy woods the lichen is frequent on the lower side of oak trees, tolerating dense shade and an inclination of up to 180°.

Almborn (1948) describes another related community which appears to be a 'species-rich' version of the Leprarietum. This he names the Opegraphetum fuscellae with a distribution on old elms, and often consisting only of three species - Opegrapha fuscella, Lepraria incana and green algae.

It is possible that the Association may be found in Britain in unpolluted areas as Opegrapha fuscella has a very similar ecological range to that of Lepraria incana. Almborn notes it on various kinds of deciduous trees, often growing in crevices of rough bark and preferably near the ground.

The British distribution of this species (now named Opegrapha vermicellifera) is given by Duncan (1970) as - trees, especially shaded bark of elm, rather common!

Previously this Opegrapha was little known in Britain, being treated by A.L. Smith (1926) under O. vulgata, but it may have been overlooked in many areas as it often appears in the sterile state.

The taxonomic position and even the composition of the Opegraphetum fuscellae is less certain in the Netherlands. Barkman notes species both of the Graphidion and Buellion in its composition. As the Association was found there only three times, no conclusions can be reached.

Association Xylographetum parallelae Šmarda 1940 TABLE VI/11 (J44)

Synonymy: Cyphelium tigillaris Klement 1955

The Association was noted by Klement on decorticated stumps and fashioned wood in the montane and subalpine zones of Czechoslovakia, Germany and Austria.

As the species Xylographa abietina (= X. parallela) had been pointed out to the author in the Teesdale Juniper scrub a further search was made and two small colonies seen. These were combined in one Aufnahmen (total area 10 sq. cm.) J44. Other species present were Lecanora conizaeoides, Cladonia coniocraea and Parmelia physodes. The habitat was decorticated Juniper.

The small stand is no doubt a fragment of the above association.

Association Calicietum hyperelli Hilitzer 1925 TABLE VI/11

Synonymy: Lecanactidetum abietinae sensu Klement 1955 p.p.

Barkman gives numerous combinations of faithful species from different parts of Europe but more records are needed before a valid set of character species can be made. A favourite position is on the underside of sloping trees, Quercus, Acer pseudoplatanus and various conifers.

In the present survey the stands noted were again fragmentary but undoubtedly belong to the Calicietum hyperelli. Host trees were Betula pubescens and Fraxinus excelsior. Slope varied from 110° to 140°. All the stands were in sheltered positions, free from any direct drying by the sun's rays. M8 was situated near a mountain stream, not in the spray zone but low enough in a ravine for atmospheric humidity to be high.

In Britain the Association is probably widespread, the author has seen it in N. Yorkshire, Durham, Northumberland and various parts of Scotland.

Association Chaenothecetum melanophaeae Barkm. 1958 TABLE VI/11
(Chaenothecetum ferrugineae)

Character species Chaenotheca ferruginea.

Two good stands of this Association were noted, each with an easterly exposure on rough flaking bark of Betula pubescens.

Chaenotheca ferruginea is a pioneer lichen of rough barked trees, a particular habitat being the underside of sloping trees. In company with other members of the Leprarietalia this species dominates habitats from which seepage water, as well as direct rainfall, is absent or deflected. Barkman remarks on the very narrow ecological amplitude of the Association, which in his ponderous English is classified as:- aerohygrophytic and photophytic but anheliophytic. In such a narrow ecological niche it is not surprising to find few species in this Association. Often, as in the Aufnahmen listed, it consists of one or two species; a thick grey sterile thallus stained by rusty or fawn patches (Chaenotheca ferruginea) together with the lighter grey and more loosely woven hyphae of Lepraria incana.

In the Netherlands the Chaenothecetum melanophaeae is restricted to such specific habitats as (1) the north edge of woods bordering on marshes, bogs, rivers and streams; (2) the S.W. edge of forest glades, where it occupies the N.E. side (most illuminated) of trunks. Sometimes there is even a choice between fissure or bark plateau according to the humidity of the surrounding air.

In Britain the Association appears to be restricted to the east. Laundon (1956) notes it on the shaded north side of old oaks throughout the woods on Bookham Common, Surrey; Hawksworth (1969) gives one locality for Derbyshire, (eastern side of one Quercus robur) and speaks of a few more fragments in the county. The author has seen it in North Yorkshire, Durham and East Northumberland.

Chaenotheca species are more susceptible to pollution than the common *Lepraria*, so the Association is retreating from otherwise suitable localities in industrial areas in favour of the *Leprarietum*. Hawksworth & Rose (1970) place it in Zone 4 of their pollution scale, indicating a tolerance of about 70 milligrams SO_2 per cubic metre.

O. LECANORETALIA VARIAE Barkm. 1958

With only one Alliance in this Order, ecology and character species are the same.

All. *Lecanorion variae* Barkm. 1958

Synonymy: *Lecanorion subfuscae* (Ochsner 1928) sensu Klement 1955 p.p.
Lecanorion conizaeae Duvigneaud 1942 ?
(inclusive of *Conizaeoidion* Laundon 1956)

Character species

Lecanora varia and *f. pityrea* (= *L. conizaeoides*), *L. dispersa*, (incl. *L. hageni* and *L. umbrina*), *Lecidea symmicta*, and *Lecania cyrtella*.

There has been considerable misunderstanding, confusion, and even misidentification in this section of the *Lecanora* complex, so it is not surprising that the true ecological picture is a very recent one. The older literature needs to be approached with caution if any attempt is made to build up a phytosociological pattern from it.

The Alliance *Lecanorion variae* comprises three Associations, two of which are able to penetrate urban areas and exist in places of high atmospheric pollution - even in Zone 2 (Table 1) of Hawksworth & Rose (1970). Barkman's diagnostics of the Alliance are:- strongly acidiphytic, aeroxerophytic, ombrophytic, photophytic, heliophytic and toxitolerant.

The *Lecanorion subfuscae* is found on dead, dry wood and bark of various trees as well as on living trunks of *Quercus*, *Betula* and conifers. It consists mainly of crustose orsquamulose lichens.

Association Lecanoretum pityreae Barkm. 1958 TABLE VI/13

(Lecanoretum conizaeoidis)

Synonymy: Lecanoretum conyzaeae Duvign.1942 n.n. ?

Character species: Lecanora conizaeoides (= L. varia f. pityrea)

Differential species: Lecanora expallens, L. chlarona

The Association was first described in Britain (as Federation Conizaeoidion with only one Union) by Laundon in 1956. He notes it throughout Northamptonshire, often dominated by the single species Lecanora conizaeoides. In his Lichen Flora of London (1957) the same author gives extensive ecological notes on the Federation which is almost ubiquitous in the Metropolis, spreading as far as the Inner Urban Ring, and absent only from the City itself. In the pollution indicator table referred to previously (Hawksworth & Rose 1970), Lecanora conizaeoides is shown as present in Zone 2, along with Pleurococcus viridis, and is thus able to withstand an atmospheric pollution of 150 milligrams of SO_2 per m^3. The Association is therefore, in urban areas, composed of one lichen with the green algae complex as sole companion.

An analysis of some of the stands of Table VI/13 serves to underline the salient features of the Association in less polluted areas.

Aufn. P58, P59, P60

taken in Park End wood on two birch trees conveniently uprooted by a gale. Ten twigs of roughly equal circumference were selected, and lengths of 2-10 dm. marked off as the stand area, which was thus easy to calculate. An Aufnahme was made and the process repeated at various intervals from the topmost twigs (at 120 dm.) to the lower branches. The Aufnahmen appear, after sorting, in various Association tables. A similar situation was met, and dealt with, in Mill Beck Wood (see M88, Table VI/17).

The following table shows the zonation of various epiphytes on two of these birch trees.

Species	Max. height attained in dm. (tree 1. 120 dm.)	Max. height (tree 2. 130 dm.)
Lecanora conizaeoides (+ a little L. chlarona)	110 - 120	115 - 130
Parmelia physodes	110	115
P. saxatilis	90	90
Cetraria glauca	80	85
Hypnum cupressiforme	70	70
Lepraria incana	50	50

On most of the birches examined, it was found that Lecanora conizaeoides was abundant on the uppermost half of most of the smaller and higher twigs. The only other species present (apart from a little Lecanora chlarona) above 60 dm. were Parmelia physodes, Parmelia saxatilis, and Cetraria glauca.

Aufn. J6, B43, B31

A parallel situation (though on a smaller scale) was noted on Juniperus communis. Outer twigs and branches supported only Lecanora conizaeoides (with Pleurococcus spp. in areas of high humidity - shade and rain tracks), then came members of the Parmelion saxatilis Alliance, with bryophytes only on lower bole and tree base. On this smaller scale (spectrum length 2 - 3 metres) the succession was obvious in one glance. In the Association tables it can best be seen by studying Table VI/13 alongside Table VI/14.

Examples of the Association are given on Betula pubescens, Juniperus communis, Prunus padus, Alnus glutinosa, Sorbus aucuparia, and Crataegus monogyna. Stands were noted on Fraxinus and Corylus

(Table VI/17) but other Lecanora species soon invade these smooth barked trees, changing the structural pattern and altering the successional direction.

Laundon (1956) notes that Lecanora conizaeoides is often replaced on boles of rich-bark trees such as ash and elm by L. expallens, and Barkman echoes this observation in the Netherlands. Indeed the latter author considers that the Lecanoretum pityreae is the strongly acidi- and toxitolerant counterpart of the Lecanoretum carpineae, which includes the Lecanora communities of neutral and rich-bark trees. Some observations on this Association are made in the review of Table VI/17.

Ecological summary

The Association Lecanoretum pityreae is the closest to the Pleurococcetum in growth form, species structure and ecological position. It succeeds this algal Association when conditions are favourable and is in turn succeeded by the Parmelion or the Lecanoretum carpineae.

It is a rapid coloniser and pioneer association on smooth bark: on rough-bark trees (Quercus spp.) it prefers the smoother twigs. In dry sites due to lack of competition this Association can colonise the boles of rough-bark trees. It can even colonise the bark 'plateaux' of the strongly resiniferous Pinus sylvestris.

Yet the Association is neither truly acidiphilous nor xerophilous. It seems rather to establish a hold on any site to which other lichens (owing to pollution) cannot penetrate and its habitat range, outside polluted areas, is evidently controlled by the competition of stronger epiphytes.

With a wide illumination tolerance, the Lecanoretum pityreae may be found in sunny sites, though it prefers some shade (especially as an epilithic community) and can withstand dense shade.

Another factor in its widespread distribution is its nitro-tolerance: able to withstand low concentrations in semi-natural woodland, it can also exist on roadside trees that are highly impregnated with nitrogenous products.

Distribution

Distribution in polluted areas is well dealt with by Laundon (1967), for the situation in London is a reflection of that in other conurbations.

Owing to its very wide ecological amplitude the Association is found in most areas where there is no serious competition. In Britain it is abundant over almost the whole of England except the S.W. coastal areas, extending into Scotland as far north as Perth. It is absent only from highland areas of Wales, all north Scotland and most of Ireland.

In the area studied, which is on the fringe of Zone 8 of the pollution scale already mentioned, Lecanora conizaeoides can still be found in abundance. It enters into the composition of every Association encountered and is only absent in stands of dense bryophytic cover.

Association Psoretum ostreatae Hilitzer 1925 TABLE VI/12

(Lecideetum scalaris)

Synonymy: Lecidea ostreata - Assoziation Schulz 1931

Psora ostreata - Geselschaft Mattick 1937

Lecideon ostreatae Laundon 1956

Character species: Lecidea scalaris (= Psora ostreata)

Differential species: The list of species given for the Netherlands consists mainly of Cladoniae; C. macilenta, C. chlorophaea, C. coniocraea, C. pyxidata.

The Association was found mostly on Betula (one stand on Sorbus aucuparia), on dry sloping undersides, and with a tendency to an easterly exposure. Barkman notes that in the hot and dry microclimate which it prefers, the Psoretum ostreatae favours the windward, upward side (83°) of a tree bole.

In areas where the respective trees are available the Association is common on oak and pine boles. Hawksworth (1969) notes it in Derbyshire, in fragmentary form only, on old oak boles. Laundon (1956) points out that this Association often colonises decorticated wood when lichens of other communities have fallen off with the bark. Lecidea granulosa is a common associate in Northants. (cf. Aufn. B35).

The stands of Table VI/12 were all associated with flaking bark, two being concentrated around large vertical fissures. On the one hand there is a shading of the Association into the Parmelion saxatilis, on the other, evidence that Lecidea scalaris can smother Lecanora conizaeoides in areas of low toxicity.

The presence of Cladonia species in some stands, especially on dry stumps and tree bases is a link with the Cladonion Alliance which is recognised by Laundon (1958) but passed over by Barkman.

On the continent there is a universal preference of the Association for conifers (Barkman 1958) followed by oak and birch, especially dead and dry logs, and even fences.

O. ARTHONIETALIA RADIATAE Barkman 1958

Synonymy: Lecideetalia parasemae Klement 1947 p.min.p.
Graphidetalia scriptae Mattick 1951 p.max.p.

This Order comprises pioneer Associations of abundantly fertile crustose lichens on smooth living bark of various trees. Unlike the Lecanoretalia variae, which has a large proportion of leprose or sorediate lichens in its constitution, the Arthonietalia consists mainly of non-leprose species. The constituent Associations are ombrophilous, more mesophytic, light loving, and much less toxi-tolerant than those of the previous Order.

Two Alliances are given by Barkman, the Graphidion of more shaded trees and the Lecanorion carpineae of more open habitats.

All. Graphidion scriptae Ochsner 1928 em. Barkm. 1958

TABLE VI/16 Pl-M70

Synonymy: Lecanorion subfuscae Klement p.p.

The Alliance is found on most smooth barked trees, Fagus, Corylus, young Fraxinus, Ilex, Abies, Alnus, Sorbus, etc. However, not only is it toxiphobous but strongly nitrophobous, suffering greatly from human activity.

In Britain the Graphidion occurs in south and west England and Wales, south west Scotland and throughout Ireland. The Alliance is absent from north and east Scotland, "where the climate is probably too severe" (Laundon 1958), most of the midlands and eastern England. From old records of the component species Laundon concludes that the Alliance was perhaps common in the Midlands until about 1900.

A single specimen of Graphis elegans was found on Bookham Common, Surrey, in which county a few scattered localities of the Graphidion still persist.

It is interesting to note also a single specimen of Graphis elegans in the area surveyed. However Table VI/16 shows from the character species, Arthonia radiata (plentiful) and Lecidea limitata (one record) that the Order is present, and other character species of the Graphidion indicate that this Alliance is present. It is possibly better to call it a vicariant Alliance, at the extreme eastern range of the Graphidion rather than term it a fragmentary portion of the Graphidion.

As there is little data in Britain about communities of this Alliance it seems best to leave the Aufnahmen Pl - M70 in one table, noting at the same time their relationship with the Pertusarietum amarae Hil. 1925 em. Barkm. 1958. This group of Aufnahmen differs from group M63-M78 mainly in the presence of sorediate Pertusaria and Ochrolechia species and the absence of Lecanora chlarona, L. chlarotera and Arthonia radiata.

The stands in this second community group are also situated on the mid boles of larger and older trees, where they find a fuller expression than do the stands of the first group which are common on Corylus avellana.

Barkman's related Association, the Pertusarietum, is unsatisfactory, for as he himself says, "evidently the Pertusarietum amarae is best developed in S. Scandinavia .... and least in the Netherlands." The Scandinavian lists of Almborn (1948) are in fact a much closer parallel with those made in Teesdale than anything in Barkman. Further work needs to be done on these communities in Britain before any conclusions can be drawn.

All. Lecanorion carpineae (Ochsner 1928) Barkman 1958 TABLE VI/16

Synonymy: Lecanorion subfuscae Ochsner 1928, Klement 1955 p.min.p.

Character species: Lecanora carpinea, Lecidea limitata (= L. olivacea)

Differential species: Lecanora chlarona, Buellia punctata, Xanthoria parietina.

It is unfortunate that there was so much confusion surrounding the aggregate species Lecanora subfusca, for, had the components been fully known and recognised, and their taxonomic status clarified, it is certain that the lists of Ochsner and Klement would have been more acceptable to Barkman and might have altered his conception of the Alliances within the Arthonietalia.

Certainly the Danish lists align more easily with British records within this Order.

Laundon (1958) follows the Danish school in describing a new Federation which he styles the Olivaceion, more or less synonymous with Ochsner's Lecanorion subfuscae. Unfortunately (a) Laundon uses Danish terminology and (b) Lecidea olivacea is now known as L. limitata, so his terminology is unacceptable to the Z.-M. school. A possible name for Laundon's Alliance would be the Lecideion limitatae.

The nodum, as described by Laundon, is a photophilous Federation on smooth bark, especially ash, the main constituents being Lecidea limitata, Arthonia radiata, Arthopyrenia punctiformis, Lecanora chlarotera, L. confusa and Opegrapha atra.

It is common in south and west coastal districts of Britain, throughout Ireland and at low altitudes in parts of north Scotland usually in less shaded areas than the Graphidion.

In Table VI/16 an Association provisionally named the Parmelio-Lecanoretum chlaronae is recognised as a secondary community of smooth bark, especially small branches of Corylus and Fraxinus. The Association is typified by the presence and high cover of Lecanora chlarona and Parmelia glabratula, with high cover values also for the Order character species Arthonia radiata. In areas further south and west Lecidea limitata and Lecanora chlarotera no doubt play a greater part in the Association.

The high cover of the dominants limits the performance of Lecanora conizaeoides, but species from the Parmelion saxatilis succeed, and overrun the Association when light and humidity requirements are met.

The typical Association appears to flourish best in dense thickets of Corylus, where direct light is rather restricted, and in these conditions it appears to remain stable.

Laundon notes Lecanora chlarona on young Fraxinus branches, in his notes on the Physodion, a further pointer to this stage being a step in the succession to Parmelietum furfuraceae.

Lecanoretum carpineae community TABLE VI/17

Characteristics of the nodum

At first sight the Aufnahmen of Table VI/17 appear very similar to those of VI/16, but on closer inspection two points emerge:

(i) The community presented in Table VI/17 is more of a pioneer, containing no Parmelia glabratula and no Pertusaria species. Lecanora conizaeoides is common, and often dominant, and exists side by side with this pioneer Association which we have related to the Lecanoretum carpineae complex.

(ii) The stands of the community are quite varied as regards host-tree species and can evidently withstand light, open, dry situations. Aspect can be rather misleading when applied to canopy branches, and it should be stated that most of the Aufnahmen were on trees whose canopy was open to the south.

The community was seen on Fraxinus, Sorbus aucuparia, Betula pubescens and Corylus.

Succession appears to be in two directions:

(a) As the trees mature the Parmelion saxatilis becomes dominant on the upper bole and branches and somediose Ochrolechia and Pertusaria spp, gain a hold on the middle bole.

(b) In mature Corylus scrub, or on single Corylus trees in shade, the Lecanoretum carpineae passes over to the Association we have provisionally named the Parmelio-Lecanoretum chlaronae, with Arthonia spp. Parmelia glabratula and others adding to the new species composition.

The nodum does not clearly fit either of Barkman's Associations i.e. the Lecanoretum carpineae montanum and the Lecanoretum carpineae atlanticum but appears to come somewhere in between, perhaps Assn. typicum! Barkman is of course using Klement for much of his information and it might be better to go back to Klement for guidance on the nodum. Unfortunately Klement's name is invalid but his description of the nodum tallies fairly well with that of the Aufnahmen in Table VI/17.

Being photo- and xerophytic the nodum prefers fairly open situations. A very high proportion of the component species is regularly found fruiting, whilst sorediate species are usually absent. The species belong for the most part to the Lecanoraceae or the Lecideaceae.

Characteristic habitats in Britain seem to be smooth to neutral bark of various trees, especially Corylus and Fraxinus, but also Fagus, Prunus and Sorbus. Laundon (1956) refers to certain species of the smooth bark of immature trees - Lecanora chlarona, Pertusaria amara and Parmelia subaurifera, but discusses them within the Physodion Alliance.

O. PARMELIETALIA PHYSODO-TUBULOSAE Barkm. 1958

Synonymy: Usneetalia Mattick 1951

Usneion barbatae Ochsner 1928 sensu Barkman 1954

Physodion Du Rietz 1945, Almborn 1948, Laundon 1956

Character species: Parmelia physodes, P. tubulosa, P. furfuracea, Cetraria glauca, Alectoria fuscescens, Usnea hirta, Usnea subfloridana, (= U. comosa).

This Order has been studied in many parts of the continent and comprises the most complicated and highest developed epiphytic Associations of Europe. Most are three-, some four-layered. The predominantly grey aspect of the whole Order is in sharp contrast with the brown-grey-white-green-yellow Alliances of the Xanthorion.

Barkman characterises the Order as strongly acidiphilous strictly nitrophobous and toxiphobous, photophytic and ombrophilous. He states that the Order is never found on the lower side of slanting boles and stout branches. This is undoubtedly true as a general statement, but the present survey has shown that in open situations where the Parmelietalia is extremely vigorous, a luxuriant growth of this Order may completely cover branches up to 1 dm. in thickness and spread twothirds of the way round thick tree boles, at least to an inclination of 110°.

Further details will be discussed under the Alliance or Association in question.

All. Parmelion saxatilis Barkm. 1958

Synonymy: Usneion barbatae Ochsner 1928

Cetrarion pinastri Ochsner 1928

Character species: Parmelia saxatilis, Cetraria chlorophylla, Parmeliopsis ambigua.

Foliaceous lichens are dominant and the fruticose layer is weakly developed in this Alliance: it is probably the most xerophytic and photophytic of the Order.

Ass. Parmelietum furfuraceae Hil. 1925 sensu Ochsner 1928

(Pseudevernietum furfuraceae) TABLE VI/14

Character species: Parmelia furfuracea, Parmelia tubulosa, Cetraria chlorophylla, Parmeliopsis ambigua, Usnea hirta.

This is without doubt the dominant epiphytic Association in the area. It can be found in some form or other on almost every tree, certainly on every species of tree, and extends down the boles into bryophyte and Cladonia communities and upwards into the Lecanoretum pityreae. Only the most shaded and moist habitats are free from it and even there, the odd specimen of Parmelia physodes can usually be found.

The typical species-poor variant of the Association consists of Parmelia physodes, Cetraria glauca, and Parmelia saxatilis. Examples can be seen in the table, from Aufn. J32 onwards, some extending into the Scopario-Hypnetum filiformis at 2 dm. and others admixed with Lecanora conizaeoides at 10 dm. and over. Examples from the Birch Wood (B stands) appear to be less frequent, but this is simply because enough Aufnahmen were already to hand and it was pointless adding another 50 or so (which could quite easily have been done).

The best stands were on the upper sides of slightly sloping trunks, though as has already been pointed out, rich communities could be seen spreading round to the undersides of well lit trunks.

Owing to the small to medium girth of many trunks, care had to be taken in selection of stands. Barkman stating that this is the best studied Association in Europe instances the 1487 records made of it by Hilitzer. Unfortunately many of the earlier phytosociologists used fixed heights and areas for their stands producing lists which are very mixed in composition, so that from Hilitzer's total of 1487, Barkman can only distinguish 86 typical records of the Parmelietum furfuraceae.

The extreme height to which the Parmelietum furfuraceae ascends was noted on fallen birches, 9 metres being the usual limit for the full Association, with Parmelia physodes persisting to 11 metres. (Barkman notes 11m. in the Netherlands and 15m. in Brandenburg.)

The list of host trees will not be given here. It is sufficient to say that every species mentioned in the legenda of tables should be included. Fraxinus supports only one Aufnahmen in the table but this is mainly because the richest bryophyte and lichen communities were situated on the lower boles of the few larger trees (including Fraxinus) and the Parmelion saxatilis Alliance was usually out of reach.

Numerous Sub-associations and varieties are distinguished by Barkman. In the present work the Assn. table shows the various facies clearly but further British studies are necessary before the true hierarchical position of each can be decided.

The species poor facies of the Association has already been referred to.

The remaining Aufnahmen can be clearly divided into (i) a typical facies or Sub-association, where Parmelia furfuracea is present, sometimes with fairly high cover; (ii) a species-rich variant with rich and partly exclusive facies of Alectoria fuscescens, Usnea subfloridana, Cetraria chlorophylla and Parmelia tubulosa.

A rather anomalous variant was found on Juniperus communis and Taxus baccata with Mycoblastus sanguinarius as a differential. The latter stands were situated near flush or marshy vegetation, suggesting a fairly high atmospheric humidity all the year round.

Distribution

The Association is widespread in Europe especially in the montane-subalpine zone and absent only from the mediterranean, dry Eastern, and hyperatlantic regions.

In Britain also the Association is widespread. Laundon (1956, 1958) notes it in Northamptonshire and Surrey, Hawksworth reports it as present in Derbyshire, especially in steep-sided dales and ravines. In the east and in industrial areas the Parmelietum furfuraceae persists in microhabitats particularly those protected in some way from atmospheric pollution.

In Scotland the Association is rich in many areas, fruticose lichens sometimes exceeding the cover of the main character species. The western range of the Association is limited by humidity and it gives way to the Parmelietum trichotero-scorteae in Oceanic climatic districts.

All. Cladonion coniocraeae (Duvign. 1942; Laundon 1956)

This Alliance receives only a brief mention from Barkman who considers it under the Usneion florido-ceratinae. However he does say that "the great number of Cladonia spp. places this Association outside the scope of the Alliance and links it up with the Cladonion coniocraeae of Duvigneaud" when he discusses the Cladonieto-Usneetum tuberculatae. Observations in Britain lead one to believe that Laundon is correct when he retains the Federation (Alliance) of

Duvigneaud.

Association Cladonietum coniocraeae Duvign. 1942 TABLE VI/15

The Association is frequent on the bases of trees and especially old stumps. The character species are a group of common Cladoniae of which C. coniocraea is usually dominant.

Other constituents of the Association in well developed stands are Lecidea granulosa, L. scalaris, L. uliginosa and Lepraria incana. The variety of Cladonia species seems to depend on the age and humidity of the stump as well as the main climatic region. In the east of Britain Cladonia coniocraea is often the only species present, further west Cladonia macilenta, C. squamosa and C. polydactyla reach higher cover values. C. fimbriata seems to be best developed on well rotted wood, or in areas of higher rainfall. Certain Cladoniae develop best where there is a light covering of soil or humus present, notably C. chlorophaea and C. pyxidata.

Although best developed on lower boles and stumps the Cladonietum coniocraeae can develop at higher levels. Hawksworth (1969) notes it at 3.5 m. on Fraxinus in the limestone dales of Derbyshire.

In the present survey hardly any stumps were encountered, but some quite well developed stands of the Association were seen on tree bases, mainly between 1 and 5 decimetres up the trunk. The stands were made on Alnus glutinosa, Betula pubescens, Sorbus aucuparia, Juniperus communis and Taxus baccata.

It is worth noting, when comparing cover values, that Cladonia ochrochlora and C. polydactyla are considered by some authorities to be only fully developed forms of C. coniocraea and C. macilenta respectively.

The Association is certainly widespread in England and Scotland.

EPIPHYTIC BRYOPHYTE COMMUNITIES

Rich bryophyte communities, and the ubiquitous Parmelion saxatilis lichen Alliance, do not usually go together. At least, if this widespread lichen Alliance descends below a tree crown, it means that the microclimate is unsuitable for luxuriant bryophytes at any distance up the trunk.

This means, regionally, that most oceanic bryophyte communities are absent, and locally, that the microclimate is unsuitable for most bryophyte communities save on a few old sheltered trees. However the Association tables showed evidences of two reasonably well developed communities, another rather fragmentary Association, and a fourth fairly rich, but mixed, community.

O. LOPHOCOLETALIA HETEROPHYLLAE Barkm. 1958

This Order consists of acidiphytic associations usually connected with rotten logs, stumps and moist tree bases. Character species include Lophocolea heterophylla, Tetraphis pellucida, Lepidozia reptans, Orthodontion lineare and some Plagiothecium and Isopterygium species.

There are two Alliances, one of which includes communities of very acid, rotten, decorticated logs and stumps in damp woodland and need not be considered here.

All. Tetraphido-Aulacomnion (Von Krusenstjerna 1945) Barkm. 1958

Synonymy: Tetraphidion Von Krus. 1945

This rather less hygrophytic Alliance is found in the more subatlantic and continental areas of Europe and much of eastern, central and northern Britain, and lowland Scotland, where there are suitable patches of woodland. Character species include Plagiothecium curvifolium and Aulacomnium androgynum.

A number of characteric bryophytes differentiate the Alliance, such as Pohlia nutans, Mnium hornum, Polytrichum formosum and Dicranella heteromalla. The four last mentioned bryophytes are also terrestrial, but on trees they reach their optimum development in the Tetraphido-Aulacomnietum.

Ass. Leucobryo-Tetraphidetum Barkm. 1958 TABLE VI/20

Coker (1967) believes that bark moisture, rather than tree species, is the greatest factor controlling epiphytic bryophyte communities. The stands of this Association bear witness to the assertion, for although they appear to be concentrated on Betula pubescens the one linking factor between them all is humidity. All the host trees except Taxus baccata were situated on steep banks of river or mountain-stream and the Taxus was on a flush slope not far from living Sphagnum.

Estimation of humidity at stand site is very subjective. In the present survey, the symbol 'm' was not used unless quite moderate mechanical pressure would have wrung some moisture from a sample of the vegetation. Where the stand appeared reasonably dry, but with clear evidence of water seepage at every shower, the symbol 'md' was used. It will be seen from the Association tables that this community, and the Ass. Mnio horni-Isothecietum, together, contained a large proportion of the moderately moist stands. Only one really damp stand was noted in this whole survey, which stand received spray continually from a small waterfall.

The Leucobryo-Tetraphidetum is well characterised by its character species. Locally these are fairly constant - Tetraphis pellucida, Dicranum scoparium, Lophozia ventricosa and Lepidozia reptans. Leucobryum is not among them, but may need more extensive patches of woodland for its full expression. Companion species of high constancy are Mhium hornum, Lepraria incana and Lophocolea cuspidata rather than L. heteromalla. Two epilithic bryophytes were found frequently around tree boles in the area. Barbilophozia floerkei and B. attenuata and the distinguishing Cladonias appear to be C. macilenta and C. squamosa rather than C. coniocraea.

Coker (1967) notes the Association in E. Anglia, Herts., Beds., Middlesex, Essex, Kent, Surrey, Sussex, and Hampshire, "where a low rainfall does not permit the development of the more hygrophytic Blephorostomion Associations." In its fragmentary form, it is undoubtedly found in most fairly moist patches of woodland throughout eastern and northern England.

O. DICRANETALIA Barkman 1958

The component Associations of this Order are found on the bark of living trees, mainly on the middle and lower bole. Differential species with regard to the Lophocoletalia are Hypnum cupressiforme var. filiforme and Isothecium myosuroides.

All. Isothecion myosuroidis Barkm. 1958

The main character species of this Alliance, Isothecium myosuroides, is an atlantic species, so that it is not surprising that Barkman gives the distribution as "siliceous rocks and base of Quercus and Fagus in acid, deciduous woods of Atlantic Europe, with optimum development in Ireland". The writer has seen the Alliance in Devon, Wales, Shropshire, Cumberland and parts of Scotland. Three Associations have been described within this Alliance. One is a particularly hyperatlantic community with Plagiochila spinulosa and Hymenophyllum in its constitution. A third is found in various imperfect stages in the Teesdale area and is described below.

Ass. Mnio horni-Isothecietum myosuroidis Barkm. 1958 TABLE VI/19

In areas where Isothecium species are never abundant, the Association often lacks its characteristic appearance, the dark green loosely dendroid or hypnaceous mats on tree bases being replaced by a lighter green, rather crimped turf of Mnium, with various admixtures of Dicranum scoparium.

The Association is always rather poor in species and often heterogeneous, due no doubt to its proximity to the ground. It is, both by composition and habitat, somewhat intermediate between the Leucobryeto-Tetraphidetum (described from Table VI/20) and the Scopario-Hypnetum filiformis (which will be described later, Table VI/18). Coker (1967) notes that the Association is replaced on birch by Leucobryo-Tetraphidetum, and also that it is adversely affected by high levels of air pollution.

The table (VI/19) could no doubt be combined with its counterpart, (VI/20), except for the fact that great care was taken in the field to separate the two communities by habitat: and, although the Mnio horni-Isothecietum is quite fragmentary in the stands examined, it is quite devoid of the more acid-humus loving mosses Tetraphis, Lepidozia reptans and so on.

The Association is characterised in the area by typical mats of Mnium hornum and Dicranum scoparium on living wood. Care should be taken in separating rather similar epigeic communities which often encircle tree boles. When Isothecium is present the Association is clearly separated from the ground communities.

Stands in which Isothecium was present

Aufn. (B28) was made on a fairly large old Corylus bole, growing at first almost horizontally from a steep river bank where it was well shaded by ferns.

(B19) made on Betula pubescens: again growing on the steep Tees banks, in full shade from the southern sun, but well lit from the north.

(P13) made on the base of a large well shaded Sorbus aucuparia.

Barkman notes the Mnio horni-Isothecietum throughout the Quercetea robori petraeae and in parts of the Querco-Fagetea in Europe. He distinguishes two Sub-associations:

(i) with Isothecium myurum, Plagiothecium sylvaticum and

Eurhynchium praelongum var. stokesii in damp eutrophic woods.

(ii) a Sub-association of dry, acid woods sometimes without both Mnium hornum and Lophocolea heterophylla. This is the type often met with in the eastern half of England.

All. Dicrano-Hypnion filiformis Barkm. 1958

No character species are found, but there is a characteristic species combination which typifies the Alliance consisting of Hypnum cupressiforme var filiforme, Dicranum scoparium, Dicranum montanum, Lepraria incana, Ptilidium pulcherrimum and Cladonia species.

Ass. Scopario-Hypnetum filiformis (Von Krus. 1945) emend Barkm. 1958

This Association is the typical representative of the Alliance. The characteristic species combination consists of Hypnum cupressiforme, Dicranum scoparium and Dicranoweisia cirrata.

The physiognomy of this Association is unmistakeable. Smooth shiny adpressed mats of Hypnum hang from middle bole or lie draped over branch or root bastion, forming a mosaic with turfs of Dicranoweisia or Dicranum species. On the mats of Hypnum are thalli of numerous Cladonia spp. or patches of Lepraria incana. Coker (1967) calls this "the most widely distributed epiphyte association in the British Isles .... only absent where atmospheric pollution is a limiting factor to epiphytes in general."

Quite typical stands were seen in all the woods surveyed.

A Dicranoweisia facies was often very apparent in trees with a fairly sheltered crutch, to which rainwater was apparently diverted. The facies is identical with the var. Dicranoweisiosum of Barkman. The abundance of Dicranoweisia appears to be due only to competition with Hypnum, the former gaining dominance in habitats unfavourable to Hypnum. These habitats are as follows:

(i) On rough barked trees, especially on slopes less than vertical.

(ii) near rain-water tracks and bole hollows or crutches, excess rain water being apparently adverse to the spread of Hypnum

(iii) sometimes on smaller horizontal branches

(iv) in drier habitats, i.e. higher up the tree bole or on the driest exposure. In the Table (VI/18) Dicranoweisia seems to favour the eastern part of the tree.

A Mnium hornum facies often indicated a transition community with the Mnio horni-Isothecietum where the latter encroached upon the normally, somewhat higher placed, Hypnum community.

Cladonia spp. most frequent within the Association were C. coniocraea and C. macilenta whilst the ubiquitous lichen Association of the area, the Parmelietum furfuraceae, was often present.

Stands were taken from every tree species except Ulmus, on which species there was a transition to some rather richer bryophyte community.

HOMALION COMMUNITIES TABLE VI/21

In the woodlands surveyed there were very few habitats suitable for the formation of rich epiphytic bryophyte communities. Humidity was undoubtedly the main factor: another was the scarcity of really old trees apart from Betula pubescens.

A community with Omalia trichomanoides, Porella platyphylla Brachythecium species, Frullania dilatata and Plagiothecium succulentum was noted on one large Ulmus glabra. The same tree supported fragments of other communities with Camptothecium sericeum, Bryum capillare and Tortula ruralis.

On ash, a similar, less rich community was seen but containing Radula complanata and Peltigera praetextata.

Aufn. M35 was quite untypical being on a branch of Sorbus aucuparia which received continuous spray from a small waterfall. It contained a curious mixture of Thamnium alopecurum, Lejeunea cavifolia, Metzgeria furcata, Eurhynchium striatum and Trichostomum tenuirostre.

TABLE V/3 General floristics: epiphytic species

Epiphytic bryophytes

Hepatics

Barbilophozia attenuata	8
floerkei	9
Cephalozia bicuspidata	+
Cephaloziella sp.	1
Conocephalum conicum	+
Diplophyllum albicans	4
Frullania dilatata	4
Lejeunea cavifolia	2
Lepidozia reptans	7
Lophocolea cuspidata	16
heterophylla	1
Lophozia ventricosa	13
Metzgeria furcata	3
Plagiochila asplenioides	5
Porella platyphylla	4
Radula complanata	1
Scapania gracilis	+
undulata	+

Mosses

Brachythecium plumosum	+
rutabulum	2
velutinum	1
Bryum capillare	7
Camptothecium sericeum	5
Campylopus flexuosus	2
Climacium dendroides	1
Dicranella heteromalla	7
Dicranoweisia cirrata	20
Dicranum scoparium	48
(Drepanocladus uncinatus)	
(Drepanocladus exannulatus)	
Eurhynchium praelongum	1
E. striatum	2
(Fissidens bryoides)	
(F. adianthoides)	
Hypnum cupressiforme	76
Isopterygium elegans	+
Isothecium myurum	3
myosuroides	7
Mnium hornum	39
(M. punctatum)	
(M. undulatum)	
M. stellare	1
Omalia trichomanoides	3
Orthodontium lineare	2
Orthotrichum affine	2
Plagiothecium denticulatum	2
curvifolium	3
succulentum	6
Pohlia nutans	2
P. cruda	1
Polytrichum formosum	+
Tetraphis pellucida	11
Thamnium alopecurum	1
Tortula ruralis	3

Epiphytic lichens

	Alectoria fuscescens	11
++	Arthonia punctiformis	
	A. radiata	9
	Arthopyrenia punctiformis	2
++	A. fallax	
	Bacidia chlorococca	1
	B. rubella	1
	Buellia punctata	3
	Calicium viride	2
	Caloplaca citrina	+
	Catillaria griffithii	+
	Cetraria chlorophylla	12
	C. glauca	121
	Chaenotheca ferruginea	2
	Cladonia chlorophaea	15
	coccifera	1
	coniocraea	71
	fimbriata	2
	macilenta	58
	ochrochlora	16
	polydactyla	2
	pyxidata	3
	squamosa	18
	Coniocybe furfuracea	3
	Evernia prunastri	8
	Graphis elegans	1
	Lecanora carpinea	4
	chlarona	25
	chlarotera	8
	conizaeoides	104
	expallens	3

	Lecidea granulosa	1
	limitata	1
	scalaris	16
	symmicta	+
	uliginosa	+
	Lepraria incana	61
	Mycoblastus sanguinarius	8
	Ochrolechia androgyna	18
	tartarea	+
	turneri	11
	Parmelia caperata	+
	furfuracea	29
	glabratula ssp. glabratula	+
	glabr. ssp. fuliginosa	16
	physodes	157
	saxatilis	97
	sulcata	4
	tubulosa	6
	Parmeliopsis ambigua	2
	Peltigera polydactyla	+
	praetextata	2
	rufescens	+
	Pertusaria albescens	7
	albescens var. corallina	+
	amara	12
++	hymenea	
	leioplaca	+
	pertusa	13
	Phlyctis argena	+
	Porina chlorotica var. carpinea	1
++	Ramalina farinacea s.l.	

++ <u>Tomasellia gelatinosa</u>	
<u>Usnea subfloridana</u>	13
<u>Xylographa abietina</u>	1

The number of stands in which each species appears is given. Total number of stands = 253.

\+ = epiphyte but not in the tables.

++ = recorded for the woods but not seen by the author.

( ) = those species found on a layer of soil or in other habitats not truly epiphytic.

TABLE V/4 REFERENCE FRAMEWORK FOR EPIPHYTIC COMMUNITIES

ALGAL ASSOCIATION

Pleurococcetum vulgaris Schorler 1914 sensu Hilitzer 1925

EPIPHYTIC LICHEN ASSOCIATIONS

O. LEPRARIETALIA Barkm. 1958

All. Calicion hyperelli Hadač 1944 em. Barkm. 1958

(Calicion viridis)

Ass. Xylographetum parallelae Šmarda 1940

Ass. Calicietum hyperelli Hilitzer 1925

Ass. Chaenothecetum melanophaeae Barkm. 1958

Ass. Leprarietum incanae Almborn 1948

O. LECANORETALIA VARIAE Barkm. 1958

All. Lecanorion variae Barkm. 1958

Ass. Lecanoretum pityreae Barkm. 1958

(Lecanoretum conizaeoidis)

Ass. Psoretum ostreatae Hil. 1925

(Lecideetum scalaris)

O. ARTHONIETALIA RADIATAE Barkm. 1958

All. Graphidion scriptae Ochsner 1928 em. Barkm. 1958

Ass. Pertusarietum amarae Hil. 1925 em. Barkm. 1958

All. Lecanorion carpineae (Ochsner) Barkm. 1958

Ass. Lecanoretum carpineae atlanticum Barkm. 1958

Ass. Lecanoretum carpineae montanum Barkm. 1958

EPIPHYTIC BRYOPHYTE ASSOCIATIONS

O. LOPHOCOLETALIA HETEROPHYLLAE Barkm. 1958

All. Tetraphido-Aulacomnion (Von Krusenstjerna 1945) Barkm. 1958

Ass. Leucobryo-Tetraphidetum Barkm. 1958

O. DICRANETALIA Barkm. 1958

All. Isothecion myosuroidis Barkm. 1958

Ass. Mnio horni-Isothecietum myosuroidis Barkm. 1958

All. Dicrano-Hypnion filiformis (Von Krusenstjerna 1945) Barkm. 1958

Ass. Scopario-Hypnetum filiformis (Von Krus. 1945) Barkm. 1958

O. LEUCODONTETALIA Von Hübschmann 1952

All. Anomodontion europaeum Barkm. 1958

Sub.-all. Homalion Barkm. 1958

Ass. Anomodonto-Isothecietum Lippmaa 1935

O. PARMELIETALIA PHYSODO-TUBULOSAE Barkm. 1958

All. Parmelion saxatilis Barkm. 1958

Ass. Parmelietum furfuraceae Hil. 1925 sensu Ochsner 1928

All. Cladonion coniocraeae Duvigneaud 1942

Ass. Cladonietum coniocraeae Duvign. 1942

Chapter 19

Epilithic communities.

ORDER HYDROVERRUCARIETALIA Hadač 1948

All. Aspicilion lacustris Klem. 1955

The following Aufnahmen were made on rocks, and boulders, forming the bed and sides of a mountain stream. Shelter was afforded by the 6' high banks of the stream, whilst two large sycamores gave dense vertical cover.

	M	M	M
Aufnahme No.	037	038	039
Total plant cover %	100	100	100
Bryophytes	25	75	80
Lichens	75	25	20
Lichens sterile & immature	20	10	5
Brachythecium plumosum	3	5	7
Thamnium alopecurum	5	7	6
Eurhynchium riparioides	4	.	.
Fontinalis antipyretica	3	.	.
Verrucaria aquatica	7	4	4
V. cf. praetermissa	4	2	3
V. (sterile)	5	2	2
Lecidea lithophila	.	2	3
L. albocaerulescens	.	1	2
L. lucida	.	2	1
Peltigera praetextata	.	3	2
Rhacomitrium canescens	.	1	.
Campylopus flexuosus	.	1	.
Parmelia saxatilis	.	.	4

M 037: Mountain stream bed frequently inundated; Mill Beck Wood 35/913266; alt. 820'; aspect -; slope 0-90°; 100 sq.dm.

M 038: Same stream bed a little lower downstream; numerous small boulders nearer the stream banks; inundation periods less frequent; aspect NNW; slope, all; 200 sq.dm.

M 039: Boulders at the same stream side; aspect N; slope, all; 100 sq.dm.

Zonation is clearly seen in the three stands. Bryophytes of fast flowing streams such as Fontinalis antipyretica and Eurhynchium riparioides clothe rocks in the stand, which is submerged for a large part of the year. Here the only lichens to gain a footing are those of the hydrophilous Verrucaria complex; all Order character species of the Hydroverrucarietalia.

When inundation periods are less frequent, the two bryophytes mentioned give way to higher cover of Thamnium alopecurum and Brachythecium plumosum. Peltigera species invade the moss carpet, and Lecidea species make up the lichen complement of the stand. Lecidea lucida, a strikingly mustard-yellow granular lichen, is found on those damp vertical or overhanging rocks which are not usually submerged.

In the stand which forms part of the lower bank, members of the Parmelion saxatilis gain a hold, especially on horizontal or slightly sloping rock surfaces.

It is interesting to note that another O. character species of the Hydroverrucarietalia, namely Rhizocarpon lavatum, was found on stones bordering the R. Tees in the Birch Wood, but an Aufnahme was not made.

Community of vertical dripping rocks

B 02: Vertical shaly rocks forming small cliffs in river gorge; some overhang; Birch Wood 35/881284; 1000'; N; 400 sq.dm.

	B 02
Total plant cover %	35
Flowering plants & ferns	10
Bryophytes	25
Lichens	3
Cratoneuron commutatum	5
Amphidium mougeotii	4
Preissia quadrata	4
Mnium punctatum	3
Fissidens adianthoides	3
Pellia endiviifolia	2
Riccardia pinguis	2
Plagiobryum zierii	2
Bryum pallens	1
Lepraria cf. membranacea	4
Viola riviniana	4
Melica nutans	4
Selaginella selaginoides	3
Crepis paludosa	3
Oxalis acetosella	3
Pinguicula vulgaris	2
Polygonum viviparum	2

Also: Campanula rotundifolia 1; Potentilla erecta 1; Festuca rubra 1; Solidago virgaurea 1; Cystopteris fragilis 1; Carex demissa 1; Cirsium palustre k.

This sedimentary strata, in an otherwise dolerite intrusion, supported an interesting bryophyte population. That the rock was easily fragmented could be seen, both from the cliff overhang and the paucity of epilithic lichens. The community as a whole seems to be composed of damp, rock-ledge, species. Evidently the small sedimentary strata bore some relation to the limestone series underlying and outcropping below High Force, some hundred yards upstream, as the plants growing in it were essentially those of basic flushes. The only anomalous bryophyte was Amphidium mougeotii, which normally forms large cushions on cliffs having seepages of more acid water. Watson (1968), however, notes that Amphidium is not confined to acid habitats.

Communities of small boulders in woodland

The Aufnahmen were all made on small dolerite boulders not more than 3 dm. in height, in the woods indicated by the Aufnahmen symbols. The average area of the stands examined was 35 sq.dm. and the average slope less than 45°. Aspect was N-NE, except in M 08, which was W.

	P	P	P	P	M	M	P
Aufnahme No.	01	04	03	06	08	07	09
Total plant cover %	90	100	100	95	100	100	95
Bryophytes	60	90	95	90	90	90	70
Lichens	30	10	5	5	10	10	25
Isothecium myosuroides	6	.	4	4	7	8	5
Hypnum cupressiforme	.	4	.	.	5	6	6
Lecidea coarctata	6	4	2	2	.	.	4
Barbilophozia floerkei	.	7	7	2	.	.	.
B. attenuata	.	4	3	1	.	.	.
B. barbata	.	.	.	.	.	3	4
Lophozia ventricosa	.	1	6	1	.	.	3
Mnium hornum	.	.	.	8	5	.	.
Cladonia squamosa	.	.	5	2	.	.	3
Dicranum scoparium	5	3	.	.	.	.	4
Polytrichum juniperinum	6	.	.	3	.	.	.
Porina chlorotica var. chlorotica	4	4	.	.	.	.	.
Lecidea tumida	.	4	3	.	.	.	.
Rhacomitrium heterostichum	.	1	.	.	.	.	4

Also: (P 01) Cladonia ochrochlora 4; C. coniocraea 2; Lecanora intricata var. soralifera 4; Parmelia physodes 1. (P 04) Andreaea rupestris 3; Scapania irrigua 3; Diplophyllum albicans 1; Bacidia lignaria 4. (P 03) Peltigera polydactyla 4; Cladonia coccifera 1. (P 06) Scapania nemorosa 4; Dicranum majus 1; Lecidea leucophaea 2. (M 07) Mnium undulatum 2; Plagiothecium succulentum 3; Cladonia macilenta 2. (P 09) Cladonia chlorophaea 4; Parmelia saxatilis 4; Plagiochila asplenioides 2; Rhacomitrium fasciculare 3.

The stands appear to be typical of small, fairly smooth, boulders in woodland. As well as the shade of shrub or tree, there is usually some effect from surrounding vegetation. Stands with a higher proportion of Barbilophozia species were on slightly damper rocks, in small flush areas.

The extra species appear indicative of small changes in micro-climate or increasing depths of soil and humus. Both Lecidea tumida and Porina chlorotica were absent from stands which appeared to undergo any period of dessication.

There are no comparable communities in Klement (1955) who deals only with one-layered communities, i.e. the Class which he names the Epipetretea lichenosa. Unfortunately members of the Swedish school as a whole adopt this approach. Sjögren (1964) deals with epilithic and epigeic bryophyte communities on the Island of Öland, but the bryophyte vegetation of these Swedish woodlands is so much richer than that in N.E. England that no comparable stands are available.

Communities of large dolerite boulders

ORDER RHIZOCARPETALIA Klement 1950

This Order, as Klement interprets it, comprises the Lichen communities of dry to moderately dry acid rocks and reaches optimum development as higher altitudes are approached. The character species he recognises include:- Lecanora intricata and var. soralifera, L. polytropa, Lecidea pantherina, Rhizocarpon geographicum, R. obscuratum and R. badioatrum.

Four Alliances are given, but these will no doubt have to be revised when more work has been done on epilithic communities.

Large boulders are often very varied in physiognomy and appear to need careful and critical scrutiny before stands are selected. The primary divisions of Klement (1955 p.25) into basal area, overhang, brow, incline and apex (see Discussion later) are satisfactory for moderately sized, reasonably smooth boulders.

Most weathered boulders however present fissures both horizontal and inclined, ledges both deep and shallow, steps, hollows, pockets, and so on. The problem of how to describe the totality of bryophytes and lichens in such epilithic communities has not yet been solved. The tendency in the past, especially amongst Scandinavian phytosociologists, has been to describe synusiae or single layered communities. Thus Klement (op. cit.) monographs the epilithic, epigeic and epiphytic lichens, Sjögren (1961, 1964) deals with the bryophyte communities.

In the present survey no attempt was made to resolve this major dilemma, although certain points were noted for discussion. The large boulder communities are therefore presented in two groups only:

(i) those in open habitats and exposed to full sunlight;

(ii) partially shaded or more humid stands.

All. Crocynion membranaceae Klem. 1950

Synonymy: Leprarietalia Hadač 1944

Leprarion chlorinae (Gams 1927) Hadac 1944

Character species: Baeomyces rufus, Lepraria membranacea, L. neglecta, Lecidea cinereoatra, L. crustulata, L. phaea, L. plana, L. tumida, Pertusaria lactea.

The Crocynion (= Leprarion) is not particularly satisfactory as an overall Alliance. Personal observation, and perusal of the literature, suggests that two Alliances may be necessary to comprehend all the Associations of shaded to moderately shaded acid rocks. Indeed a better solution would be the retention of the Order Leprarietalia Hadač to include all the communities of shaded acid rock crevices and overhangs. Klement's description of the Crocynion fits these communities very well but, in the Associations of the Alliance, he includes communities which are not typical, either in species composition or in habitat, of the Alliance he has so thoroughly described. James (1970) in his "key to lichens of shaded, acid rock crevices and overhangs", notes that many common crustaceous lichens characteristic of exposed habitats (he includes Lecidea albocaerulescens, L. crustulata,

L. lithophila and L. tumida) frequently manage to survive in relatively shaded habitats. He goes on to say, "they are frequently poorly developed .... and are omitted as being uncharacteristic of the habitat". Yet Klement includes some of these species as "Charakterarten" of Associations within an Alliance, whose description would seem to preclude them.

Ass. Pertusarietum corallinae Klem. 1923

	J	J	B
Aufnahme No.	011	06	011
Total species cover %	95	95	95
Bryophytes	5	.	.
Lichens	90	95	95
Ass. character spp.			
Pertusaria corallina	5	3	5
P. pseudocorallina	.	4	.
All. character spp.			
Lecidea tumida	4	4	.
L. crustulata	.	3	.
O. character spp.			
Rhizocarpon geographicum	3	3	4
R. obscuratum	4	4	.
Lecanora polytropa	5	5	.
L. intricata var. soralifera	6	5	.
L. badia	5	5	5
Cl. character spp.			
Lecanora atra	3	.	5
L. campestris	.	.	6
Other spp.			
Parmelia saxatilis	.	4	3
Lecidea fuscoatra	4	2	.
L. coarctata	.	3	.
L. albocaerulescens	3	.	.
Lepraria incana	3	.	.

J 011: Large dolerite rock dome with some crevices; height 2 dm.; slope 0-5°; area 150 sq.dm.; aspect N; in a large exposed clearing surrounded by Juniperus communis.

J 06: Block boulder cliff; height 2 m.; slope 50°; aspect E; area 70 sq.dm.

B 011: Large dolerite boulder, almost 2m. cube; upper surface; slope 15°; aspect W; lichen stand separated from bryophyte 80 sq.dm.

This group of Aufnahmen appears to fit very easily into Klement's Association the Pertusarietum corallinae. The Association is one of the easiest of the crustose lichen communities to pick out. Large patches of grey-white Pertusaria species stand out against the mainly grey-brown or green-brown lichens making up the Association. Often, on almost vertical surfaces, the Pertusarietum is quite devoid of bryophytes. The two Pertusaria species with coralloid or papillate isidia are easy to recognise in the field and can be readily separated in identity by the application of Potassium Hydroxide solution.

Aufn. B 011 was somewhat untypical. Situated on the upper surface of a large boulder, the complete stand included a large number of bryophytes and Cladonia species. The bryophytes and squamulose lichens were growing on shallow layers of humus, rather than on the rock itself, and probably belong to an Association which is gradually overrunning the Pertusarietum. On the other hand, the two Associations may be in equilibrium as long as the external environment remains the same.

The details of the bryophyte cover are given below as a separate Aufnahme (B 01) was made. Area 100 sq.dm.; other details the same as for B 011.

	B 01
Total species cover %	100
Rhacomitrium lanuginosum	8
R. fasciculare	3
R. heterostichum	3
Andreaea alpina	4
Barbilophozia floerkei	3
Dicranella squarrosa	3
Camyplopus flexuosus	3
Cladonia gracilis	3
Cornicularia aculeata	3
Cladonia pyxidata	2
Diplophyllum albicans	1
Lophozia ventricosa	1
Cepahlozia bicuspidata	1
Polytrichum piliferum	2
P. juniperinum	1
Barbilophozia attenuata	1

The nodum bears some relationship to the Rhacomitrion, an Alliance of moss (lichen) communities on acid rocks with a good light supply, and described for Sweden by Krusenstjerna (1945).

All. Acarosporion fuscatae Klem. 1950

This Alliance includes most of the photophilous, pioneer, crustose lichens of upland regions. Many species-poor variants are however found in the lowlands away from towns. In many areas the Alliance is characterised by the abundance of Acarospora fuscata, especially on sandstone and millstone grit. On upland dolerite, Diploschistes scruposus and other Alliance character species seem more common.

The following table includes Aufnahmen made on large rather shaded dolerite boulders.

J 04: Dolerite boulder 8 dm. high; Aspect NNW: slope 80°; area 30 sq.dm.; shaded by *Juniperus communis*.

J 03: ditto; 6 dm. high; aspect E; slope 80°; area 40 sq.dm.

J 02: Small dolerite cliff with fissures; aspect E; slope 90°; area 500 sq.dm.; no tree or shrub cover.

J 05: Small cliff with fissures and dripping water; aspect NE; slope 80°-90°; area 400 sq.dm.; no tree or shrub cover.

P 02: Dolerite slab in short turf ± ground level; aspect NNW; slope 5°; area 120 sq.dm.; sunny situation.

P 07: Small dolerite boulder among tall grasses and ferns; aspect W; slope 40°-100°; area 40 sq.dm.; tree cover *Corylus* and *Betula pubescens*.

P 05: Shaded dolerite block in wet vegetation; aspect NW; slope 100°; area 16 sq.dm.; tree cover *Alnus*.

	J	J	J	J	P	P	P
Aufnahme No.	04	03	02	05	02	07	05
Total species cover %	95	100	100	95	95	100	100
<u>All. Crocynion membranaceae character spp.</u>							
Lecidea crustulata	.	.	.	.	.	3	.
L. tumida	.	.	.	.	.	3	3
Baeomyces rufus	.	.	.	.	.	4	4
<u>All. Acarosporion fuscatae character spp.</u>							
Diploschistes scruposus	3	5	4	6	.	.	.
<u>O. Rhizocarpetalia character spp.</u>							
Lecidea lithophila	4	.	5	.	4	.	.
Lepraria incana	.	3	3	.	.	.	4
Lecanora intricata v. soralifera	4	4	.	5	5	.	.
L. polytropa	4	3	.	.	.	.	.
Rhizocarpon obscuratum	.	.	.	.	.	5	.
<u>Class character spp.</u>							
Lecanora atra	.	.	.	.	.	.	7
L. gangaleoides	.	.	3	.	.	.	.
<u>Other spp.</u>							
Parmelia saxatilis	5	3	5	.	5	3	6
Ochrolechia androgyna	6	4	5	.	.	4	.
Lecidea coarctata	4	.	3	.	3	5	.
L. albocaerulescens	3	.	4	5	.	.	.
Haematomma ventosum	3	5	6	.	.	.	.
Pertusaria corallina	4	.	.	.	.	3	.
Lecidea leucophaea	.	.	.	.	4	5	5
L. polioides	.	.	.	.	.	6	.
L. lucida	.	.	.	.	.	3	.
L. cinereorufa	.	.	.	.	4	.	.
Lecanora caesiocinerea	.	.	.	.	7	.	.
Catillaria chloroscotina	.	.	.	.	.	.	2
Lecidea crustulata	.	.	.	4	.	.	.
L. lacustris	.	.	.	3	.	.	.
L. pelobotrya	.	.	.	4	.	.	.
L. macrocarpa	.	.	.	4	.	.	.
Cladonia coccifera	2	4	.	3	.	.	.
C. macilenta	2	4	.	.	.	2	.
Andreaea rupestris	4	5	.	.	.	.	.
Rhacomitrium fasciculare	2	.	.	4	.	.	.
R. heterostichum	3	.	.	3	.	.	.

<u>Also</u>: (J 04) Stereocaulon evolutum 4; Sphaerophorus globosus 3.
(J 03) Parmelia physodes 1; Lepidozia reptans 4.
(J 05) Cladonia impexa 2; C. arbuscula 2; Diplophyllum albicans 3.
(P 07) Parmelia omphalodes 4.

The stands J 04 - J 05 are well typified by Diploschistes scruposus, and high cover of lichens, which point to some Association as yet undescribed. The combination Ochrolechia androgyna, Lecidea albocaerulescens and Haematomma ventosum appears to be frequent in the area on large shaded boulders.

P 02 differs from the rest of the group in being completely unshaded, and fully open to the sun's rays. The very high cover of Lecanora caesiocinerea points directly to an Association of the Acarosporion - the Aspicilietum cinereae Frey 1923.

Character species given by Klement (1955) are three of the Lecanora complex, section Aspicilia, viz. Lecanora cinerea, L. caesiocinerea, L. gibbosa. Added to these is Lecanora rupicola.

J 05 shows the influence of continual trickles of water by the presence of Lecanora lacustris and Lecidea pelobotrya, both being species of rocks alongside mountain streams.

Edge community

In shallow soils where large rocks just break the surface there is often a characteristic edge community around the rock, only three or four centimetres wide, which bears very little relationship with either the surrounding vegetation or that of the rock surface. Strictly speaking these communities would be classed as epigeic, even though they are so intimately linked with outcropping rock.

Two lists follow:-

Aufnahme No.	J 01	P 022
Total species cover %	100	100
Polytrichum juniperinum	6	6
P. piliferum	4	4
Rhacomitrium heterostichum	.	6
Grimmia apocarpa	5	.
Rhacomitrium fasciculare	4	.
Barbilophozia floerkei	3	4
B. attenuata	.	2
Brachythecium albicans	4	.
Campylopus flexuosus	3	.
Cladonia impexa	4	.
C. ochrochlora	3	.
C. furcata	5	.
Peltigera polydactyla	4	.
Rhytidiadelphus squarrosus	3	.
Cladonia pyxidata	.	4
C. gracilis	.	4
Bryum capillare	.	3
Ceratodon purpureus	.	3
Ptilidium ciliare	.	1

J 01 taken around (J 011) q.v. total area 4.5 sq.dm.

P 022 taken around (P 02) q.v. area 4 sq.dm.

Wall community

All. Umbilicarion cylindricae Frey 1933

Ass. Parmelietum omphalodis Frey 1937

The Alliance includes light loving communities of acid rocks in both dry and moist situations. Boulder tops on south facing walls in mountain areas are the most common localities. As higher altitudes are reached the foliaceous group of lichens increase and in sub-alpine and alpine areas Umbilicaria species often dominate the Alliance. The Umbilicarion cylindricae is a later successional stage to the two Alliances of the Order Rhizocarpetalia already mentioned.

Although Parmelia omphalodes is not as common as P. saxatilis in the area, the single Aufnahme made would appear to belong to the Parmelietum normally rich in P. omphalodes. Umbilicaria species too are found locally, mostly above the 900' contour, but those in walls flanking the Pennine Way are often broken or destroyed.

S. facing wall community

Total species cover %	90
Parmelia omphalodes	4
Umbilicaria cylindrica	3
U. polyphylla	2
Lecidea scabra	4
L. sulphurea	3
Lecanora badia	3
Pertusaria corallina	4
Order character species	
Lecanora intricata	4
" " var. soralifera	6
L. polytropa	5
Rhizocarpon geographicum	3
Parmelia saxatilis	4
Haematomma ventosum	4
Sterile indet.	4

TABLE V/5

FRAMEWORK OF REFERENCE FOR EPILITHIC COMMUNITIES

Cl. EPIPETRETEA LICHENOSA Klement 1955

- O. Rhizocarpetalia Klement 1950
  - All. Acarosporion fuscatae Klem. 1950
    - Ass. Aspicilietum cinereae Frey 1923
  - All. Crocynion membranaceae Klem. 1950
    - Ass. Lecideetum crustulatae (Duvign. 1939) Klem. 1955
    - Ass. Lecideetum soredizae Klem. 1946 Ms.
    - Ass. Pertusarietum corallinae Frey 1923
    - Ass. Biatoretum lucidae (Schade 1916) Klem. 1955
  - All. Umbilicarion cylindricae Frey 1933
    - Ass. Umbilicarietum cylindricae Frey 1933
    - Ass. Parmelietum omphalodis Frey 1937
  - All. Parmelion saxatilis Klem. 1950
- O. Hydroverrucarietalia Hadač 1948
  - All. Aspicilion lacustris Klem. 1955

PART V

DISCUSSION AND CONCLUSIONS

Chapter 20

Discussion.

Every academic discipline has its basic premises and methods of application which must be examined from time to time. This is true, more especially, of the new sciences but occasionally of older sciences when studied by a new generation. However, it is hardly necessary to challenge or discuss basic premises and ways of procedure every time a paper is written, unless the exercise aims at being essentially of a philosophical or polemical nature.

Reference has already been made in this context (Chapter 3) to papers appraising or defending the aims and methods of the Z.-M. school of phytosociology, and to a summary of the situation in Britain today (Shimwell 1968). Since that date there has been a seminar at Preston Montford led by Professor R. Tüxen and Fr. J.J. Moore which the writer was privileged to attend. The outcome of this meeting was a growing conviction that more British ecologists should be learning the discipline or at least the language of phytosociology.

The intention behind the present paper was the study of a limited area by phytosociological methods. As these methods are normally used in examining community types within a large area or region, it would seem more profitable to discuss here the limitations or possibilities which such an approach has brought to light. The broad regional approach is not possible for every would-be phytosociologist and the tenor of this discussion is that a more limited approach does furnish useful data for other workers who attempt an overall synthesis.

The Z.-M. system is applied in two stages, (A) the collection of data and (B) interpretation of the results, and the problems of working in a restricted area can be divided accordingly.

I The Ground Flora

(A) Collecting the data

Provided that the area selected for study is reasonably varied in physiognomy and habitat few problems arise in collecting the data. Within a limited area it may be more difficult to find the best stands of any particular community and more transition communities and minor variants have to be sampled. However the more traditional British ecologist should feel fewer objections to a more concentrated and less selective approach for the following reasons:-

(i) In a limited area it is possible to obtain a really full and representative sample of all the different vegetation units encountered.

(ii) Full attention can be given to the lower plant groups and bryophytes and lichens can be studied, both within, and apart from, the main vegetational stands.

(iii) It is possible to have a more intensive plan coordinating epigeic, epilithic and epiphytic vegetation.

The area selected for this thesis was woodland, within a small geographical area, of much the same climatological and geological pattern throughout. However ample variation was found.

(i) Each wood had its peculiar and distinguishing characteristics, as can be seen from the general floristic table (II/1) and reflected eventually in the phytosociological pattern which emerged.

(ii) No difficulty was encountered in finding a most varied assortment of stands.

(B) Interpreting the data

The main problems and pitfalls would appear to lie in the interpretation of the data. Variation on the whole will be infra-Associational and great problems are encountered in the preliminary sorting of sixty or seventy rich and varied Aufnahmen. With few preconceived ideas as to the place of emerging groups of species, within the overall hierarchical pattern, the process is very slow and laborious.

However, once the preliminary sorting is completed the literature may come to one's aid. Groups of species become meaningful and their place among the higher units of vegetational classification established. Personal observation next plays a part and the emerging pattern must be placed against the back cloth of experience.

In the present studies it soon became clear that there were close parallels between the northern English birch and juniper woods and certain noda in Scotland, described by McVean and Ratcliffe (1962). It was possible also after studying the work of Tansley (1949) and other British ecologists to see that the north western birch woods formed a vegetation unit different from any Alliance described on the Continent. After further observation, and above all discussion with other phytosociologists, it was felt that a new Association, the Oxalido-Betuletum, within the Alliance put forward by Shimwell (1968) was valid.

If there is no available literature, parallel with the communities being described, the task of interpretation becomes so much harder. Indeed the finally sorted Association tables can only be described and left for other workers to interpret. The fuller exposition in this thesis was only possible because of McVean and Ratcliffe's monograph. Associations were not created in this paper so much as crystallised from the Scottish work.

The main pitfall of the small scale approach is therefore obvious, i.e. that of creating Associations within a small geographic region which has not been at least partially explored before.

II Epiphytic Communities

(A) Collecting the data

Bryophytes and lichens are much more dependent upon micro-climate than are the higher plants. So therefore epiphytic and epilithic vegetation is more varied than the ground flora within most unpolluted areas. Consequently there should be no difficulty is finding sufficient variety amongst the epiphytic communities of a small area.

(B) Interpretation of the data

Interpretation of results depends to a large extent on the availability of other data against which the results may be compared. Once again the scene was favourably set and Barkman's classic monograph was invaluable in the interpretation and evaluation of the Association tables. It is interesting to note the use Barkman has made of the results of previous workers in the same field. Not only does he utilise the work of orthodox phytosociologists but he also presses into service lists of epiphytic species from many and varied sources.

One important lesson the worker in a restricted area has to learn is that many Aufnahmen will have to be rejected as mixed or untypical. This is true of both epigeic and epiphytic vegetation.

A specific problem, mostly connected with epiphytic ecology, but also with epilithic communities, is the weight that is put upon the term - 'fragmentary Association'. This has been referred to in the description of the *Lecanoretum pityreae*. Much work has been done recently on, and more understanding gained of, environmental pollution especially in regard to epiphytic communities. It has come to be recognised that pollution of the atmosphere is but another factor in man's interference with the environment. Burning, grazing, draining and numerous agricultural activities have long been recognised as factors the ecologist has to come to terms with. Natural vegetation free from man's influence is hard to find, yet phytosociologists analyse and classify the whole. One could instance the *Arrhenatherion elatioris* and the *Cynosurion cristatae*, two of the most anthropogenic Alliances in the whole grassland complex (O'Sullivan 1965). These are described complete with Associations, Sub-associations, variants, etc., and the noda described are not reckoned as fragments but complete in themselves.

So it would appear that communities of epiphytes in polluted areas should be given full status even though they are made up of only one or two species, and Laundon (1967) is correct in giving the *Lecanoretum pityreae* full Association (Union) status in London when only one lichen is present.

III Epilithic Communities

Epilithic communities pose many problems, most of them not in the least accentuated by work being restricted to a limited area. It will be best to enumerate the most outstanding difficulties and discuss those which are not self-explanatory.

(i) difficulties of species identification, especially among the sterile crustose group and the genus Lecidea.

(ii) fragmentation of the uniform stand because of crevices, soil layers, etc.

(iii) choice and size of stand have never been satisfactorily worked out.

(iv) the necessary data is very detailed.

(v) no agreement yet on classification by uni- or pleuristratal societies.

(vi) the literature is very scanty.

(vii) the few monographs which have been written either tackle the problem from the angle of the Swedish school, or deal with unistratal communities, or do both.

(ii) and (iii) The Stand

Klement's division of the area (Fig. V/1) is quite satisfactory for certain weathered rather smooth boulders. The rock habitat is often much more complex (Fig. V/2) with fissures, soil crevices, pockets, steps, etc., to complicate the pattern. All this makes the choice of simple stands difficult and composite areas have to be chosen. This in itself causes no great problems once a distributional pattern has been recognised. The problem is how to convey all the information in tabular form without a multiplication of symbols and stand data. Yarranton (1967), in his quantitative study of Bryophytes and Macrolichens on the Dartmoor granite, needs 64 columns, each with 30 kinds of symbols and figures, to convey all the essential information about his stands. This is additional to the floristic details and tables.

(iv) Collection of data

The epilithic vegetation sheet (Fig. III/4) was not used in its entirety for the present survey. It is based upon personal observation, after consideration of Klement (1955), Barkman (1958), and Yarranton (1967), and offered as an example of the maximum information it would be possible and reasonable to collect in any medium-sized survey.

(v) Unistratal Associations

It does seem that many epiphytic lichen and bryophyte Associations are unistratal and must be separated. The differing layers of a forest community may be rooted in different depths of soil, with different microclimates for the separate layers, but they have an interdependence which many rock communities do not. e.g. The common occurrence in suitable climatic areas of bryophytes overrunning and smothering crustose lichen layers is a more or less physical process which has no exact counterpart in the separate layers of a wood. Here there is shading out, and crowding out by dominance, but when stability is reached the different layers remain ± in equilibrium.

However the phytosociologists who accept unistratal societies seem to have pushed this conception to extreme lengths and allowed for no mixed communities of bryophytes and lichens, which situation is manifestly not true. Barkman (p.330) discusses the problem and accepts some pluristratal Associations but unfortunately he deals only with epiphytes and there is no comparable work on epilithic communities.

The problem of classification, at least of the higher units, still remains. Klement's (1955) primary division into Epipetretea lichenosa, Epiphytetea lichenosa, and so on, is wrong for as Barkman says these are ecological and not sociological units. This author rightly leaves the erections of Classes until much more data shall be available.

With all these difficulties to face it would seem that it is almost impossible not to restrict the complete study of epilithic communities to a workable area.

FIGURE V/1 Epilithic habitats

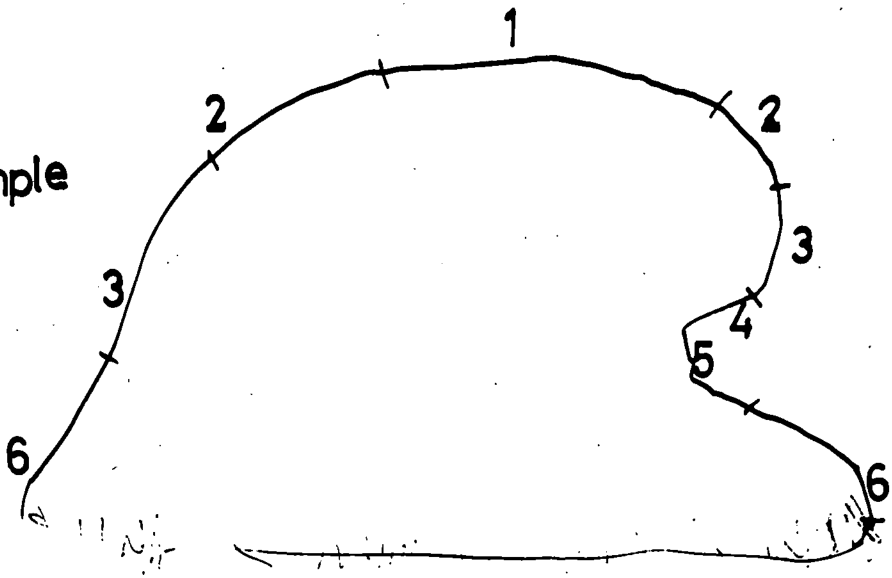
Legend:

(as Klement 1955)

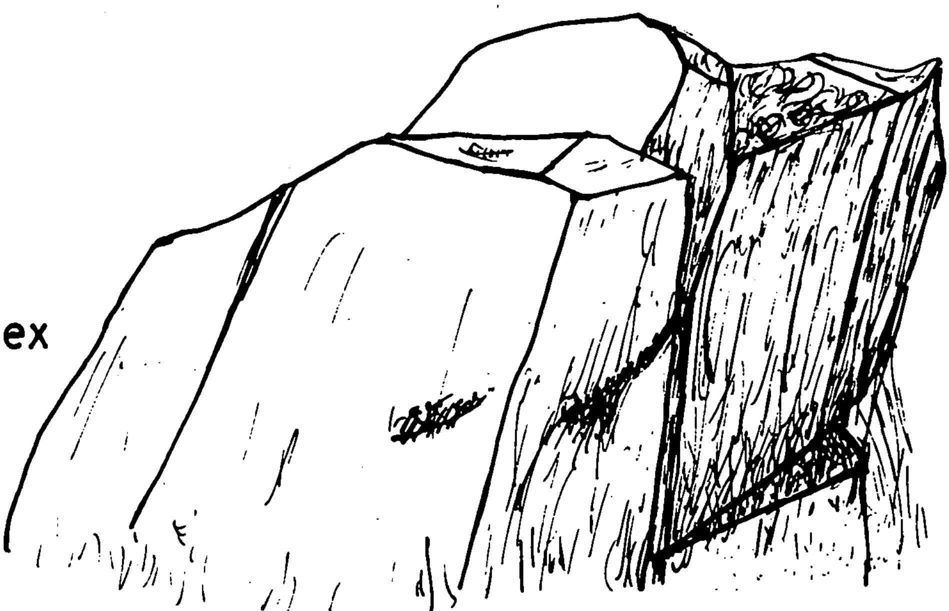
1. Surface area, apex.
2. Incline (5-75°)
3. Brow (75-90°)
4. Overhang
5. "grotto area"
6. Basal area, foot

EPILITHIC HABITATS

Simple



Complex



Chapter 21

Conclusions.

1. In describing the vegetation and evaluating the various noda encountered, this thesis provides material in such a format that (a) it may readily be compared with descriptions of similar vegetation on the Continent, (b) it may be of use to British workers attempting a broader regional woodland survey.

2. The phytosociological survey of a restricted area is shown to be both possible and useful. Interpretation and evaluation of noda is possible by comparison with the work of other authors but should not be attempted in a primary survey.

3. Additional proof has been adduced for (i) a hierarchical classification of the N.W. Atlantic birch woods, (ii) the contention that the vegetation of Northern Britain has more contacts with parts of Scandinavia than with Central and North West Europe.

4. The survey has, it is hoped, shown the woodlands in question to be rich invegetation types and worthy of conservation.

BIBLIOGRAPHY

ALMBORN, O. (1948). Distribution and Ecology of some South Scandinavian Lichens, Botaniska Notiser, Suppl. Vol. 1:2. Lund.

ANDERSON, M.L. (1932). The Natural Woodlands of Britain and Ireland. Dept. of Forestry, Oxford.

ARNBORG, T. (1950). Phytogeographical forest excursion to North Sweden. 7th Intern. Bot. Congr., Stockholm 1950. Excursion Guide C IIId Uppsala.

ARNELL, S. (1956). Illustrated Moss Flora of Fennoscandia I. Hepaticae Lund.

BACKHOUSE, J. & BACKHOUSE, J. Jun. (1844). An account of a visit to Teesdale in the summer of 1843. The Phytologist, 1, 892-895.

BAKER, J.G. (1906). Flora of North Yorks. 2nd Ed. London.

BANNISTER, P. (1966a). The use of subjective estimates of cover-abundance as the basis for ordination. J. Ecol. 54, 665-674.

BARKMAN, J.J. (1958). Phytosociology and Ecology of Cryptogamic Epiphytes. Assen, Netherlands.

BECKING, R.W. (1957). The Zurich-Montpellier school of phytosociology. Bot. Rev. 23.7. 411-488.

BIRSE, E.L. & ROBERTSON, J.S. (1967) In: RAGG, J.M. & FUTTY, D.W. The Soils of the Country round Haddington & Eyemouth. Chapter V, Vegetation. Memoirs of Soil Survey of Great Britain: Scotland. H.M.S.O. Edinburgh.

BLACKBURN, K.B. (1931). The Late-glacial & Post-glacial periods in the North Pennines. II Possible survivals in our flora. Trans. North. Nat. Union 1, 32.

——— (1952). The dating of a deposit containing an elk-skeleton found at Neasham near Darlington, Co. Durham. New Phyt., 51, 364.

BRADE BIRKS, S.G. (1959). Good Soil. London.

BRAUN-BLANQUET, J. (1932). Plant sociology, the study of plant communities. Engl. transl. G.D. Fuller & H.S. Conrad. New York, McGraw Hill.

——— SISSINGH, G. & VLIEGER, J. (1939). Prodromus der Pflanzengesellschaften 6. Klasse der Vaccinio-Pi Montpellier.

——— & TÜXEN, R. (1952). Irische Pflanzengesellschaften. In LUDI, W. (Ed.) Die Pflanzenwelt Irlands. Veroff. d. Geobot. Inst. Rübel Zürich, 25.

BRIDGEWATER, P. (1970). Phytosociology and Community Boundaries of the British Heath Formation. Ph.D. thesis, Univ. of Durham.

BRIGHTMAN, F.H. (1965). The distribution of the lichen Lecanora conizaeoides Cromb. in Northern Ireland. Irish Nat. Journ. 14 (11) 258-262 (1964).

BURNETT, J.H. (Ed.) (1964). The Vegetation of Scotland. 613 pp. London & Edinburgh.

CLAPHAM, A.R., TUTIN, T.G. & WARBURG, E.F. (1962). Flora of the British Isles. Ed. 2. Cambridge.

CLEMENTS, F.E. (1916). Plant succession. An analysis of the development and structure of vegetation. Carnegie Inst. Wash., Publ. 242, 512 pp.

COKER, P.D. (1964). Some observations on the ecology of epiphytic bryophytes in Hertfordshire (Summary). Trans. Brit. Bryol. Soc. 4 (4), 753-4.

——— (1967a). The effects of sulphur dioxide pollution on bark epiphytes. Trans. Brit. Bryol. Soc. 5 (2), 341-347. (In press).

——— (1967). Some aspects of the ecology & phytosociology of epiphytic bryophyte communities. Ph.D. thesis. Univ. of London.

COUSENS, J.E. (1965). The status of the Pedunculate and Sessile Oaks in Britain, in: Watsonia, 6 (3).

CRAMPTON, C.B. (1911). The Vegetation of Caithness considered in relation to the Geology. Committee for the survey & study of Brit. Vegetation.

DAHL, E. (1956). Rondane. Mountain vegetation in South Norway and its relation to the environment. Diss. - Skr. Norske Vidensk. - Akad. 1. Mat. - naturv. kl., 1956: 3. Oslo.

DANSEREAU, P. (1951). Description and Recording of Vegetation on a structure basis. Ecology 32 (2).

DARBY, H.C. (Ed.) (1936). The historical geography of England before 1800. Cambridge.

DOING, H. & WESTHOFF, V. (1959). Die Stellung der Buche im West-und Mitteleuropäischen Wald. Jaarb. Ned. Dendrloog. Ver. 21. 226-254.

EDDY, A., WELCH, D. & RAWES, M. (1968). The vegetation of the Moor House National Nature Reserve in the Northern Pennines, England. (Unpubl.).

ELKINGTON, T.T. (1962). Experimental taxonomy of some members of the Teesdale flora. Ph.D. thesis. Univ. of Durham.

——— & WOODELL, S.R.J. (1963). Biological Flora of the British Isles: Potentilla fruticosa L. J. Ecol., 51, 769-781.

ELLENBERG, H. (1956). Aufgaben und Methoden der Vegetationskunde. In: H. Walther, Einführung in die Phytologie. Vol. IV Grundlagen der Vegetationsgliederung, Pt. I. Stuttgart, Eugen, Ulmer.

——— (1963). Vegetation Mitteleuropas mit den Alpen in Kausaler, dynamischer und historischer Sicht, ex. Einführung in die Phytologie. Vol. I.

——— (1963). Vegetation Mitteleuropas mit den Alpen. Einführung in die Phytologie. IV, 2 (H. Walter). Ulmer, Stuttgart.

——— (1965). ~~Vegetation Mitteleuropas mit den Alpen. Stuttgart.~~

FENTON, E.W. (1933). The Vegetation of an upland area. (Boghall Glen, Midlothian). Scottish Geogr. Mag. 49.

GALLÖE, O. (1927-39). Natural History of the Danish Lichens, I-VI. Köbenhavn.

GIMINGHAM, C.H. (1961). Dwarf Shrub Heaths. In: The Vegetation of Scotland, ed. J.M. Burnett, Edinburgh.

——— & BIRSE, M. (1957). Ecological studies on growth-form in Bryophytes. I. J. Ecol., 45, 533-45.

——— & ROBERTSON, E.T. (1950). Preliminary investigations on the structure of bryophyte communities. Trans. Brit. Bryol. Soc. 1 (4), 330-344.

GLASSPOOLE, J. (1932). The rainfall of the Tees Valley. Brit. Rainf., 72, 289-291.

GLEASON, H.A. (1926). The individualistic concept of the plant association. Bull. Torrey Bot. Club, 53, 7-26.

——— (1939). The individualistic concept of the plant association. Amer. Mid. Nat., 21, 92-110.

GODWIN, H. (1949). The spreading of the British flora considered in relation to conditions of the Late-glacial period. J. Ecol., 37, 140-147.

——— (1956). The History of the British Flora. Cambridge Univ. Press, 383 pp.

HALE, M.E. & W.L. CULBERSON. (1966). A Third Checklist of the Lichens of the Continental United States and Canada. The Bryologist, 69, 141-182.

HAWKSWORTH, D.L. & ROSE, F. (1970). Qualitative Scale for estimating Sulphur Dioxide Air Pollution in England & Wales using Epiphytic lichens. Nature, 227, pp. 145-148.

HEWETSON, V.P. (1968). Studies on the vegetation history of Widdybank Fell, Upper Teesdale. M.Sc. thesis, Univ. of Durham.

HORST, K. (1964). Klima und Bodenfaktoren in Zwergstrauch-und Waldgesellschaften des Naturschutz-parks Lüneburger Heide. Natursch. u. Landschaftspfl. in Niedersachsen 2.

HÜBSCHMANN, A.VON. (1952). Zwei epiphytische Moosgesellschaften Norddeutschlands. Mitt. Florist.-Soziolog. Arbeits. N.F. heft 3, 97-107.

——— (1960). Einige Ackermoos-Gesellschaften des nordwest-deutschen Gebietes und angrenzender Landsteile und ihre soziologische Stellung im pflanzensoziologischen System. Mitt. Flor.-soz. Arbeitsgem. N.F. 8, 118-126.

——— (1967). Uber die Moosgesellschaften und das Vorkommen der Moose in den übrigen Pflanzengesellschaften des Moseltales. Schriftenr. Vegetationsk. 2, 63-121.

HUGHES, R.E. (1949). The vegetation of the north western Conway Valley, N. Wales - Part 1. Environmental factors (climatic and edaphic). J. Ecol., 37, 306-334.

ING, B. (1966). Studies on bark epiflora. Sch. Sci. Rev. 164, 37-44.

IVIMEY-COOK, R.B. & PROCTOR, M.C.F. (1966a). The Plant Communities of the Burren, Co. Clare. Proc. Roy. Irish Acad., 64 B, No. 15, 211-301.

JAMES, P.W. (1970). The lichen flora of shaded acid rock crevices and overhangs in Britain. The Lichenologist, 4.4, pp.309-322.

JENNY, H. (1941). Factors of Soil Formation. New York.

KLEMENT, O. (1955). Prodromus der mitteleuropaischen Flechtengesellschaften. Feddes Rep. Beih. 135, 5-194.

KRUSENSTJERNA, E. VON. (1945). Bladmossvegetation och bladmossflora i Uppsalatrakten. (Moss flora and moss vegetation in the neighbourhood of Uppsala.) Diss. - APhS. 19. Uppsala.

LAUNDON, J.R. (1956). The Lichen Ecology of Northamptonshire, in: The first fifty years. A History of the Kettering & District Naturalists' Soc. & Field Club, pp. 89-96. Kettering.

——— (1958). The lichen vegetation of Bookham Common. Lond. Nat. 37, 66-79.

——— (1963). The taxonomy of sterile crustaceous lichens in the British Isles. 1. Terricolous species. The Lichenologist 2.1: 57-67.

——— (1963). The taxonomy of sterile crustaceous lichens in the British Isles. 2. Corticolous & lignicolous species. The Lichenologist, 2.2: 101-151.

——— (1967). A Study of the Lichen Flora of London. Lichenol. 3.3.

LEE, J.R. (1937). The moss flora of tree trunks. N.W. Nat. 12, 11-26.

LEWIS, F.J. (1904). Geographical distribution of the vegetation in the basins of the rivers Eden, Tees, Wear and Tyne. Geogr. J., 23.

LOHMEYER, W. et al. (1962). Contribution a l'unification du systeme phytosociologique pour l'Europe moyenne et nord-occidentale. Melhoramento, 15, 137-151.

MALMER, N. (1965). The South-Western Dwarf Shrub Heaths. In: The Plant Cover of Sweden, Acta Phyt. Succica 50. Uppsala.

MANLEY, G. (1936). The climate of the Northern Pennines: the coldest part of England. Quart. J. R. Met. Soc., 62, 103-113.

——— (1942). Meteorological observation on Dun Fell, a mountain station in northern England. Quart. J. R. Met. Soc., 68, 151-162.

——— (1945). The effective rate of altitudinal change in temperate Atlantic climates. Geogr. Rev., 62, 408-417.

——— (1959). The Late-glacial climate of North-west England. L'pool & Manch. Geol. Journ., 2, 188-215.

MARTIN, I.H. (Ed.) (1927). Field Club Flora of the Lothians. Edinburgh.

MARTIN, N.M. (1938). Some observations on the epiphytic moss flora of trees in Argyll. J. Ecol. 26, 82-95.

MATTHEWS, J.R. (1957). The origin and distribution of the British Flora. London.

McVEAN, D.N. & RATCLIFFE, D.A. (1962). Plant communities of the Scottish Highlands. Monog. Nat. Cons. I. H.M.S.O. London.

MEIJER-DREES, E. (1953). A tentative design for rules of phyto-sociological nomenclature. Vegetatio, 4 (4), 205-214.

MITCHELL, J.B. (1954). Historical Geography. London.

MOOR, M. (1960a). Zur systematik der Querco-Fagetea Mitt. Flor. soz. Arbeitsgem. N.F.8, 262-293.

MOORE, J.J. (1962). The Braun-Blanquet system: a re-assessment. J. Ecol., 50, 761-769.

MOSS, C.E. (1913). Vegetation of the Peak District. Camb. Univ. Press, 235 pp.

NORDHAGEN, R. (1927-1928). Die Vegetation und Flora des Sylenegebeites. Oslo.

OBERDORFER, E. (1957). Süddeutsche Pflanzengesellschaften. Burdes. f. Naturschutz u. Landschafts. B10, Jena.

——— (1962). Pflanzensoziologische Exkursions-flora für Suddeutschland und die angrenzenden Gebiet, 2nd Ed. Stuttgart.

——— (1967). Systematische Ubersicht der westdeutschen Phanerogamen-und Gefasskryptogamen-Gesellschaften. Ein Diskussionsentwurf. Sond a.d. Schriftenreihe f. Vegetationskunde, 2, 7-62. Bad Godesberg 1967.

O'SULLIVAN, A.M. (1965). A phytosociological survey of Irish lowland pastures. Ph.D. thesis, University College, Dublin.

PEARSALL, W.H. (1950). Mountains and Moorlands. New Nat. Series, London.

PERRING, F.H. & WALTERS, S.M. (Ed.) (1962). Atlas of the British Flora. B.S.B.I. Publ., 432 pp.

PERRING, F., WALTERS, S.M. & SELL, P.D. (1968). Critical Supplement to the Atlas of the British Flora. London.

PETTERSSON, B. (1965). Gotland and Öland. Two limestone islands compared. In: The Plant Cover of Sweden, pp. 131-140.

PIGOTT, C.D. (1956). The vegetation of Upper Teesdale in the North Pennines. J. Ecol., 44, 545-586.

POORE, M.E.D. (1955a). The use of phytosociological methods in ecological investigations. I. The Braun-Blanquet System J. Ecol., 43, 226-244. II. Practical issues involved in an attempt to apply the Br. Bl. system. J. Ecol., 43, 245-269.

——— (1955b). The use of phytosociological methods in ecological investigations. III. Practical applications. J. Ecol., 43, 606-651. IV. General discussion of phytosociol. problems. J. Ecol., 44, 28-50.

——— & McVEAN, D.N. (1957). A new approach to Scottish mountain vegetation. J. Ecol., 45, 401-439.

RAISTRICK, A. (1931). The Late-glacial and Post-glacial periods in the North Pennines. Pt. I. The Glacial maximum and retreat. Trans. Northern Nat. Union, 1, 16-29.

RATCLIFFE, D.A. (1960). The Mountain Flora of Lakeland. Proc. Bot. Soc. Brit. Is., 4, 1-25.

RAY, J. (1689). Synopsis Methodica Stirpium Britannicarum. 2nd Ed.

RICHARDS, P.W. (1938). The bryophyte communities of a Killarney oakwood. Ann. Bryol. 11, 108-130.

SCOTT, D.H. (1900). Studies in Fossil Botany, 1st Ed. London.

SHIMWELL, D.W. (1968). Vegetation of the Derbyshire Dales. Nature Conservancy.

——— (1968). The Phytosociology of Calcareous Grasslands in the British Isles. Ph.D. thesis. Univ. of Durham.

SJOGREN, E. (1964). Epilithische und epigäische Moosvegetation in Laubwäldern der Insel Öland (Schweden). Diss. - APhS 48. Uppsala.

SMITH, A.L. (1922). Lichens. Cambridge Botanical Handbooks.

SMITH, J.E. (1824). The English Flora, London.

SMITH, R. (1900a). Botanical Survey of Scotland: I. Edinburgh District. Scott. Geogr. Mag., 16, 385-416.

TANSLEY, A.G. (1911) (Ed.). Types of British Vegetation. Camb. Univ. Press.

——— (1920). The Classification of Vegetation and the concept of development. J. Ecol., 8, 114-149.

——— (1939) (1949). The British Islands and their vegetation. (1st Edn.) (2nd Edn.) Cambridge Univ. Press.

TAYLOR, E.G.R., in DARBY, H. (1936). An Historical Geography of England before A.D. 1800. Cambridge.

TURNER, J. (1970). Vegetational History, in: Durham County with Teesside. British Association, Newcastle upon Tyne.

TUTIN, T.G. et al. (Ed.) (1964). Flora Europaea. Vol. I. 1969 Vol. II.

TÜXEN, R. (1937). Die Pflanzengesellschaften Nordwestdeutschlands. Mitt. flor.-soz. Arbeitsgem. Niedersachsen, 3.

——— (1955). Das System der nordwestdeutschen Planzengesellschaften. Mitt. flor.-soz. Arbeitsgem. NF 5, 155-176.

WALTER, H. & LIETH, H. (1967). Klimadiagramm Weltatlas, Jena.

WALTON, J. (1953). An Introduction to the Study of Fossil Plants 2nd Edn. London.

WATSON, H.C. (1847-59). Cybele Britannica. London.

——— (1873-74). Topographical Botany. Thames Ditton.

WATSON, W. (1936). The bryophytes and lichens of British Woods II. J. Ecol., 24, 446-478.

WESTHOFF, V.& DEN HELD, A.J. (1969). Planteen-Gemeenschappen in Nederland. Zutphen.

WINCH, N.J. et al. (1805). The Botanist's Guide through the Counties of Northumberland & Durham. Vol. I

YARRANTON, G.A. (1962). Bryophytic communities of the exposures of Breidden Hill ex. Rev. Bryologique et Lich. T.XXXI Fasc. 3/4.

——— (1966). A plotless method of sampling vegetation. J.Ecol., 54, 1. 229-237.

——— (1967). A Quantitative study of the Bryophytic & Macrolichen vegetation of the Dartmoor Granite, in: The Lichenologist 3.3. pp. 392-408.

——— (1967a). Organismal and individualistic concepts and the choice of methods of vegetation analysis. Vegetatio, 15, 113-116.

——— (1967b). Principal components analysis of data from saxicolous bryophyte vegetation at Steps Bridge, Devon. I. A quantitative assessment of variation in the vegetation. Cand. J. Bot., 45, 93-115.

TAXONOMIC REFERENCES

ARNELL, S. (1956). Illustrated Mossflora of Fennoscandia I. Hepaticae, Lund.

BERTSCH, K. (1964). Flechtenflora von Südwestdeutschland. Stuttgart.

CLAPHAM, A.R., TUTIN, T.G. & WARBURG, E.F. (1962). Flora of the British Isles, 2nd edn. Cambridge.

——— (1968). Excursion Flora of the British Isles, 2nd edn. Cambridge.

DIXON, H.N. (1924). Student's Handbook of British Mosses, 3rd edn. Eastbourne.

DUNCAN, U.K. (1959). A guide to the study of lichens. Arbroath.

——— (1970). Introduction to British Lichens. Arbroath.

JAMES, P.W. (1965). A new check list of British Lichens. The Lichenologist, 3 (1), 95-153.

MACVICAR, S. (1926). Student's Handbook of British Hepatics, 2nd edn. Eastbourne.

NYHOLM, E. (1954-65). Illustrated Mossflora of Fennoscandia, II. Musci. Teil (1-5) Lund.

PATON, J.A. (1965). Census Catalogue of British Hepatics, 4th edn. Ipswich.

PODPERA, J. (1954). Conspectus muscorum Europaeorum, Prague.

SMITH, A.L. (1921). British Lichens. London.

WARBURG, E.F. (1963). Census Catalogue of British Mosses, 3rd edn. Ipswich.

WATSON, E.V. (1968). British Mosses & Liverworts, 2nd edn. Cambridge.

WOLLEY-DOD, A.H. (1930-31). A Revision of the British Roses Journ. Bot. 68, 69. Supplement.

APPENDIX A

Comprehensive data

Table App./1 COMPREHENSIVE DATA : JUNIPER SCRUB (J)

Field plot	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12A	C14	C15	C21	C22	C23
Aufnahme No.	1	2	3	4	5	6	7	8	9	10	11	12	14	15	21	22	23
Species total	35	28	38	32	32	37	44	41	39	38	24	19	25	25	34	38	48
Aspect	NNE	NNE	NNE	NNE	NNE	NNE	NE	NW	NNE	NE	NNE	N	N	N	N	NE	NE
Slope °	8	8	10	10	5	5	5	10	10	10	5	5	5	10	2	10	5
Quadrat size ($m.^2$)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cover (Domin): Shrubs	9	8	9	10	9	8	8	8	10	9	.	9	.	.	.	5	6
Herbs	9	8	9	8	8	9	6	9	8	7	10	10	10	10	9	5	7
Bryophytes	7	6	8	6	7	8	6	7	5	8	6	5	5	6	4	9	7
Cover % Bare (earth & litter)	.	.	.	5	2	.	25	.	3	6	.	.	.	.	6	2	3
Logs	6	4	3	3	1	2	50	8	5	5	.	.	.	.	.	.	.
Exposed rock	.	.	.	3	.	2	.	.	3	1	.	.	.	.	.	.	2
Height (dm.): Shrubs	15	15	13	12	15	15	21	24	27	30	.	4	.	.	.	20	12
Herbs	2	7	6	4	3	6	10	3	6	9	4	5	5	5	4	6	8
Bryophytes	0.6	1.0	0.7	0.3	1.3	0.3	1	0.7	0.3	0.8	0.3	0.3	0.4	0.4	0.3	1.2	0.9
Soil depth (dm.)	2	2	1	0.2	1.5	0.2	1.0	0.5	0.5	0.5	0.2	1.5	0.5	0.5	1.5	1.5	1
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	m	m	g	f	g	g	f	m	m	i	i	m	i	f

Table App./1 (continued)

Field plot	C26	C27	C28	C29	C30	C31	C32	1	2	3	4	5	6	7	8	9	10
Aufnahme No.	26	27	28	29	30	31	32	41	42	43	44	45	46	47	48	49	50
Species total	14	16	12	25	31	28	22	31	32	42	40	33	38	37	40	24	28
Aspect	NE	NNE	NNE	NNE	NNE	NNE	NNE	NE	NE	NNE	NNE	N	NNE	NNE	NNE	NNE	NNE
Slope °	5	2	2	2	10-60	20	20	5	12	15	10	10	8	20	6	2	12
Quadrat size (m.^{2})	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cover (Domin): Shrubs	9	.	3	.	.	5	9	9	9	9	9	8	9	9	8	9	9
Herbs	7	9	9	8	10	9	7	9	9	9	9	8	8	9	8	9	8
Bryophytes	5	6	6	8	7	6	6	4	6	8	7	6	7	9	7	7	4
Cover % Bare (earth & litter)	50	5	5	2	.	3	10	6	3	20	2	20	25	10	10	5	25
Logs	2	.	3	.	.	5	20	2	3	10	3	10	5	5	20	5	5
Exposed rock	20	.	.	.	.	3	20	.	2	20	4	4	.	5	.	2	.
Height (dm.): Shrubs	30	.	6	.	.	13	30	21	10	22	21	25	12	24	9	30	25
Herbs	9	5	3	5	4	9	11	6	4	8	7	11	7	9	10	13	7
Bryophytes	0.3	0.2	0.8	1.0	0.9	0.5	0.8	0.8	0.4	0.7	0.3	0.4	0.4	0.8	0.3	0.5	0.8
Soil depth (dm.)	2.5	2.5	1.5	2.5	1	2.5	1	1.5	1	1	1.5	1	1	1	2	2	2
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	m	i	i	i	g	g	g	g	m	g	g	m	g	m	g	g

Table App./1 (continued)

Field plot	11	12	13	14	15	15A	17	18	19	20	21	22	23	24	25	26	27
Aufnahme No.	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Species total	27	27	18	30	30	25	25	21	22	28	25	24	23	22	18	.	22
Aspect	NE	N	NNE	N	N	N	NNW	NNW	NE	NNW	-	-	-	-	-	NE	-
Slope °	20	6	10	6	15	15	18	12	6	12	-	-	-	-	-	4	-
Quadrat size ($m.^2$)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cover (Domin): Shrubs	8	8	9	8	8	8	9	8	8	9	.	.	.	.	.	.	.
Herbs	9	9	9	9	9	8	8	9	8	9	10	10	10	10	10	10	10
Bryophytes	5	6	4	5	4	4	5	5	6	4	4	4	5	5	5	5	5
Cover % Bare (earth & litter)	20	2	3	10	.	25	10	15	25	20	.	.	.	.	.	.	.
Logs	3	4	3	10	.	20	5	5	20	3	.	.	.	.	.	.	.
Exposed rock	.	1	4	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Height (dm.): Shrubs	16	20	26	22	19	16	30	18	12	11	.	.	.	.	.	.	.
Herbs	6	7	9	8	7	6	8	8	9	5	6	6	6	6	7	6	6
Bryophytes	0.3	0.4	0.3	0.4	0.6	0.4	0.5	0.4	0.4	0.3	0.2	0.3	0.3	0.3	0.3	0.8	0.8
Soil depth (dm.)	2	2.5	2	2	2	3.5	2.5	1.5	2.5	1.5	2	2	1.5	2.5	2.5	2.5	2
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g

Table App./1 (continued)

Field plot	28	29	30	31	32	33	34A	35	36	37	38	38A	39	39A	40	41	42
Aufnahme No.	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
Species total	21	21	25	29	22	19	22	23	33	23	25	21	29	26	27	12	18
Aspect	-	NE	NE	NNE	NNE	NNE	NNE	NNW	N	NW	N	N	NNE	NNE	NNE	-	NE
Slope °	-	4	4	10	4	5	4	20	8	2	2	2	4	4	5	5	20
Quadrat size ($m.^2$)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Cover (Domin): Shrubs	.	.	.	8	8	9	8	7	8	8	9	8	8	7	8	.	.
Herbs	10	10	10	9	9	9	9	9	9	9	9	9	9	9	8	5	10
Bryophytes	6	7	7	5	9	7	6	6	7	8	7	7	6	6	8	5	5
Cover % Bare (earth & litter)	.	.	.	4	10	5	20	5	.	.	4	5	4	5	15	.	.
Logs	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Exposed rock	.	.	.	5	.	.	.	1	.	.	.	.	.	.	.	75	.
Height (dm.): Shrubs	.	.	.	4	4	4	3	4	3	3	4	4	4	3	4	.	.
Herbs	6	6	6	5	5	6	5	5	4	6	4	4	5	5	6	3	6
Bryophytes	0.4	0.3	0.4	0.3	1.3	0.4	0.3	0.5	1.5	1.1	0.3	0.5	0.3	0.5	1.4	0.4	0.3
Soil depth (dm.)	2	2	3	1	3	2	1	1	2	2.5	1	1	2.5	1.5	2	0.2	1.5
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	i	m	g	g	i	m	m	g	g	g	m	g	g

Table App./2 COMPREHENSIVE DATA : BIRCH WOOD (B)

Aufnahme No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Species total	30	42	48	31	24	28	41	35	37	30	31	35	22	16	17	13
Aspect	N	N	NNE	N	NNE	NE	NNE	NNE	NE	N	NE	NE	NE	NNE	N	N
Slope °	30	5	5	45	5–30	50	35	30–50	15–45	20–35	60	30	40	80–100	45–70	80–90
Quadrat size (m.^{2})	2	2	2	2	2x$\frac{1}{2}$	2	2x4	10	10	10	10	10x4	2	2x$\frac{1}{2}$	1	1
Cover (Domin): Trees	4	.	.	8	.	.	6	9	8	8	5	6	9	9	9	6
Shrubs	9	.	9	.	.	.	6	4	3	.	.	4	.	.	.	.
Herbs	9	10	9	9	5	10	9	10	10	10	9	9	9	4	4	4
Bryophytes	5	4	7	7	6	5	7	7	7	7	6	6	7	9	9	7
Cover % Bare (earth & humus)	10	5	10	2	10	60	.	.	.	.	60	2	2	5	5	20
Logs	.	.	.	.	.	.	.	.	.	.	.	2	.	5	.	.
Exposed rock	5	.	2	2	60	2	15	.	2	2	20	2	2	5	5	20
Height (dm.): Trees	45	.	.	75	.	.	90	90	90	90	45	90	75	70	75	60
Shrubs	18	.	7	.	.	.	30	20	10	.	.	40	.	.	.	.
Herbs	6	5	7	7	2	9	8	9	7	6	10	7	7	4	4	2
(cm.) Bryophytes	2	2	3	4	2	4	5	6	7	7	6	12	3	5	7	2
Soil depth (dm.)	1.5	5	5	1	.	1	0.5	1	1	1	.	0.5	1	0.5	0.5	0.2
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	f	f	g	f	g	f	g	g	g	g	g	g	g	g	g

Table App./2 (continued)

Aufnahme No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Species total	40	50	46	22	27	33	27	28	13	21	18	28	18	21	29	13
Aspect	N	N	NNE	NNE	N	NNE	NNE	NNE	NE	NNE	NE	NNE	N	NNE	NNE	NE
Slope °	20-40	80-90	20-40	30	50	50	50	65	10	5	10	15	10	10	10	10-40
Quadrat size ($m.^2$)	4	4x6	1x5	1	3x2	10	10	2x4	4	2x4	4	10	5x2	4x2	4	1x4
Cover (Domin): Trees	9	6	6	4	.	4	6	8	5	.	.	.	4	.	.	9
Shrubs	3	7	.	9	3	3	4	5	5	9	.	4	6	9	10	.
Herbs	9	8	8	8	4	10	10	9	10	7	10	10	9	8	9	5
Bryophytes	8	9	9	8	8	5	4	8	7	6	8	8	9	9	8	8
Cover % Bare (earth & humus)	.	.	.	20	.	20	10	20	.	10	15	.	.	5	10	5
Logs	.	.	.	.	.	.	.	.	.	5	.	.	.	.	5	10
Exposed rock	5	50	40	.	40	70	90	40	.	5	.	.	5	5	2	10
Height (dm.): Trees	70	60	70	60	.	60	70	90	60	.	.	.	60	.	.	70
Shrubs	30	30	.	45	5	30	50	50	20	20	.	15	20	20	30	.
Herbs	6	11	5	3	5	15	15	10	5	5	12	12	4	6	12	3
(cm.) Bryophytes	5	6	4	5	3	5	5	6	4	3	5	5	14	10	10	6
Soil depth (dm.)	.	.	.	1	.	.	.	0.5	0.5	0.5	0.5	0.5	.	0.5	0.5	0.5
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	f	g	g	g	g	g	g	g	g	g	g	g	g	g

Table App./2 (continued)

Aufnahme No.	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Species total	13	21	20	15	26	29	33	29	34	12	18	16	27	29	45	42
Aspect	N	N	NNE	N	N	NNE	-	NE	-	N	E	-	NE	N	N	N
Slope °	10-45	35	5	5	5	45-60	.	50	.	80	30	.	35	30-45	10	20-30
Quadrat size (m.^{2})	1x2	4	8	10	4	4x10	10	5	5	1x½	1x½	1	4	5	2x4	2
Cover (Domin): Trees	8	.	10	10	3	.	.	.	.	4	4	4	5	.	.	.
Shrubs	.	.	.	.	10	4	9	4	9	.	.	.	.	5	7	.
Herbs	5	9	8	10	8	10	9	9	9	3	4	5	10	8	9	9
Bryophytes	8	8	3	4	5	6	8	6	8	5	9	8	8	9	5	5
Cover % Bare (earth & humus)	10	20	10	20	20	40	15	10	10	20	5	.	.	2	10	5
Logs	.	.	5	.	5	.	5	.	5	5	.	5	.	.	.	.
Exposed rock	5	50	2	5	.	30	.	90	.	10	5	2	.	5	.	20
Height (dm.): Trees	70	.	60	80	30	.	.	.	.	80	80	80	80	.	.	.
Shrubs	.	.	.	.	30	12	40	15	30	.	.	.	.	30	5	.
Herbs	5	9	5	10	12	14	11	12	10	3	4	4	6	9	7	6
(cm.) Bryophytes	7	8	3	3	5	5	6	4	6	1	1	3	6	2	4	7
Soil depth (dm.)	1	.	2	1.5	1	.	1	.	1.0	0.5	1.5	0.5	0.5	.	1	0.5
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	g	g	g	g	g	g	g	g	g	f	f	f

Table App./3 COMPREHENSIVE DATA : PARK END WOOD (P)

Aufnahme No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Species total	20	25	22	16	20	24	25	30	34	37	38	23	52	35	25	25
Aspect	W	W	W	SW	-	W	SW	NW	NNW	NNW	N	-	SSW	SW	NW	NNW
Slope °	10	5	2	2	.	10	10	2	2	2	2	.	2	2	5	5
Quadrat size ($m.^2$)	2	2	2	2	2	2	2	4	4	4	4	4	6	4	2	2
Cover (Domin): Trees	7	4	4	4	6	8	7	8	8	5	4	.	.	9	.	.
Shrubs	.	.	.	4	.	.	5	7	.	.	.	8	4	4	.	.
Herbs	9	10	10	10	10	9	9	10	9	10	10	8	10	9	10	10
Bryophytes	5	4	4	4	4	4	4	4	5	5	6	7	5	4	5	5
Cover % Bare (earth & litter)	5	.	.	.	.	.	.	.	5	.	.	10	.	5	.	.
Logs	.	.	.	.	.	.	.	.	5	.	.	5	.	.	.	.
Exposed rock	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Height (dm.): Trees	80	80	90	35	70	90	90	90	90	90	60	.	.	70	.	.
Shrubs	.	.	.	20	.	.	30	60	.	.	.	30	30	12	.	.
Herbs	4	4	8	10	10	8	7	5	4	10	10	10	8	10	7	8
Bryophytes	0.5	0.3	0.3	0.2	0.3	0.2	0.3	0.4	0.6	0.5	0.6	0.6	0.5	0.3	0.3	0.3
Soil depth (dm.)	1.5	1	2	2	1.5	1	1.5	3	1	2.5	3.5	4	1.5	3	1.5	1.0
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	g	g	g	m	i	i	i	m	g	g	g	g

Table App./3 (continued)

Aufnahme No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Species total	34	21	50	41	38	42	25	33	32	18	20	33	31	27	23	27
Aspect	NNW	NNW	N	NNW	NW	W	WNW	WNW	NW	NW	NW	NE	NE	NE	E	NE
Slope °	5	10	15	40	80	15	3	3	10	10	10	20	50	40	2	5
Quadrat size ($m.^2$)	4	4	4	2	2	2	4	2	2	2	4	1	2	2	4	4
Cover (Domin): Trees	5	7	4	4	4	5	8	.	9	8	7	7	5	.	4	6
Shrubs	3	3	5	3	3	.	.	4	3	.	.	.	.	.	.	.
Herbs	8	7	9	9	9	9	8	9	7	5	6	8	9	9	10	10
Bryophytes	8	4	5	7	7	5	8	6	7	5	7	9	9	8	8	7
Cover % Bare (earth & litter)	.	10	10	.	30	5	5	5	10	10	15	.	15	10	.	.
Logs	.	.	.	4	5	.	.	5	.	.	.	.	.	.	.	.
Exposed rock	.	10	10	2	10	.	5	.	50	70	60	10	10	10	.	.
Height (dm.): Trees	60	140	50	45	45	60	80	.	80	100	60	60	60	.	80	80
Shrubs	20	30	20	20	20	.	.	20	20	.	.	.	.	.	.	.
Herbs	10	9	9	8	7	8	7	12	7	9	10	9	9	14	7	7
Bryophytes	1.5	0.4	0.4	0.6	0.6	0.5	0.4	0.4	0.4	0.4	0.5	0.7	0.7	0.6	1.0	1.0
Soil depth (dm.)	2.0	1.0	2	1.5	1	1.5	3	3.5	1	0.5	1	1.2	0.5	0.5	1.5	1
Drainage (g = good; m = moderate; i = impeded; v.i. =very impeded; f = flushed or flooded)	v.i	f	f	g	g	i	g	g	g	g	g	f	g	g	m	i

Table App./3 (continued)

Aufnahme No.	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Species total	13	17	18	20	28	36	38	29	32	53	22	24	52	52	37	23
Aspect	N	-	NE	NE	S	S	SW	NE	NE	SW	NE	NE	N	NNW	NW	NE
Slope °	2	.	5	2	10	20	30	2	2	40	30	50	40	40	70	40
Quadrat size (m.^{2})	2	2	2	4	4	4	4	4	4	4	10	10	10	4	2	2
Cover (Domin): Trees	4	9	9	.	3	4	8	9	7	.	9	7	9	.	.	8
Shrubs	.	.	.	4	.	4	7	.	.	9	3	.	3	4	8	.
Herbs	5	7	6	10	7	9	8	10	10	9	8	9	9	9	8	5
Bryophytes	9	7	8	6	5	4	6	4	4	7	8	8	8	9	9	6
Cover % Bare (earth & litter)	.	10	10	.	.	.	30	.	5	5	25	10	10	2	.	20
Logs	.	20	15	.	.	.	2	.	.	5	2	.	2	.	.	.
Exposed rock	.	10	.	.	50	10	2	.	.	2	60	80	4	.	.	30
Height (dm.): Trees	80	90	90	.	90	90	50	80	90	.	100	100	90	.	.	80
Shrubs	.	.	.	15	.	15	30	.	.	30	.	.	.	30	30	.
Herbs	6	6	4	9	9	9	8	7	8	7	8	10	10	5	4	10
Bryophytes	2.5	0.3	1.8	0.5	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.5	0.4	1.0	1.2	0.5
Soil depth (dm.)	0.5	0.5	0.5	1	0.5	1	1.5	6	8	2	1	.	0.5	0.5	0.5	0.5
Drainage (g = good; m = moderate; i = impeded; v.i. = very impeded; f = flushed or flooded)	v.i.	m	i	g	g	g	g	i	i	g	g	g	g	g	g	g

Table App./4 COMPREHENSIVE DATA : MILL BECK WOOD (M)

Aufnahme No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Species total	57	48	39	44	37	39	51	48	61	49	64	68	33	17	29	19
Aspect	N	NNE	NNE	N	W	NW	N	NNE	N	NW	N	NNE	N	N	NNE	NNE
Slope °	2	4	5	8	2	2	5	2	10-60	30	2	2	30	45	15	30-70
Quadrat size ($m.^2$)	10	10	4	10	4	4	4	4	4	10	10	10x4	5	1	4	1
Cover (Domin): Trees	8	7	.	9	9	9	.	.	5	4	(+)	4	.	.	5	.
Shrubs	6	9	8	.	.	.	8	6	7	9	7	9	7	6	8	8
Herbs	9	6	8	9	9	8	9	10	9	9	9	9	9	7	8	7
Bryophytes	6	5	6	7	8	7	7	7	7	5	5	6	5	9	4	7
Cover % Bare (earth & litter)	10	5	2	20	.	10	.	2	5	15	10	5	10	5	20	50
Logs	5	5	.	10	.	.	.	.	.	.	.	.	.	.	.	.
Exposed rock	.	3	.	.	.	2	.	.	3	3	.	5	2	.	2	.
Height (dm.): Trees	100	90	.	90	50	50	.	.	75	100	90	50	80	.	80	.
Shrubs	30	40	20	.	.	.	30	20	20	30	30	40	50	50	50	50
Herbs	7	4	9	6	4	4	10	5	8	6	7	7	6	5	6	5
Bryophytes	0.3	0.3	0.4	0.3	0.4	0.5	0.5	0.6	0.5	0.4	0.4	0.8	0.3	0.3	0.3	0.5
Soil depth (dm.)	2.5	3	3	3	3	2	1.5	0.5	1.5	2.5	5	1.5	1	1.5	2	2
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	m.f	m	g	i	m	m	m	g	g	g	i.f	g	g	g	m	g

Table App./4 (continued)

Aufnahme No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Species total	33	23	21	32	23	15	18	50	59	46	59	40	46	48	49	49
Aspect	NE	NE	N	NE	N	NNW	W	S	ESE	E	NE	-	N	SW	W	N
Slope °	15	60	5	20	30	30	10-30	45-60	30-70	30-60	30-70	-	5	2	20-70	15
Quadrat size ($m.^2$)	2x1	5	4	5	10	1x2	2	2	4	2x4	2x4	4	4x10	5	2x5	10
Cover (Domin): Trees	9	5	.	9	8	7	4	5	7	7	5	.	8	.	8	.
Shrubs	.	.	.	4	5	.	.	6	4	8	8	9	.	10	7	9
Herbs	10	10	10	10	10	7	9	8	8	7	7	9	7	9	6	7
Bryophytes	5	6	4	8	7	8	3	6	6	5	8	5	5	8	6	4
Cover % Bare (earth & litter)	.	30	.	.	.	.	50	5	20	5	20	.	30	.	20	40
Logs	.	.	.	.	.	.	.	.	10	.	10	.	.	.	.	.
Exposed rock	5	10	.	.	5	.	.	10	10	2	20	.	20	.	30	5
Height (dm.): Trees	50	50	.	90	90	90	40	65	75	60	60	.	90	.	90	.
Shrubs	.	.	.	40	50	.	.	40	30	30	30	20	.	40	40	60
Herbs	6	10	7	7	7	6	9	5	7	6	5	4	12	5	5	4
Bryophytes	0.3	0.5	0.2	0.2	0.2	0.5	0.3	0.4	0.3	0.4	0.5	0.6	0.3	0.6	0.3	0.3
Soil depth (dm.)	0.5	0.5	2	1	1	1	0.5	0.5	1	1	1	4	0.5	1	0.5	1
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	g	g	g	f	g	g	g	m	g	g	g	g

Table App./4(continued)

Aufnahme No.	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Species total	43	50	45	44	34	38	43	44	44	42	51	46	43	32	49	32
Aspect	SE	E	E	E	-	NNW	N	NE	N	NW	W	NNE	-	NW	N	WSW.
Slope °	25	10	10-50	15	-	50	0-10	5	10	5	5	15	-	25	60	50
Quadrat size ($m.^2$)	2x4	10x5	5x2	5	5	4x2	4	10	10	10	2x4	1x4	4	4	5	1
Cover (Domin): Trees	8	(+)	9	.	.	9	10	9	9	6	9	8	-	4	4	9
Shrubs	6	9	4	8	10	4	.	.	.	.	2	1	7	6	4	4
Herbs	6	9	6	9	7	8	7	9	9	10	7	9	7	9	10	8
Bryophytes	7	8	5	7	4	6	6	8	6	7	6	5	7	8	8	6
Cover % Bare (earth & litter)	5	.	20	5	40	10	5	2	2	.	.	.	.	.	25	5
Logs	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	5
Exposed rock	90	.	40	.	.	5	60	.	5	.	60	10	.	.	10	.
Height (dm.): Trees	70	.	80	.	.	90	90	60	60	80	90	60	.	90	60	70
Shrubs	50	20	30	45	30	30	.	.	.	.	30	20	15	45	45	30
Herbs	5	7	6	5	5	7	6	5	7	7	6	5	8	5	10	3
Bryophytes	0.5	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.5	0.3	0.3	0.6	0.5	0.2
Soil depth (dm.)	0.5	4	0.5	1	1	0.5	0.2	3	1.5	2.5	0.5	0.5	2	4	0.5	1
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	i	g	g	g	f	f	f	g	i	m	f.i	m	g

Table App./4 (continued)

Aufnahme No.	49	50	51	52	53	54	55	56	57	58	59	60	61
Species total	37	29	32	28	26	19	39	27	34	73	74	32	31
Aspect	SW	SW	SW	SW	SW	SW	E	E	S	SE	S	SSE	SE
Slope °	70	45	30	30	45	5-10	40	25	25	5	10	20	20
Quadrat size ($m.^2$)	4	4x2	4	4x2	10	1x2	10	10x4	10	10x2	4	5	2
Cover (Domin): Trees	9	7	10	9	8	5	9	7	5	8	7	10	9
Shrubs	6	9	5	4	5	4	4	.	4	3	9	6	7
Herbs	8	6	7	10	9	9	9	10	10	9	7	8	8
Bryophytes	6	7	6	4	7	8	6	6	8	6	6	6	5
Cover % Bare (earth & litter)	5	30	40	.	2	.	10	.	.	5	50	20	20
Logs	.	.	.	.	.	.	5	.	.	.	.	.	.
Exposed rock	5	.	.	5	.	.	.	.	.	2	2	10	70
Height (dm.): Trees	70	70	90	80	80	.	70	80	70	90	90	70	70
Shrubs	30	40	20	30	30	20	40	.	40	45	60	60	6
Herbs	7	6	5	4	8	7	6	6	9	7	4	6	6
Bryophytes	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.5	0.4	0.3	0.3	0.3
Soil depth (dm.)	0.5	0.5	0.5	0.5	0.5	1	1.5	2	2.5	2	0.5	0.5	0.5
Drainage (g = good; m = moderate; i = impeded; f = flushed or flooded)	g	g	g	g	g	i	g	g	g	m	g	g	g

APPENDIX B

Legenda of the tables

LEGENDA OF THE TABLES

Degree of exposure

pp = much sheltered (from winds)

p = sheltered

mp = moderately sheltered

me = moderately exposed

e = exposed

ee = strongly exposed

Illumination

ss = much shaded

s = shaded

ms = moderately shaded

ml = moderately light

l = light

ll = very light and sunny

Humidity and water supply

w = wet

m = moist

md = moderately dry

d = dry

dd = very dry

i = inundated in winter

r = rain track

rb = rain track border zone

Woodland symbol

B = Birch Wood

P = Park End Wood

M = Mill Beck Wood

J = Juniper Scrub

Area of plot

In epiphytic stands the plots were very rarely square and total area has been given in square decimetres.

Tree species

Ag = Alnus glutinosa

Ap = Acer pseudoplatanus

Bp = Betula pubescens

Ca = Corylus avellana

Cm = Crataegus monogyna

Fe = Fraxinus excelsior

Jc = Juniperus communis

Pp = Prunus padus

Sa = Sorbus aucuparia

Sp = Salix pentandra

Tb = Taxus baccata

Ug = Ulmus glabra

Tree Altitude

These are not given in individual tables as the variation is small.

B stands	950' - 1000'	av. 290 m.
P stands	840' - 870'	av. 258 m.
M stands	830' - 900'	av. 258 m.
J stands	1050' - 1100'	av. 320 m.