Phytosociology and community boundaries of the British heath foundation

P. Bridgewater

Phytosociology and Community Boundaries of the British Heath Formation.

A thesis submitted by

P. Bridgewater, B.Sc. (Dunelm),

to the University of Durham,

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Department of Botany,
University Science Laboratories,
South Road,
DURHAM.

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This thesis, which is entirely the result of my own work, has not been accepted for any degree, and is not being submitted concurrently in candidature for any other degree.

P. Bridgwater

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ABSTRACT

A review of phytosociological techniques, including the Zürich-Montpellier (Z-M) system, Association analysis and Simple ordination is made, using a standard data set. The complementary nature of the results obtained is noted.

As classification erects divisions and boundaries in a data set, and the prime method used in the analysis of Heath vegetation is classificatory, evidence for the prescence of 'real' vegetation boundaries is presented, together with a discussion of their nature and function.

Heathland vegetation in Britain has been classified using the Z-M phytosociological system, and four main types have been distinguished, which are equated with alliances at present in use in Europe. These are;

Erica cinerea Heath: Ulicion nanae (Duvignd, 1944)em. Van den Bergen.
Calluna vulgaris Heath: Calluno-Genisition pilosae (Duvignd, 1944)
Vaccinium myrtillus Heath: Myrtillion boreale (Böcher, 1943).
Erica tetralix Heath: Ericion tetralicis (Schwick, 1933).

The first three are typical of Dry heaths, whereas the fourth indicates Wet heath. A phytogeographical analysis of the Heath vegetation gives further validity to these four types, indicating the dependance of the three dry 'Heaths' on species which are geographically restricted.

Use of the Z-M system and some other techniques to indicate the nature of recent vegetation in areas now urbanised or agriculturalised is made, using South Gloucestershire as such an area.

SPECIES NOMENCLATURE.

Species are named from the following sources;

Lichens	James, P.W. - A new check-list of British Lichens. The Lichenologist, (3), 1965.
Hepatics	Jones, E.W. - An annotated list of British Hepatics. Trans. B.B.S., 3, 1958.
Mosses	Richards, P.W. and Wallace, E.C. An annotated list of British Mosses. Trans. B.B.S., 1, 1950.
Vascular plants	Dandy, J.E. - List of British Vascular Plants, London, 1958, together with changes noted in Dandy, J.E. - Nomenclatural changes in 'List of British Vascular Plants'. Watsonia, (7), 1969.

Species named from other sources are;

Zygogonium ericetorum, Kütz.

Helianthemum nummularium, (L) Miller.

Pilosella officinarum, C.H. and F.W. Schultz.

P. peleterana (Mérat), C.H. and F.W. Schultz.

In the text and tables the following abbreviated names are used;

Agrostis montana for A. canina ssp. montana.

Sarothamnus maritimus for S. scoparius ssp. maritimus.

Hypnum ericetorum for H. cupressiforme var. ericetorum.

Also, the two species Hieracium vulgatum and Rubus fruticosus are named to the infra specific section, where possible (i.e. R. discolores).

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I. INTRODUCTION.

I.1. Aims of the project.

The major part of this project has been a study, over as wide a range as possible, of vegetation belonging to the British heath formation and the construction of a classification of this vegetation, in relation to existing information on the continent of Europe. In addition, studies have been made on the nature of 'boundaries' within the Heath formation, and between vegetation of the Heath formation and other formations.

At the outset it was realised that some restrictions would have to be imposed on the Geographical areas studied. To this end Britain (mainland Scotland, England and Wales, with associated Islands and the Isle of Man) was taken as the unit area, and Ireland excluded. The extreme oceanity of this latter country, with its attendant wide range of Heathland vegetation made its inclusion untenable at this stage. An additional part of the project was to test the effect of several differing 'numerical' methods against a standard data set.

This introduction deals with some theoretical aspects of the Zürich-Montpellier (Z.M.) School of Phytosociology, existing "synsystematics" of the Heath formation, and the results of previous work attempted in Britain on the heath formation.

I.2. Terminology.

'Phytosociology' is usually regarded, in English speaking countries, as the study (quantitative or qualitative) of plant communities, and that is the sense in which it is used from now on.

The term Formation has been used and defined many times in the early ecological literature. First used by Grisebach (1838) with reference to the controlling influence of marcoclimate on vegetation, Weaver and Clements (1929) reinforced this idea, terming formation as "a fully developed, or climax, community of a natural area in which the essential climatic relations are similar, or identical - It is a product of the climate and controlled by it."

Raunkiaer (1910) distinguished between Plant climatology, "the science dealing with the distribution of the major types of world vegetation, controlled by climate" and the Theory of Formations "dealing with the grouping of Individual species of the Flora on a given substratum".

Moss (1907, 1911) used the idea that all associations (his sense) that are developed on the same habitat constitute a 'formation' (i.e. all communities developed over chalk, including grassland, scrub, chalk heath, beechwood etc., would constitute a 'formation'). With respect to this useage of the term, Tansley (1920) observed; "So far as England is concerned this is a perfectly good, workable, objective classification, affording an excellent conspectus of the actual vegetation." Though this may be true, the system is obviously untenable in an international context, and, it would be difficult to reconcile it with existing International Systems.

Tansley (1939) synthesised some of these differing viewpoints and defined formations as "relatively stable communities determined by edaphic or biotic factors, each marked by the dominance of a characteristic life-form, but divisible into Geographical regions."

Dansereau (1957), further simplified this into the following definition "one or more plant communities exhibiting a definite structure and physiognomy; a structural or physiognomic unit of vegetation." As this is the most elegantly simple definition, it is the one adopted in all future references to formation.

Perhaps two of the most abused terms in phytosociological useage are "Community" and "association".

(a) Community (German: Pflanzengemeinschaft). This term is taken as meaning - "a group of individuals of plant species, the composition of which being determined by the environmental conditions and the mutual relations of these species, i.e. composition, abundance, dominance, sociability (cf. the phytocoenose concept of Becking, 1957)." N.B. the term 'community' used in Section V is used strictly in the terms of hierachical position. (sensu de Smidt, 1966).

(b) Association. This has been used as the 'basic unit' of several differing synsystematic schools, and it has been defined in rather different ways. Here its definition is taken as, "an abstraction of several plant communities, identified by its own characteristic species composition."

'Heath' is defined by Tansley (1939) as "an oceanic or sub-oceanic plant formation dominated by ericaceous undershrubs, mainly the common heather or ling (Calluna vulgaris), but also by other members of the Ericaceae. In countries bordering the North Sea or Atlantic, this formation is prevelant on porous soils and well drained slopes or plateaux."

There are, however, vernacular distinctions within the formation, i.e. between 'Heath' and 'Moor'. (N.B. here the useage in Germany of the two terms 'Heide' and 'Heidemoor'.) Use of the term 'Upland Heath' was quite considerable in the early literature, e.g. Smith (1911), Elgee (1914) and Watson (1932). The dividing line between 'Heath' and 'bog' is also rather confused in the literature - leading to use of the term 'Wet Heath'.

To try and integrate some of these problem areas, the following definition was made at the start of the project; "Heathland is defined as that type of land covered wholely or partly by ericaceous shrubs, with a peat depth of not more than 220mm". This includes not only all the types of Tansley's 'Heath Formation' (1939), but also is compatible with 'Heathland' of all other continents.

I.3. Choice of Method.

There is an extremely wide range of methods currently in use for studying vegetation, some of which are described in Section II. The main criteria considered in this present study in choosing the most suitable "method" for a large scale study of Heath vegetation were (i) ease of useage, (ii) availability of European descriptions for comparative purposes, (iii) production of a classification, preferably by a polythetic process (i.e. one which considers all of the factors (species) when making a division or fusion of data). The one method which satisfied all these requirements was that used by the Zurich-Montpellier School (Braun-Blanquet, 1964) and Section (V) shows a classification derived using the principles of this school.

Other factors which count in favour of the use of this system are as follows:-

(i) Although there are other schools in use on the continent, (Upsala School, DuRietz, 1920) and the Russian School of Biocoenology, Wawilow, 1950), they are often integrated with the Z-M System. For example, several of the higher divisions of the hierachy of some vegetation types of the Z-M system are based on those derived from

Nordhagen and other Scandinavian workers (e.g. Scheuchzerio-Caricetea fuscae Nordh, 1936). This is possible because the basic underlying tennets are similar in all three cases, unlike some of the more mathematical methods used in Britain and America, which have virtually no common ground with the European schools.

(ii) From the vegetational units produced by the application of this system, both large scale local and smaller scaled national and international vegetation maps are easily produced. Naturally, a map of this sort is of immense use in conservation, planning, landscape architecture and land use management.

(iii) The publication of "Irische Pflanzengesell-schaften" (Braun-Blanquet and Tüxen, 1952), clearly shows the applicability of this system to British vegetation, as have more recent theses by O'Sullivan (1965) and Shimwell (1969).

I.4. Theory and Practice of the Z-M System.

I.4.1. Introduction. There has been surprisingly little published in the English language on the theory or methodology of the Z-M School. Poore (1955,56) has outlined some of the theoretical points behind the school, but has also modified them by proposing additional facets to the system, particularly the concept of 'nodum' or abstract vegetation unit of any category, as a reference point in a field of more or less continuous variation. Whilst this idea has valuable potential in some types of vegetation, it is perhaps unfortunate to be advanced as a general principle. Moore (1962) points out that many of the criticisms made by Poore (particularly his over-emphasis on the importance of 'Fidelity') do not apply to the system as practised by most European Phytosociologists today, and adds a little more detail on the methodology of the Z-M system. Becking (1957) has produced an excellent review of the system, particularly from the American standpoint, but, again, rather over-emphasised the importance of Fidelity.

As Moore (1962) points out, the use of the term "Charakterarten", implict from the faithfullness of character species, has now declined, and has been replaced by the terms 'kennarten' ("know-species") and Trennarten (differential species), which become applied to groups of species in the defined associations that either enable one to "know" the association, or to be able to differentiate sub-divisions of the association. Kennarten are essentially merely a special case of Trennarten. That this is true is obvious, because very few species have so narrow an ecological amplitude that they will be found in one association alone.

If one considers an elementary classification of plant species as follows:-

I. Geographically widely distributed, Ecological amplitude wide.
II. Geographically widely distributed, Ecological amplitude narrow.
III. Geographically restricted, Ecological amplitude wide.
IV. Geographically restricted, Ecological amplitude narrow.

then species on Category IV are very likely to be suitable Kennarten (i.e. Arctous alpina, Erica ciliaris), species in Categories II and III are likely to be employed as Trennarten, (i.e. Vaccinium myrtillus, Erica tetralix), and species in Category I are likely to be of little use in the structuring of associations.

I.4.2. Methodology. There is even less published in the English language on the methodology - the best account being O'Sullivan (1965).

Ellenberg (1956) gives a very useful and detailed account in German. A very brief stepwise account of the method, and some of the theoretical aspects of the method is attempted in this Section. There are essentially two phases to the system, (i) analysis and (ii) synthesis.

I.4.2(i) Analysis. The main function of analysis is to collect field notes of the vegetation. As there is no satisfactory English term for describing such action, the French relevé (=German Aufnahme) is used throughout the text.

The most important point of this phase is the selection of stands, and this is also one of the biggest stumbling blocks to followers of the Anglo-American methods, who insist completely on random sampling. As Van der Maarel (1966) states, "Advocates of the multiple plot, or plotless sampling methods, sometimes think that the Zürich-Montpellier Students locate their single plots more or less haphazard within a stand. In fact, in many cases, the selection of the stand has taken place so as to make it opportune to analyse the entire stand as a single plot. In other words, the Z-M student considers only a very limited area, sufficiently uniform for sampling and in those cases it is easy to defend the single plot method."

There are two main criteria to observe in selecting plots for sampling, (i) the plot must be homogenous and (ii) it must be at least as large as the minimal area. The latter is the minimum area in which the vegetation unit can express itself. This is determined by taking a small size area ($\frac{1}{4}$ - $\frac{1}{2}$ m^2) and progressively doubling the size of the area. At each step the number of new species is noted. After an initial increase the graph will flatten out, and the minimum area is taken as the area corresponding to the point on the graph where it begins to flatten (see Fig.1., which shows two such graphs, one from Blackdown, Dorset (G.R. 30/612875) and the other from Waldridge Fell, Co. Durham (G.R. 45/251497).) If the vegetation maximum size is exceeded, the graph will show a sudden accelerated rise. This situation is very important in the context of mosaic vegetation. Fig.2. shows a graph from an area with ombrotraphic hummocks in a rich fen mat, forming two distinct vegetation units, although apparently intimately mixed.

The minimal area for the two Heathland sites shown in Fig.1. is about 8 m^2, and in general an area of 10 m^2 has been used in most of the analyses made.

Vegetational homogeneity is a particularly 'tricky' problem, as few communities, if any, are completely homogeneous. As Poore (1955[b]) states, "without having recourse to mathematical treatments, it is quite clear that homogeneity is a question of Scale..... In fact, the more one examines vegetation, the more one is forced to the conclusion that absolute uniformity is an illusion."

There are two alternative approaches to the problem - (i) use of statistics, which would be time consuming and (ii) the main method used by Continental phytosociologists, that of "die Pflanzensoziologische Blick", or assesment of homogeneity by eye. The criteria used most often are those defined by Dahl and Hadač, 1949; "a plant species is said to be homogeneously distributed within a certain area if the probability of catching an individual of the species, within a test area, is the same in all parts of the area. A Plant Community is said to be homogeneous if the individuals of the component plant-species, used for community characterisation, are homogeneously distributed."

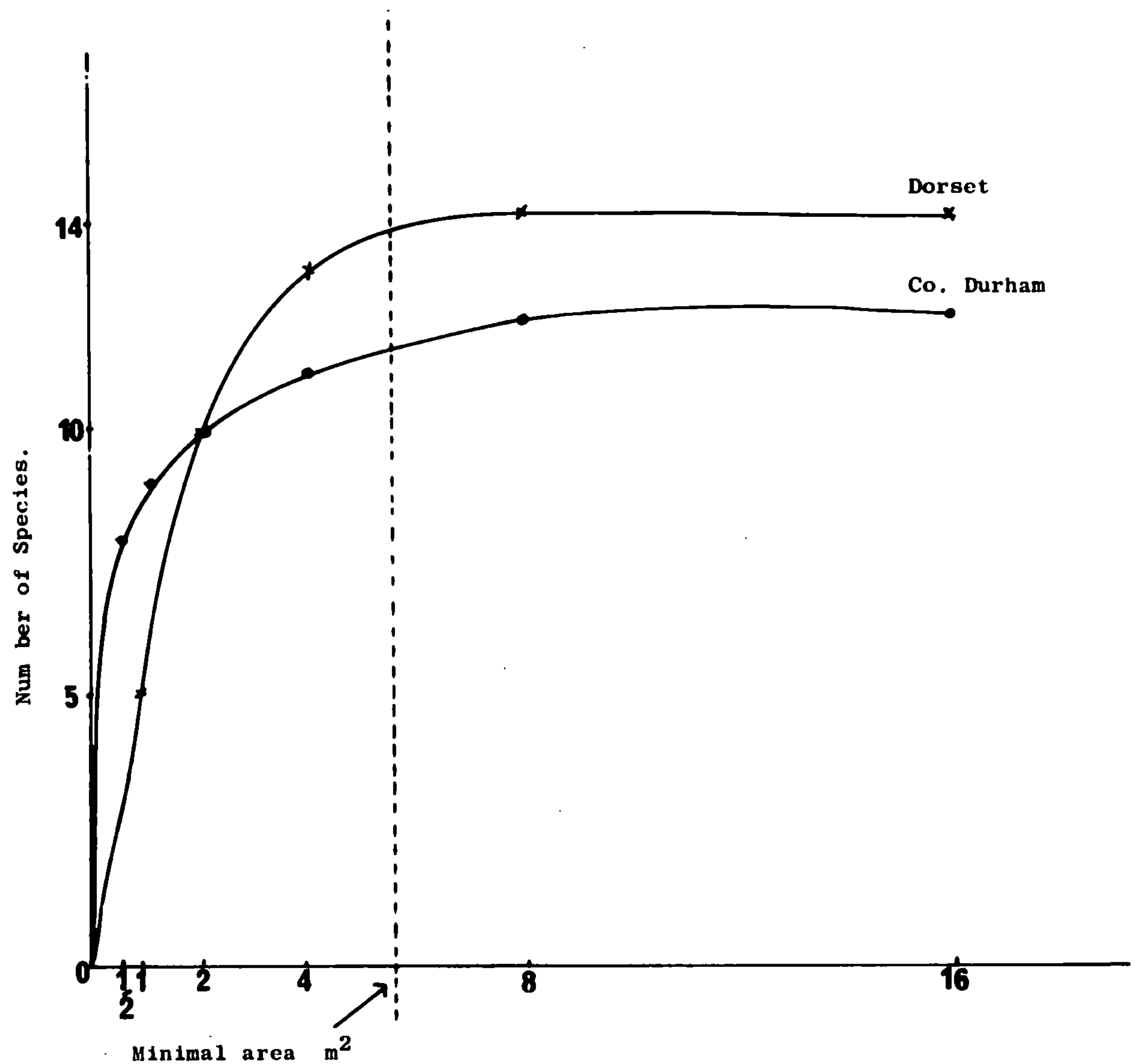


Fig. I/1 - Minimal Area Curves.

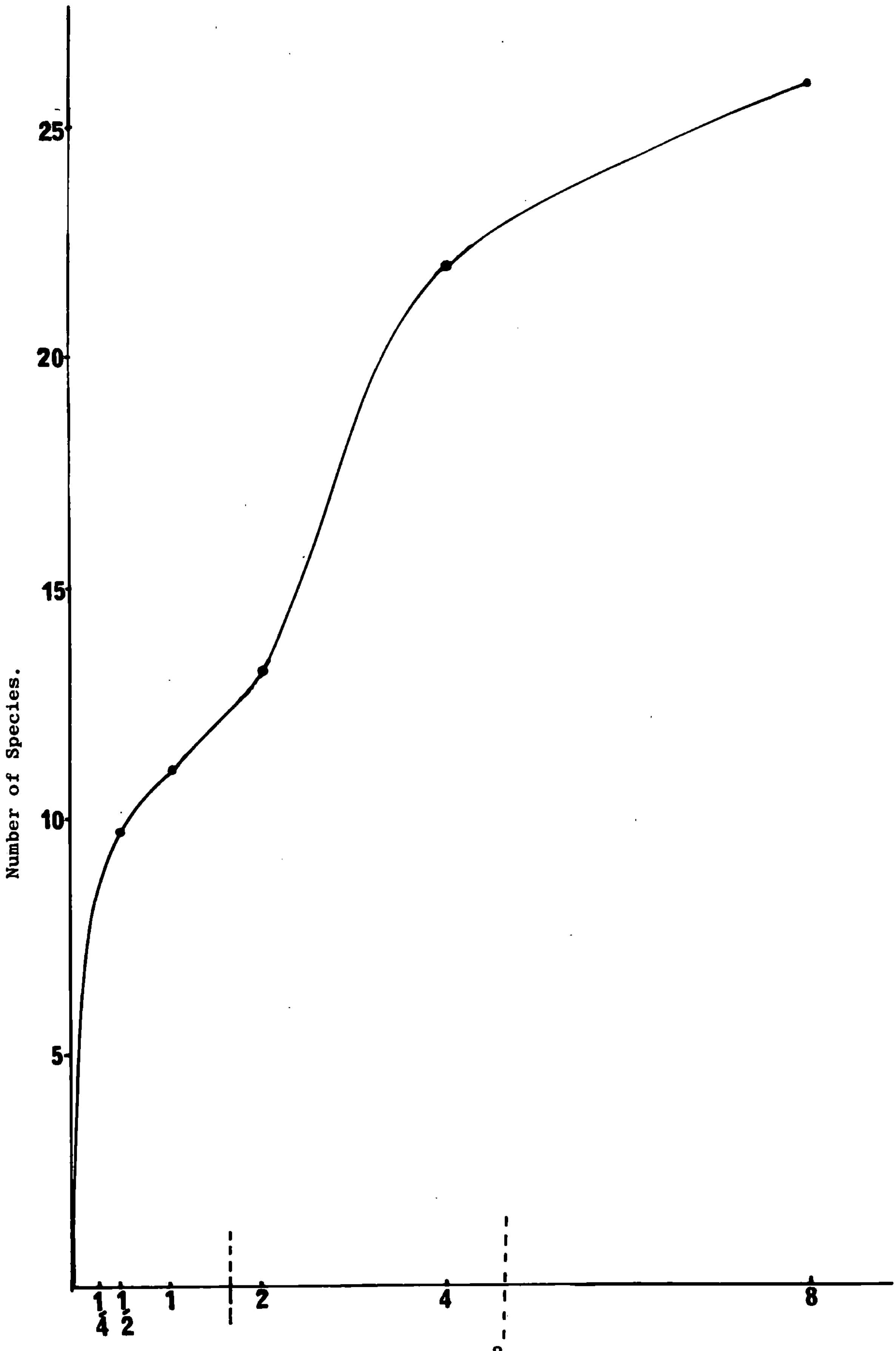


Fig. I/2.

With these definitions borne in mind, it is possible to make quite successful estimates of the homogeneity of areas of vegetation.

Once the stand has been selected, all the species present are listed and assigned a value on a scale of cover/abundance, and sociability. These scales used in the analyses made in the Heathland vegetation are those in Ellenberg (1956). Other scales have been proposed, and these are reviewed in Appendix III. In addition, simple environmental information available at the time is added (Slope, Exposition, % cover of the various vegetational strata, etc). It has been found best to use a standard form for this (see Fig.3.), as the subsequent storage and retrival of the data is made considerably easier.

I.4.(ii) Synthesis. In order to clarify the processes used, a set of 30 relevés from Dorset are used as an example to show the manipulations involved. (They are the same 30 used as a 'model' for a comparative study of mathematical methods, as described in Section II). The steps involved are enumerated below:

(i) The relevés are grouped in a table, preferably on squared paper (Table 1). This is known as the 'Raw table'.

(ii) Species which are seen to be either mutually inclusive with other species or exclusive of other species are then marked as "potential differential species", and are transferred to a new table (the 'Partial table'; Table 2), re-arranged to bring out the maximum possible disparity between distinct groups. With a large table, and many potential differentials, several partial tables may be necessary before the final picture becomes clarified.

(iii) The whole raw table is then re-written, with the rearranged plot numbers, and species now in their "differential groups".

Fig. I/3

The standard recording form used in the Heathland survey.

Date. Location.

Grid ref. Exposition. Altitude.

Field layer ht. % cover. Bryophyte layer % cover

Stand area. Notes.

Ach. mill.
Age. mont.
set.
stol.
ten.
Aira cary.
Anag. ten.
Ant. dio.
Anth. od.
Arc. (u-u)
Arm. mar.
Aul. pal.
Bet. off.
Betula ?
Ble. spic.
Brac. pin.
syl.
Breu. chr.
Briza med.
Bry. pseu.
Call. vul.
Caly. fis.
tri.
Camp. rot.
Cam's. atr.
bre.
fle.
fra.
Carex big.
bin.
dem.
ech.
fla.
hos.
nig.
pan.
pil.
pul.
Ceph. bic.
con.
Cet. isl.
Chry. leu.
Cirs. aca.
dis.
pal.
Clad. arb.
chl.
coc.
c-r.
cri.
deg.
fim.
flo.
fur.
gra.
imp.
mac.
pap.
pyx.
sqa.
unc.

Corn. acu.
Cornu. su.
Cus. epi.
Dact. gl.
Da'o. eri.
Dauc. gum.
Des. fl.
Dic. sco.
Dip. alb.
Dros. int.
rot.
Dryo. dil.
Emp. herm.
nig.
Endy. n-s.
Erica cil.
cin.
tet.
vag.
Erio. ang.
vag.
Eup. bre.
mic.
Fest. ovi.
rub.
Fili. vul.
Gal. sax.
ver.
Gen. ang.
pil.
Gymn. inf.
Heli. num.
Hier. vul.
Hypo. rad.
Holc. lan.
mol.
Hydr. vul.
Hylo. spl.
Hyp. pul.
Hypn. eri.
Jas. mon.
Junc. art.
con.
eff.
squ.
Koel. cri.
Leuc. gla.
Linum cat.
Liste. co.
Lois. pro.
Loph. bid.
Lo'z. flo.
ven.
Lotus cor.
uli.
Luzu. cam.
mul.
Lyco. sel.

Mela. pra.
Moli. cae.
Mylia ano.
tay.
Nard. str.
Nart. oss.
Nowe. cur.
Odon. sph.
Parm. phy.
Ped. syl.
Pelt. can.
Pilo. off.
pel.
Pimp. sax.
Ping. lus.
vul.
Pinus syl.
Plag. den.
sil.
und.
Plant. lan.
mar.
Pleu. sch.
Pohl. nut.
Polyg. ser.
vul.
Polyt. com.
jun.
pil.
str.
Pot. ere.
Poter. san.
Prim. ver.
Prun. spi.
Pseu. pur.
Pter. aqu.
Ptil. cil.
Quercus ?
Rhac. lan.
Rhyn. alb.
Rhyt. lor.
squ.
Rubus cha.
fru.
Rumex ace.
ell.
Salix rep.
Sang. off.
Saro. mar.
sco.
Scho. nig.
Scil. ver.
Sedum ang.
Selag. sel.
Serr. tin.
Sieg. dec.
Sile. mar.
Soli. vir.
Sorb. auc.

Spha. com.
con.
cus.
pal.
pap.
qui.
rec.
rub.
ten.
Succ. pra.
Tara. off.
Teuc. sco.
Thel. lim.
Thui. tam.
Thym. dru.
Tric. cae.
Trie. eur.
Ulex. eur.
gal.
min.
Vacc. myr.
uli.
v-i.
Viola can.
lac.
Zygo. eri.

Raw Table.

Relevé # → / Species name ↓		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Calluna vulgaris	(A)	4·4	5·5	4·4	5·5	2·2	4·4	5·5	4·4	1·2	1·2	+	5·5	3·3	3·3	5·5	4·4	5·5	4·4	1·2	4·4	4·4	3·3	5·5	5·5	1·2	5·5	5·5	4·4	3·3	4·4
Molinia caerulea	(B)					1·2	1·2			2·2	1·2	+		+	1·2	1·1	+	+		2·2	1·2	+		+	+	1·2			1·2	1·2	
Agrostis setacea	(C)	1·2	+	1·2			2·2				(+)		+	2·2	(+)	1·2	2·2		1·2			1·2	1·2	+					2·2	2·2	1·2
Erica cinerea	(D)	1·2	2·2	3·3	+	+		1·2	1·2		+	r	2·2	3·3	+	2·2	2·2	+	2·2			2·3	3·3	2·2	2·2		+	+	1·2	+	3·3
Ulex minor *	(E)		1·2			2·1		1·1		+	+	+	+	2·3	+	1·3	1·2		1·2	+	1·3	3·3	3·3	3·3	1·2	1·3			2·2	1·2	
Erica tetralix *	(F)		+			5·5	3·3	2·2	3·3	4·4	4·4	4·4	+	3·3	4·4		+	1·2	2·2	4·3	2·2				1·2	5·5			2·2	3·3	1·2
E. ciliaris *	(G)									2·2	1·2	3·3							1·2	1·2	1·2										
Scirpus caespitosus *	(H)									+	+	2·2			+				+	+											
Vaccinium myrtillus *	(I)	2·3		+	+																										
Ulex gallii *	(J)	3·2		2·2	1·2																										

* - potential differential species

TABLE I/1

Partial Table.

Relevé # → / Species name ↓	1	3	4	9	10	11	19	20	18	26	27	25	13	14	2	12	16	5	7	28	29	24	15	21	22	23	30	6	8	17
Ulex gallii (J)	3.2	2.2	1.2																											
Vaccinium myrtillus (I)	2.3	+	+																											
Erica ciliaris (G)				2.2	1.2	3.3	1.2	1.2	1.2																					
Scirpus caespitosus (H)				+	+	2.2	+		+					+																
Ulex minor (E)				+	+	+	(+)	1.3	1.2			1.3	+	2.3	1.2	+	1.2	2.1	1.1	2.2	1.2	1.2	1.3	3.3	3.3	3.3				
Erica tetralix (F)				4.4	4.4	4.4	3.2	2.2	2.2			5.5	4.4	3.3	+	+	+	5.5	2.2	2.2	3.3	1.2					1.2	3.3	3.3	1.2

Transfer strips (see text for full details).

'A' → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

'B' → 1 15 2 3 18 28 19 29 4 5 6 16 13 14 23 17 30 9 7 8 24 25 26 22 12 10 11 20 21 27

TABLE I/2

At each stage, the transfer is aided by 'transfer strips'. These are two strips of squared paper. When the new arrangement of the original relevés is known, for the partial table, these are entered along the top of this table. Over them is placed a strip (A), with numbers arithmetically arranged, sufficient to match with the total of relevés. Strip (B) is then placed over the original numbers in the raw table, and a new sequence is recorded on this Strip, to correspond with the position of the relevé in the partial table. Table 2 illustrates this point, i.e. over Number 2 in the raw table, is placed Number 15 on the Strip (B). The new order of relevés, and species having been determined, they are entered with the species that were not used as 'potential differentials', into a completed, final table, (Table 3.)

The vegetation is thus characterised by species groups, and by extending the geographical range of the investigation, a more complete classification can result. It must be stressed, however, that the classification obtained is always a working hypothesis, subject to change.

I.4.3. Evolution of the Z-M School.

As with any methodology, that of the Z-M School has changed quite considerably since the outset. One of the most significant changes has been concerned with the concepts of Fidelity and character species.

At its inception, the concept of species Fidelity was of prime importance in this system of Phytosociology, each being calculated on consideration of its presence, abundance, dominance, sociability and

Final Table.

Relevé # → / Species name ↓		1	3	4	26	27	9	10	11	19	20	18	25	14	13	2	12	16	5	7	28	29	24	15	21	22	23	30	6	8	17
Calluna vulgaris	(A)	4·4	4·4	5·5	5·5	5·5	1·2	1·2	+	1·2	4·4	4·4	1·2	3·3	3·3	5·5	5·5	4·4	2·2	5·5	4·4	3·3	5·5	5·5	4·4	3·3	5·5	4·4	4·4	4·4	5·5
Agrostis setacea	(C)	1·2	1·2					(+)				1·2		(+)	2·2	+	+	2·2			2·2	2·2		1·2	1·2	1·2	+	1·2	2·2		
Erica cinerea	(D)	1·2	3·3	+	+	+		+	r			2·2		+	3·3	2·2	2·2	2·2	+	1·2	1·2	+	2·2	2·2	2·3	3·3	2·2	3·3		1·2	+
Molinia caerulea	(B)						2·2	1·2	+	2·2	1·2		1·2	1·2	+			+	1·2		1·2	1·2	+	1·1	+		+		1·2		+
Ulex minor	(E)						+	+	+	+	1·3	1·2	1·3	+	2·3	1·2	+	1·2	2·1	1·1	2·2	2·1	1·2	1·3	3·3	3·3	3·3				
Erica tetralix	(F)						4·4	4·4	4·4	4·3	2·2	2·2	5·5	4·4	3·3	+	+	+	5·5	2·2	2·2	3·3	1·2					1·2	3·3	3·3	1·2
Ulex gallii	(J)	3·3	2·2	1·2																											
Vaccinium myrtillus	(I)	2·3	+	+																											
Erica ciliaris	(G)						2·2	1·2	3·3	1·2	1·2	1·2																			
Scirpus caespitosus	(H)						+	+	2·2	+	+			+																	

TABLE I/3

and vitality.

The idea that species could be exclusive to associations (gesellschaftstreue) is, with the exception of one or two endemic species, hardly a satisfactory one. This has led to the lack of useage of the term "charakterarten", and the use of the two terms "Trennarten" and "Kennarten" (the latter from the Dutch 'Kennsoort'), as described earlier.

The system has been modified still further by the idea that the traditional 'association table' should be abandoned as a means of displaying results, and that the interaction of species groups, determined from these tables, should be the end product of the analysis phase. This has been successfully used by Scamnoni and Passarge (1959) in their revision of Classification of the Woodland associations of N. W. Germany, and by Doing (1962) in his studies on Netherlands Shrub and Forest vegetations.

This gives rise to the idea that perhaps the system is capable of being exploited in several rather different ways on a local or regional basis, but these can be 'looked into' the Overall classification, with damaging the structure. Such a system is likely to be very successful in terms of international co-operation, and it is to be hoped that this is the way the system will evolve further. Van der Maarel (1969) has shown how the alliances of the hierachial classification can be related to various ordination techniques, adding to the value of both - a further example of the receptiveness of the system to changes. In addition to this, means of mechanizing the table work have been developed and are being refined. Benninghoff (1964) suggested using a computer to sort out the differential species, and such methods have been developed by Moore and used in preparation of published work. (Moore, 1968).

I.4.4. Synsystematics of European Heathlands.

I.4.4.(i) Synsystematics is the end product of vegetation study, and like systematics, has a fairly rigid set of rules. The endings of the various divisions of the Hierachy are as follows:-

Class	-	etea
Order	-	etalia
Alliance	-	ion
Association	-	etum
Sub-Association	-	etosum
Variant	-	no ending.

Associations below are usually a particularly 'local' phenomenon. Because the British Heath is so much more variable than that described from Continental Europe, the vegetation units described in Section V have not been given association names - rather the following terminology has been used (as in de Smidt (1966)):

Heath
Complex
Community
Variant
Sub-variant.

The 'Heath' unit is, in fact, comparable to Alliances described, so the system is perfectly compatible with existing European classifications, as detailed below. Further comments on the classification System used for the vegetations may be found in Section V.

I.4.4(ii) Heathlands have been described fairly completely from Continental Europe. The formation according to Rübel (1930) is the Ericifruticea, the only subdivision of the Ericilignosa grouped with other 'woody' formations into the Lignosa. Doing (1962) suggests a new 'Chief Formation' division of the hierachy which would include several classes. He grouped the Heaths with dry anthropogenic grasslands and some degraded Forest Communities in the Terriberbosa. This latter is more compatible with the existing phytosociological hierachy than were the rather clumsy divisions of Rübel.

'Wet Heath' (Sensu Tansley, 1939) has always been considered separately from 'Dry Heath' within the synsystematic framework, as they have usually been included in the Class Oxyocco-Sphagnetea Br-Bl-et Tx.1943 Moore (1968) has a useful review of this class and his classification is followed: i.e.

Order	-	Ericetalia tetralicis	Moore 1968
Alliance	-	Ericion tetralicis	Schwick 1933.

The Erica tetralix Heath described under Section V, may be equated with this alliance. The first detailed synsystematic treatment of 'dry heaths' is found in Tüxen (1937). Several associations described from the North-West German Heaths are grouped into the alliance Ulicion, first described by Malcuit, 1929, forming a sub-division of the order Calluno-Ulicetalia (Quantain, 1935). Tx. 1937.

Duvigneaud (1944) proposed the use of two alliances within the latter order - the Calluno-Genistion pilosae sub-atlanticum (North and Central Europe) and the Ulicion nani euatlanticum (West Europe). Lebrun et al. (1949) working from Belgian Heaths, proposed an alliance Ulicion, contained within the order Calluno-Ulicetalia within the class Querco-Ulicetea. This was an attempt to show the relationships between heathland and the Forest degradation which they represent. The major disadvantage of this scheme was the structuring of a class on the relatively local area of Belgium and N.W. France.

Preising (1949) combined the order Calluno-Ulicetalia with a new order - Nardetalia, into a class which has become the most accepted grouping of Heath, Heather Moor and degraded montane grassland vegetation - the Nardo-Callunetea. The Calluno-Ulicetalia comprised the proposals of Duvigneaud (1944), the alliance Empetrion boreale, Bőcher, 1943 and the alliance Sarothamnion, proposed by Tüxen (1945).

Schubert (1960) suggested a division of the order Calluno-Ulicetalia (Quantain 1935) Tx. 1937 into the Euatlantic Ulicetalia (Quantain 1935) em. Schubert 1960 and the sub-Atlantic Vaccinio-Genistetalia Schubert 1960. The first order would comprise the Ulicion nanae Duvigneaud 1944 and Ericion umbellatae, Br.-Bl., Pinto da Silva, Rozeira and Fontes, 1952.

The second order comprised the Empetrion boreale, Bőcher, 1943, em. Schubert 1960, Vaccinion vitis-idea Bőcher 1943 em. Schubert 1960, Euphorbio-Callunion Schubert 1960, and Genistion pilosae Duvigneaud 1942 em. Schubert 1960, with the Sarothamnion scoparii R.Tx.1945 apud Prsg.1949 as a sub-alliance. The Vaccinion vitis-idae and Genistion pilosae are usually referred to the Calluno-Genistion Duvigneaud 1944 - separation seems unecessary.

Lohmeyer et al (1961), usually taken as a standard summary synthesis of the classification to that date, has the following:

Nardo - Callunetea Prsg 1949
Calluno- Ulicetalia (Quantain 1935) R.Tx. 1937
Calluno - Genistion Duvign 1944.
Ulicion nanae Duvign. 1944 em. Vanden Bergen 1958.
Ulicion galiii Des.Abb. et. Corillion 1949
Empetrion boreale Bőcher 1943
Sarothamnion R.Tx. 1945 apud Prsg. 1949

The author's note the provisional status of the last alliance, as being not completely proven phytosociologically. Doing (1952) unites these Sarothamnus scoparius and Ulex europeaus communities into the alliance Ulici-Sarothamnion (order Pteridio-Rubetalia) included in the Class Franguletea.

Braun-Blanquet (1966), looking at the problem from the focus of the Iberian Heath, uses the class name Calluno-Ulicetea Br.Bl. et Tx. 1943, with two orders; the Erica-Ulicetalia Br-Bl, Pinto da Silva and Rozeira 1964, and a rather ill-defined order for Northern Europe - the Erica-Genistetalia, which he suggests might replace the Ulicetalia of Quantain (1935).

Within the Erica-Ulicetalia two alliances are suggested - the Ericion umbellate of Lusitania and the Ulicion minoris-nanae covering France, S. Belgium, S. England, Wales and S. Ireland. Whilst the former alliance is well documented, the latter I believe to be unsound - as there are basic differences between the communities of S. England and Wales and those of S. W. France.

The best solution so far attempted seems that of Rivas-Martinez (1968), i.e.

Class:	Nardo-Callunetea Prsg 1949.
Order:	Calluno-Ulicetalia (Quantain 1935) Tx.1937 (N.W. and Central Europe)
Alliances:	Calluno-Genistion Duvign 1944. Ulicion nanae (Duvign 1944) em Vanden Bergen, 1958. Sarothamnion R. Tx. 1945 apud Prsg.1949 Empetrion boreale Böcher 1943.
Order:	Erica-Ulicetalia Br.-Bl., Pinto da Silva, Rozeira, 1964. (S.W. Europe).
Alliances:	Cistion hirsuti (Br.-Bl. et al 1953). Br.-Bl., Pinto da Silva, Rozeira 1964. Genisto-Ericion aragonensis Rivas-Mar.1962. Ericion umbellatae Br.-Bl., Pinto da Silva Rozeira 1964.

The Calluno-Genistion is equivalent to the Calluna Vulgaris Heath, described in Section V, Ulicion nanae to the Erica cinerea Heath and Empetrion boreale to the Vaccinium myrtillus Heath.

This classification was the framework within which the project was carried out. Further discussions are included at the end of Section V.

I.4.5 Potential Natural Vegetation.

The Z-M system has given rise to the concept of Potential Natural Vegetation (P.N.V.), i.e., the unit of wooded vegetation that would exist on an area of land, provided no change occured within this area. This, of course, means that anthropogenic factors are always taken into account, and show one of the main distinctions between the Anglo-American 'climax' theories of vegetation, and the use of P.N.V. The polyclimax theory of Tansley is closest to the idea of P.N.V., as it takes into account differences in soils, as well as those of climate.

The P.N.V. of an area is usually assessed after considering the following factors with respect to a complete description of all the plant communities within the area. (the "coenecosystem", Braun-Blanquet 1964).

(i) any species which might be relict of former communities.
(ii) Pioneer species.
(iii) the communities bordering the area under consideration.
(iv) the soil profile, colour and sub-stratum.
(v) any crops being grown within the area.
(vi) the form of Land utilisation, including size and type of human communities, etc.

From these factors if is possible to predict the P.N.V., assuming <u>no major change</u> in conditions (edaphic, climatic, etc). It is thus just as easy to produce maps of the P.N.V. as it is to produce maps of the extant communities.

For the 'Heaths' described under Section V, the following units represent their P.N.V:

<u>Erica cinerea Heath</u>	-	Quercion robori-petraeae Br.-Bl., 1932
<u>Calluna vulgaris Heath</u>	-	Luzulo-Fagion Lohm, et R.Tx. 1954
<u>Vaccinium myrtillus Heath</u>	-	Dicrano-Pinion Libbert, 1933.

I.5. Previous studies on British Heathland.

During the period 1900-1940, a large number of descriptive papers were published on British vegetation, including Heathland. Also during the early part of this period, some attempts were made at the mapping of vegetation - these were to be found in the series of papers "Geographical distribution of the vegetation of the ------ district.", published in the 'Geographical Journal'. The culmination of this descriptive era was the publication of "The British Isles and their Vegetation", Tansley (1939), which followed the handbook he had edited - 'Types of British Vegetation' (1911). Heathland associations (sensu Tansley, 1920, Clements 1916) were described in these publications under the following headings:

Callunetum	-	Heather moor and lowland heath areas dominated by Calluna vulgaris.
Vaccinetum	-	Areas dominated by Vaccinium myrtillus and/or V. vitis-idoea. High level moorland.
Pteridietum.	-	Areas dominated by Pteridium aquilinium These include many heathland fringe communities. The ecological 'balance' between P. aquilinium and C. vulgaris has been the subject of a series of papers by Watt (1940 et. seq.)
Ulicetum.	-	Areas dominated by Ulex europeas - these are again 'fringe' communities of Heathland.
Grass Heath.	-	Heathland in which the ericaceous shrubs are mixed with a large number of acid grassland species.
Nardetum.	-	Typical poor Hill grassland, dominated by Nardus stricta, with an admixture of species from Heather moor.
Oak-Birch Heath.	-	Open woodland of Quercus species and Betula species, with ground flora of typical grass Heath or Callunetum species.
Wet Heath	-	Areas of Heathland on deep peat, with an admixture of species typical of both 'Heath' and bog formations. Usually defined by the constant prescence and dominance of Erica tetralix.

This scheme takes little account of regional (phytogeographical) differences in the 'associations'. The composition of some Grass Heaths, Calluneta and Oak-Birth Heaths is outlined below, as noted by some of the contemporary papers, to show some of the variation noted. Many of these lists have been included because the original vegetational unit has been quoted as a synonym in Section V. **

(i) Grass Heath. Definitions of this vegetation type are not usually formulated, and the composition of the quoted species lists varies considerably. Species common to almost all lists are; Agrostis tenuis, Festuca ovina, Luzula campestris, Deschampsia flexuosa, Nardus stricta, and Campanula rotundifolia.

Farrow (1915, 1911 and 1919), lists the following species:

Erophila verna	Arenaria serpyllifolia	Silene conica *
Teesdalia nudicalis	Minuartia hybrida	Muscari atlanticum *
Cerastium semidecandrum	Myosotis ramosissima	Carex ericetorum *
C. atrovirens	Erodium cicutarium	Medicago falcata *
C. arvense	Carex arenaria **	M. sylvestis *
Potentilla argentea	Phleum arenarium **	Veronica verna *
Campanula rotundifolia	Silene otities *	V. triphyllos *
Festica ovina	Thymus serpyllum *	
Agrostis tenuis	Artemesia campestris *	

Within this list, two groups stand out as being unusual, those marked (**) being typical of coastal sands and those marked (*), typical of Continental steppe regions. This grass heath is thus of extreme interest, and is represented in the classification presented in Section V as II.4.a.

Summerhayes, Cole and Williams, (1924, 1926) give two types of Grass Heath from the Surrey Heaths (Oxshott and Esher), the second being characteristic of damper areas.

**N.B. The species lists should be read from left to right.

(i) Aira praecox	Achillea millefolium	Alchemilla arvensis
Anthoxanthum odoratum	Cerastium holosteoides	C. semidecandrum
Leucanthemum vulgare		Plantago coronopus
Ranunculus bulbosus	Rumex acetosella	Stellaria media
S. graminea	Taraxacum officinale	Trifolium dubium
Galium saxatile	Hieracium pilosella	Luzula campestris
Ornithopus perpusillus	Veronica officinalis	Trifolium repens
T. campestre.		

(ii) Nardus stricta	Deschampsia flexuosa	Juncus squarrosus
Molina caerulea	Calluna vulgaris	Festuca ovina
Hypochoeris radicata.	Luzula campestris	L. multiflora
Potentilla erecta	Rumex acetosella	

The Heather Moor has an associated grassHeath of slightly different composition, as shown in this list from Cader Idris (Price-Evans, 1932)

Nardus stricta	Galium saxatile	Juncus squarrosus
Erica tetralix	Vaccinium myrtillus *	Potentilla erecta
Empetrum nigrum *	Festuca ovina	Lycopodium selago *
L. clavatum *	L. alpinum *	Deschampsia flexuosa
Polygala vulgaris	Carex binervis	C. panicea
Luzula campestris	Anthoxanthum odoratum	Sieglingia decumbens
Agrostis tenuis	Cirsium vulgare	Rhacomitrium lanuginosum
Pleurozium schreberi	Polytrichum commune	Cladonia arbuscula
C. uncialis	Sphagnum spp.	

Species marked thus (*) are typical of 'montane' situations.

Lewis (1904) gave the following list from Murton Fell, Westmorland (N.B. _Ulex nana_, presumably is _U. gallii_).

(ii) Nardus stricta	Juncus squarrosus	Sesleria caerulea
Agrostis tenuis	Potentilla erecta	Galium saxatile
Vaccinium myrtillus	Polytrichum commune	Lycopodium selago
L. clavatum	Ulex nana (not above 1300')	

One of the most unusual Grass Heaths described was the limestone Heath of Moss (1907), which was extremely rich in calcicolous species, i.e.

Ulex europaeus	Crataegus monogyna(dwarfed)	
Festuca sp.	Calluna vulgaris	Erica cinerea

Polygala vulgaris
Hypericum pulchrum
Linum catharticum.
Lotus corniculatus
Rubus sp.
Poterium sanguisorba.
Pimpinella saxifraga.
Galium saxatile
Cirsium paulstre.
C. acaulon
Hieracium pilosella
Leontodon hispidus
L. taraxacoides
Centaurium erythraea.
Veronica officinalis.

Euphrasia officinale.
Thymus sp.
Plantago media.
P. lanceolata
Rumex acetosella.
Luzula campestris.
Carex flacca.
C. pilulifera.
C. caryophylla.
Anthoxanthum odoratum.
Briza media.
Phleum pratense.
Holcus lanatus.
Trisetum flavescens.
Helictotrichon pubescens.
Arrhenatherum avenaceum
Sieglingia decumbens.
Bromus mollis.
Cynosurus cristatus.
Dactylis glomerata.

Festuca ovina
Pteridium aquilinum.
Hypericum humifusum.
Ononis repens.
Anthyllis vulneria.
Filipendula Vulgaris.
Alchemilla vulgaris (sl)
Silaum silaus.
Carlina vulgaris.
Carduus acanthoides.
Centauraea scabiosa.
Campanula rotundifoli
Blackstonia perfoliata.
Gentianella amarella
Marrubium vulgare.
Anacamptis pyramidalis.
Orchis morio.
Aira caryophylla.
Koeleria cristata.
Brachyopodium pinnatum.
Ophioglossum vulgatum
Botrychium lunaria.

(ii) Oak-Birch Heath.

This association was described by Tansley (1911) as "existing in a broad belt across the midlands of England, from the Bunter sandstone of Nottingham to that of Delamere Forest (Cheshire), and on the Greensand of S. E. England." Hopkinson (1927) makes the suggestion that Oak-Birch Heath, particularly that of the Nottingham region, is merely a sylvan form of Grass Heath. The following species list is taken from Tansley (1911):

Quercus spp.
Pinus sylvestris
Castnea sativa *
Malus sylvestris
R. caesius
Prunus spinosa
Rhamnus frangula
S. cinerea
Calluna vulgaris

Betula spp.
Ilex aquifolium
Quercus cerris *
Sorbus aria
R. fruticosus agg.
Ulex europaeus
Juniperus communis
S. aurita
Vaccinium myrtillus

Fagus sylvatica
Sorbus aucuparia
Prunus cerasus
Crataegus monogyna
Sarothamnus scoparius
Rubus idaeus
Salix caprea
Lonicera periclymenum
Erica cinerea

Pteridium aquilinium	Deschampsia flexuosa	Argostis canina
Teucrium scorodonia	Potentilla erecta	Polygala serpyllifolia
Melampyrum pratense	Galium saxatile	Succisa pratensis
Solidago virgaurea	Veronica officinalis	Viola riviniana
Blechnum spicant	Scutellaria minor	Chamaenerion angus-tifolium
Dactylorchis maculata ssp. ericetorum		Molina caerulea
Wahlenbergia hederacea		Leucobryum glaucum.

*- indicates non-native species that are frequently found in this vegetation.

(iii) Callunetum. The most 'typical' Heath and Heather Moor association, this vegetation is usually rather species poor.

Farrow (1915) gives this list for the Brecklands:

Calluna vulgaris	Erica tetralix	Pteridium aquilinium
Polytrichum piliferum	Pleurozium schreberi	Leucobryum glaucum
Dicranum scoparium	Ceratodon perpureus	Cladonia coccifera
C. cervicornis	C. alicornis	C. arbuscula
C. furcata	C. uncialis	

The Callunetum of the Surrey heaths is described by Summerhayes, Cole and Williams (1922):

Calluna vulgaris	Erica cinerea	Ulex minor
Deschampsia flexuosa	Potentilla erecta	Pinus sylvestris(s)
Malus sylvestris(s)	Hypnum cupressiforme	Polytrichum juniperinum
Leucobryum glaucum	Cladonia pyxidata	

Somewhat similar is the list from Hindhead Common, given by ~~Firtsh~~ Fritsch & Parker (1913).

Calluna vulgaris	Erica cinerea	E. tetralix
Ulex minor	Vaccinium myrtillus	Deschampsia flexuosa
Potentilla erecta	Pinus sylvestris(s)	Molinia caerulea
Cuscuta epithymum *	Agrostis canina	Sieglingia decumbens
Rhamnus frangula	Betula pendula (s)	Crataegus monogyna
Sorbus aucuparia (s)	S. aria (s)	Ilex aquifolia (s)
Pteridium aquilinum	Blechnum spicant	Ulex europaeus *

* scattered patches only   s = seedling.

Western Callunetea are described in Heath, Luckwill and Pullen (1937), from Blackdown, Somerset:

Polygala serpyllifolia	Ulex gallii	Potentilla erecta
Vaccinium myrtillus	Calluna vulgaris	Erica tetralix
Juncus squarrosus	Galium saxatile	E. cinerea
Pedicularis sylvatica	Deschampsia flexuosa	Molinia caerulea
Nardus stricta	Polytrichum commune	Luzula multiflora
Trichophorum caespitosus		Sieglingia decumbens
Polytrichum juniperinum	Dicranum scoparium	Rhacomitrium lanuginosum
Pohlia nutans	Cladonia coccifera	C. pyxidata
Parmelia physodes		

and Price-Evans (1932) from Cader Idris, Merioneth (which is essentially similar to a list in Leach (1931) from the Long Mynd, Salop.)

Calluna vulgaris	Erica cinerea	E. tetralix
Empetrum nigrum	Vaccinium myrtillus	Potentilla erecta
Galium saxatile	Blechnum spicant	Rhacomitrium lanuginosum
Polytrichum commune	Plagiothecium undulatum	Dryopteris dilatata
Genista pilosa	Sphagnum spp.	

For the Midland Heaths, two lists are available. (i) from the Birmingham area, Rees and Skelding (1950), and (ii) from the Bunter sandstone of Notts. (Hopkinson).

Calluna vulgaris	Deschampsia flexuosa	Chamaenerion angustifolium
Erica cinerea	Galium saxatile	Genista anglica
Nardus stricta	Plantago coronopus	Polygala serpyllifolia
Pteridium aquilinium	Knautia arvensis	Thymus drucei
U. gallii	Vaccinium myrtillus	

Heather moor is also included in the Callunetum association, for example Adamson (1918) gives the following list for Pennine Callunetum:

Calluna vulgaris	Eleocharis quinquelflora	Empetrum nigrum
Molina caerulea	Vaccinium myrtillus	V. vitis-idaea
Erica tetralix	Potentilla erecta	Juncus squarrosus
Eriophorum vaginatum	Nardus stricta	Lycopodium selago
L. clavatum		

The Easternmost expression of High Heather Moor is to be found on the North York Moors - Elgee (1914):

Potentilla erecta	Empetrum nigrum	Erica cinerea
Vaccinium myrtillus	Hypnum cupressiforme	Cladonia spp.
Juncus squarrosus		

The lower Coal measures of Co. Durham form 'Fells' with typical Heathland vegetation, as Jeffreys (1916) shows:

Calluna vulgaris	Ulex europaeus	Potentilla erecta
Vaccinium myrtillus	Erica cinerea	E. tetralix
Empetrum nigrum	Luzula multiflora	Nardus stricta
Agrostis tenuis	Holcus mollis	Deschampsia flexuosa
Pteridium aquilinum		

The Northernmost Callunetum is that of the Scottish Eastern river valleys. Tansley (1911), gives a good general list:

Calluna vulgaris	Vaccinium myrtillus	V. vitis-idaea
Empetrum nigrum	Arctostaphylos uva-ursi	Erica tetralix
E. cinerea	Nardus stricta	Hypnum spp.
Polygala vulgaris	Potentilla erecta	Galium saxatile
Antennaria dioica	Luzula multiflora	Carex nigra
C. dioica	Deschampsia flexuosa	Agrostis tenuis
Anthoxanthum odoratum	Festuca ovina	Blechnum spicant
Lycopodium clavatum	Cladonia spp.	Genista anglica
Melampyrum pratense	Trientalis europaea	Juniperus communis

The one remaining type of Callunetum not described above is that developed over dune sands.

Good (1935) reviewed the Dune Callunetum of the South Haven Peninsula, Dorset, and produced the following list:

Calluna vulgaris	Agrostis tenuis	Carex arenaria
Cuscuta epithymum	Erica cinerea	Centaurium erythraea
Festuca rubra	Filago minima	Hypochoeris glabra
H. radicata	Jasione montana	Leontodon taraxacoides
Polypodium vulgare	Ammophila arenaria	Rumex acetosella
Sedum anglicum	Senecio jacobaea	Ulex europaeus

A further list of Dune Heath is given in Moore (1931) from the Ayreland of Bride (Isle of Man):

Agrostis spp,	Ammophila arenaria	Calluna vulgaris
Carex arenaria	Deschampsia flexuosa	Erica cinerea
Erodium cicutarium	Festuca ovina	F. rubra
Hieracium pilosella	Dicranum scoparium	Polytrichumm juniperinum
P. alpinum	Jasione montana	Lotus corniculatus
Polygala vulgaris	Rosa pimpinellifolia	Sedum anglicum
Silene maritimum	Thymus drucei	Ulex gallii
Viola canina	Cladonia cervicornis	Peltigera spp.

After the publication of Tansley's "British Isles and their vegetation", in 1939 and reprinting in 1949, there has been little published data on individual areas of Heathland. There have been general 'area' studies that included heath, i.e. Ratcliffe (1959) McVean and Ratcliffe (1962), Edgell (1969), but the only major publication devoted to Heath description has been Coombe and Frost (1956) which utilised the domin scale for the vegetational analysis. They proposed an initial quadripartite division of the heaths of the Lizard Peninsula into (a) Short Heath, (b) Tall Heath, (c) Mixed Heath and (d) Rock Heath.

The data presented above represents the state of knowledge of Heath vegetation by the start of the project. Besides this, Gimmingham (1961, 1969) had endeavoured to show that the N. W. European Heaths formed part of a 'network of variation', a theme discussed in Section V. The main point to emerge is that there are obviously distinctly different Heath vegetations in Britain, and that some correlation of these vegetations should be attempted.

II.

COMPARATIVE METHODOLOGY.

"Tal er videnskabens versefødder" - Raunkiaer, 1910.

(Numbers are the metrical feet of Science).

II.1. Introduction.

In contemplating an analysis of vegetation, one is faced with a plethora of 'methods', all of which seem to produce widely differing kinds of result. This tends to generate the question "which method is the most fitting for this particular study?" The purpose of this section is to attempt to answer this question, by subjecting a 'model' of vegetation to several of these differing methods.

II.2. Historical.

Although there are numerous methods that have been proposed, and are in use, as analytical tools, they can be grouped into two main sections; (i) Ordination techniques and (ii) classification techniques. The origins of these two techniques is interesting, as they stem from rather different philosophies.

At the turn of the 19th Century, the ideas that vegetation must be described and classified for useful further study had been taken up by many botanists, i.e. Braun-Blanquet in Montpellier, France, Rübel in Zürich (the initial proponents of the Zürich-Montpellier system described in the introduction), Nordhagen in Scandinavia, Tansley in Britain and Weaver and Clements in North America. All of these authors were united in their desire to describe and classify vegetation, but often rather deeply divided on the ways in which this should be done. However, there was, and is, an underlying theme, which led Whitaker (1956) to group these various systems into the "Community-Unit Theory".

Perhaps the best reasons for classifying vegetation were given by Tansley (1920) - "We cannot proceed to deal systematically with the vast and varied assemblage of plant life on the Earth's surface without some kind of classification of vegetation, and the quasi-organismic nature of the units of vegetation is precisely the character we must recognise if we are to have a firm foundation for our classification."

These remarks were intended as much a criticism of Gleason (1911) as a defence of classification, Gleason states, "The phenomena of vegetation depends completely on the phenomena of the individual." He set the stage, by this statement, for a move away from the active proponents of the "Community unit theory". A later paper (1926) gave his "individualistic concept of the plant association". This thesis rested on two main points;
(i) that each species is distributed in relation to all environmental and biotic factors it encounters, according to its genetic structures, physiological characteristics and population dynamics; and
(ii) the principle of community continuity, i.e. each community grading imperceptibly into the rest, along an environmental gradient.

This latter hypothesis or concept was the starting point for the now widely employed 'continuum theory' McKintosh (1967).

Surprisingly enough, Gleason's ideas had little initial acceptance in America, due to opposition from the proponents of the "Community units Theory". Quite by change, European workers (e.g. Kulczinski (1928), Czcekanowski (1909)) were working on similar concepts to those of Gleason, but they were also swamped by the wide acceptance and practice of forms of the "Community unit theory" chiefly the Z-M school. In essence, their work consisted of producing "ordered matrices" of similarity coefficients for a number of quadrats. The population sample were then arranged along a 'gradient'. As Whittaker (1967) has pointed out, however, "It is not necessarily the case that the axis of an ordered matrix will represent a single environmental gradient."

Some twenty years after the publication of the "individualistic concept", these ideas became more widely accepted, as various workers (e.g. Whittaker, Curtis and McKintosh) found ample proof in the deciduous forests of the Rocky mountain foothills. The study of "gradient analysis" was thus born.

Initially, work concentrated on "direct" gradient analysis, i.e. the study of vegetational change along a pre-determined environmental gradient. A full review of this technique may be found in Whittaker (1967).

"Indirect" gradient analysis, using the occurence of species to cause the environmental relationships to appear, were developed later. The first major work of such a kind is that of Bray and Curtis (1957). Their technique is now often referred to as "simple ordination", because of the multiplicity of refined techniques now available.

From these initial ideas Dagnelie (1960) introduced the idea of factor analysis and principal component analysis (PCA) as a tool to ordinate stands. This trend was continued by Orlocci (1966), who proposed a more refined form of 'simple ordination' as well as advocating the use of PCA. This latter method is designed to produce maximum "efficiency" in data presentation, i.e. the first axis is produced in the direction of maximal variation. This method is clearly the best of ordination techniques, so far described. An improvement has been noted by using either graphical or computational methods to rotate the axis for a more explicit data presentation (Ivmey-Cook and Proctor, 1967).

Whilst these methods were being consolidated, chiefly in Britain and America, the predominantly Continental European schools, based on the classificatory approach, were also developing. The development of the Z-M school has been noted in the Introduction, whilst in Britain after the publication of "Types of British Vegetation" (Tansley, 1911) and "The British Isles and their Vegetation" (Tansley, 1939) much of the original interest in synecological research was lost, and auteological research took precedence.

The publication by Goodall (1953) began to reverse this trend, setting the scene for the introduction of multivariate analytical techniques to figure prominently in descriptive Ecological research. He showed how these techniques could be used to elucidate the relationships between sets of dependent variables. These techniques had just begun to be used by the developing science of Numerical Taxonomy (Sneath, 1957)

Not unnaturally, some of these methods appealed equally to the ordination based schools as to the new British based "objective classification" school. For some thirty to forty years British ecologists had objected to the methodology employed by the Z-M school, not least because of their apparent subjectivity and biased plot selection. This was due almost as much to misunderstanding the system, as to genuine objections.

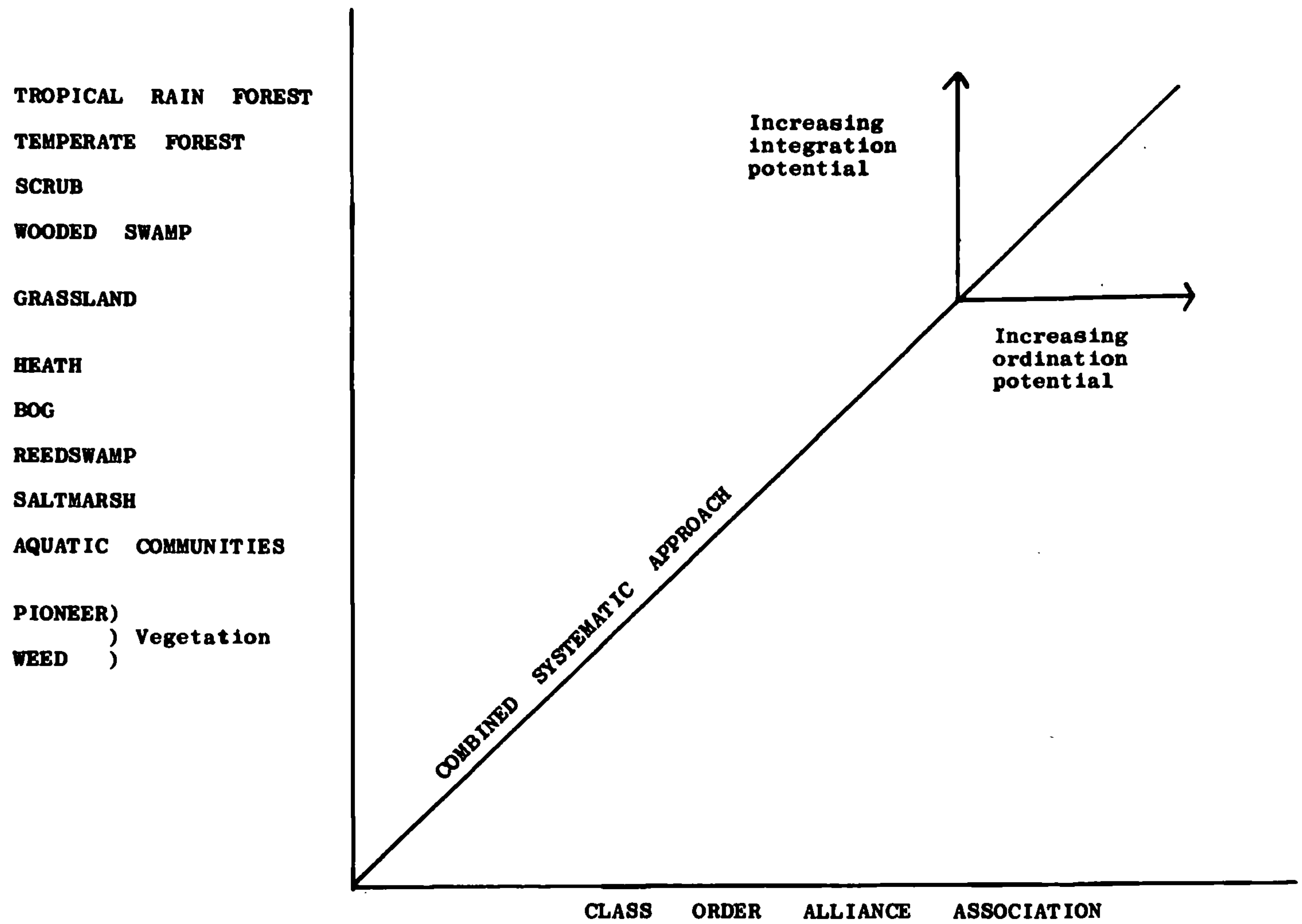
The basic desire to produce vegetational classifications had not diminished, however, and Goodall's initial work rekindled the flames. His original suggestions were modified by Williams and Lambert (1959, 1960, 1961, 1962), who redefined his system of hierachical classification, producing the now widely used methods of "Association analysis", and "Nodal analysis". This latter method was then compared rather favourably to the Z-M system of phytosociology by Ivimey-Cook and Proctor (1966).

Initially, the methods employed were diverse in nature, i.e. attempted to divide down an initial population into sub-units, whereas later methods were of the agglomerative type (building up individuals to a final population). The main kind of diversions of these methods has been through the use of differing coefficients, though a rather basically different approach was made by Crawford and Wishart with their 'Group Analysis' (1967, 1968).

Relatively little contact has been made between the three types of method ('subjective' classification, 'objective' classification and ordination). Despite the basic differences, there are signs that there is a beginning in the cross-fertilization of ideas. One of the best examples of this is in Van der Maarel (1969) in which he shows how "principal axes" ordination (a more advanced form of 'simple' ordination') may be related to the simple descriptive approach of the Z-M school, by illustrating that the 'clusters' obtained in an ordination can be classified neatly into alliances of the Z-M school hierachy.

II.3. Theoretical.

Fig.1. shows the relationships between vegetation types, their hierachical units used in the Z-M system, and their respective ordination/classification potential, i.e. the 'order' unit of hierachy and Salt marsh vegetation have a low ordination potential, although both are easily 'classifiable'. Equally, they are much less 'integrated' than other types. Still, unfortunately lacking in application, such an approach is vital to the continued existence of vegetation study that has some potential use. It clearly shows the interdependence of classification and ordination, their complementary, rather than contradictory, action. Proctor (1967) stated that "I consider ordination methods inherently complementary to classification, rather than a



(adapted from van der Maarel, Westhoff and van Leeuwan, Int. Bot. Cong. 1964)

Fig. II/1.

potential substitute for it." With these comments borne in mind, some theoretical aspects of both systems are considered below.

II.3.a. Ordination methods.

Hayata (1921), with reference to the concepts of experimental systematics, observed that "similarity is multidimensional, for each 'feature' there is one dimension, and to represent these 'features' one needs a multidimensional space." If 'species' is inserted instead of 'feature' the statement is transposable to ecological situations. Goodall (1963) described ordination as "an attempt to rearrange ecological units (quadrats) in a spatial model, with a relatively small number of axes, such as to reflect the relationships (environmental) between these units in terms of their characteristic variables (species)".

Ordination methods (sensu lato) obviously have an advantage in analysing vegetation that is not easily divisible into communities, since it does not require the placing of each unit into a "box", regardless of fit, as do classificatory techniques. They are most suitable for explaining the relationships within groups, produced by classificatory analysis, or between such groups, once established. Fresco (Pers.Comm.) observes, "the best approach at present seems to be to conduct an association analysis, and then subject the results to P.C.A."

Ordination methods in general are not well adapted to explaining relationships at several levels of complexity. Because of this factor, and also the fact that Heath vegetation (low ordination potential) has been used to test the various methods examined, only the 'simple ordination' has been used.

II.3.b. Classificatory methods.

Perhaps because of mens insatiable urge to regularise and classify, there are a large number of these methods in the literature. In addition, the end product of a classification, as opposed to ordination, is a unit which is capable of being used for mapping and other descriptive purposes.

Lambert and Dale (1964) point out that there are several forms of classification, dependent on the following three types of process:

(i) Hierachical v. reticulate arrangement of units.

(ii) Divisive v. agglomerative mode of structuring.

(iii) Monothetic v. polythetic division of the data.

In addition, the problem may be approached from a grouping of species, or from a grouping of quadrats (analagous to the Q&R techniques of Cattell, 1952). 'R' studies involving correlation calculations between all pairs of attributes (species) and 'Q' studies involving correlation calculations between all pairs of individuals (quadrats). Where there are more attributes than individuals, the 'R' type of approach is best; if, however, there are more individuals than attributes, then the 'Q' approach would seem best.

Reticulate arrangements of units are seldom satisfactory from an ecological point of view, and have not been pursued further. In this study, the methods used have been either monothetic divisive or polythetic agglomerative.

Agglomerative fusion may be accomplished in several ways, the most frequently used for the construction of dendograms being:

(a) Nearest Neighbour, which sorts by calculating similarity coefficients and then gradually fusing individuals into groups. The method is simple, but rather poor, as the information level of a single individual is the only feature of the analysis;

(b) Centroid sorting, perhaps the most commonly employed system, using the similarity coefficients of all pairs of individuals to evaluate the two most similar. These are then grouped together as a new individual, and the similarity coefficients recalculated. This process is repeated until all individuals are fused into a single hierachical network.

A note on similarity coefficients, together with synopses of the most important features of the methods used in this section, (Normal and Inverse association analysis, Information analysis, Group analysis, Nodal analysis and simple ordination) may be found in Appendix IV.

II.4. The Model.

For the purposes of testing and evaluating the use of several different analytical techniques, a standard data set is needed. Most useful, of course, would have been a completely artificial data set, generated by computer. Previous attempts at providing artificial communities have not been particularly successful, or progressed very far since the 'color-counter' technique used by Greig-Smith (1952), although Newnham (1967) has suggested a rather promising approach.

As a very simple data set was needed, but one which had a certain amount of built-in variation, that the method could detect, the following procedure was adopted.

From the Heathland complex of Dorset, thirty relevés were made (3 west of Weymouth, to include Ulex gallii heath as a phytogeographic variant), and all species occurring not more than twice were eliminated. The relevés were all made from a standard size area of 10 sq.m. Seven of these relevés were from 'wet heath' (Erica ciliaris and Scirpus caespitosus present), and together with the three containing Ulex gallii, both ecological and phytogeographical variation was present in the data. This same data was subjected to a Z-M analysis, and has been used for the example shown in the Introduction. Therefore, for the method to be effective, division of the data into at least three sub-sets should be achieved (corresponding to those outlined above, with the residue of "typical" heath). The Z-M system clearly reaches this aim, and provides greater information, as it differentiates the "typical" residue into a further four sections. (See Table I.3.) The results from the mathematical methods are shown below.

II.5. Results. **

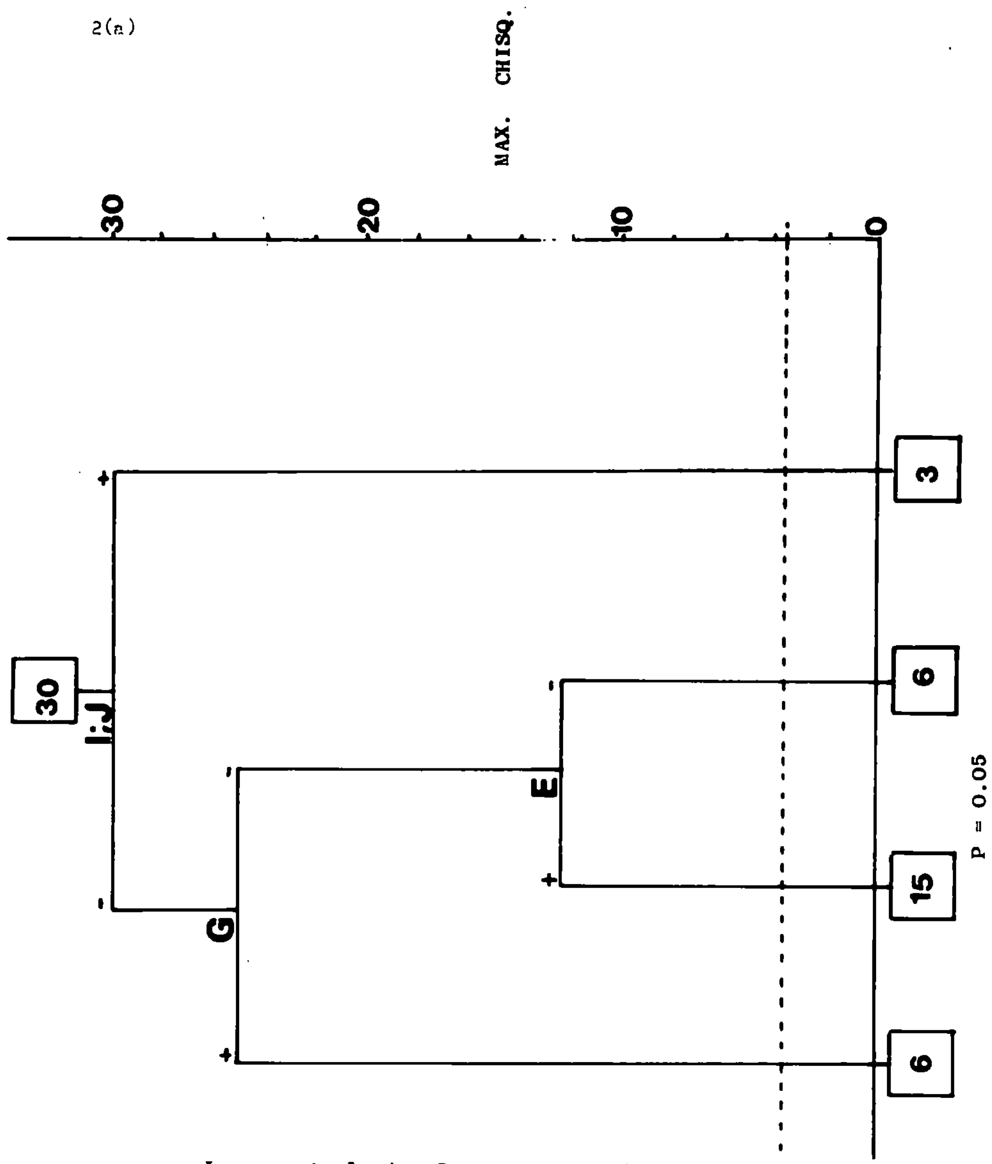
(i) Normal analysis. (Fig.2a). In this analysis, the 5% probability level (x^2 value = 3.84) has been used to stop division. Four quadrat groups have been produced by this method. Initially, the three quadrats (1, 3 and 4) characterised by Ulex gallii divided from the remainder, followed by division of the six quadrats defined by Erica ciliaris(9, 10, 11, 18, 19, 20). At a lower level Ulex minor divides the remaining quadrats into two unequal groups, one of the 15 quadrats (the 'typical' Dorset heath) and another of six quadrats which are particularly species poor.

**N.B. All letters on the figures refer to those in Table I/1

(ii) Inverse analysis (Fig.2b) This analysis, using the quadrats to divide the species into groups, yields three groups, (a) one containing Ulex gallii and Vaccinium myrtillus, and (b) one

2(a)

NORMAL ANALYSIS - DORSET DATA 1967.



Inverse Analysis, Dorset Data 1967

2(b)

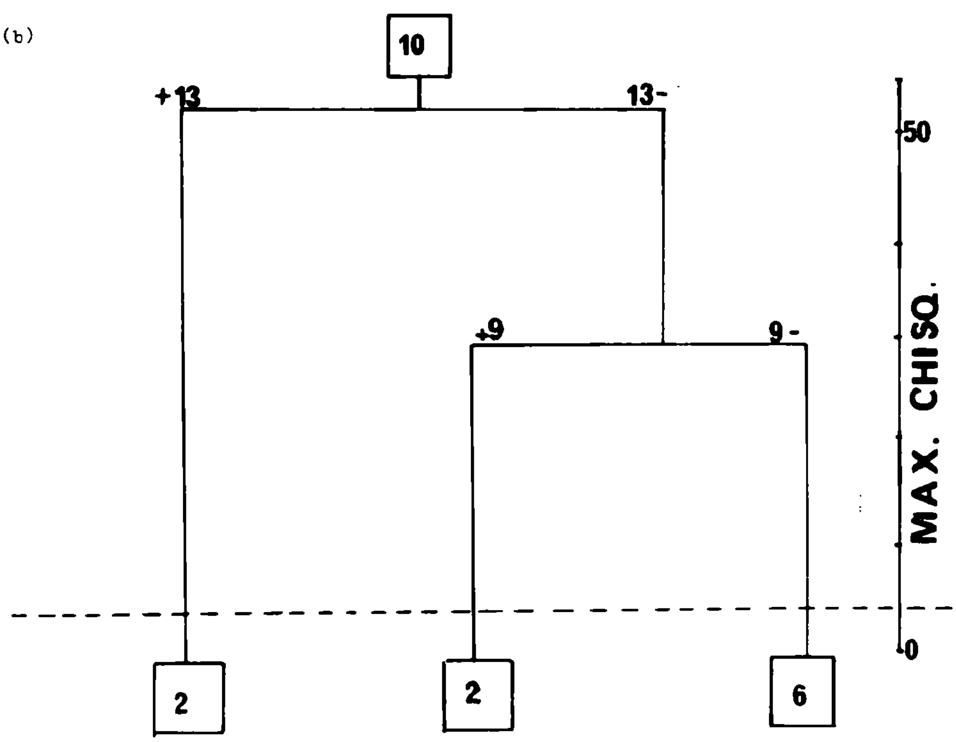


Fig. II/2

containing Erica ciliaris and Scirpus caespitosus, and (c) a group containing the remaining species. Table 1 shows the raw data re-written taking into account the results of these two analyses.

(iii) Nodal Analysis.(Table 2). This has produced four full Noda, and two minor sub-noda (sensu Lambert and Williams, 1962). The four noda are defined as follows: Molina Caerulea/13; Erica ciliaris/9; Ulex gallii/1; Molina caerulea/9 and the two minor sub-noda as Molina caerulea/x, x/8.

(iv) Group Analysis (Fig.3.) Four groups of quadrats are produced by this analysis, although their constituents are somewhat different from those of the Normal analysis. The species dividing the data initially is Erica cinerea. The first group (-E. cinerea) therefore contains only some of the E. ciliaris defined quadrats. The group of quadrats with E. cinerea divides again by Ulex minor, and the group with Ulex minor present divides again by E. tetralix. The level of Group Coefficient used to terminate these divisions was 0.85. In order to clarify these results, the raw data has been reassembled into the four groups (Table 3).

(v) Information Analysis. (Fig.4, 5) Five quadrat groups were obtained from this analysis, the quadrats not being distributed in the same ways as the Group and Normal analyses. Both the Ulex gallii quadrats and Erica ciliaris quadrats are rather widely scattered throughout the groups.

An 'inverse' information analysis yields six groups of species (i) U. gallii, Vaccinium myrtillus, (ii) E. ciliaris, Scirpus caespitosus, (iii) Agrostis setacea, (iv) Molinia caerulea, E. cinerea, (v) Ulex minor, E. tetralix and (vi) Calluna vulgaris.

TABLE II/1.

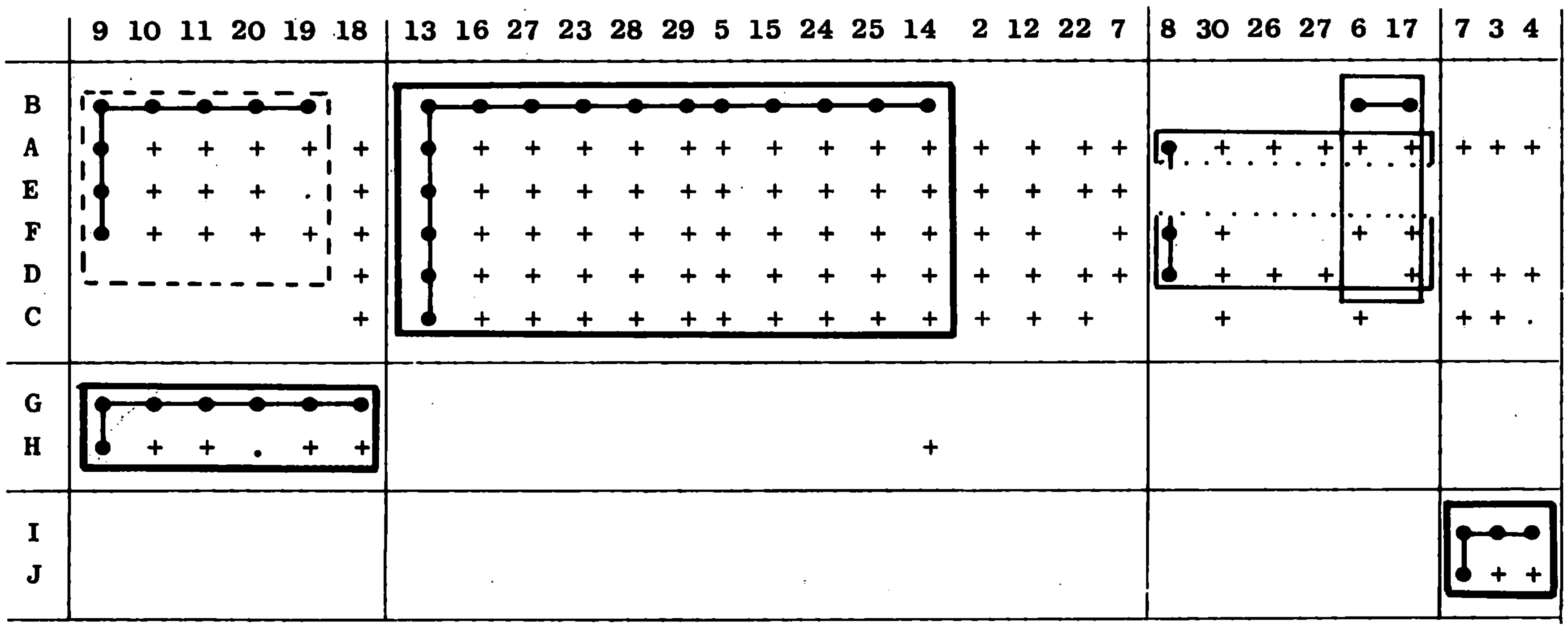
Association Analysis: Two-way Table.

QUADRAT GROUPS

Species groups		1						2															3						4		
		9	10	11	18	19	20	2	5	7	12	13	14	15	16	21	22	23	24	25	28	29	6	8	17	26	27	30	7	3	4
A	A	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	B	+	+	+		+	+		+			+	+	+	+	+		+	+	+	+	+	+		+						
	C				+			+			+	+		+	+	+	+	+			+	+	+					+	+	+	
	D	+			+			+	+	+	+	+	+	+	+	+	+	+	+		+	+		+	+	+	+	+	+	+	+
	E	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+									
	F	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+			+			
B	G	+	+	+	+	+	+																								
	H	+	+	+	+	+							+																		
C	I																												+	+	+
	J																												+	+	+

Nodal Analysis.

DORSET DATA 1967



- full nodum.
- major sub-nodum of high rank.
- minor sub-nodum.

Table II/2

<u>GROUP ANALYSIS - DORSET DATA 1967.</u>

Group coefficient

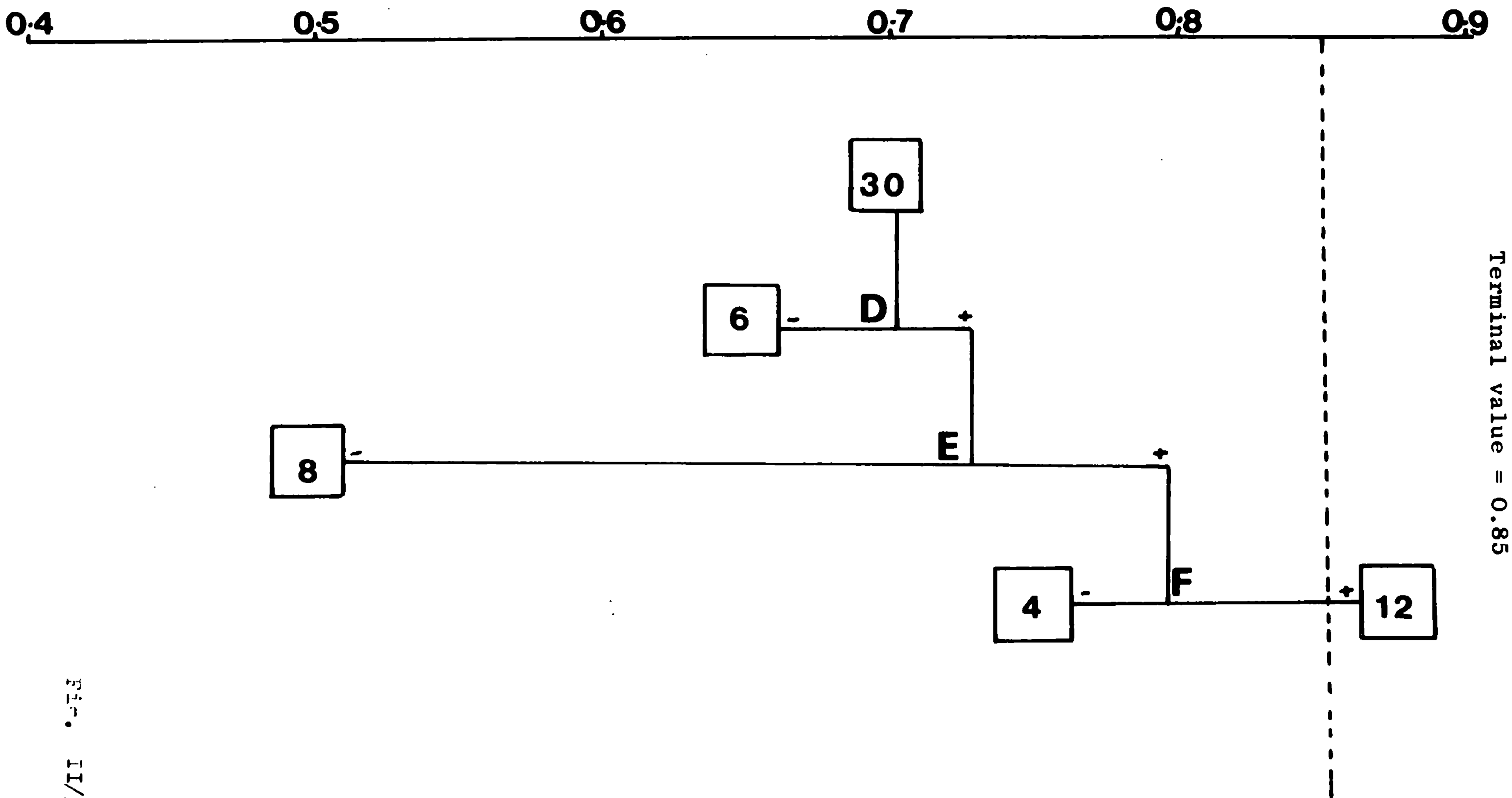


Fig. II/3

TABLE II/3

Quadrat number :		25	9	11	19	20	6	1	3	4	30	8	17	26	27	15	21	22	23	14	10	18	13	2	12	16	5	7	28	29	24
Species.																															
Calluna vulgaris	A	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Molinia caerulea	B	+	+	+	+	+	+						+			+	+			+	+		+			+	+		+	+	+
Agrostis setacea	C						+	+	+		+					+	+	+	+			+	+	+	+	+			+	+	
Erica cinerea	D							+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ulex minor	E	+	+	+	+	+	+									+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Erica tetralix	F	+	+	+	+	+	+				+	+	+							+	+	+	+	+	+	+	+	+	+	+	+
E. ciliaris	G		+	+	+	+															+	+									
Scirpus caespitosus	H		+	+	+															+	+	+									
Ulex gallii	I							+	+	+																					
Vaccinium myrtillus	J							+	+	+																					
Quadrat group number		1						2								3				4											

INFORMATION ANALYSIS - DORSET DATA 1967.

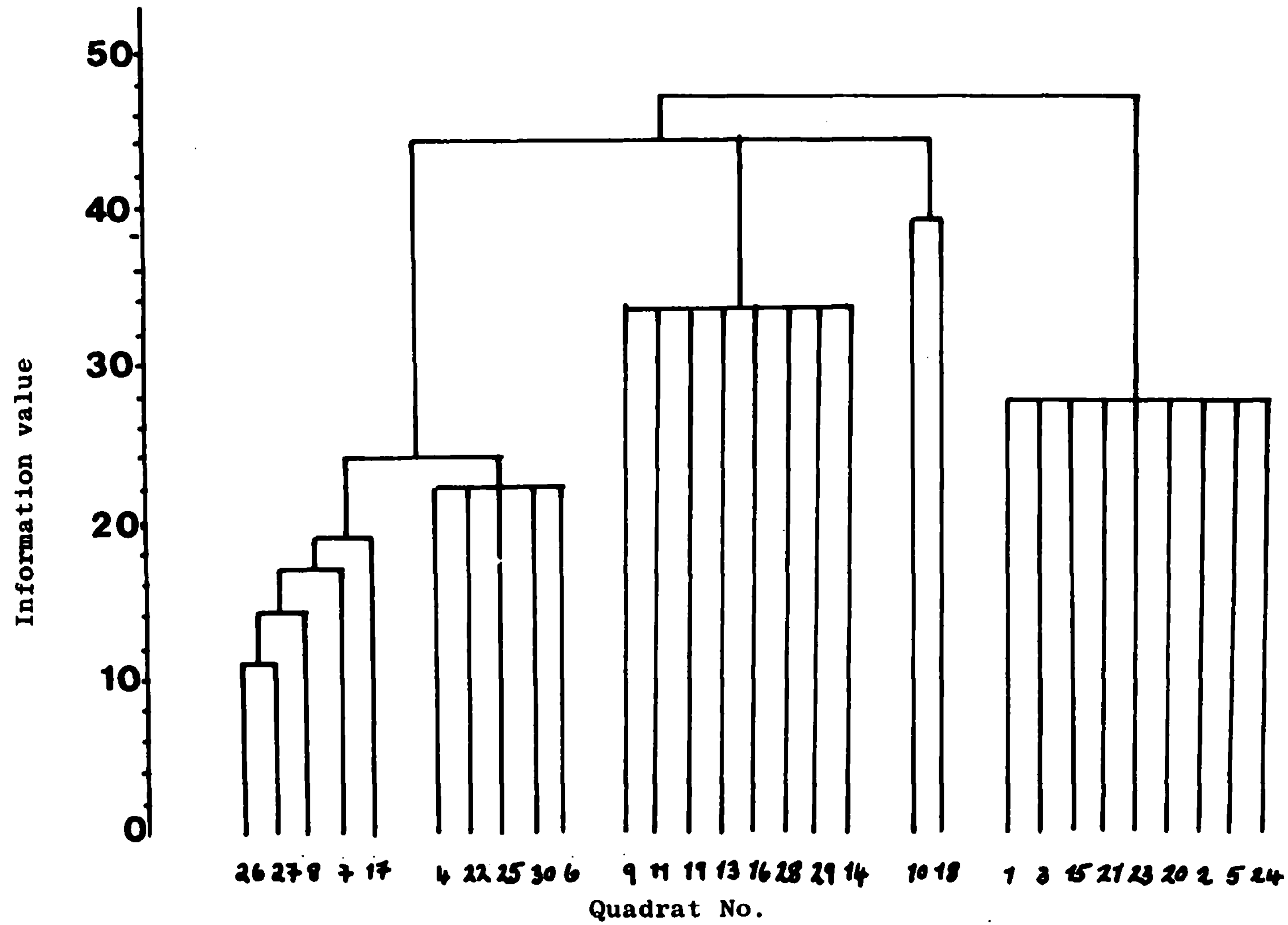
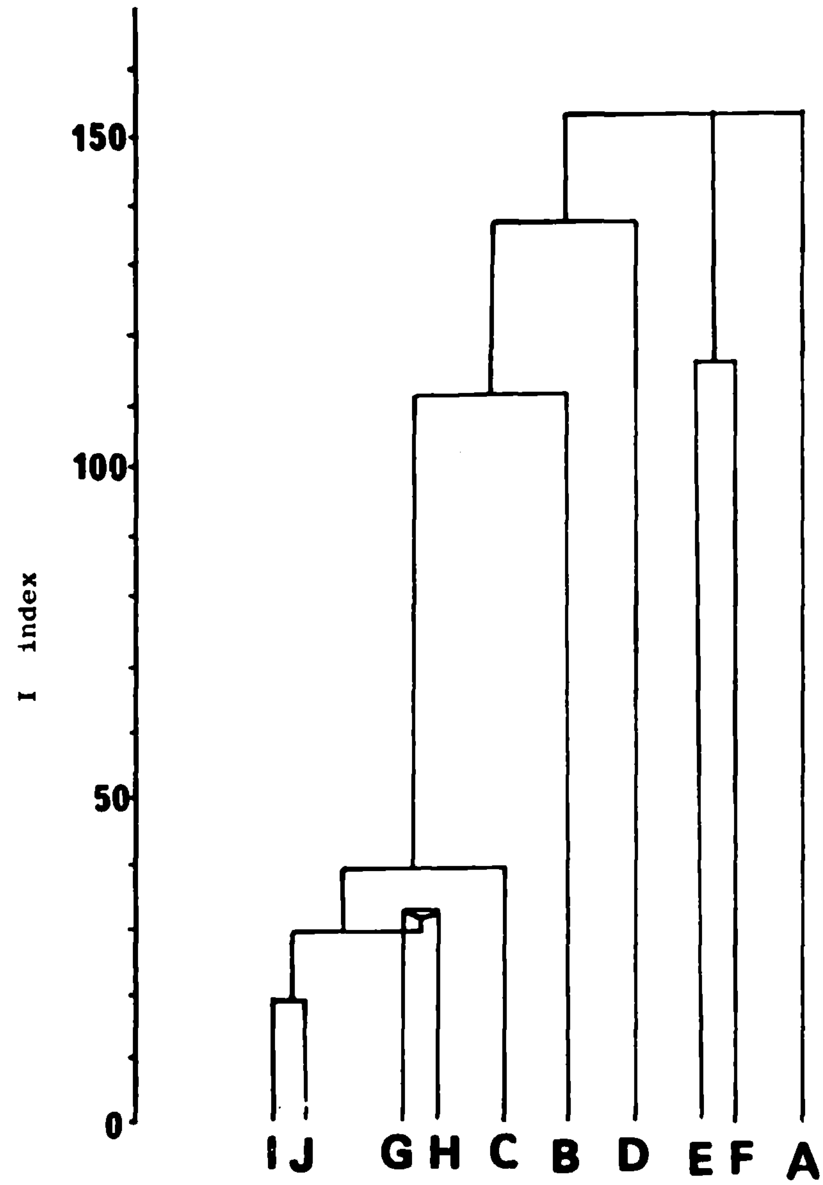


Fig. II/4

Inverse Information Analysis - Dorset Data 1967



species (as table I.1).

Fig. II/5

The results of these two analyses have been placed in a two-way table (Table 4), which shows more clearly the division of the species groups. The results have produced a 'finer' distinction of groups - for example the Erica ciliaris/9 nodum of the nodal analysis is found in three differing segments of this two-way information analysis table.

(vi) Simple Ordination. (Fig. 6, 7, 8) This was approached in two ways - use of a simple community coefficient (the 2a/b + c coefficient of Sørenson, 1948) and use of an importance value (cover values of the species). Fig.6 shows the two-way graphs for three axes using the Community coefficient. Obviously little can be resolved from the x, y and z,y graphs - the x,z graph on the other hand does provide some kind of separation; albeit a little confusing. Fig.7, using the importance values creates a rather clearer image, showing a fairly constant and clear separation of quadrats 9, 10 and 19 from the rest.

Fig.8, showing a three dimensional model of the graphs obtained from the Importance value analysis, is a little clearer, by producing four groups. Quadrats 1, 3 and 4 remain on the x plane, 9, 10, 11 and 19 form a very distinct group (= part of E. ciliaris group of other methods), but this also includes quadrats 5 and 25 - both of which are 'wet heaths', as shown by the large amount of E. tetralix they contain. This places them with the other E. ciliaris characterised heaths, which also have high cover values for E. tetralix. This also explains why 18 and 10 (low cover of E. tetralix) are not consolidated with the rest of the E. ciliaris group.

II.6. Discussion.

All these methods produce essentially the same groupings, although certain quadrats tend to oscillate between differing groups, dependent on the methods used. The fact that ordination produced four

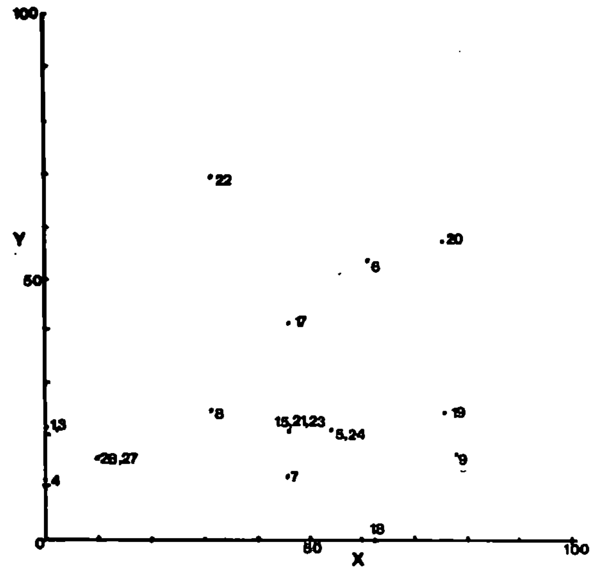
Table II 4. **Information Analysis. Summary Table.**

DORSET DATA 1967

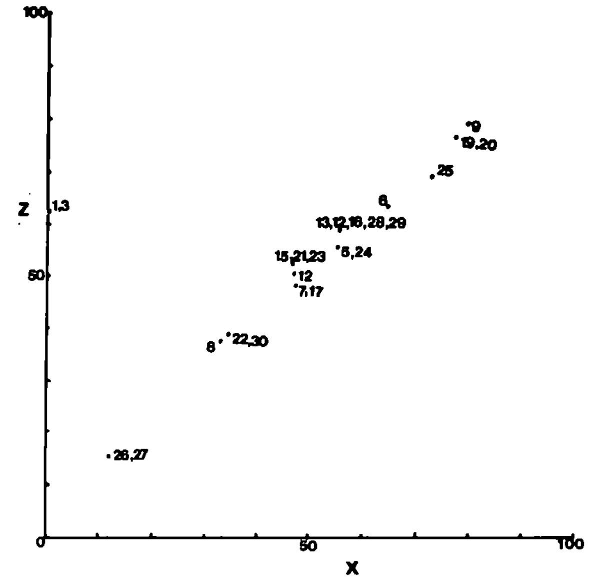
	26	27	8	7	17	4	22	25	30	6	9	11	19	13	16	28	29	14	10	18	1	3	15	21	23	20	2	5	24
I						+															+	+							
J						+															+	+							
G											+	+	+						+	+						+			
H											+	+	+					+	+	+									
C							+		+	+				+	+	+	+			+	+	+	+	+	+		+		
B								+		+	+	+	+	+	+	+	+	+	+				+	+	+	+		+	+
D	+	+	+	+	+	+	+		+					+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
E				+			+	+			+	+	+	+	+	+	+	+	+	+			+	+	+	+	+	+	+
F			+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+						+	+	+	+
A	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Fig. II/6

Ordination of the Dorset sites, showing quadrats against three axes, using the Community Coefficent.



Y
X
0
50
100
22
20
6
17
8
15,21,23
5,24
19
1,3
26,27
4
7
9
18



Z
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19,20
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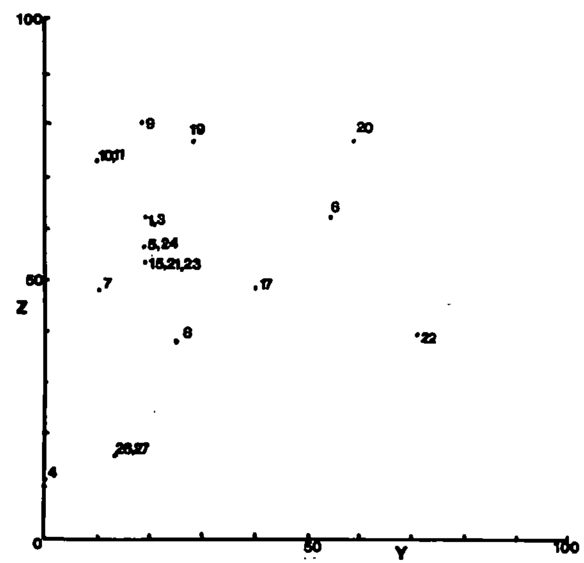
5,24
12
7,17
8
22,30
26,27
1,3



Z
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15,21,23
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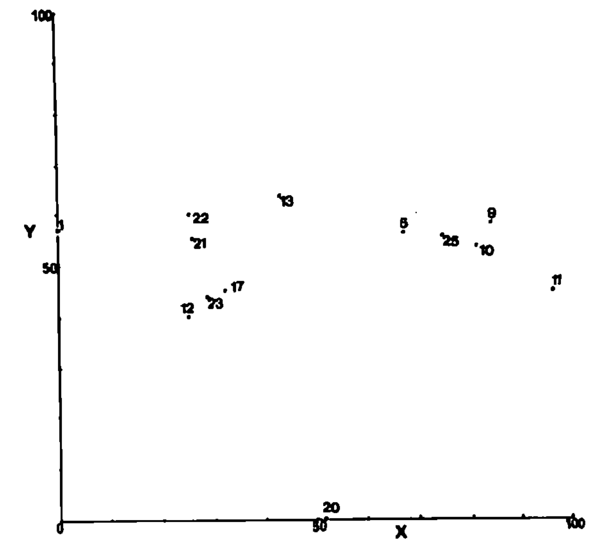
17
8
22
26,27
4

Fig. II/7

Ordination of the Dorset sites, showing quadrats against three axes, using Importance values.



Y
X
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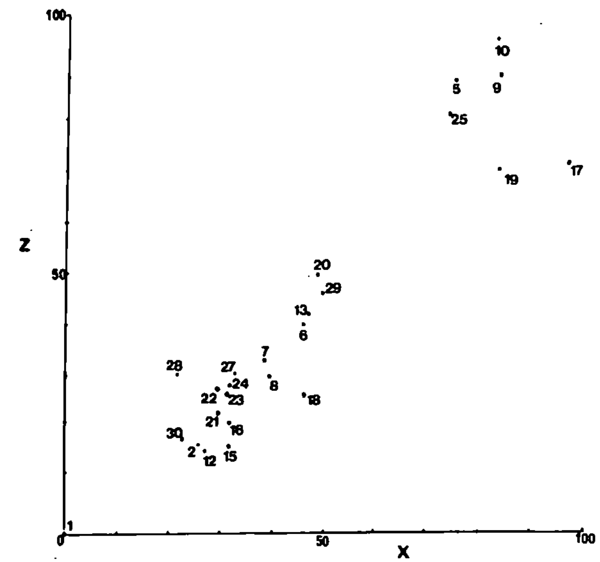

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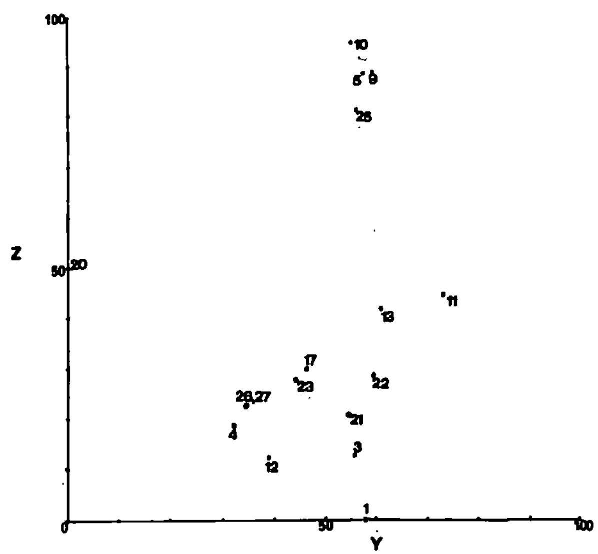
15
1



Z
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100
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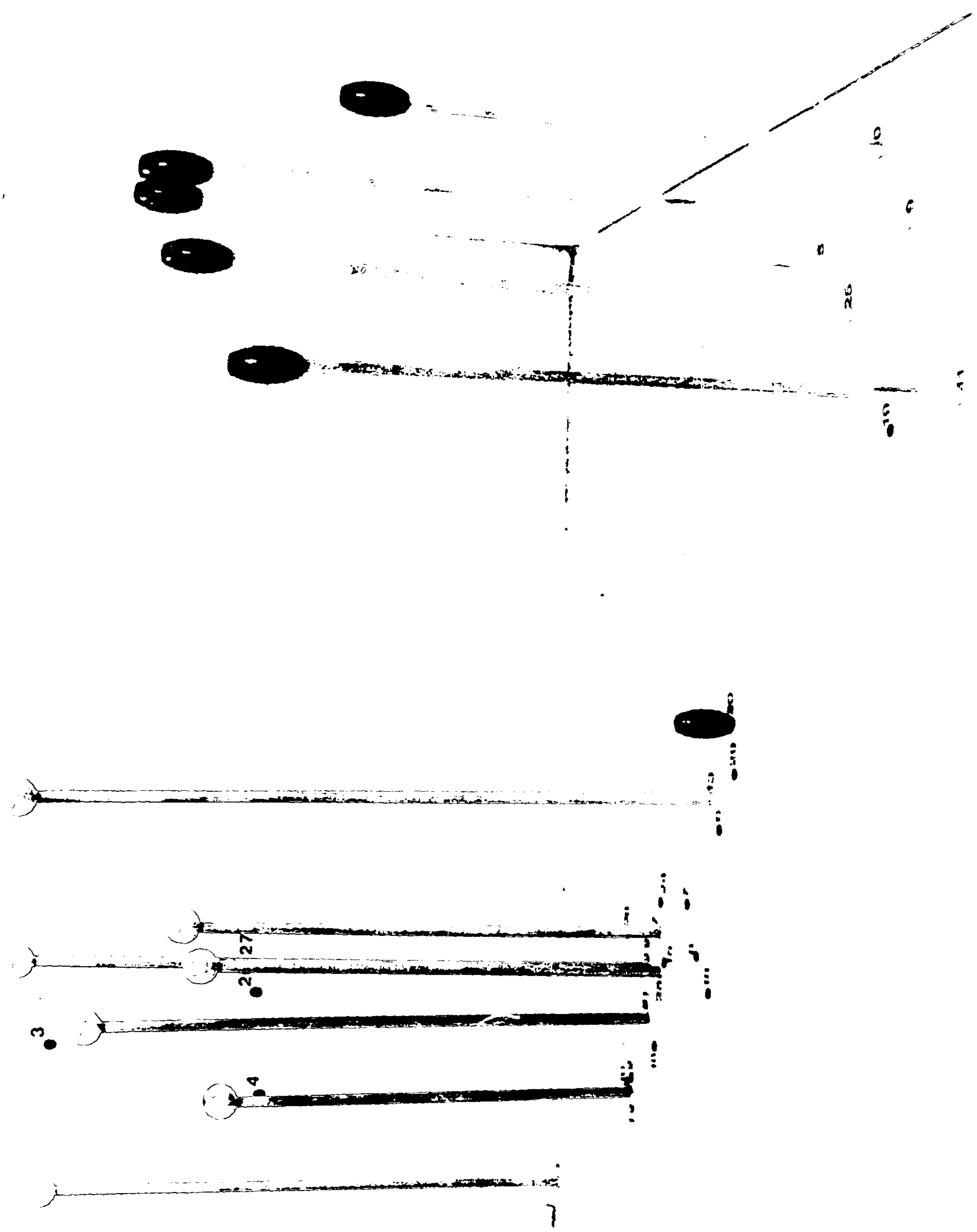
5
9
25
20
11
13
17
23
22
26,27
21
4
3
12
1

Fig. II/8

Ordination of the Dorset sites, showing a three- dimensional model of the quadrats, constructed from their Importance Values.


27
2
3
4

rather clear-cut groups may be taken as an indication that the model is fairly homogeneous, in that where internal divisions occur, they are found at certain defined points, and there is little ambiguity about the position of quadrats with respect to these divisions. This, then, is the expected situation from the information given in Fig.1.

The picture produced by Nodal Analysis is the simplest and most clear-cut abstracted picture - showing clearly the phytogeographically distinct section of the model, and also the ecologically distinct section. In fact, on the surface it seems the information provided is just that which is derived from the Z-M processing. However, the breakdown of the vegetation into abstracted units allows much more 'weighting' to be applied to them. For example, the Erica ciliaris Nodum (E. ciliaris/9) is accompanied by a further nodum (Molinia caerulea/9) - which is analagous to part of the Molinia caerulea/13 Nodum. One quadrat not included in this Nodum is 18 - it is interesting to note that this is the most misplaced of all the E. ciliaris group in the ordination. Thus, more about the sociological relations between individuals is revealed, i.e. that the E. ciliaris group can be thought of as a group of species superimposed on a 'standard species set' for a vegetation type (lowland Heath). Some of the more recent advances within the Z-M system have involved this type of 'species group' interpretation - the work of Scammoni and Passarge (1959) and Doing (1962) are good examples.

The usefulness of Nodal analysis lies in its ability to detect and resolve some of the sociological patterns of differing species groups within communities - and thus it is extremely valuable for small-scale vetetational analyses. For widespread useage, however, the final units are likely to be a little confused and disjunct for the mapping and investigation of vegetation.

The results from the group analysis do not show clearly the variation present in the model. In part, this is due to the species used to divide the data, selected because the method utilizes species gregarity rather than vegetational homogeneity. Heath vegetation is typically species poor, but the species present are particularly gregarious or 'social'. Thus the presence of Erica cinerea in quadrats 10 and 18 means these quadrats are separated from the E. ciliaris group and the absence of E. cinerea from 6 and 25 includes these with quadrats 9, 11, 19 and 20 as a new group.

Further, the Ulex gallii set of quadrats is not divided off from its containing group - which on inspection (Table III) shows clearly three sub-divisions (one with U.gallii/Vaccinium myrtillus, another with Erica tetralix and a third group with none of the above mentioned species). This form of analysis is thus not particularly well suited to analysing begetation with only a few species, and with relatively few quadrats. The Heterogeneous vegetation of sand dunes used by the originators (Crawford and Wishart, 1967, 1968) was an ideal choice because of the large number of species and extreme heterogeneity of the vegetation.

Information Analysis, in its two-way table form is more fragmented than the Nodal Analysis two-way table, but does provide additional information. Lambert, Williams and Dale (1966) suggest this type of analysis could be more useful in continuously varying vegetation - and that although the 'normal' form will differ little from 'normal' association analysis, the inverse form usually provides a picture of greater clarity (as in this case).

The two-way table, on inspection, gives a very detailed picture - including a separation of the Erica ciliaris group into three sections. (i) lacking E. cinerea, (ii) with E. cinerea and (ii) lacking Scipus caespitosus and E. cinerea. This is not unlike the picture from rearranging the Group Analysis results - but the results depict more clearly even fairly minor differences in the vegetation. Similar, the Ulex gallii group is split into two subgroups, defined by the presence/absence of Agostis setacea. This is another example where the Sociological implications of the interaction of defined groups is of extreme importance.

Thus, this shows clearly the advantage of agglomerative, polythetic techniques over the divisive, monothetic methods. As with the group analysis, it is obviously a method of analysis very suited to gradient and mosaic situations.

Ordination has shown, as previously noted, the unsuitability of 'homogenous', simple, vegetations for the ordination type analysis. The main point brought home by these results concern the siting of quadrats 5 and 25 with the Erica ciliaris group - a feature not noted in any of the other forms of analysis, but one of importance, since these are very definitely 'wet heaths'. A major danger of the other methods outlined is that 'false' information may be utilised to confuse, or even destroy, the actuality of the vegetation.

Lange, Stenhouse and Offler (1967) make a useful "caveat" of this nature, with specific reference to two methods of classification - Sneath Q. Analysis (1957) and Williams and Lambert's Association analysis (loc.cit.); "(These) embody two of the best contemporary approaches to emperical classification. Nevertheless, they have various differences which the rational biologist can ignore only at the risk of making faulty inferences."

All of these analyses, and the many others to be found in the literature, therefore have something to contribute to vegetational studies, but each is tailored to suit varying types of vegetation. The method to be used in each case should be chosen after careful consideration of all the factors involved, to achieve a satisfying and useful classification of the vegetation.

Perhaps the most fitting way of ending this discussion, is with a quote from Proctor (1967); "My own belief is that a classification is both possible and desirable, -----I would hope, and expect, to see such a classification achieved by a developing traditional phytosociology, using numerical methods as tools wherever appropriate. I think the achievement of such a classification, or rather its continuing growth, would be of immeasurable benefit to Ecology."

Suffice it to say these views correspond exactly with my own.

II.7. Non-Floristic Phytosociological systems.

Although this work refers chiefly to systems of vegetation description based on Floristics, it would be wrong to omit mention of some non-floristic systems. Though, naturally, not as effective as systems based on Floristics they have been used by geographers in Land use Surveys, particularly of Tropical lands, and are, in some cases, easily relatable to standard phytosociological units.

The impetus given to structure and physiognomy in vegetation was provided by the interest at the beginning of the 20th Century shown in life-form of plants by several botanists, especially Raunkiaer (1934). This made it possible to think of vegetation in terms other than component species, and so opened the study to non-botanists. Dudley Stamp (1930) produced the idea of a 'Vegetation formula', analagous to the Floral formula of traditional Botany. He suggests the use of the following symbols:

A	-	Trees;	G	-	Grasses;
F	-	Shrubs;	C	-	Cryptograms;
H	-	Herbaceous plants (excluding grasses).			

to be used to describe vegetation within a standard area, and he suggests 1 Hectare.

The basic formula can be represented as:

$$xA + yF + zH + uG + vC,$$

where x,y,z,u,v are the numbers of individuals per hectare. The height of the components may be included in parenthesis after the symbols, and differing layers of the same life-form can be distinguished by using primed symbols, i.e. F and F'. In addition, the general character of the trees and shrubs may be denoted by suffices (c = coniferous, s = evergreen, etc.)

An example is: $150 \quad A^{c} a \quad (50)$

This indicates a coniferous forest, one dominant; the trees having an average height of 50 m, averaging about 150 per hectare, with no undergrowth. This is therefore a perfectly utilizable method where fine details are not required.

Richards et. al. (1940) propose a more ambitious scheme for Tropical Rain Forest, but the underlying principle of utilising structure and physiognomy is still maintained.

The first attempt to utilise structure on a refined basis was that of Dansereau (1951,1957). He states that structure is "the organisation in space of the individuals that form a stand (and by extension a vegetation type or association). Their primary elements are growth-form, stratification and coverage."

He selected six criteria for description - Life-Form, size, coverage, function, leaf shape/size and leaf texture. The result description was a series of graphic cymbols and diagrams. Fig.9. illustrates these.

It has been found useful to create a new criteria of Life Form - Lichens, which in Heath, Bog and Tundra Vegetation form a very important constituent of the vegetation.

This system is particularly useful in situations where species are relatively unimportant, but the structure of the vegetation is so. Just such a case was the requirement, by a hydrologist, to distinguish the differing types of vegetation present in a small catchment area (Weardale, N. England). Five types were distinguished by this method (Fig.10). Species present in these types were listed (Table 5.) and the differences show that this simple descriptive method is really quite 'sensitive', as well as illustrating the range of structure - an exceedingly important feature, often neglected. Further examples of the usefulness of this method are found in studies of the change in vegetation structure of 'zonal' communities, of Lakes, ponds, bogs, etc.

Some writers in the Z-M school have tried to integrate more detail about the structure of vegetation into their studies (Barkman, Doing and Segal, 1964), but the results obtained are usually rather too cumbersome to handle easily.

The underlying trend of this Section has been to explore several of the many 'numerical' methods available, and these, together with the Non-floristic systems just described point to one conclusion; to be effective, any study of vegetation should encompass more than one such method, depending on the scope and needs of that study.

Fig. II/9

Six criteria of classification, modified after Dansereau, 1957.

SIX CATEGORIES OF CRITERIA USED IN VEGETATION DESCRIPTION
(MODIFIED AFTER DANSEREAU (1957))

1 LIFE FORM

- T trees
- F shrubs
- H herbs
- M bryoids
- E epiphytes
- L lianas
- S lichens

2 SIZE

t - tall (T = minimum 25m
F = 2-8m
H = minimum 2m)

m - medium (T = 10-25m
F,H = 0·5-2m
M,S = min. 10cm)

l - low (T = 8-10m
F,H = maximum 50cm
M,S = maximum 10cm)

3 FUNCTION

- d deciduous
- s semi-deciduous
- e evergreen
- j evergreen leafless

4 LEAF SHAPE & SIZE

- n needle or spine
- g graminoid
- a medium or small
- h broad
- v compound
- q thalloid

5 LEAF TEXTURE

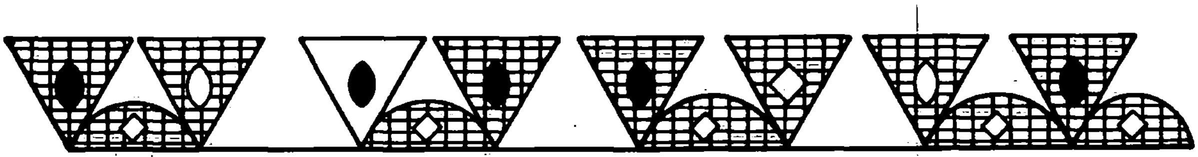
- f filmy
- z membranous
- x sclerophyll
- k succulent or fungoid

6 COVERAGE

- b barren or sparse
- i discontinuous
- p tufts
- c continuous cover

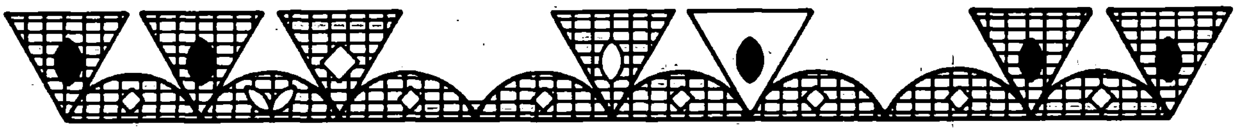
Fig. II/10

Five vegetation types from Weardale, N. England, determined using the Criteria in Fig. II/9.



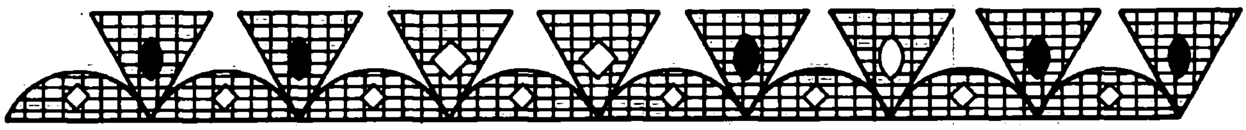
Hmegxp, ml(m)eazi, Hmegzp, Hmdgxp, Hleazp

1 DAMP GRASSLAND



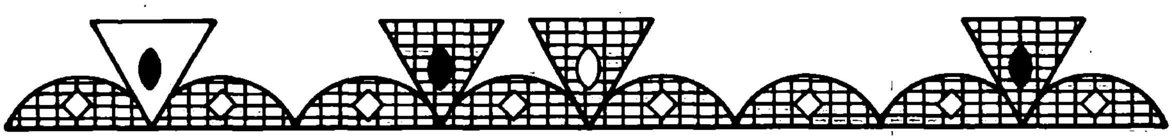
Hmegxp, mleazc, mlevzi, Hleazp, Hmegzp, Hmdgxp

2 DEGENERATE BLANKET PEAT



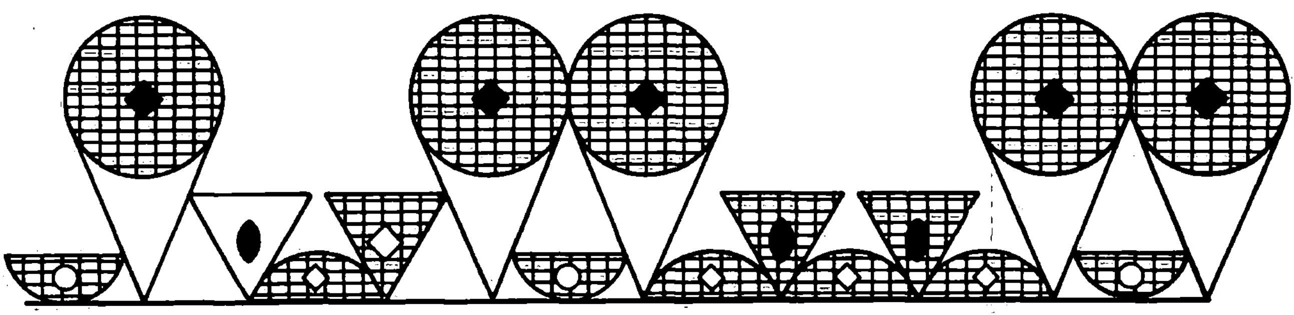
ml(m)eazc, Hmegxp, Hleazp, Hmegzp

3 JUNCUS EFFUSUS FLUSH



ml(m)eazc, Hmdgxp, Hmegxp, Hmegzp

4 SPHAGNUM FLUSH



sleqkp, fleaxc(i), Hmdgxp, ml(m)eazp, Hmeazi, Hmegxp

5 CALLUNA MOOR

TABLE II/5

Species.	Vegetation type 1	2	3	4	5
Juncus squarrosus	+	+		+	+
Galium saxatile	+	+	+		+
Deschampsia flexuosa	+	+			+
Nardus stricta	+	+		+	+
Pleurozium schreberi	+	+			+
Polytrichum commune	+	+	+	+	
Agrostis tenuis	+	+			+
Sphagnum recurvum		+	+	+	
Juncus effusus		+	+	+	
Carex nigra		+	+		+
Dicranum scoparium		+			+
Agrostis canina			+	+	
Eriophorum angustifolium		+	+		
Scirpus caespitosus	+	+			
Plagiothecium undulatum	+	+			
Rhytidiadelphus squarrosus	+				
Sieglingia decumbens	+				
Hylocomium splendens	+				
Sphagnum plumulosum		+			
S. rubellum		+			
Ptilidium ciliare		+			
Aulaucomnium palustre		+			
Calypogeia trichomanes		+			
Lophocolea bidentata		+			
Sphagnum subsecundum			+		
Equisetum fluviatle			+		
Viola palustris			+		
Sphagnum cuspidatum				+	
Calluna vulgaris					+
Vaccinium myrtillus					+
Empetrum nigrum					+
Parmelia physodes					+
Cladonia coccifera					+
C. pyxidata					+
C. squamosa					+
C. furcata					+
Hypnum ericetorum					+
Lophozia floerkii					+

Showing the species complements of the five Vegetation types (see text & Fig. II/10)

III.

VEGETATION BOUNDARIES.

"Der Grenzeraum ist das Wirkliche, die Grenzline die Abstraktion davon."

Ratzel 1895.

III.1. Introduction.

In most studies of vegetation, especially those involving a classificatory approach, the choice of stands implies the delimitation of vegetation types in the field, and hence detection of boundaries. Those detections are often based on the behaviour of 'dominant' or otherwise conspicuous species, and may, in fact, prove to be quite erroneous. Thus the accurate detection, and, if possible, typification and classification of boundaries in vegetation is of prime importance. Although the vegetation boundary has had both conscious and unconscious consideration in some of the early literature, there are few or no quantitative studies of boundaries in their field situations.

The concepts behind a 'boundary' are essentially anthropic in nature, and so it is perhaps best to start this review of 'boundaries' with some of the ideas and terminology used by Political Geographers in their study of the subject.

III.2. Concepts.

III.2.1. The Geographical View.

Ratzel (1895) maintained that the boundary was an abstraction, and the border area the reality. Lapradelle (1928), agreed with this - but distinguished 'boundaries' and 'frontiers'. Fawcett (1918) defines frontier as "a region of transition - whilst it is admitted that all regions are transitional, only when this is the dominant landscape feature is the region recognised as a true frontier." This latter definition has much importance for the ecologist, since in essence, what is true of landscapes is true of their component parts, the plant and attendant animal communities or ecosystems.

Lapradelle (loc.cit.) noted the frontier as "un mileau de transformation" and suggested a triple division of the boundary/frontier complex (Fig.1.) A central zone of fusion (territoire limitrophe (T.L.)) is flanked on both sides by the extreme peripheral zones of adjacent states (their 'frontières' - F.A. & F.B.). The whole system he terms 'le voisinage' (V).

This provides a valuable working model of boundary situations for the plant sociologist, enabling many situations encountered in field to be related to this basic model. A system of relating the width of the T.L. in any situation to the importance of the flanking peripheral zones (F.A. & F.B.) allows a more flexible approach to, whilst complementing, the system proposed by van Leeuwen (see later). In its most 'typical' form, i.e. a narrow, but definite T.L., banked by clearly distinct F.A. & F.B. zones, this model corresponds to the 'ecotone' situation (sensu van Leeuwan 1966). The term 'ecotone' has, of recent years, come to be taken as meaning " a sharp, defined boundary", despite the fact that Weaver and Clements (1929) proposed the term to cover all forms of transition vegetation. It is perhaps, therefore, better to drop this term, and use those proposed by van Leeuwan (1965,1966) - limes convergens and limes divergens (see later).

Most previous studies on boundaries have concentrated on the T.L. zone, largely ignoring the existence of the FA and FB zones. Future Ecological studies should concentrate on the whole boundary system - following Ancel's (1936) proposition that "as a boundary reflects the relationships between neighbouring groups, it should be studied to this end rather than as a single element of the landscape."

III.2.2. Biological view.

Although the ideas collated above provide a useful working model, they derive from the Geographer's position that at some stage

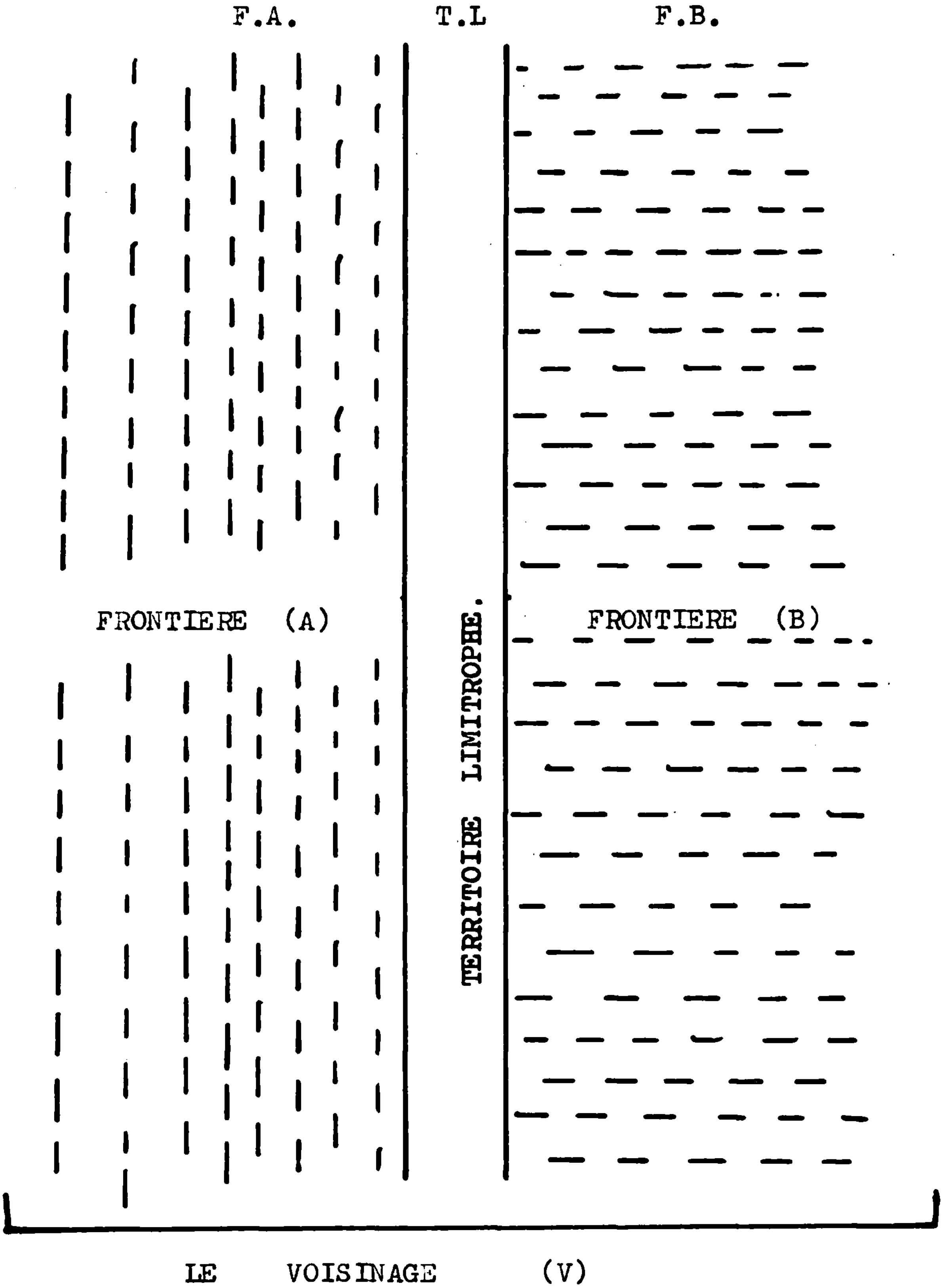

F.A.
T.L
F.B.
FRONTIERE (A)
TERRITOIRE LIMITROPHE.
FRONTIERE (B)
LE VOISINAGE (V)

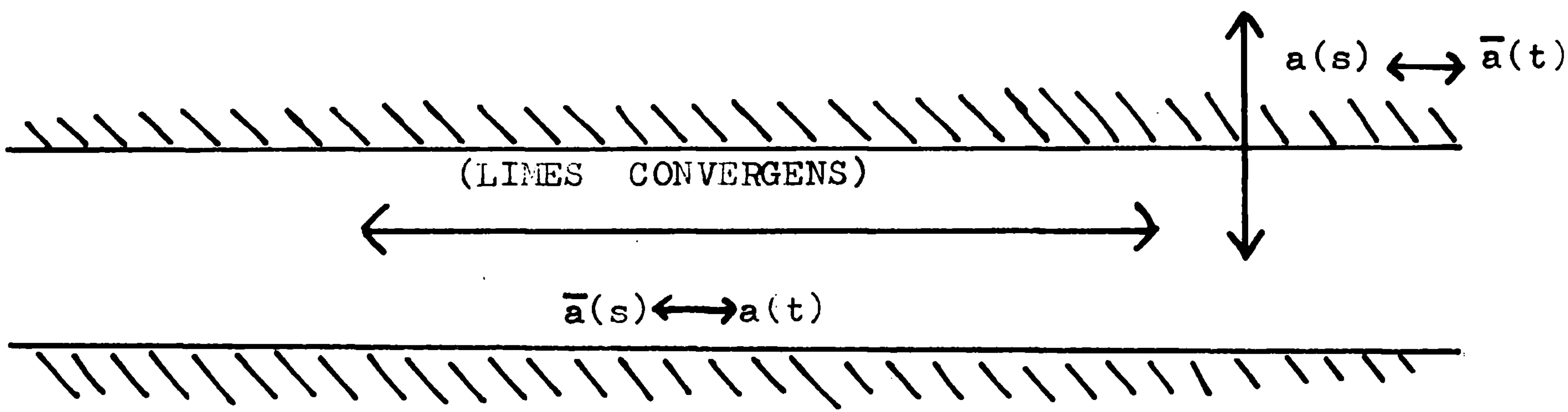
Fig.III/1

a dividing line will be placed in the landscape - however appropriate - whereas biologists are never forced to recognise such artificiality.

In fact, many Political boundaries often correspond to sharply dividing natural features, i.e. mountain ranges, rivers, etc., as in the boundary of France and Spain - the Pyrenean Mountains. In some cases, however, there is no such feature, and although a boundary is laid down by Law, it may not be respected culturally, lingually or topographically (viz. the border of N. W. German/ Netherlands). There, two contrasting conditions illustrate perfectly the two extreme boundary types of van Leeuwan (loc.cit.) The sharp, clear boundary he termed limes convergens, the vague, fuzzy, indistinct boundary, the limes divergens. (based on their contrasting environmental milieu).

(a) The limes convergens patterns show a coarse granulation, with sharp, easily discernable lines of demarcation. The vegetation is typically poor in species, but large numbers of individuals present. Life circumstances in those areas have a high degree of temporal instability, but show spatial stability (i.e. homogeneity). As van der Maarel (1966) has indicated, these conditions may change according to the direction in which they are viewed (Fig.2.)

Examples of the type of vegetation associated with the limes convergens environment are Weed Communities and Salt marshes. Many of the species cited as a characteristic of this type of boundary are "trennarten" of the synsystematic class. Plantaginetea maioris Tx and Prsg. 1950, and Thero-Salicornietea strictae R.Tx. 1954. Associations of these classes are typically found in situations where there is a high degree of environmental "noise" (i.e. alternation of wet/dry, salt water/ fresh water, nutrientpoor conditions/ nutrient rich conditions, and disturbance of the habitat.)



<u>KEY TO SYMBOLS</u> (after van Leeuwan, 1966)

a = variety ; $\bar{a}$ = no variety

s = space ; t = time

Fig. III/2

The connection of the underlaying common "noisy" environment may explain why species such as Trifolium fragiferum, Agrostis stolonifera, Agropyron repens, Potentilla anserina, etc., occupy such seemingly ecologically disparate situations as Saltmarsh, roadside verges and brackish marshes. It may also help to rationalise the occurence of certain "bimodal" species (e.g. Plantago maritima, Armeria maritima), in both sea-level salt marsh and rocky high montane habitats.

(b) Limes divergens patterns contrast with the limes convergens by having a fine granulation and faint or non-existent lines of demarcation. They are rich in species, which have only a few individuals present. Further, their internal conditions are usually 'stable', in that they are not subject to massive, rapid changes. Typically they occur as a gradual transition between two distinct end states, appear rather homogeneous. As van der Maarel (loc.cit.) has pointed out, however, they "represent the ultimate state of heterogeneity", as each limes divergens is divided from the juxta positionof numerous micro-limes convergens situations.

Examples of vegetation typical of this situation is rich marshland, sand dune slacks and 'scrubby' moorland edges - the latter van Leeuwan (1966) calls"the biological culminating point of the limes divergens". It is much more difficult to refer species characteristic of the situations to synstematical units, chiefly because these zones have been little studied from a synsystematical viewpoint. The chief exception is the Trifolio-Geranietea. Certain associations described within the Tofieldietalia are also typical of these situations.

Typically, Limes divergens vegetation is formed anywhere where gradal differences in some milieu components are found. Also, the boundaries between eutrophic(nutrient rich) and dystrophic(nutrient poor) environments, where poor dominates rich, as opposed to rich dominating poor, which is typically expressed as a Limes convergens situation.

As the limes convergens has been wrongly compared to the 'ecotone', so the limes divergens has been assigned synonymously to the term 'ecocline'. (Van der Maarel (1966), van Leeuwan (1966)). Although used in some of the Zurich-Montpellier synstematic literature, in the sense of limes divergens (van der Maarel & Westhoff (1964)) in Anglo-American literature the term is usually restricted to primely systemic useage, and its use as a synonom should be discontinued. It would be helpful if van Leeuwan's terminology could be accepted internationally as the correct term for such ecological situations.

In terms of the model put forward by Lapradelle (q.v.) in the first section, the limes convergens situation can be seen as a situation with a pronounced T.L., blurred or non-existent FA and FB zones and complete separation of the two units. Conversely, the limes divergens is seen as a blurred or non-existent T.L., wide ranging FA and FB zones, and with the units being separated and restricted to a small amount of space at either end of the system.

III.3. Theory of Boundaries.

A boundary may be seen as a separator of adjacent systems, showing some differences between the variables constituting those systems. Boundary definition, therefore, implicitly uses the full information structure of both systems, and depends on the scale of the observations on a system. When differences between the systems at any point within the duo-system is seen to be great, compared with differences at other points in the duo-system, a sharp boundary is detected. Similarly, if no great disparity between variables is found, then a blurred, indistinct or non-existant boundary may be recognised.

If the scale of these observations is how increased, the blurred boudary may become sharp and distinct. Thus, a problem of analytical quadrat size exists, which has yet to be answered. In practice, for most herbaceous and dwarf shrub vegetation types, a basic unit of observation of 1/16th m^2 has been used, although larger units may be preferable in other vegetation types, i.e. Forests and Scrubland.

III.4. Methods of Analysis.

All boudary studies must take into account the end states, as well as the transitional zone itself. Therefore, a transect of contiguous quadrats through the vegetation is the most profitable means of boundary detection and study. As noted above, a quadrat size of 1/16th m^2 has been used throughout. Quadrats of smaller area than this increase the amount of work involved, without further refination of the results obtained. van der Maarel(1968) also notes the 1/16th m^2 as the most useful size for boundary studies.

He further suggested a formula for the analysis, i.e.:

$$H = \frac{1}{2}\sum_{i=1}^{G} \frac{|p(g_i,a) - p(g_i,b)|}{p(max.)}$$

where $p(g_i,a)$ is the performance of the i'th species in quadrat a, p(max.) is the maximum performance of any species. Performance here is defined as frequency,cover, abundance etc.. Essentially, therefore, this formula measures heterogeneity of adjacent quadrats. The 'H' values obtained from this formula are then plotted against transect distance of the quadrats to yield a 'vegetation differential profile', along which disparities in the system can be noted, and hence boudaries detected.

With this form of analysis, the contribution of 1 species, occurring in one of two adjacent quadrats is defined as "1 bit of selective information", or $\frac{1}{2}$ bit per quadrat. Van der Maarel also noted a qualitative form of this formula, i.e:

$$H = \frac{(Ga - Gc) + (Gb - Gc)}{2}$$

where Ga,Gb = number of species in quadrats a,b and Gc = number of species common to both. This formula is monotonic to many of the 'Community Coefficients' (Appendix IV). A less defined profile is produced by this formula, and it is rarely of use.

III.5. Results of Analysis.

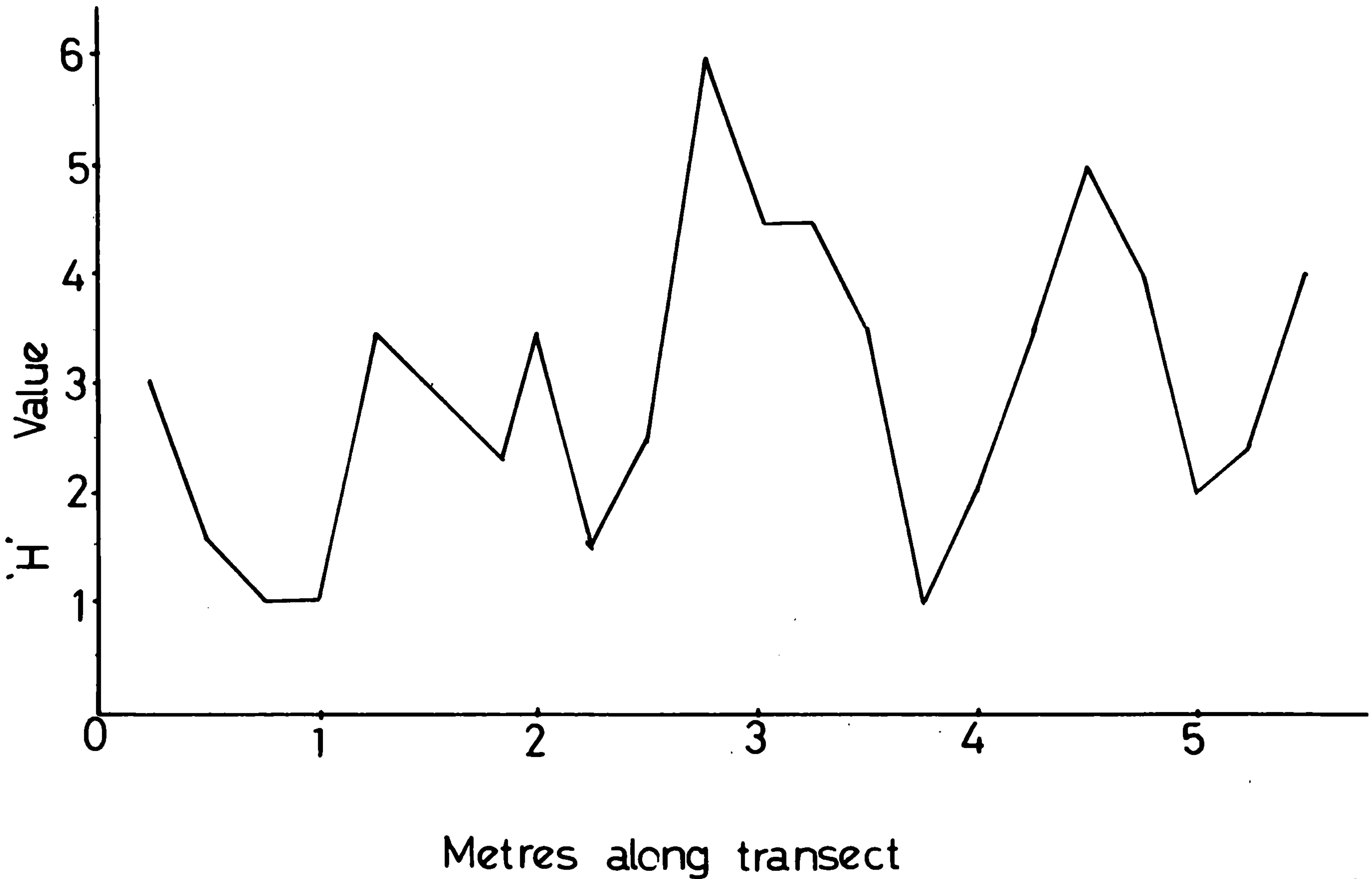
Ten profiles have been prepared across obvious and non-obvious boundaries of several vegetation types, in order to show some of the range of possible profiles. Heath vegetation is typically 'poor' and as most of these profiles were made from 'rich', non-heath communities (grasslands of various types, nutrient rich bogs, etc), to heath, the limes convergens situation is the one most commonly depicted. Conversly, boundaries within a Heathland Complex typically yield limes divergens situations.

(a) This profile and the one that follows were both sited at Crook Peak, Somerset. (G.R. 31/385560).

Boundary between neutral Brachypodium-pinnatum grassland, and Calcareous grassland (Helictrotricho-Caricetum flaccae Shimwell 1969). Fig.3(a) shows the qualitative profile. The information this yields is rather little, apart from a marked heterogeneity around the 2.5, 3.5 m. point. On examining the quantitative profile (Fig.3(b)), however, a marked discontinuity can be seen at the 3m point, with low level fluctuations on either side. This situation is thus a rather typical limes convergens type, agreeing with the statement in van Leeuwan (1966), i.e. that the area under consideration is typically "rich" land dominating

Fig. III/3a

Qualitative differential profile, from Crook Peak, Somerset.



figII/3a

CROOK PEAK, N. SOMERSET.

BRACHYPODIUM PINNATUM GRASSLAND/
ASPERULA CYNANCHICA GRASSLAN]

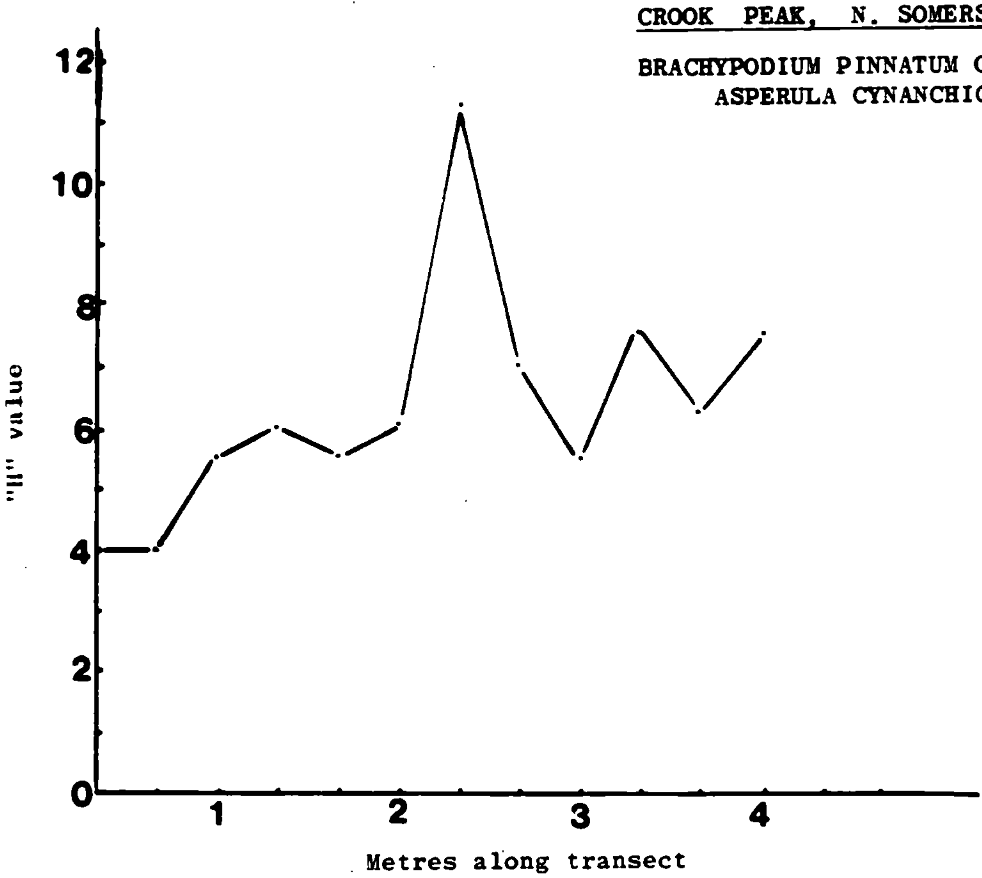


Fig. III/3b

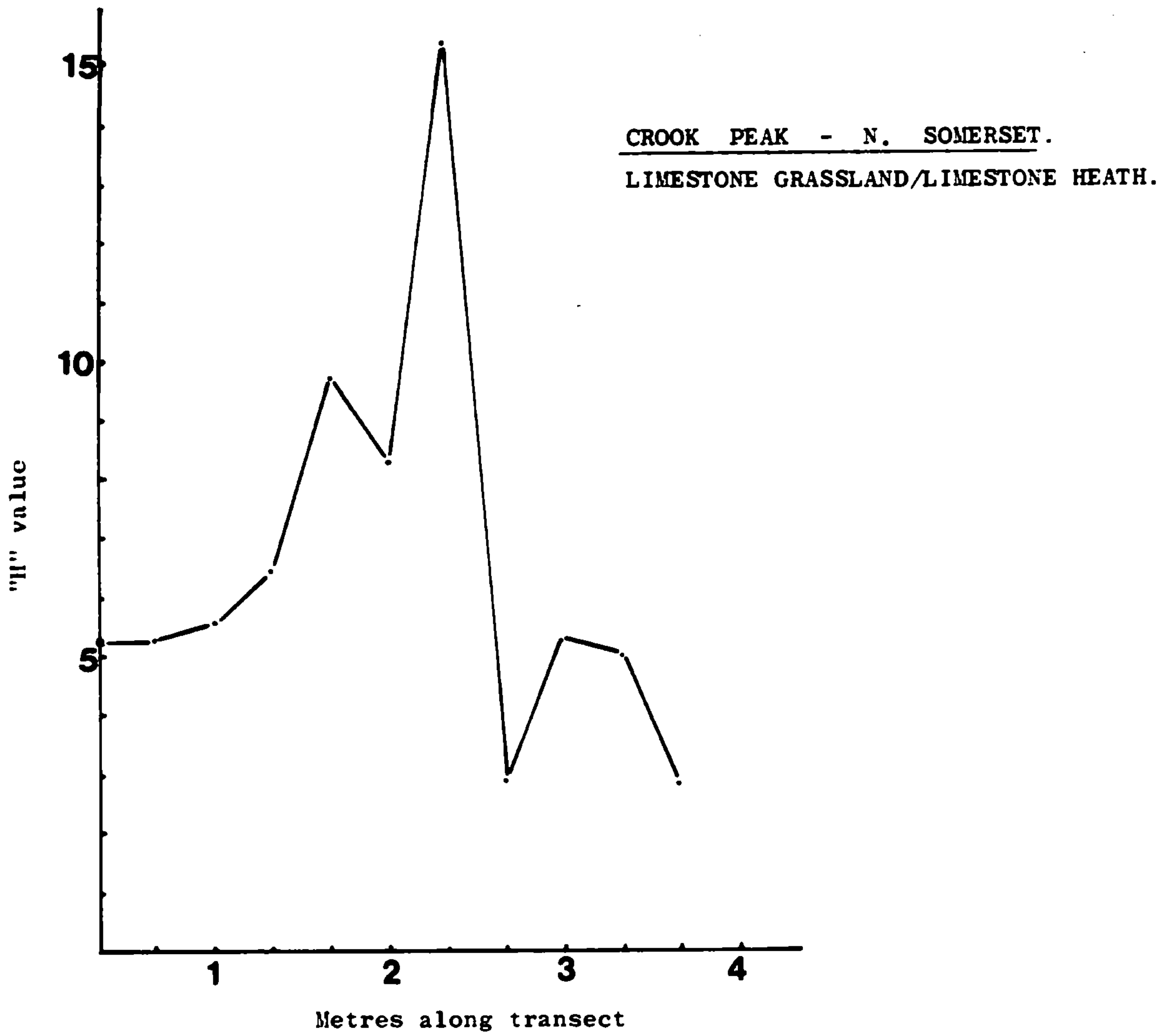
"poor", therefore one would expect to find a limes convergens boundary type.

The level of background noise in the profile is pitched as two levels - (1) 0 - 2.5 m and (2) 3.6 - 6 m. In the first stage, the 'H' values obtained vary between 4 and 5.5., whereas in the second stage they vary between 6.25 and 7. These differences derive from the fact that the Calcareous grassland (3.6 - 6 m) is more species rich than the Brachypodium pinnatum grassland.

(b) Profile between Calcareous grassland (as in (a)) and Limestone Heath (Sensu Moss (1903)). (Carex flacca Community/Ulex gallii Complex Erica Cinerea Heaths), shown in Fig.4. The profile is obviously a typical limes convergens, but there appears to be a 'double peaked' effect, i.e. a steep rise at 2.5 m, falling again at 3 m, with a further steep rise at 3.5 m. This is better explained by reference to Plate I, which shows the boundary area in detail.

There are three communities distinguishable here, (1) the Calcareous grassland, (2) a distinct boundary zone characterised chiefly by Helictotrichon pratense and (3) Limestone Heath. Community (2) is occupying an area that, temporally, is extremely instable as the Limestone Heath is tending to constantly grow out into the grassland. This phenomenon of species being peculiar to boundary zones is discussed in greater detail later in this Section. (III.4.3.)

(c) Profile between a Juncus inflexus - Pulicaria dysenterica marsh and Scirpus tabernaemontani marsh of Culver Well, Portland, V.C.9., GR. 30/685694, in August, 1969. The site is mentioned in Good (1948) "there is even a small acid bog on the top of Portland. This last is so remarkable a locality to find on what is really a huge mass of limestone - that it deserves more than a passing notice."

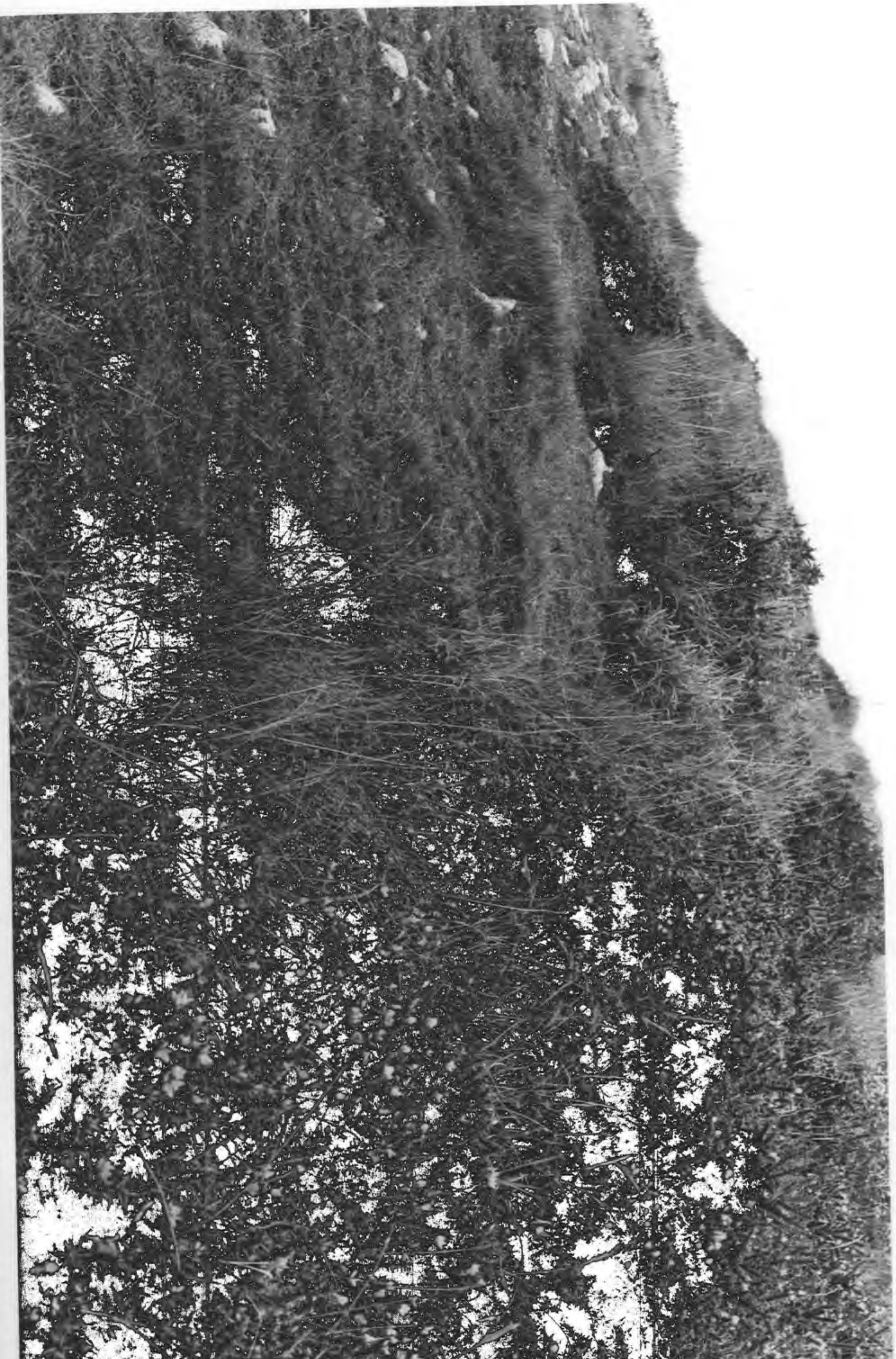


CROOK PEAK - N. SOMERSET.
LIMESTONE GRASSLAND/LIMESTONE HEATH.
15
10
5
"H" value
1
2
3
4
Metres along transect

Fig. III/4

PLATE III/1

Illustrating the boundary between Brachypodium pinnatum grassland and Limestone Heath, Crook Peak, Somerset.

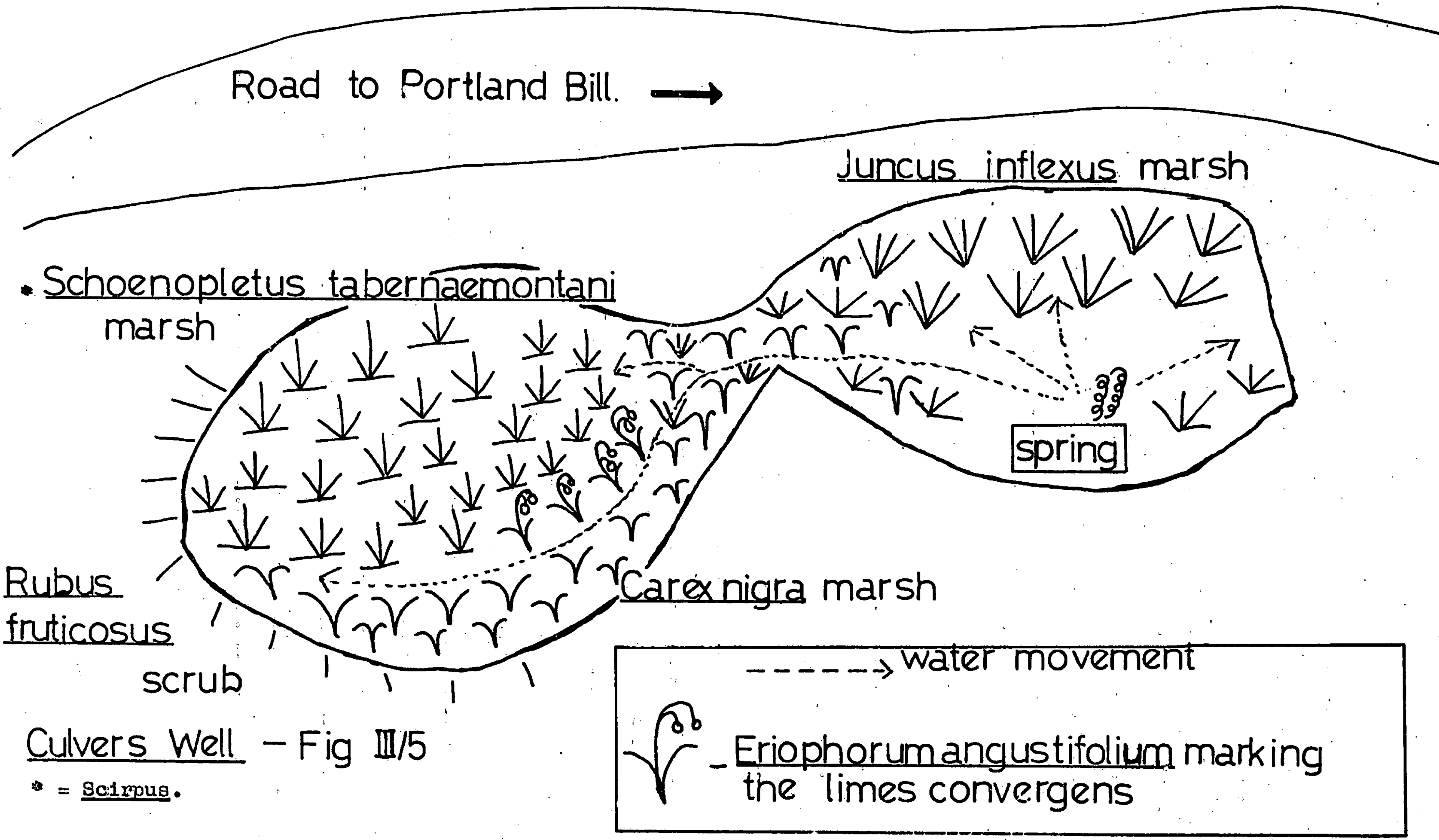


In fact, the vegetation varies from calcium rich to Neutral marsh, not acid bog, but is deserving of note, because of the proximity of vegetation types, consisting on the one hand of a springhead community, formed by tufaceous bryophtes (Acrocladium caspidatum, Hypnum Cupressiforme var tectorum) through a Juncus inflexus marsh to the Scirpus marsh. The whole system has a water flow through it, depicted in Fig.5. Again, as here is a classic case of 'rich' dominating 'poor', we expect to find the limes convergens situation. Fig.6. shows the profile confirming this expectation.

The first 3 m are rather 'noisy' due to the transect passing through a variant of Juncus inflexus marsh characterised particularly by the presence of Samolus valerandi, followed by a sharp 'peak' (4 m mark), the profile then falling to low level oscillations in the Scirpus marsh.

This vegetation proves even more interesting when the distribution of species along the transect is considered. One of those which Good used to define his 'acid bog' was Eriophorum angustifolum, certainly more typical of nutrient poor conditions than the communities present. At Culver Well, this species is found only at the boundary between the scirpus marsh and the Juncus inflexus marsh.

(d) This profile, and the following one, were taken from Studland Heath, V.C.9., G.R. 40/024845. This profile runs from dry heath to Valley Bog (Sensu Tansley 1939). The dry heath occurs on a gently (5^o) sloping plateau, which steepens to a 25^o slope before reaching the valley bog. Physiognomically, this section of the profile is distinguished by the occurence of occasional dominance of Scirpus caespitosus. A sketch of the transect site is shown in Fig.7., and Fig.8., shows the profile.



Culvers Well – Fig III/5

* = Scirpus.

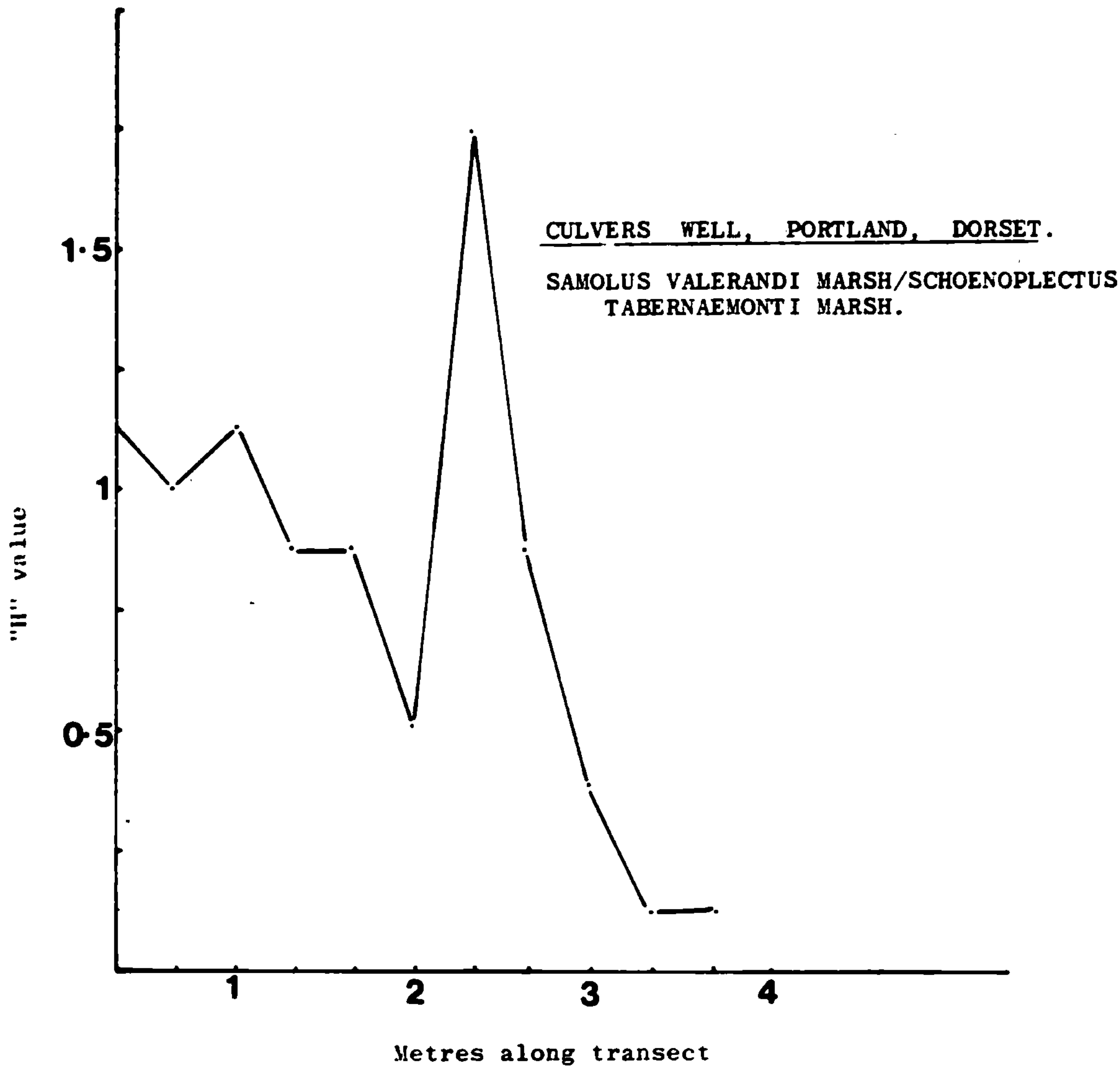
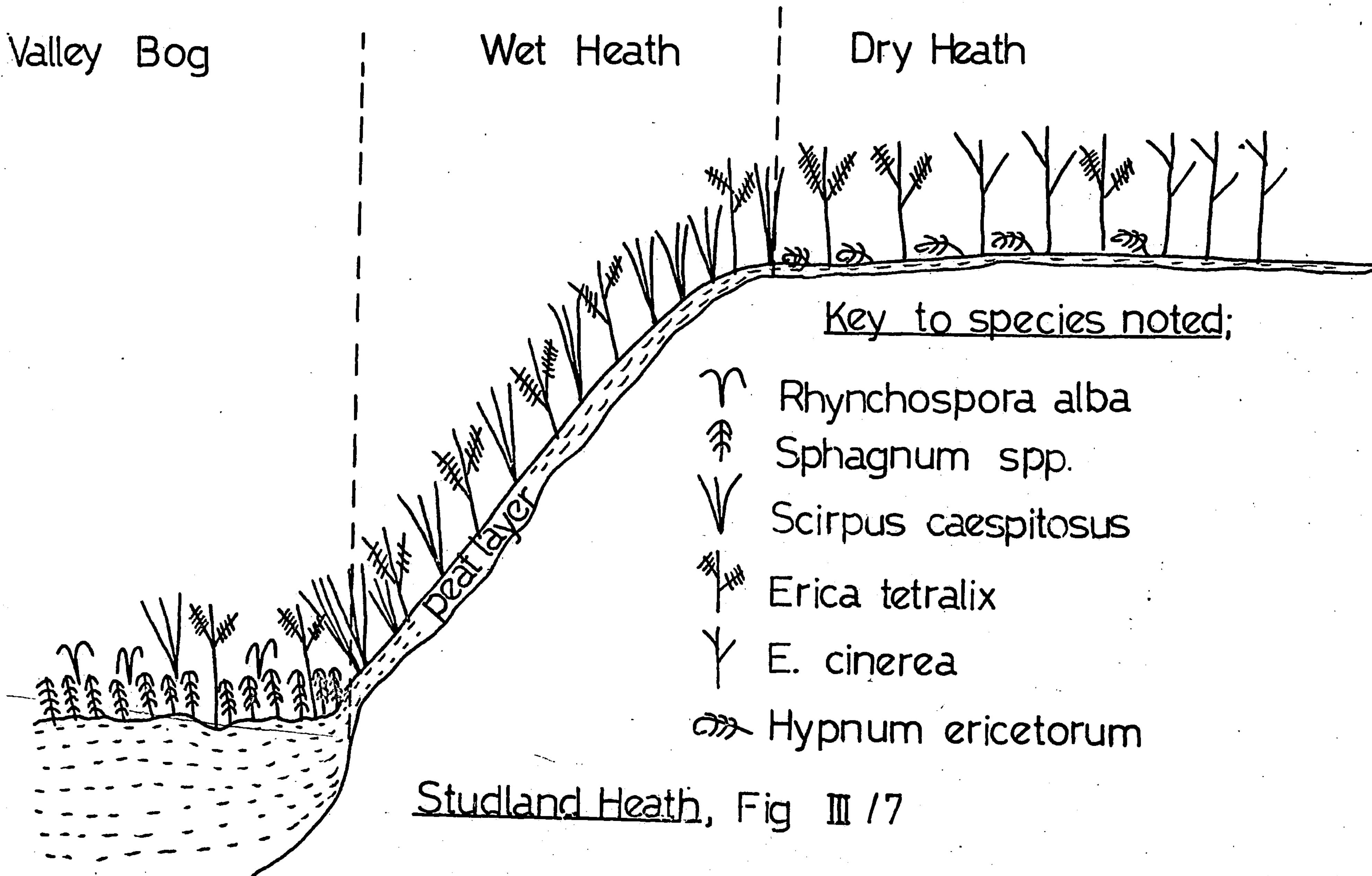

CULVERS WELL, PORTLAND, DORSET.
SAMOLUS VALERANDI MARSH/SCHOENOPLECTUS TABERNAEMONTI MARSH.
1·5
1
0·5
"H" value
1
2
3
4
Metres along transect

Fig. III/6



Studland Heath, Fig III/7

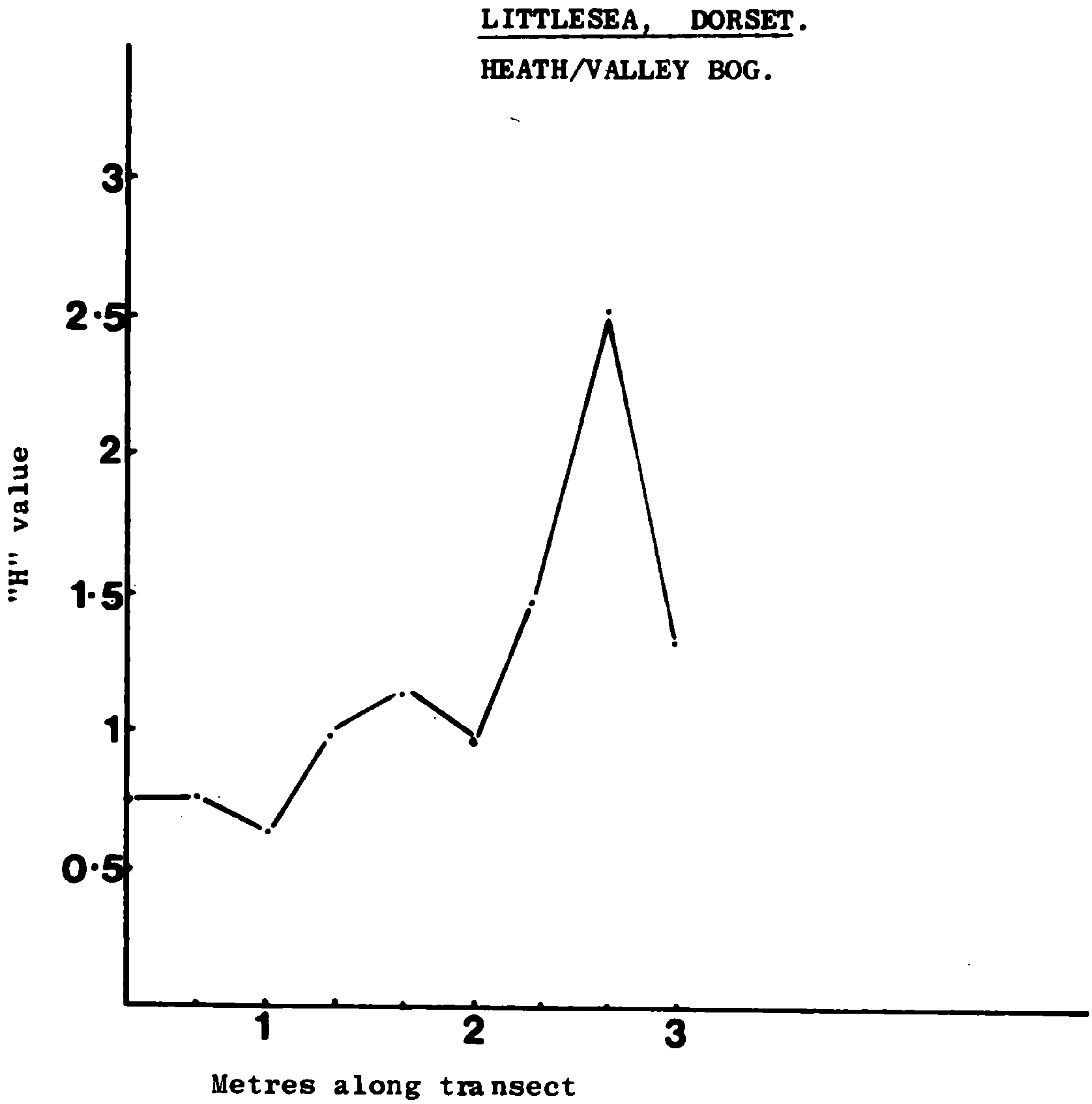

LITTLESEA, DORSET.
HEATH/VALLEY BOG.
"H" value
3
2·5
2
1·5
1
0·5
1
2
3
Metres along transect

Fig. III/8

Up to 2m the profile is steady, it then rises between the 2 and 4 m levels, peaking at 4.5 m, and then rapidly falling to low-level oscillations. The latter part of the profile (4.5 - 6 m) is indicative of a limes convergens situation (much water present/ little water present is the important factor), whereas the outer portion of the transect has indications of a limes divergens situation (due to a constantly fluctuating water level).

Scirpus caespitosus is the species mainly responsible for this condition, and it is interesting to note that, commonly, at the junction of waterlogged podsolic soils and dry podsolic soils in the South of Britain, S. caespitosus is frequently observed, concentrated as a thin band between adjacent communities. About 50 m from the transect line, Cattle trampling has broken down this Scaespitosus slope, and here there is no limes divergens, but a limes convergens situation (i.e. regular soil disturbance). S. caespitosus occurs only sparodically here, but a new species, typical of restricted distribution, - Gentiana pneumonanthe - is rather common. This species, on the edge of its range, seems characteristic of limes convergens situations. Simmonds (1945) notes "Persisted on St. Leonards Common Dorset, for at least 3 years after ploughing for forestry purposes ----Rather commonly seen in Dorset on ground which appears to have been disturbed e.g. shallow, rectangular, depressions of unknown origin."

(e) This profile (Fig.9.) results from a transect between damp heathland and Saltmarsh. An initial peaking effect is noticeable at the 1.5 m level, due to the presence of several bryoids in an otherwise species poor vegetation. The main peak, indicating the limes convergens nature of this profile is between 3.5 and 5.5 m mark. Instead of a sharp,

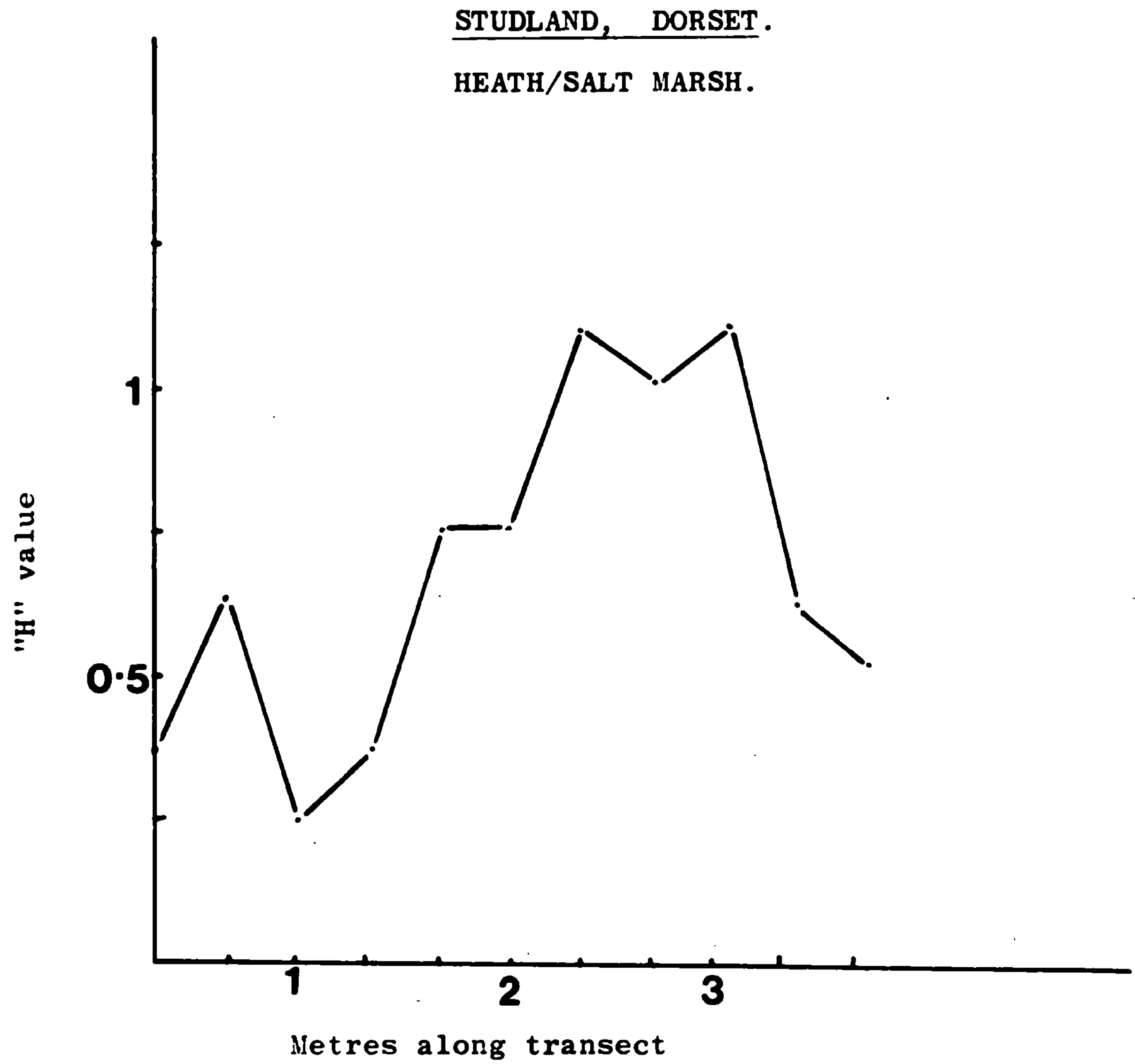

STUDLAND, DORSET.
HEATH/SALT MARSH.
"H" value
1
0·5
1
2
3
Metres along transect

Fig. III/9

clean peak, however, the profile has an 'inverted peak' at the 4.5 m level. This results from a footpath running parallel to the saltmarsh at this point. It is, in fact, anentirely separate zone, coincidentally peaking within the area of the limes convergens. Although not particularly restricted to any one community, it is interesting to note the concentration of Shoenus nigricans is the greatest at the limes convergens site.

(f) This profile (Fig.10) is one of the most interesting of all the examples, it being most typical of a limes divergens type of boundary, though including a limes convergens situation at one extreme of the boundary. Physiognomically, the vegetation showed no clear boundaries as did some of the other sites chosen, but the two end states (dry heath and valley bog) are obviously different.

The transect, sited at Winfrith Heath, vac.9. GR.30/802862, was land from dry heath (Ulex minor community of Calluna vulgaris Heath) through Wet Heath (Sphagnum compactum community, Erica tetralix heath) to what can best be described as Rheophilous mire (sensu Bellamy 1966). An extremely sharp peak is detectable 3m from the start of the transect, representing the transition between the reophilous mire, characterised by Campylium stellatum, Scorpidium scorpiodes, Cirscum disectum and the wet heath characterised by Erica tetralix, Sphagnum compactum, S. tenellum and Narthecium ossifragum.

This is a typical limes convergens situation clearly showing the effect of a rich environmental milieu dominating over poorer conditions.

After this peak, the profile then shows a general fluctuation, with a sub-convergens peak at the 12-14 m. mark. Although scarcely sufficient to indicate a limes convergens situation, it corresponds

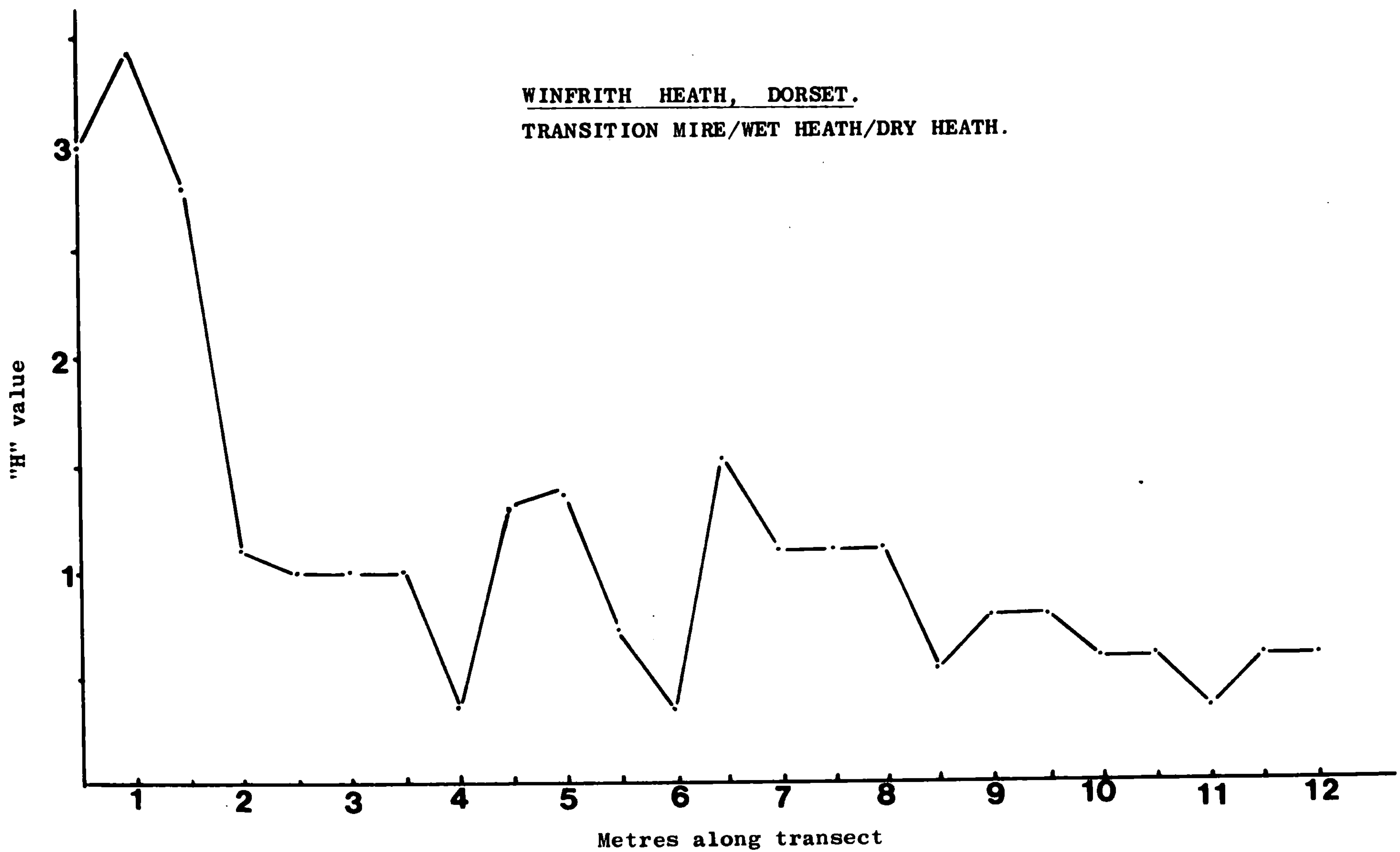

WINFRITH HEATH, DORSET.
TRANSITION MIRE/WET HEATH/DRY HEATH.
"H" value
1
2
3
1
2
3
4
5
6
7
8
9
10
11
12
Metres along transect

Fig. III/10

to an area of much steeper slope than is common in the rest of the area, and therefore is subject to more drastic fluctuations in the water table. Taking the profile from 3 m to the end, however, it is an excellent demonstration of a limes divergens situation.

(g) Profile (Fig.11) from Waldridge Fell, v.c. 66, GR. 45/252495, between a neutral bog and dry sandy heath. The profile shows the typical limes convergens form, but the width of the peak base is rather large (3 - 3.5 m).

The floristic analysis taken for this profile shows that there is a distinct community occupying the boundary zone, characterised by species such as Juncus effusus, Galium saxatile, Anthoxanthum odoratum and Aulaucomnuim palustre, which are not found in either the bog or the heath. Fig.12 shows a sketch on essentially similar situation, though unanalysed for a boundary, from Priddy Pool, v.c.6., G.R. 31/547516.

(h) These last two profiles are both taken from Slapstone Syke, Teesdale, v.c.66., G.R. 35/872303. Some account of the nature of the boundaries in Teesdale has been given (Bellamy et. al., 1969, Bridgewater and Marshall, 1969) This first profile (Fig.13), taken from Calcareous sedge marsh to species rich Calluna Vulgaris heath, (Festuca ovina variant/ Calluna vulgaris community/Vaccinium myrtillis Heath) exhibits a largely limes divergens structure from 6-16 m, although a pronounced 'peak' occurs between the 3 - 5 m marks, i.e. limes convergens. The profile is further discussed below.

(i) Again taken from Slapstone Syke, this profile (Fig.14) was also derived from a transect between sedge marsh and heath. Although not as variable a profile as (h), there are many similarities. The extreme peak detected in (h) does, however, appear to be absent. There is a slight increase in peaking at the 4 - 5 m mark, but this is not pronounced

WALDRIDGE FELL, CO. DURHAM.

HEATH/ERIOPHORUM ANGUSTIFOLIUM BOG.

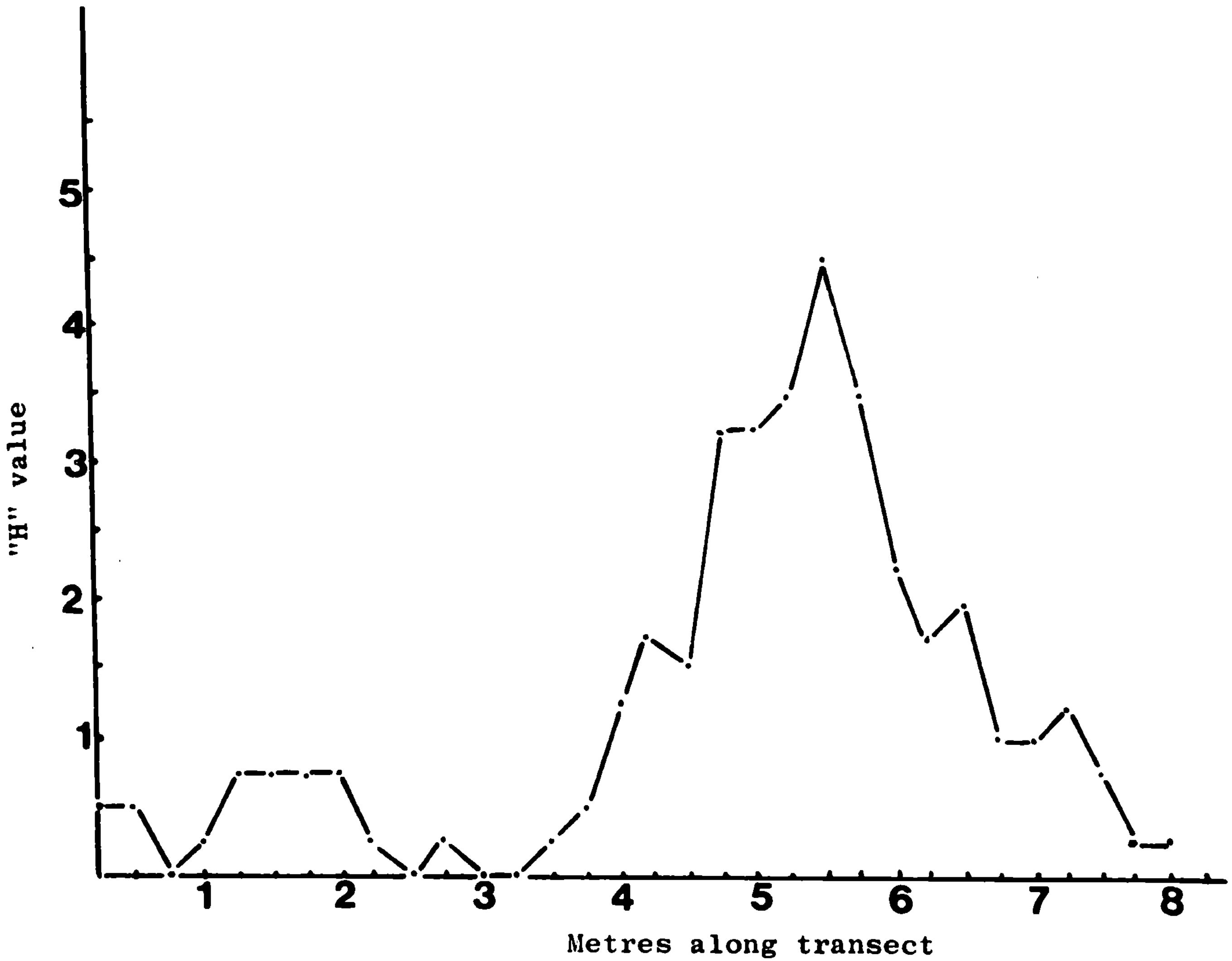


Fig. III/11

Sketch of communities at Priddy Pool, Somerset

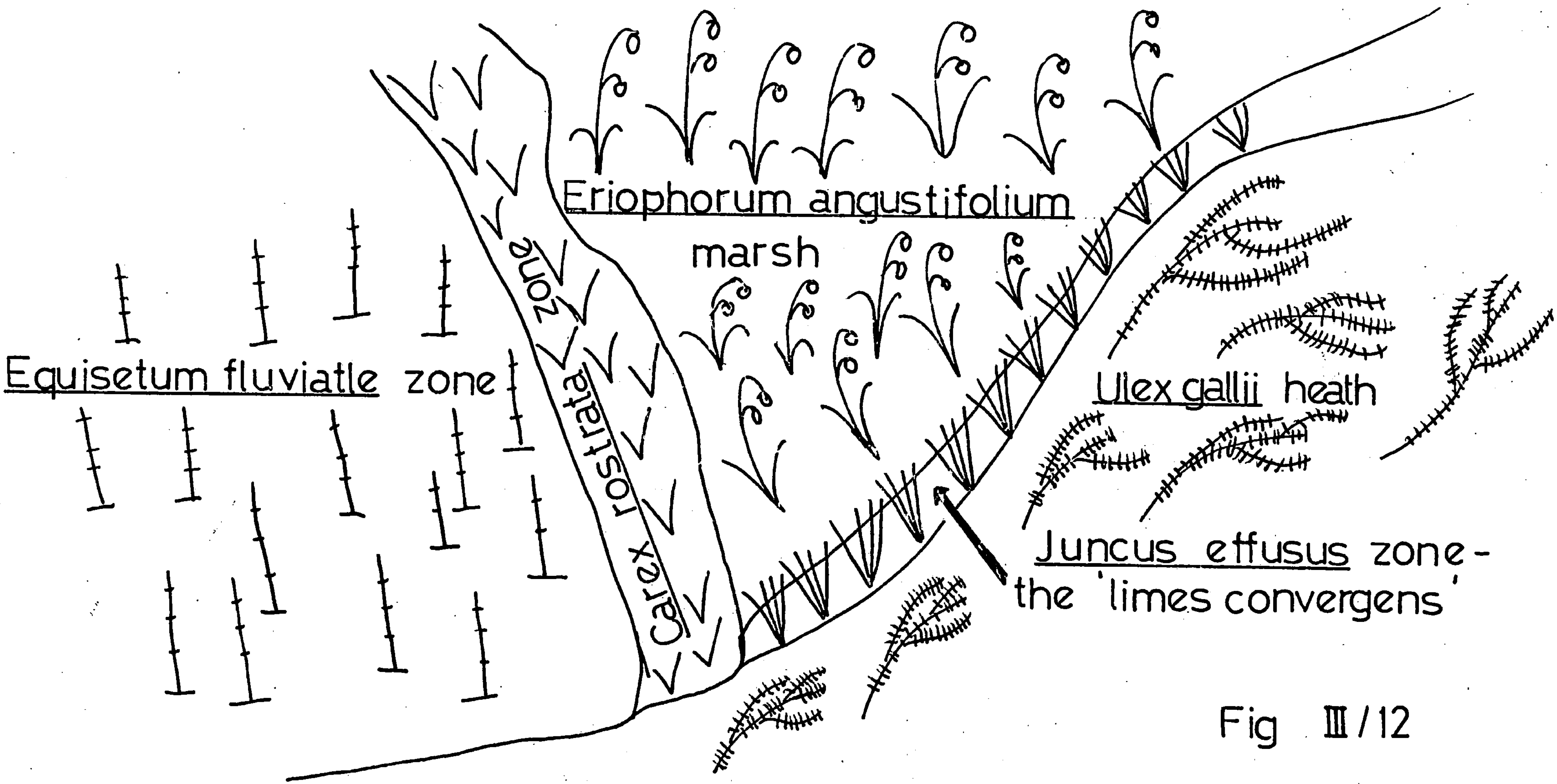


Fig III/12

Fig. III/13

Differential profile from sedge marsh to *Calluna* heath, Slapestone syke, Co. Durham.

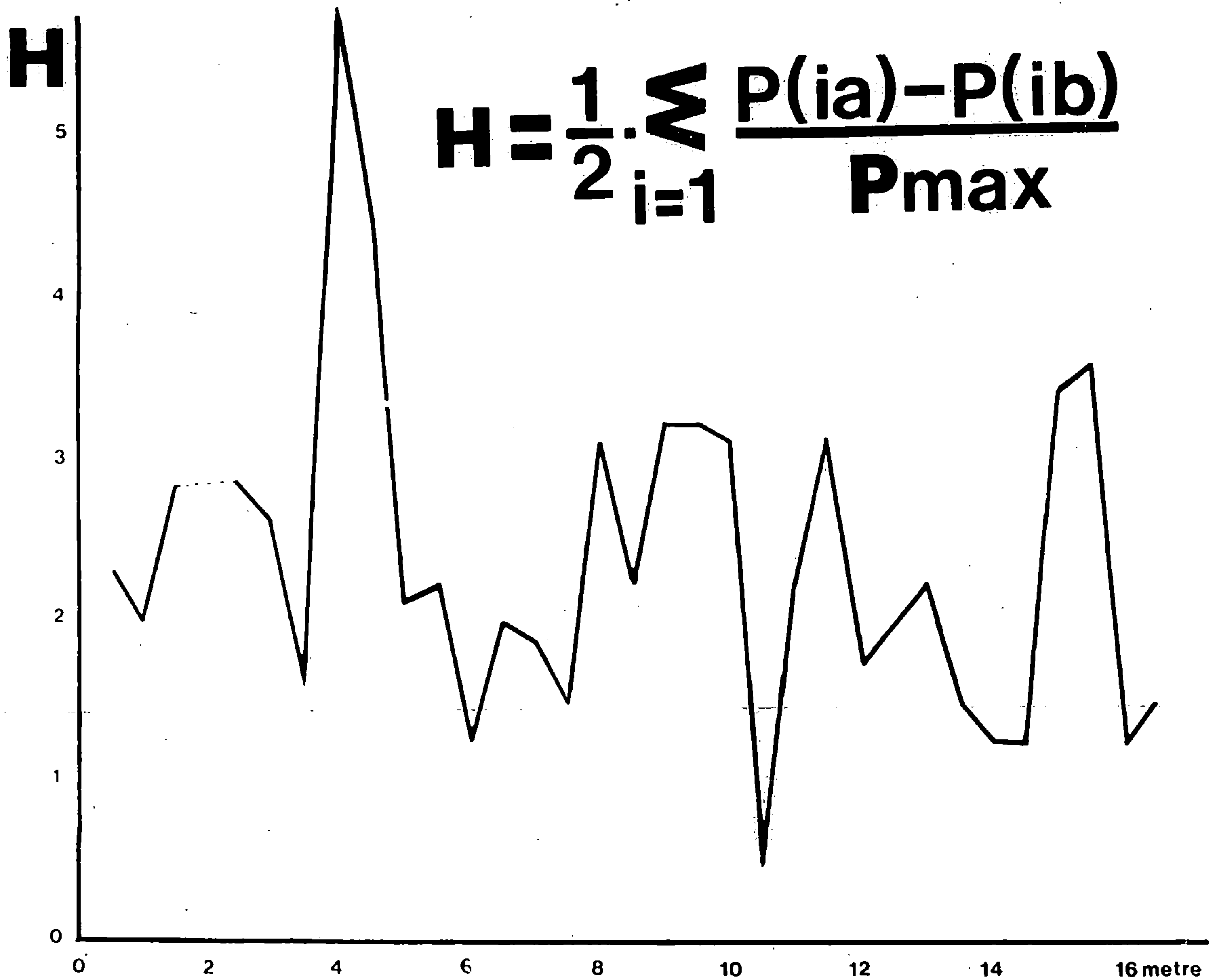

H
$H = \frac{1}{2} \cdot \sum_{i=1} \frac{P(ia) - P(ib)}{P_{max}}$
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16 metre

Fig. III/14

Differential profile from sedge marsh to *Calluna* heath, Slapestone syke, Co. Durham.

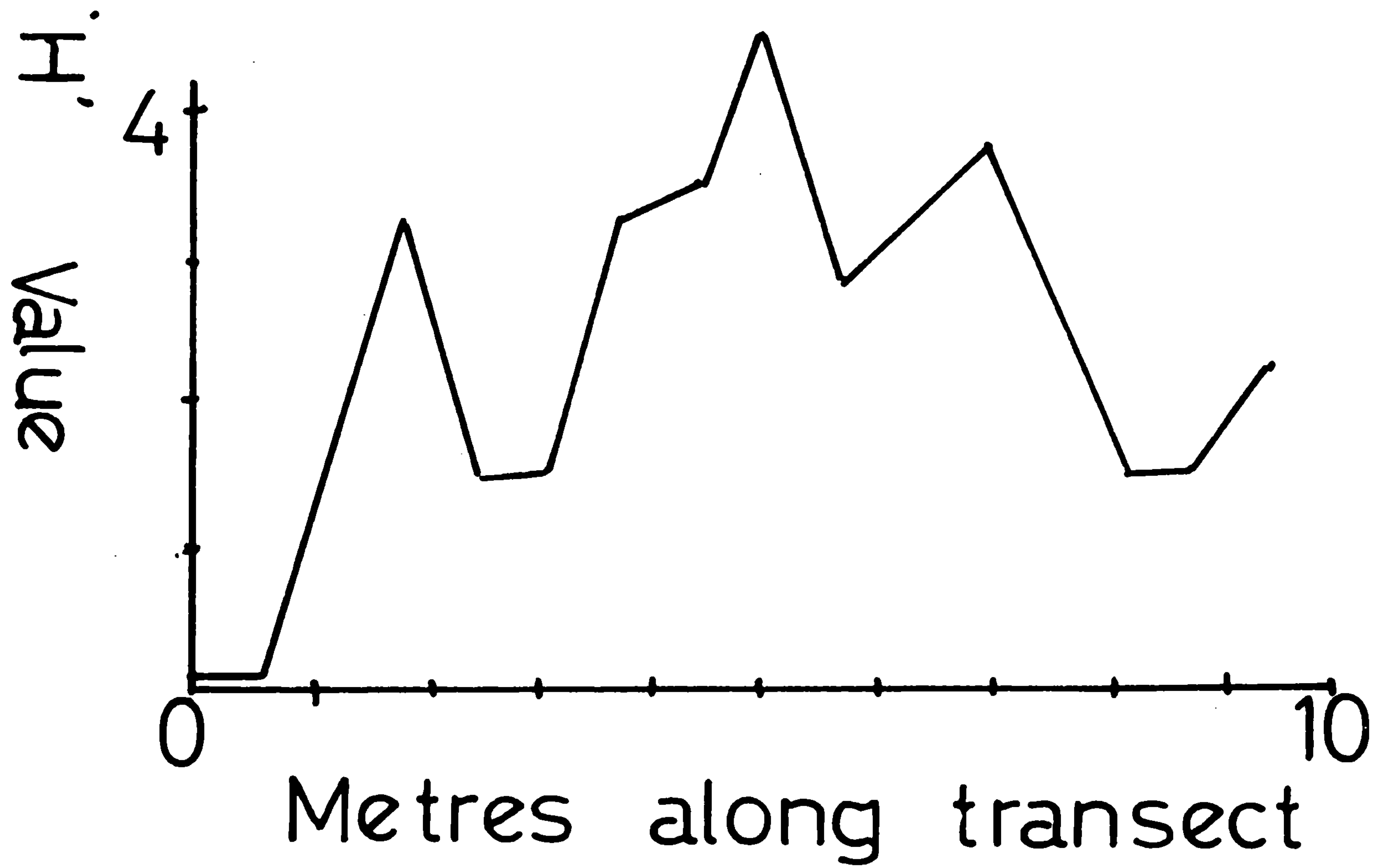


fig III/14

enough to indicate a typical limes convergens situation. Thus the conclusion that can be drawn from this evidence is that the situation is of the limes divergens type, although this is also discussed in more detail below.

These ten examples of profiles show the usefullness of this technique in determining (a) boundary size and (b) boundary type. Inevitably, however, more information about the vegetation on either side of, and across, a boundary will be required than a profile can give, particularly if the boundary zone is going to be 'managed' in any sense. Certain of the classificatory methods (Section II), applied across boundary zones, can do much to elucidate more of their structure and function.

III.4.2. The application of the "Groupanalysis" technique to a boundary situation.

The data from the transect described for (h) was subjected to Group analysis (Crawford and Wishart, 1968). Eight synecological groups were produced by this method (Table 1). Fig.15 shows the relationship of these groups and their possible synsystematical position, to the transect.

The sedge marsh was composed of a mixture from groups D, G and G, all typified by species such as Carex panicea, C.lepidocarpa, Juncus articulatus and several "Brown mosses" (sensu McVean and Ratcliffe, 1962). These groups occur to the left of the 'peak' in the differential profile. Immediately to the right of this peak is a group of five contiguous quadrats (E), distinguished from D, H and G by the relative absence of bryoids and presence of species such as Thymus drucei, Festuca ovina, Potentilla erecta. The other groups which follow (B, C, F) all exhibit relatively stable, slight changes in species composition. This analysis complements the observations made earlier that the latter portion of the profile is limes divergens (gradal

TABLE III/1

Showing the % occurence of species in the 8 groups produced by Group Analysis.

Species	Groups	H	G	D	E	A	B	C	F
Pellia epiphylla		33	100						
Agrostis canina		67	50						
Sagina nodosa		33	50						
Philonotis fontana		100	100	50					
Kobresia simplicuiscula		67	50	100					
Drepanocladus fluitans		100	100	100					
Bryum pseudotriquetrum		100	100	100	20				
Riccardis pinguis		67	100	100	20				
Pinguicula vulgaris		33	100	50	20				
Eriophorum angustifolium		100	100	100	100	100			
Equisetum variegatum		100	50	50	100		67		
Juncus articulatus		100	100	100	100	67	67		
Carex lepidocarpa		100	100	100	100	100	67		
Carex panicea		100	100	100	100	100	100		
Selaginella selaginoides		33		50	80	100	100		
Breutelia chrysocana					20	100	67		
Rhacomitrium lanuginosum					80	100			
Tofieldia pusilla					20	100	100		
Carex capillaris					100	67	100		
Ctenidium molluscum					100	100	67		
Peltigera aphosia				50	80	100	100		
Cornicularia aculeata					40	33	33	15	
Prunella vulgaris			100		100	100	100	7	
Thymus drucei				100	100	100	100	76	
Potentilla erecta				100	100	100	100	100	
Minuartia verna						33	100	7	
Viola lutea						33	100	69	
Rhytidiadelphus triquetrus							100	15	
Cerastium holosteoides							33	7	
Festuca ovina					80	100	100	100	100
Hyalocomium splendens						100	100	100	100
Cladonia arbuscula							67	92	100
Agrostis tenuis							100	100	50
Gallium saxatile							67	100	100
Rhytidiadelphus loreus								54	100
Pleurozium schreberi								100	50
Campanula rotundifolia								69	100
Anthoxanthum odoratum								69	100
Calluna vulgaris								46	100
Hypnum cupressiforme								38	100
Polytrichum juniperinum								24	50
Carex ericetorum								15	100
Thuidium tamariscinum								7	50
Plantago maritima			50		20				
Fissidens adiantoides			50		20				
Cardamine pratensis				50					
Lophocolea bidentata				100					
Polygola vulgaris					40				
Riccardia multifida					20				
Cephalozia bicuspidata					20				
Nardus stricta					20				
Rhytidiadelphus squarrosus								54	
Luzula compestris								24	
Dicranum scoparium								62	
Bazzania trilobata								24	
Certraria islandica						33		15	
Viola riviniana								7	
Armeria maritima		33					33		
Ditrichum flexicaule									

(Figures quoted refer to percentage occurrence of species in groups).

Fig. III/15

Shewing the relationship of the results from the Group Analysis of the Slapestone syke transect (Fig. III/13) to the boundary situations present.

SLAPESTONE SYKE, WIDDYBANK FELL.

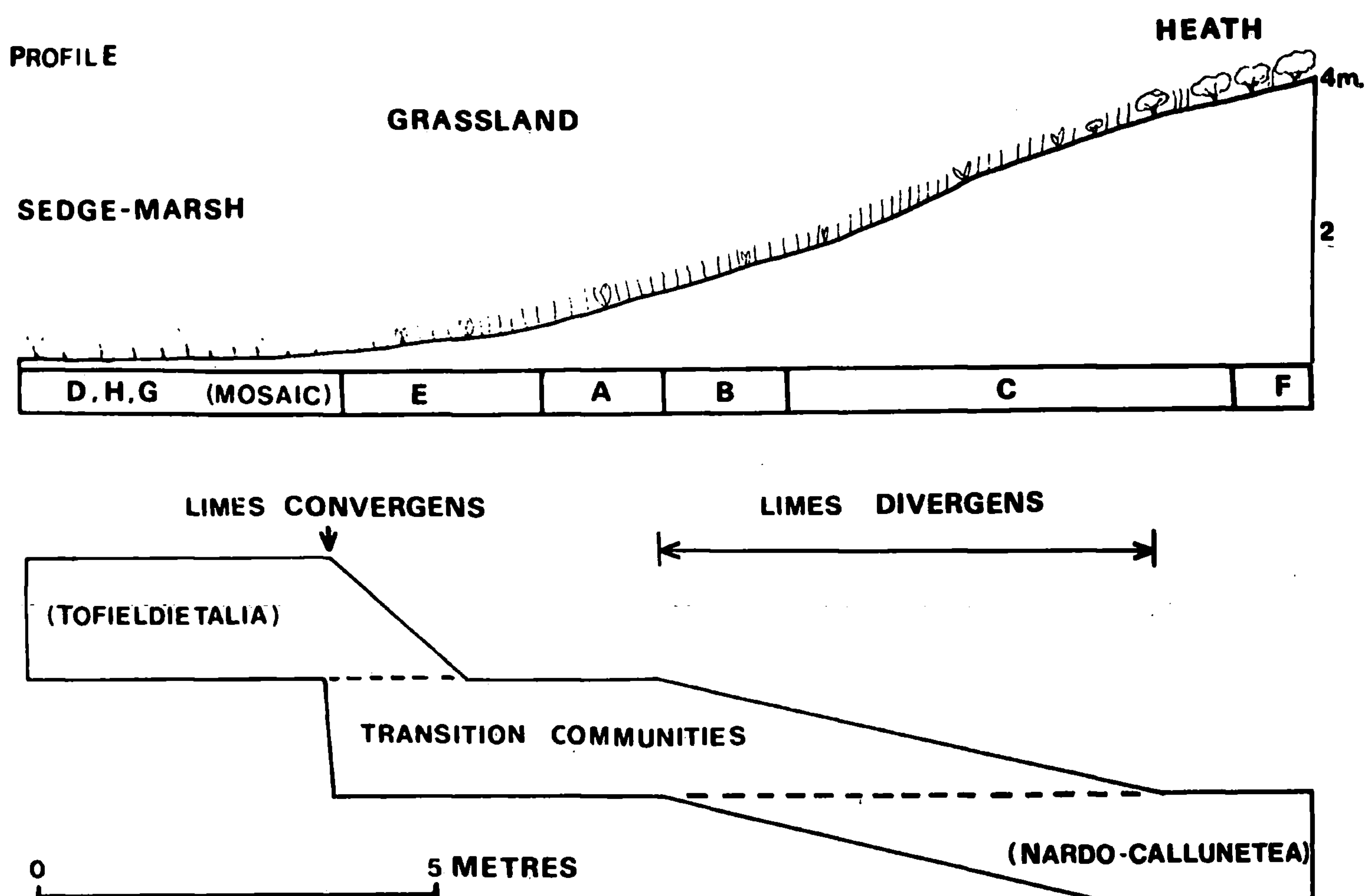


Fig. III/16

Nodal analysis of the vegetation along a transect in Slapestone syke, Co. Durham. (See text under III.4.1.h)

group	ref. no.	SPECIES \ QUADRATS group	4 (12, 8, 10, 11, 14)	5 (1, 2, 3, 5, 6, 13)	2 (7, 9, 4)	3 (15, 16)	1 (18, 19)	8 (23, 24, 20, 27, 22, 17)	6 (31, 32, 25)	7 (26, 27, 28, 29, 3, 33)
A	4 1 2 3	KOBRESIA SIMPLICIUSCULA CAREX PANICEA C. LEPIDOCARPA JUNCUS ARTICULATUS	4/12	4/1	4/7	4/15	–/18			
E	13 14	PRUNELLA VULGARIS CAMPYLIUM STELLATUM	13/12			13/15	14/–			
B	5 6	CTENIDIUM MOLLUSCUM POTENTILLA ERECTA	5/12	5/1	5/7	5/15	5/18	6/23		
G	10	MINUARTIA VERNA				(10)/15				
H	17 18 19 20 21	CLADONIA IMPEXA RHACOMITRIUM LANUGINOSUM EQUISETUM VARIAGATUM PLANTAGO MARITIMA RICCARDIA PINGUIS				–/15 –/16	–/18			
D	31 32 26 9	PLEUROZIUM SCHREBERI CALLUNA VULGARIS RHYTIDIADELPHUS SQUARROSUS CAMPANULA ROTUNDIFOLIA			(9)/7				–/31	31/28
F	25 27 4	PSEUDOSCLEROPODIUM PURUM THUIDIUM TAMARISCINUM POLYTRICHUM JUNIPERINUM						25/(24)	(14)/37	
C	29 23 15 22 12 24	GALIUM SAXATILE RHYTIDIADELPHUS LOREUS THYMUS DRUCEI FESTUCA OVINA SESLERIA CAERULEA HYLOCOMIUM SPLENDENS					–/18	24/23	24/31	24/28

vegetation units), whereas there is an obviously sharp demarcation (limes convergens) between the D,H,G mosaic and group E. This method can, therefore, add much more structural detail to that given by the profile.

(b) The application of Nodal analysis.

In dissussing Nodal analysis in section II, mention was made of the usefullness of the technique in providing vegetation units that are of differing 'strengths'. To test the possible application of this analysis to boundary situations, transect (i), from Upper Teesdale has been used. The profile from this transect is rather unclear in form, illustrating some limes convergens and some limes divergens attributes.

The real value of Nodal analysis lies with its' property of 'doubly - defined' species /habitat coincidences, that are of strong ecological validity (Lambert and Williams, 1962). Fig. 16 shows the abstracted vegetation units arranged with sedge marsh at top left, and heath at the bottom right.

From the noda (sensu Lambert and Williams, loc. cit.) produced, there are clearly two main vegetation types present.

Type 1. (defined by the presence of noda 4/12, 4/1, 4/7) has the following species as constants - Juncus articulatus, Kobresia simpliciuscula, Carex panicea and C. lepidocarpa. (Note here the similarity with the mosaic of species groups D,H,G of the Group analysis)

Type 2. (defined by noda 24/23, 24/31, and 24/28) has the following species as constants - Hylocomium splendens, Sesleria caerulea, Festuca ovina, Thymus drucei and (except in nodum 24/31) Galium saxatile, Rhytidiadelphus loreus.

Within each of these 'types' there are a number of sub-divisions, indicating a reason for the rather 'noisy' profile. Type 2 is of interest in this respect, as the subjective description in Bellamy et al (1969) refers to "....the upper part supports species with open heath and grassland communities dominated by Sesleria caerulea (referable to the Seslerietalia)..." On examining Fig.16., the 'species rich open heath' is shown to consist of the 'grassland' nodum (24/28), on which is superimposed a major sub-nodum of high rank (37/28), containing as constants Pleurozium schreberi and Calluna vulgaris. Also, quadrats 37 and 32 are defined by nodum 24/37 with a minor sub-nodum (x/31) (with Calluna vulgaris, Rhytidiadelphus squarrosus) and a major sub-nodum of low rank present (30/37 - with Polytrichum juniperinum). This situation suggests a possible interpretation of 'limestone' and 'chalk' heath, i.e. that they could, sociologically be a grassland matrix with superimposed 'heath' species groups.

Between Type 1 and Type 2, communities, there is a zone of five quadrats which differ from the rest by their essentially 'fragmented' appearance due to the presence of many ill-defined units (minor sub-noda, major sub-noda of low rank, etc.) This zone corresponds exactly to the possible limes convergens peak seen in the profile.

It is to be expected that areas of instability and change will be represented by this type of fragmentation of vegetation units, and so the type of pattern described above would suggest the presence of a limes convergens situation. Thus, this analysis clarifies the suggestions that profile offers.

The 'noisy' profile obtained by 'H' analysis has been mentioned but can be more clearly explained with reference to the nodal analysis. The 'peak' around the 1.5 - 2.5 m point corresponds to the emergence of a wet sub-type of the Type 1, defined by noda 5/4, 5/7 and 5/12, accompanying the 'type' noda. Similarly, the 'peak' around the 5.5m point is explained by the emergence of the Heath sub-units.

In the 'transition zone' now firmly quantified by the Nodal analysis, several species absent from the main two types are found, i.e. Rhacomitrium lanuginosum, Equisetum variagetum, Plantago maritima, Ricardia pinguis. As Bellamy et. al (1969) state, two of these are members of the species assemblage known as the "Teesdale rareities", and their occurrence in this zone is rather interesting (see below).

III.4.3. The co-incidence of "rare" species and boundary zones.

Evidence that 'rare' species are often associated with boundary zones is fairly well substantiated - as in the Teesdale profile above, the occurrence of Gentiana pneumonanthe in profile (d) and van Leeuwan (1966) cites many species of restricted distribution as typical of this limes divergens. Further investigation is likely to yield more species whose typical habitat is a boundary zone. A rigid definition of which environmental factors are responsible for this is virtually impossible, but may not be necessary. Just the "life-conditions" in the zones could be all that is necessary to restrict species to such zones - this may also explain the curious bimodality of certain species (e.g. Plantago maritima, Armeria maritima) which are found at sea-level and high alpine sites - both areas typified by vegetation of the limes convergens type, with, certainly, instable habitats.

It would be a mistake, however, to consider that merely species of restricted distribution are common to boundary zones. As profiles (b), (c) and (g) show, perfectly 'common' species also, in these situations, seem restricted to boundary zones. These species, however, in each case, are not commonly associated with either 'end-state' community, and in this sense could be considered 'rare'. Thus perhaps a general principle could be suggested, i.e. Boundary zones of both limes convergens and limes divergens sites may provide tangible habitats for species whose requirements throughout its typical range of communities are not catered for by either the juxtaposed 'end state' communities.

6.4.4. Environmental measurements.

All data to date obtained, points to the existence of various boundaries (from the typical limes divergens to typical limes convergens), and their importance in all types of land management. Measurement of environmental variables to evaluate some of these sociological conclusions is obviously essential. To this end, a small series of pilot environmental measurements were carried out on the Slapstone Syke, transect (h).

The factors used were (a) soil organic content, total calcium, sodium and potassium. Soil organic content was determined by weighing samples before and after dry ashing at 440°C in a muffle furnace and the determinations were made either by Atomic absorbtion spectrophotometry or flame photometry after wet ashing samples. The results are depicted in Fig.s 17 and 18.

The results show that the peaks observed in the profile corresponds exactly to the dramatic fall off in amounts of sodium and calcium ions, and a corresponding rise in the % content of organic material (i.e. from 10% - 50% at the 4 m. point). The % Organic matter then declines as the 10 m. is approached. This decline appears 'Stepped';

Fig. III/17.

% organic material & mg/g K^+ in the soil along a transect in Slpestone syke, Co. Durham. (See text under III.4.1.g)

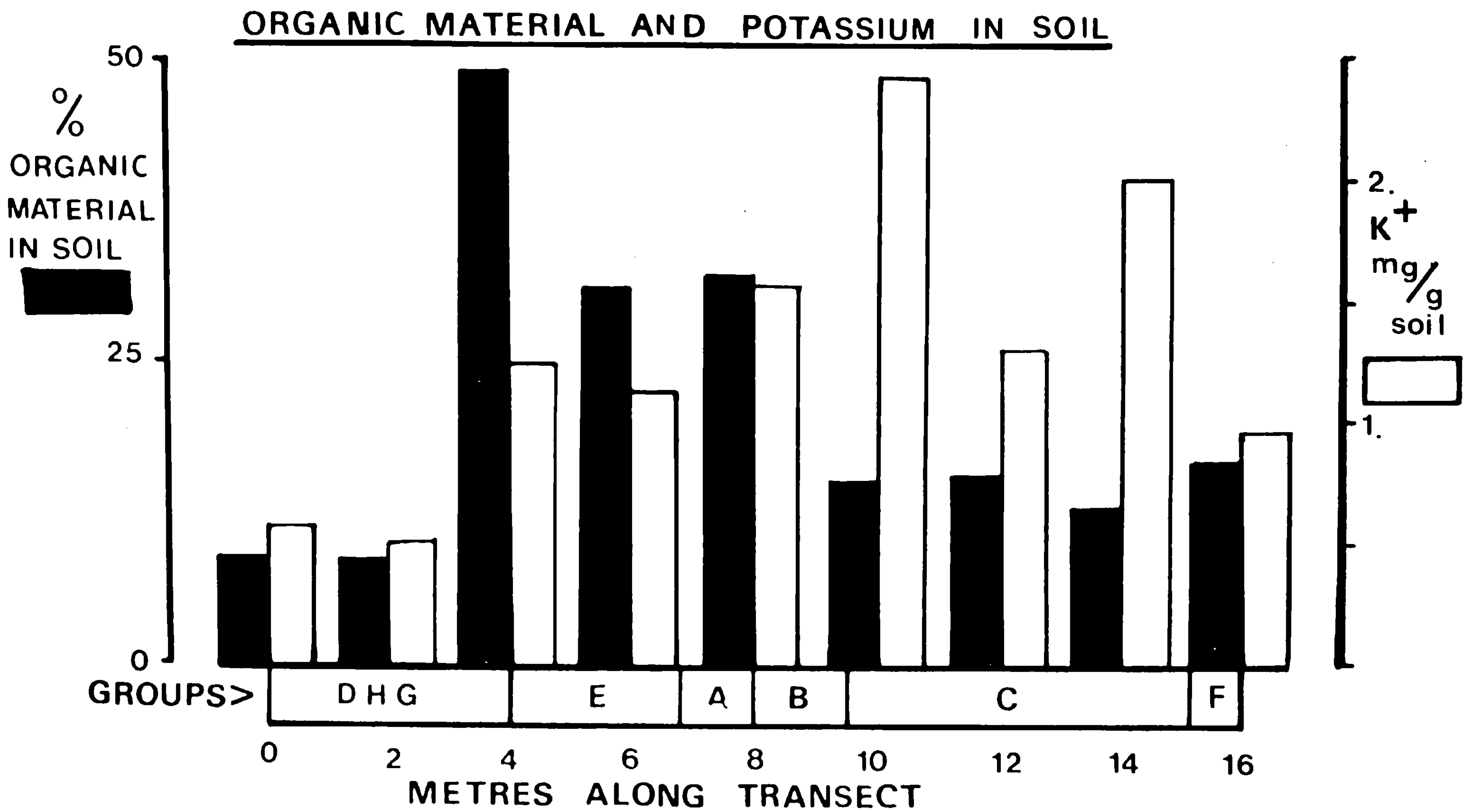
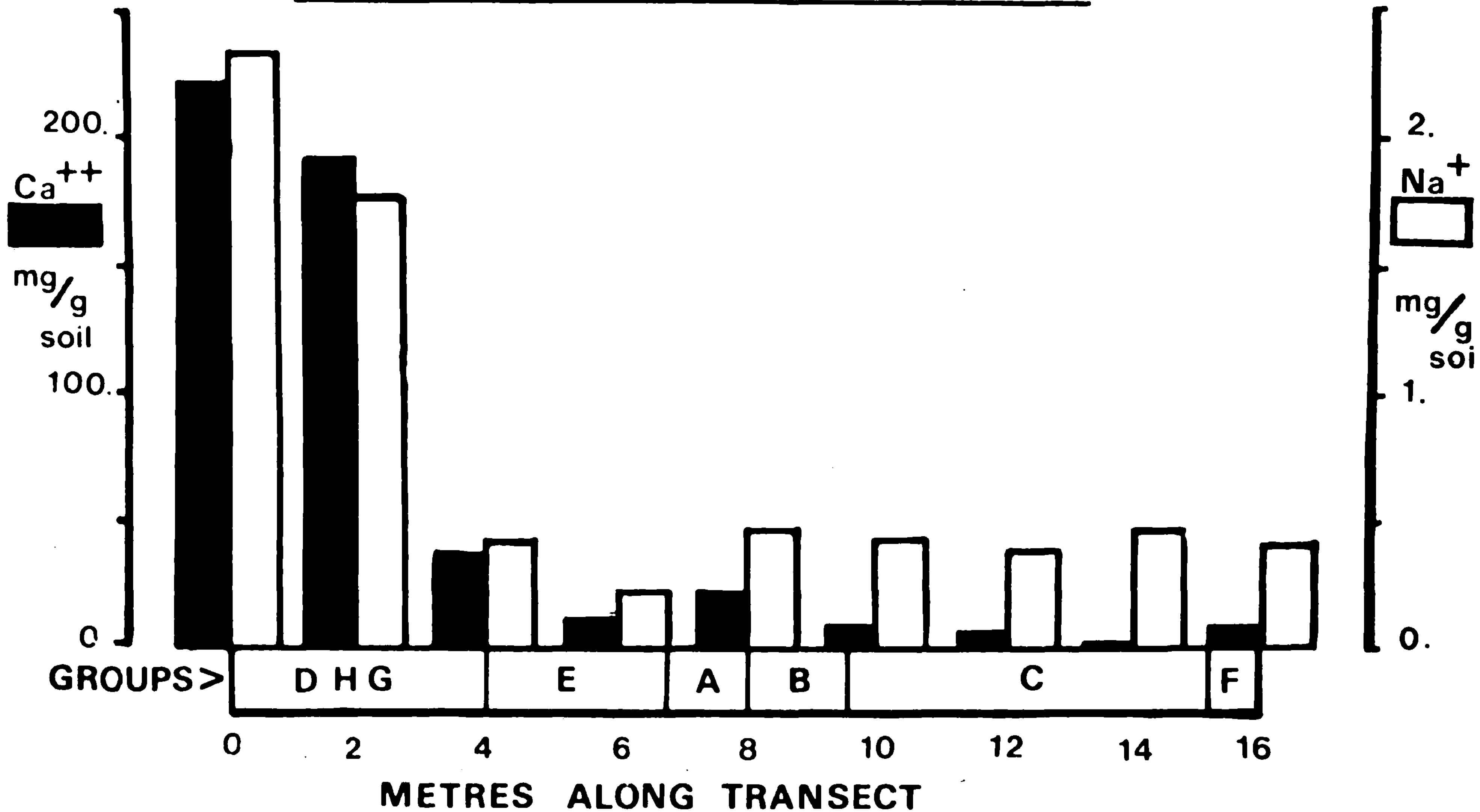

ORGANIC MATERIAL AND POTASSIUM IN SOIL
50
25
0
%
ORGANIC
MATERIAL
IN SOIL
2.
1.
K+
mg/g
soil
GROUPS>
DHG
E
A
B
C
F
0
2
4
6
8
10
12
14
16
METRES ALONG TRANSECT

Fig. III/18

Total Ca^+ and Na^+ present in the soil along a transect in Slapestone syke, Co. Durham. (See text under III.4.1.g)

TOTAL CALCIUM AND SODIUM IN SOIL



the 'steps' following rather closely the occurence of the groups detected in the group analysis. Correspondingly, the amount of Potassium in the soil increases stepwise along the transect, also following the positions of the floristic groups.

The analysis of these simple parameters , therefore, reinforces the thesis that vegetation boundaries are not 'chance' phenomena, but correspond rather closely to specific, detectable changes in the environmental milieu.

IV.

PHYTOGEOGRAPHY OF THE BRITISH HEATH FORMATION.

IV.1. Introduction.

Phytogeographical studies of the British Flora have been rather scant. Watson (1847-59) provided the initial basis for British Plant Geography, by his method of recording the distribution of plant species within the 112 'vice-counties' he created. These in turn were amalgamated into 18 'provinces'.

To create these vice-counties, Watson used the existing administrative county boundaries, and then either split or occasionally fused these counties to give more or less equal areas. The use of this system for data collection and collation of plant (and also animal) distributions continued until the early 1960's. Since 1962, the publication by the Botanical Society of the British Isles of the 'Atlas of the British Flora' (Perring and Walters) has introduced the idea of the preparation of dot-distribution maps on a 10 km^2 basis. Thus the vice-county system is now rather disused for the purpose of recording distribution.

For this present work, it was found necessary to 'regionalise' Britain into convenient areas for studying the phytogeographic affinities of component species comprising the Heath vegetation within these discrete areas. It is hoped these regions will prove useful for other problems of plant distribution. There are several courses open for the 'regionalisation' of Britain, i.e. using the standard census regions; Watson's original eighteen provinces, etc. In this section a division of Britain into fourteen regions, based on several criteria, has been attempted, and these regions used to analyse the phytogeographical elements with the Heath formation.

IV.2. Definition of Regions.

Map 1 illustrates these 14 regions. As the Orkneys and Shetlands (Region 14) have not been considered in the Heath survey, only the other 13 regions are discussed in detail.

The primary determination of these regions was use of the 112 vice-counties described by Watson. In many cases the boundaries of these do not correspond exactly to those of the present day administrative counties, but relate to the status quo in 1847. This means that many of the old, long standing boundaries, usually corresponding to some easily identifiable natural feature, are used in the delimitation of these units. Hence the grouping of these units into regions could be said to be reasonably 'natural'.

Although the vice-counties were used as a base, three major additional factors have been taken into account in the grouping of these units into regions; climate, topography and geological sub-stratum. The sources for these have been Walter and Leith (1967) for the climatic data, maps and memoirs of the Geological survey for the Geological data, and ordnance survey maps at a scale of 1 : 63360 for the topographic data. A list of the component vice-counties of the region, with comments on on the structure of the region, is given below.

IV.2.1. The Regions

(1) The South-West Peninsula, vice-counties 1 - 6 and 34 (east of the River Severn). An extremely 'Atlantic' area of land, particularly maritime. Essentially under the influence of two climatic zones (Walter, 1967) - V (VI) 2 and VI (VI) 2. Geologically the region consists chiefly of acidic Hercynion rocks, with a gently undulating topography.

(2) The 'New Forest' Region vice-counties 7 - 11 and 12 (South of a line from Whitchurch (Hants) to Petersfield) Climatically the region is chiefly V (IV), the only region to have this unusual warm temperate/

mediterranean climate type. Geologically the Southern half is formed from Eocene sand and gravel, whilst the chalk of Salisbury Plain occurs in the northern half.

(3) The South-East Region vice-counties 12 (not in (2)), 13-22, 23 (south of the River Way), 24 and 30. A fairly low lying area of land. Geologically consisting of younger rocks. Climatically the region is in zones VI and VI (IV).

(4) East Anglia vice-counties, 25-29, 31, 53 (parts of Holland only), 54 and 61.

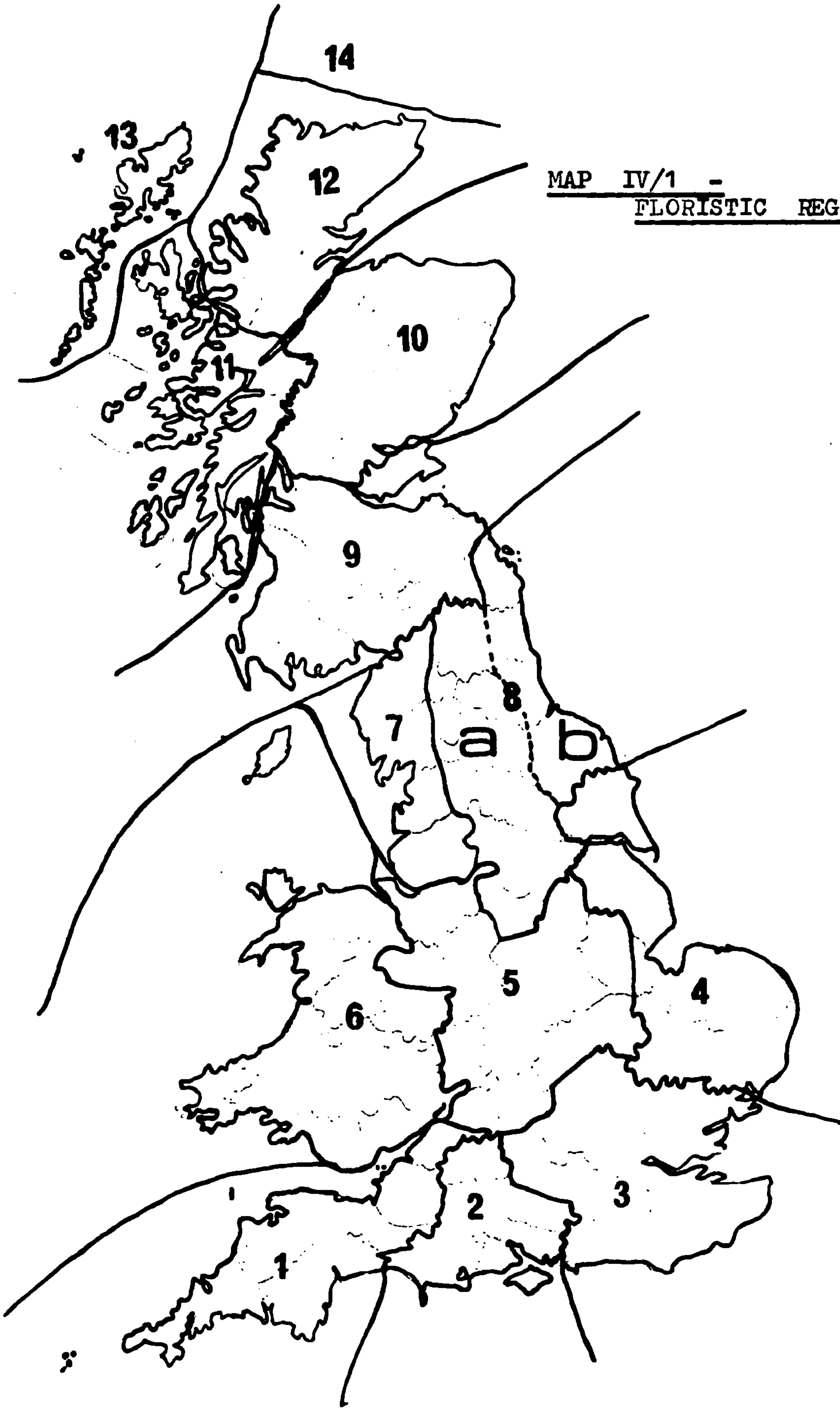
Besides the area usually referred to "East Anglia" (Norfolk, Suffolk and Essex) this region contains East Lincolnshire and Yorkshire. The reasons for this are (i) the same geological substrata are found throughout this region (Jurassic and Cretaceous rocks), (ii) The whole region is included in one climatic zone (VI). This represents the most 'continental' region of Britain.

(5) The Midlands vice-counties 23 (not in (3)), 32, 33, 37-39, 40 (north of the River Severn), 53 (not in (4)), 55, 56, 57 (south of a line joining Ashbourne and Chesterfield) and 58.

The region is rather a 'compromise' situation, in that it includes several vice-counties that are in Central England, which have no particular character that would determine their position in another region. Geologically and topographically the region is very varied, climatically it falls either into the VI or V(VI) zones.

(6) Wales. Vice-counties 34 (not in (1)), 35, 36, 37 (West of the River Severn), 40 (not in (5)), 51, 52, and 71. In addition to the administrative principality of Wales, this region encompasses the English portions of the Forest of Dean, the Malvern Hills, the upland areas of Shropshire (Long Mynd, Stiperstones, etc) and Herefordshire.

MAP IV/1 - FLORISTIC REGIONS.



These areas are referred to as the Welsh Marches, and are essentially part of Welsh region, by virtue of the contiguous geological formations (Herefordshire) or climatically (the upland Shropshire areas are linked with the rest of Upland Wales in zone VI (X), although the Cambrian mountains are in zone X).

The Isle of Man (vice-county 71) is also included within this region because geologically it is identical to North Wales, topographically it is typically Welsh, and climatically it is related to Western Wales (Lleyn Peninsula, Cardiganshire, N. Pembrokshire), both being part of zone VI (V). Its inclusion in 'Wales' is thus justifiable, but the Island remains rather a phytogeographical enigma, because compressed into its length is a great deal of vegetational variation, as much, in fact, as can be seen in the West Coast of England and Wales.

(7) North West England. Vice-counties 59, 60, 69 (West of the Eden) 70 (excluding the East of the County, defined by the Eden to the West and King Water to the North) and 64 (West of the Ribble, Northwards to Settle, then West of line joining Settle to Ingleton). A rather narrow region, comprising the Lake district and Westmorland heights, and within climatic zones VI_3 and X.

(8) North East England. Vice-counties 57 (not in (5)), 62, 63, 64 (not in (7)), 65-67, 68 (East of a line from Rothbury to Parburn, continued northwards to the Till). Capable of sub-division to (a) Pennine (climatic zone VI_3 and X) and (b) Palatine (climatic zone VI_2), as noted on Map. 1. This sub-division has not been applied in subsequent analyses, but it might be important in other contexts.

(9) Southern Uplands. Vice-counties 68 (not in (8)), 72-86. This region comprises the border country Galloway and the Midland valley of

of Scotland. Although climatically rather varied, two climatic zones account for the area; VI and VI(VIII). This whole region forms a convenient "Southern Scottish" unit for study.

(10) East Highlands. Vice-counties 87-95, 96 (East of the Great Glen). Combining the Grampian Mountains and the lower valleys of the Spey and Don, this region shows the most easternly tendencies of the Scottish regions.

(11) West Highlands and Islands. Vice-counties 97-104. This region includes the Inner Hebrides and Isle of Bute. These are included in climatic zone VI_4, but the majority of the region is classifiable into zones X and VI (VIII). Geologically, the region is fairly uniform - as it forms, with the next region, part of the Tertiary Volcanic area.

(12) Northern Highlands. Vice-counties 96 (not in (10)), 105-109. A much varied topography - from a low-lying plain in the North-East to the mountains of the North-West. Thus, climatically, there are two zones present, X and VI(VIII), corresponding to the mountains and low-lying areas. The region is, nevertheless, a 'unit' in the processing of phytogeographical data.

(13) Outer Hebrides and (14) Orkneys and Shetlands.

These form two very distinct regions, on the basis of their insularity, which gives them a particular 'Oceanic' climate and situation.

IV.3. Phytogeographical Elements.

Several classifications of Plant species into Geographical 'elements' have been proposed in the past. The earliest was Forbes (1846) who produced five such divisions; (i) Iberian (species whose continental area is in Spain), (ii) Armorican (species whose continental area is in W. France), (iii) Kentish (species whose continental area is in Northern

France), (iv) Scandinavian (montane flora of Scotland, Cumbria and Wales), and (v) Germanic (The General Flora of Britain, corresponding to Western Europe).

Watson (1847) prepared a similar scheme, but based it solely on the British distribution of the species, rather than the Continental. His categories (mostly self explanatory) are (i) British, (ii) English, (iii)Scottish, (iv) Highland, (v) Germanic (Watson used this term to refer to species found in the East and South East of the Country), (vi) Atlantic and (vii) Local.

Both schemes suffer from several defects, which can be summarily described as lack of precision. Salisbury (1932) was the first author to describe rather more 'detailed' elements, based on the whole range of the species. Unfortunately, his work was based in East Anglia, and therefore incomplete.

Matthews (1937, 1955) has produced the most satisfactory description and classification of "elements" to date, again based on the whole range of the plant species. His fifteen elements enable rather accurate estimates of the Geographical affinities of any flora to be made. In the tables which follow, his elements have been used throughout, according to the definitions in his publications (loc.cit).

In practice, the Mediterranean, Alpine and Endemic elements are not represented in the Heath vegetation used in this survey, so only twelve elements are considered.

As Matthews' work refered to Angiosperms, the following references were consulted for the distribution of the various groups of plants, and they were then assigned to the relevant 'elements':

Lichens	Leighton (1879), Alborn (1948)
Bryophytes	Arnell (1956), Nyholm (1954-65) Ratcliffe (1968), Podpěra (1954)
Pteridophytes	Flora Europoea, Vol. I.

IV.4. Data Presentation.

A total of 384 plant species were found in the Heathland Survey, including species from tables in McVean and Ratcliffe (1962), and these have been grouped, under the respective "elements" into one of four tables. Table 1 features species characteristic of the South-Western Heath, i.e. (Regions 1,2,6), Table II those of the North-West Heath, i.e. (Regions 10-13), Table III those of generally Western distributions and Table IV those widely distributed, or with scattered occurences showing no preference for the first three categories.

A Biological spectrum (Table V) has been prepared from these tables, showing the percentage of each element occuring in the different regions, and a Table (VI), showing the percentage distribution of each element in four main tables has also been prepared.

IV. 5 Species Distribution.

IV.5.1. Species with a preference for South-Western Heaths.

The Oceanic Southern element is concentrated in this group, the species forming the element being found chiefly within the *Thymus drucei* complex- *Erica cinerea* Heath. It is significant also that the Oceanic Western element is represented at its highest value (22%) in this group of species. If the coastal fringe (i.e. Sea Cliff Heath) of the vice-counties 1,2,4 is taken separately from the rest of Region 1, the following picture emerges:

	Oceanic West	Oceanic Southern.
Coastal Fringe:	20	4
Region 1, not including Coastal Fringe	13	1

Thus, the maritime communities contribute very much to overall 'oceanic' image of Region 1. From these species, preferring the South West, the proportion of the Eurasian element is relatively high (39%), compared to the 'wide' element which is only 20%. This represents a distinct reversal in behaviour of these two species elements in the other three species groups. As the wide element has a large number of 'boreal' species within it, and as the South of England and Wales, although Oceanic in climate, is phytogeographically closer to Southern and Central Europe than Scotland, the reason for this reversal is not hard to seek.

A further apparent anomaly exists in that the proportion of Continental species, although low represents an increase over the other three groups. These species, i.e. Cirsium acaule, Rosa pimpinellifolia, are associated with the limestone rich heaths (North Somerset, Derbyshire) or the Coastal fringe heaths, and so are behaving atypically. Thus though their status may be 'continental' where they occur, they are acting as 'oceanic' species. In connection with this, a feature of some plants at the edge of their range to become more tolerant of acidic environments, if their continental optimum is a basic environment, or vice-versa, has been noted from time to time in the literature (e.g. Simmons, 1945) and a plant which does just this is Gentiana pneumonanthe, (Continental Northern), which has already been mentioned in Section III.

I. SPECIES CHARACTERISTIC OF SOUTH-WEST HEATHS.

SPECIES:	REGION NUMBER: 1	2	3	4	5	6	7	8	9	10	11	12	13
(a) Oceanic Southern Element.													
Anagallis tenella	+	+											
Daucus gummifer	+					+							
Rubia peregrina	+												
Trifolium bocconei	+												
T. striatum	+												
(b) Oceanic Western Element.													
Agrostis Setacea	+	+	+										
Ammophila arenaria		+				+							
Calypogeia arguta	+						+						
Campylopus brevipilus		+	+										
Cirsium dissectum		+	+										
Cerastium atrovirens	+												
Centaurea nigra	+												
Digitalis purpurea	+					+							
Endymion non-scriptus						+							
Erica ciliaris	+	+											
E. vagans	+												
E. watsonii	+	+											
Euphrasia vigursii	+												
Hernaria ciliata	+												
Odontoschisma denudatum		+											
Ononis repens	+					+							
Pilosella peleteranum						+							
Sarothamnus maritimus	+												
Scilla verna	+					+							
Sedum anglicum	+					+							
Scutellaria minor		+											
Ulex gallii	+	+		+		+							
Viola lactea	+	+											
Juncus tenuis	+												
(c) Oceanic Northern Element.													
Myrica gale	+	+	+										
Silene Maritima	+												
(d) Continental Southern Element.													
Plantago coronopus						+							

SPECIES:	REGION NUMBER:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(e) Continental Element.													
Cirsium acaule	+				+								
Rosa pimpinell-ifoloa	+					+							
Lonicera pericly-menum	+		+										
(f) Continental Northern Element.													
Drosera intermedia		+											
Gentiana pneumonanthe		+											
(j) 'European' Element.													
Cladonia macilenta		+		+	+	+							
Genista pilosa	+					+							
Hydrocotyle vulgaris	+					+							
Hypericum tetra-pterum		+											
Jasione montana	+	+				+							
Scorpidium scor-piodes	+	+											
(k) Eurasian Element.													
Agrostis canina	+	+						+					
Aira caryophyllea	+					+							
Betonica officin-alis	+					+							
Brachypodium sylvaticum	+												
B. Pinnatum	+				+								
Briza media	+												
Bromus erecta	+				+								
Carex caryophyllea	+												
Leucanthemum vulgare	+					+							
Cirsium arvense	+			+									
Cirsium palustre	+	+			+								
Cuscuta epithymum	+	+		+									
Carlina vulgaris	+												
Centaurium ery-thraea	+												
Dactylis glomerara	+					+							
Filipendula vulgaris	+												
Geranium sanguineum	+					+							
Potentilla reptans		+											
Galium verum	+				+	+							
G. palustre		+											
Helictotrichon pratense	+												
Helianthemum nummularium	+				+	+							
Hedera helix	+												

SPECIES:	REGION NUMBERS:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Leontodon taraxacoides	+				+	+							
Minuartia gerardii	+												
Pimpinella saxifraga	+												
Potentium sanguisorba	+				+								
Primula veris	+												
Prunus spinosa	+												
Pulicana dysenterca	+												
Rhynchospara alba		+											
Rubus discolores	+		+			+							
R. glandulosi	+												
R. suberedti		+											
Scabiosa columbari	+					+							
Sanguisorba officialis	+												
Serratula tinctoria	+	+							+				
Viola hirta	+					+							
Frageria vesca	+												
Pastinaca sativa	+												

(1) Wide Element.

	1	2	3	4	5	6	7	8	9	10	11	12	13
Calypogeia fissa	+					+							
C. Mulleriana	+	+	+			+							
Campylopus atrovirens		+	+		+								
C. introflexus	+					+							
Cladonia rangiformis	+												
Campylium stellatum	+	+											
Dicranum spurium		+											
Drepanocladus intermedius	+												
Hieracium sabauda	+	+											
Lythrum salicaria		+											
Lecidia quadricolor						+							
Lophozia bicrenata						+							
Lepidozia pinnata						+							
Phragnites australis	+			+									
Schoenus nigricans	+	+											
Polytrichum gracile						+							
Sphagnum compactum	+	+	+										
S. contortum	+	+											
S. cuspidatum		+											
S. palustre	+	+				+							
S. papillosium	+	+						+					

IV.5.2. Species with a preference for the North-West Heath.

This group of species is unusual in that the percentage of Oceanic West element it contains is rather low - 9%) but this is made up by an increase in the Oceanic Northern element (11%). In addition, the group is characterised by the presence of the Continental Northern, Northern Montane, Arctic-Subarctic and Arctic-Alpine elements present to a fairly important extent. This is due as much to the Mountainous nature of Regions 9 - 13, in which this group is chiefly represented, as to the areas Northerly influence. It also is another indication of the validity of the Vaccinium myrtillus Heath vegetation unit.

The chief contribution to the Oceanic Northern element comes from Hepatics, i.e. Herberta hutchinsae, Jamesoniella carringtonii, Mastigophora woodsii and lichens, i.e. Alectoria nigricans, Ochrolechia frigida, etc. These species could well be considered "Oceanic amphi-Atlantic" as many of them are important constituents of analagous vegetation types in Coastal North America. A very small proportion of species (4%) come from the Eurasian element, but nearly half (46%) come from the wide elements, and many of these are certainly 'Amphi-Atlantics', or truly Boreal species.

Species of particular interest in this group are three eriaceous shrubs of restricted distribution in Britain (all of the Artic-Alpine element), i.e. Loisleuria procumbens, Phyllodoce caerulea and Vaccinium uliginosum.

IV.5.3 Species of a general Western distribution.

Most species exhibit a Northern/Southern preference in addition to a western preference, so the number of species in this group is rather small (forty). A few of these species are characteristic

II. SPECIES CHARACTERISTIC OF NORTH-WEST HEATHS.

SPECIES:	REGION NUMBER: 1	2	3	4	5	6	7	8	9	10	11	12	13
(b) Oceanic West Element.													
Anastrepta orcadensis										+	+	+	
Breuteilia chrysocoma	+									+	+	+	+
Bazzania tricrenata										+	+	+	
B.pearsonii										+	+	+	
Euphrasia micrantha											+		+
Lepidozoa pearsonii										+	+	+	
Nowellia curvifolia												+	
Plagiochila spinulosa										+	+	+	
Sphaerophorous globosus										+		+	
(c) Oceanic Northern Element.													
Alectoria nigricans										+	+	+	
Anastrophyllum donnianum										+	+	+	
Herberta hutchinsiae										+	+	+	
Jamsoniella carringtonii										+	+	+	
Hymenophyllum wilsonii											+	+	
Mastigophora woodsii										+	+	+	
Orchrolechia frigida										+	+	+	
Parnassia palustris											+		
Pleurozia purpurea										+	+	+	+
Platysma lacunosum										+	+	+	
Scapania nimbosa										+	+	+	
S. ornith opoides										+	+	+	
(d) Continental Southern Element.													
Luzula sylvatica										+	+	+	+
(e) Continental Element.													
Larix decidua(seedlings)										+	+	+	
(f) Continental Northern Element.													
Angelica sylvestris											+		
Galium boreale											+		
Pinguicula vulgaris													+
Pyrola media										+			
Ramischia secunda										+			
Cirsium heterophyllum											+		
(g) Northern Montane Element.													
Antennaria dioica					+					+	+	+	
Listera cordata							+	+		+	+	+	
Stereocaulon evolutoides										+	+	+	
Trientalis europaeus										+	+	+	
Trollius europaeus											+		
(h) Arctic-Subarctic Element.													
Chamaepericlymenum suecicum										+	+	+	
Empetrum hermaphroditum										+	+	+	
Rubus chamaemorus										+	+	+	

SPECIES:	REGION NUMBER:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(i) Arctic-Alpine Element.													
Ardostaphylos uva-ursi										+	+	+	
Alchemilla alpina										+	+	+	
Arctous alpina										+	+	+	
Cetraria islandica								+		+		+	
Dryas octapetala											+	+	
Empetrum nigrum					+	+	+	+	+	+	+	+	
Eriphorum vaginatum					+			+		+	+	+	
Juncus trifidus										+	+	+	
Loisleuria procumbens										+	+	+	
Thalictrum alpinum											+		
Vaccinium uliginosum										+	+	+	
V. vitis-idaea					+	+		+		+	+	+	
(j) European Element.													
Cladonia bellidiflora										+			
Cladonia glauca										+	+	+	
(k) Eurasian Element.													
Anemone nemorosa										+	+		
Filipendula ulmeria											+		
Gentianella campestris											+		
Parmelia omphalodes											+		
(l) Wide Element.													
Acrocladium cuspidatum											+		
Alectoria ochroleuca										+	+	+	
Carex bigelowii										+	+	+	
Cetaria nivalis										+		+	
Cladonia subcervicornis											+	+	
Coriscium viride										+	+	+	
Ctenidium mollascum											+		
Dicranum majus			+					+		+	+	+	
D. fuscescens										+	+	+	
Drepanocladus uncinatus											+		
Euphrasia frigida											+		
Cladonia rangiferina										+	+	+	
Fissidens osmundoides											+		
Geum rivale											+		
Hylocomium splendens						+	+	+	+	+	+	+	+
H. umbratum												+	
Junipenis communis								+		+	+	+	
Lophozia floerkii						+	+	+	+	+	+	+	
L. quinquedentata										+			
L. ventricosa	+							+		+	+	+	
Luzula pilosa						+				+	+	+	
Lycopodium selago										+	+	+	
L. clavatum									+	+	+	+	
L. alpinum										+	+	+	
Lepidozia setacea										+	+	+	
Lepidozia trichoclados										+	+	+	
Nardia scalaris										+	+	+	
Peltigera canina								+	+	+	+	+	

SPECIES: (1) Wide Element (cont'd)	REGION NUMBER: 1	2	3	4	5	6	7	8	9	10	11	12	13
P. polydactyla										+	+	+	
Polytrichum alpestre										+	+	+	
P. formosum						+				+	+	+	
P. strictum										+	+	+	+
Prunella vulgaris	+										+		+
Plagiochila asplenioides								+				+	
Ptilium crista-castrensis										+	+	+	
Parmelia saxatilis										+	+	+	
Platysma glaucum										+	+	+	
Rhytidiadelphus loreus	+				+			+	+	+	+	+	
Riccardia pinguis	+									+	+	+	
Rhinanthus minor											+		+
Selanginella selanginoides										+	+		
Rhytidiadelphus triquetrus						+				+	+	+	
Sphagnum plumulosum										+	+	+	
S. rusowii										+	+	+	
Scapania gracilis						+				+	+	+	+
Sphenolobus minuatus												+	
Thuidium tamaniscinum								+		+	+	+	
Thamnolia vermicularis										+		+	
Salix herbacea										+	+	+	

of the coastal heath (e.g. Plantago maritima, Armeria Maritima), whilst others that occur in the Coastal Heaths also occur elsewhere as indicators of nutrient rich Heaths (e.g. Thymus drucei, Viola riviniana, Lathyrus montana). The total contribution of the three Oceanic elements in this group os 20%, compared to 20% for the species group preferring the North-West Heaths and 29% for the South-West Heaths. Phytogeographically, therefore, the more oceanic regions are those of 1, 2 and 6 and the more Northerly regions, although oceanic, have additional Boreal influences affecting the full expression of oceanity.

III. SPECIES CHARACTERISTIC OF WESTERN HEATHS.

SPECIES:	REGION NUMBER: 1	2	3	4	5	6	7	8	9	10	11	12	13
(b) Oceanic West Element.													
Armeria maritima	+					+				+		+	
Carex demissa	+	+											+
Plantago maritima	+	+				+					+		+
Salix atrocinerea		+							+				
Thymus drucei	+					+			+	+	+	+	+
Hypericum pulchrum	+	+				+				+	+	+	+
(c) Oceanic Northern Element.													
Dactylorhiza ericetorum	+								+		+	+	+
Narthecium ossifragum	+	+	+							+		+	+
(f) Continental Northern.													
Carex pulicaris	+										+		+
(j) European Element.													
Cryptogramma crispa							+						
Lathyrus montana	+								+	+	+		
Viola riviniana	+					+	+		+	+	+		
(k) Eurasian element.													
Agrostis montana	+					+		+		+	+	+	
Anthyllis vulneraria	+					+					+		
Carex flacca	+				+	+					+	+	
C. hostiana	+											+	
Linum catharticum	+	+				+					+		
Lysimachia nemoreum		+									+		
Melampynum pratense	+					+				+	+	+	
Pedicularis sylvatica	+	+		+					+				+
Plantago lanceolata	+					+					+		
Primula vulgaris						+					+		
Succisa pratensis	+	+	+						+	+	+	+	
Vicia sepium						+					+		
(l) Wide Element.													
Aulaucomnium palustre					+	+				+	+	+	
Blechnum spicant	+						+	+	+	+	+	+	+
Carex echinata	+									+			
Cladonia degenerens	+	+	+							+		+	
Diplophyllum albicans	+					+	+		+	+	+	+	+
Euphrasia brevipila	+					+						+	
Frullanica tamarisci	+					+				+	+	+	+
Koeleria cristata	+			+		+					+		
Leontodon autumnalis	+										+		
Lepidozia reptans		+						+		+	+	+	
Rhacomitrium lanuginosum	+	+					+		+	+	+	+	+

SPECIES:	REGION NUMBER:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Wide element (cont'd)													
Rhytidiadelphus loreus	+				+			+	+	+	+	+	+
Solidago virgaurea	+	+							+	+			
Taraxacum offinale S.L	+				+						+		+
Trifolium repens	+					+					+		
Usnea subflorida	+					+			+				

IV.5.4 Species generally distributed.

This group also includes species which have a tendency to be located in the Eastern side of Britain (Regions 3, 4 and 5). Examples of these species are Ulex minor, Ornithopus perpusillus, Cladonia chlorophaea, etc. Although U. minor is included in the Oceanic Western element, its distribution in Britain, and W. France is predominantly Eastern within these Western areas (see also Des. Abbeyes and Corillion, 1949). Because of the disparity of distribution between U. minor and U. gallii, these species have been used to characterise two synsystematic alliances - Ulicion nanae Duvingd, 1949 and Ulicion gallii, Des.Abb et Corillion.

The inclusion of Pteridium aquilinium in this group indicates its widespread occurence in Heath - especially where the heathland has been subject to heavy grazing or burning. However, the occurence of P. aquilinium in Heathland vegetation is virtually unique to Britain, a few areas in the Netherlands, Belgium and France - i.e. strictly an atlantic phenomenon.

Of all the four species groups, this has the lowest percentage of Oceanic West (7%) and is made up chiefly by the Wide element (51%).

IV. SPECIES WIDESPREAD, OR NON-SPECIFIC IN THE BRITISH HEATH.

N.B. species marked thus - * are typical of Eastern Heath of Great Britain.

SPECIES:	REGION NUMBER: 1	2	3	4	5	6	7	8	9	10	11	12	13
(a) Oceanic Southern Element.													
Rosa arvensis *			+										
(b) Oceanic West Element.													
Carex binervis	+	+	+		+	+	+	+	+	+	+	+	
Erica cinerea	+	+	+	+	+	+	+	+	+	+	+	+	+
E. tetralix	+	+	+	+	+	+	+	+	+	+	+	+	+
Galium saxatile	+	+	+	+		+	+	+	+	+	+	+	+
Genista anglica	+	+	+			+				+	+	+	
Hypericum humifusum	+							+	+				
Juncus squarrosus	+	+	+	+	+	+	+	+	+	+	+	+	+
Ulex europaeus	+	+	+	+	+	+	+	+					
U. minor *		+	+	+									
(d) Continental Southern Element.													
Lotus uliginosus *			+										
(e) Continental Element.													
Fagus sylvatica seedlings *			+			+							
Quercus species seedlings	+	+	+	+	+	+		+					
(f) Continental Northern Element.													
Cornicularia aculeata		+	+			+	+	+	+	+		+	
Drosera rotundifolia	+	+	+	+					+				
Teucrium scorodonia	+	+	+	+		+		+	+				
Scirpus caespitosis	+	+	+	+	+	+	+	+	+	+	+	+	+
Vaccinium myrtillus	+	+	+		+	+	+	+	+	+	+	+	
Eriophorum gracile *			+										
(i) Arctic-Alpine Element.													
Eriophorum angustifolium	+	+	+		+	+		+					+
(j) European Element.													
Cladonia coccifera	+	+	+	+		+		+	+	+	+	+	
C. cornuta-radiata						+							
C. crispata	+		+	+	+	+		+		+	+	+	
C. gracilis	+	+	+		+	+	+	+	+	+	+	+	
C. uncialis	+	+	+	+		+	+	+	+	+	+	+	+
C. verticellata *			+		+								
Aira praecox *			+			+		+					
Holcus mollis			+	+	+	+		+	+				

	1	2	3	4	5	6	7	8	9	10	11	12	13
(i) European element (cont'd)													
Polygala serpyllifolia	+	+			+	+		+	+	+	+	+	+
*Sarothamnus scorparius			+	+		+				+			
Sesleria caerulea								+					
Trifolium dubium			+										
Cladonia chlorophaea*	+		+	+	+	+		+					
(k) Eurasian element.													
Arrhenatherum elaticus	+				+	+							
Senecio vulgaris				+									
Anthoxanthum odoratum	+	+	+	+	+	+		+	+	+	+	+	+
Betula species seedlings		+	+	+	+	+		+		+	+	+	
Calluna vulgaris	+	+	+	+	+	+	+	+	+	+	+	+	+
Campylopus fragilis *			+					+					
Carex capillaris								+					
C. panicea	+	+	+				+		+	+	+	+	+
C. pilulifera	+	+	+	+	+	+	+	+	+	+	+	+	
Campylopus pyriformis *			+										
Crataegus monogyna seedlings	+		+			+	+	+					
Dryopteris borreri	+							+	+				
D. dilata	+					+	+	+	+				
Eurhynchium striatum			+			+		+	+				
Ornithopus perpusillusis *				+	+								
Hypochoeris radicata	+	+		+	+	+				+			
Holcus lanatus	+	+		+	+	+		+			+		
Lotus corniculatus	+			+	+	+		+	+	+	+		
Nardus stricta	+	+	+	+	+	+	+	+	+	+	+	+	+
Oxalis acetosella						+		+		+			
Pilosella officinarium	+		+	+		+		+			+		+
Pinius sylvestris seedlings	+	+	+	+	+			+	+	+	+	+	
Plagiothecium silvaticum *				+				+					
Polygala vulgaris	+	+				+		+	+				
Potentilla erecta	+	+	+	+	+	+	+	+	+	+	+	+	+
Cerasticum arvense*				+									
Lolium perrene *				+									
Sieglingia decumbens	+	+	+	+	+	+	+	+	+	+	+	+	+
Sorbus aucuparia seedlings	+		+		+			+	+	+	+	+	+
Senecio jacobca	+				+								
Viola odorata						+							
V. canina	+	+			+	+		+	+				+
(l) Wide Element.													
Agrostis stolonifera	+	+			+	+	+	+					
A. tenuis	+	+	+	+	+	+	+	+	+	+	+	+	+
Bryum pseudotriquetrum				+				+					
Calypogeia trichomanes				+	+	+		+		+	+	+	

SPECIES:	REGION NUMBER:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) Wide Element (cont'd).													
Campanula rotundifolia	+			+	+	+		+	+	+	+	+	
Campylopus flexiosus	+	+	+	+	+	+		+	+	+	+	+	+
Carex arenaria		+		+		+			+				
C. nigra	+		+	+	+	+	+	+					
Origanum vulgare						+							
Cephalozia bicuspidata	+	+		+	+	+	+	+		+	+	+	
C. connivens			+										+
Cladonia arbuscula	+	+	+	+		+	+		+	+	+	+	+
C. fimbriata	+	+	+	+	+	+	+	+	+				
C. floerkeana	+	+	+	+		+	+	+		+		+	
C. furcata	+	+	+	+		+		+	+	+	+	+	
C. impexa	+	+	+	+	+	+	+	+	+	+	+	+	+
C. papillaria *			+										
C. pityrea						+							
Cladonia pyxidata	+	+	+	+	+	+	+	+	+	+	+	+	
C. squamosa	+	+	+	+		+	+	+		+	+	+	
Epilobium angustifolium	+	+	+	+	+	+		+	+				
Dicranum scoparium	+	+	+	+	+	+	+	+	+	+	+	+	+
D. bonjeani			+					+					
Dicranella heteromalla			+		+			+		+			
D. varia		+	+		+	+		+					
Eurhynchium praelongum				+		+							
Festuca ovina S.L.	+				+	+	+	+	+	+	+	+	+
F. rubra	+	+	+	+	+	+	+	+	+		+		
Cladonia foliacea						+							
Gymnocolea inflata	+	+	+	+		+	+	+					
Hieracium tridentata								+					
Hypnum ericetorum	+	+	+	+	+	+	+	+	+	+	+	+	+
Juncus articulatus	+	+	+	+					+				
J. conglomeratus	+	+	+					+	+				
J. effusus	+	+	+		+			+					
Leucobryum glaucum		+	+				+	+					+
Lophocolea bidentata	+	+		+	+	+	+	+	+				
Luzula campestris	+		+	+	+	+		+		+	+		
L. multiflora	+	+	+	+	+	+	+	+	+	+			+
Lecidea cf. granulosa			+	+									
Molinia caerulea	+	+	+	+	+	+	+	+	+	+	+	+	+
Mylia anomala		+								+			
M. taylori				+	+		+	+	+	+	+	+	+
Parmelia physodes	+	+	+	+	+	+	+	+	+	+	+	+	+
Plagiothecium undulatum				+		+		+	+	+	+	+	
Pleurozium schreberi	+	+	+	+	+	+	+	+	+	+	+	+	+
Pohlia nutans	+		+	+	+	+	+	+		+	+	+	
Polytrichum commune	+	+	+	+	+	+	+		+	+	+	+	+
P. juniperinum	+	+	+	+	+	+	+	+		+			
P. piliferum	+		+	+	+	+		+	+	+		+	
Pseudoscleropodium purum	+		+	+		+				+	+	+	
Pteridium aquilinum	+	+	+	+	+		+	+	+	+	+	+	+

SPECIES:	REGION NUMBER:												
	1	2	3	4	5	6	7	8	9	10	11	12	13
(1) Wide Element (cont'd).													
Ptilidium ciliare			+			+	+	+		+	+	+	
Rhytidiadelphus squarrosus	+			+		+	+	+	+	+	+	+	+
Rumex acetosa	+	+				+		+		+			
R. acetosella	+		+	+	+	+		+	+				
Sphagnum quinquefarium	+	+				+		+		+	+	+	
S. recurvum	+	+			+	+		+					+
S. rubellum	+	+	+				+	+	+	+	+	+	
S. tenellum		+			+					+	+	+	+
S. subsecundum			+										
Thelypteris limbosperma						+			+				
Zygogonium ericetorum	+	+	+	+	+	+		+					
Deschampsia flexuosa	+	+	+	+	+	+	+	+	+	+	+	+	+
Ceratodon purpureas*				+	+	+		+					
Poa pratensis				+						+			
Cephaloziella starkei					+	+							
Equisetum sylvaticum								+					
E. arvense								+					
Icmadophila ericetorum						+				+			

IV. 6 The Biological Spectrum.

This enables Britain to be divided into five heathland 'provinces' (Map.2), (i) the South Atlantic, (ii) Continental, (iii) North Continental, (iv) North Atlantic and (v) Atlantic.

Each of these provinces is composed of one or more of the regions set up initially, i.e. (i) Regions 1,2 and 6, (ii) Regions 3 and 4, (iii) Regions 7, 8 and 9 (iv) Regions 10, 11 and 12 and (v) Region 13. Region 5 is unplaced, becaused of the paucity of information from this region, but most probably should be included in the Continental province.

The South Atlantic province is distinguished bya high percentage presence of the Oceanic West element, the Continental by a much diminished percentage of the Oceanic West Element, and increased percentage of the Continental and Continental Northern elements.

VI. BIOLOGICAL SPECTRUM FOR THE 13 'REGIONS' OF THE BRITISH HEATH.

	1	2	3	4	5	6	7	8	9	10	11	12	13
(a) Oceanic Southern	3	1	1			1							
(b) Oceanic West	15	18	10	7	7	12	6	6	8	10	9	11	16
(c) Oceanic Northern	1	2	2							5	7	9	5
(d) Continental Southern			1			1			1	1	1	1	
(e) Continental Southern	2	1	3	1	2	2		1		1	1	1	
(f) Continental Northern	2	6	6	4	2	3	4	4	5	3	4	2	5
(g) Northern Montane					1		1	1		2	3	3	
(h) Arctic-Subarctic										2	2	2	
(i) Arctic-Alpine		1	1		5	2	2	4	2	7	6	7	2
(j) European	6	6	10	8	8	8	3	8	8	6	4	4	4
(k) Eurasian	31	21	11	26	29	24	10	21	23	11	16	9	21
(l) Wide	37	45	55	54	45	47	46	55	51	52	47	52	48

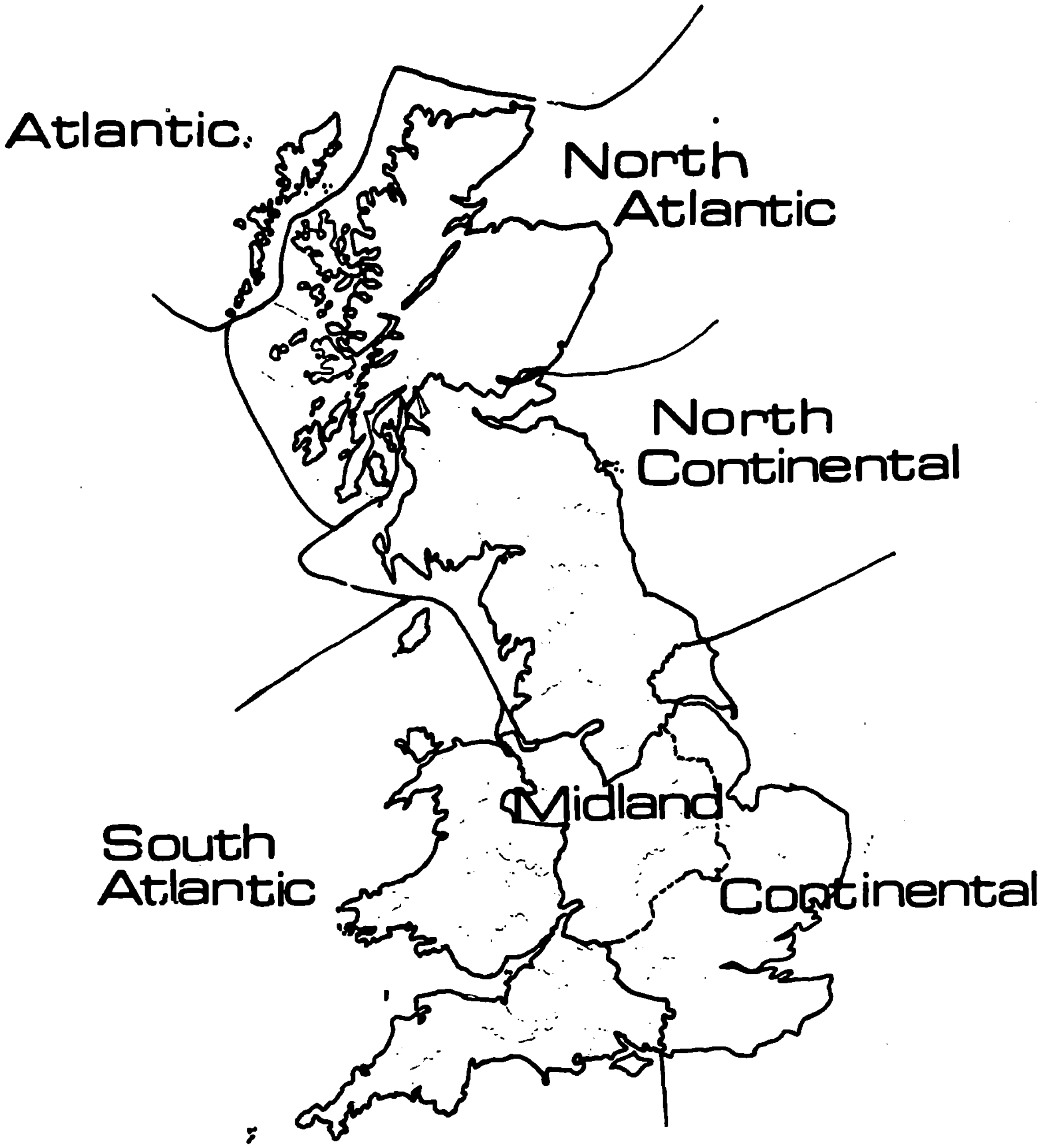
N.B. All values are percentage of the total number of species occuring in the region.

V. SPECTRUM FOR THE FOUR HEATH TYPES DESCRIBED UNDER TABLES I - IV.

		I	II	III	IV
(a)	Oceanic Southern	5			1
(b)	Oceanic West	22	9	15	7
(c)	Oceanic Northern	2	11	5	
(d)	Continental Southern	1	1		1
(e)	Continental Southern	3	1		1
(f)	Continental Northern	2	6	3	4
(g)	Northern Montane		5		
(h)	Arctic-subarctic		3		
(i)	Arctic-Alpine		12	1	
(j)	European	6	2	8	10
(k)	Eurasian	39	4	30	24
(l)	Wide	20	46	39	51

Total species number = 384

N.B. All values are percentage of the total number of species occurring in the region.



MAP IV/2 - Geographical Provinces of the British Heath Formation.

Within the South Atlantic Province, Region 2 has a relatively high percentage of Continental Northern species - indicating its position as a phytogeographic boundary zone.

The North Continental province is delimited by a low percentage of Oceanic Western element, high percentage of Continental Northern element, together with an increased percentage presence of the Arctic-Alpine element.

The North Atlantic province, on the other hand, is characterised by a fairly low percentage of Oceanic West element, but high percentage of Oceanic Northern element. Also the percentage of the Northern Montane, Arctic-subarctic and Arctic-Alpine elements, although never high, are expressed in this province alone. The Atlantic province is split from the preceeding by an absence of Northern Montane and Arctic-Subarctic elements, decreased percentage of Arctic-Alpine species and increased percentage of Oceanic Western element.

These provinces may be related to the three main divisions of the Heath vegetation (see next section) in the following way:-

The Erica cinerea Heath occurs in the South Atlantic, Atlantic, and (partly) North Atlantic.

The Calluna vulgaris Heath to the Continental and (New Forest area only) South Atlantic, and

The Vaccinium myrtillus Heath to the North Continental, North Atlantic provinces.

The rather widely overlapping nature of the Erica cinerea and Vaccinium myrtillus Heaths is an indication that they are the major types present in Britain - the Calluna vulgaris Heath, on the other hand, being merely an extension of the Continental heaths of Central Germany, Netherlands and Belgium (Schubert, 1960).

The five provinces can be related to Geographical regions described by de Smidt (1967), for the whole N. W. European Heath, i.e.

South Atlantic province	=	South Atlantic region.
North Atlantic province + Atlantic province	=	Boreal Atlantic region.
North Continental province + Continental province	=	Sub-Atlantic region.

The data derived from this phytogeographic survey illustrates the variability of the British heath vegetation, and underlines the classification which is discussed fully in the following section.

SECTION V.

The Plant Communities.

V.1. Introduction.

This Section presents the communities described from the British Heath, using the methods of the Z-M School, as detailed in Section I. Both because of the wide variety of vegetation encountered, and the possibility of a readjustment of existing continental terminology (de Smidt, in prep.), full association names have not been given to the communities. Instead, the "community-complex" system described in Section I has been adopted, and a summary of the classification given in Appendix I. Subsequent ennumeration of this section follows the pattern detailed in that Appendix.

The vegetation units have been assembled into a 'Key' (Appendix II). Earlier attempts to produce such keys were made in Rübel (1930) and Ellenberg (1956). Because of the dependence in the characteristic species and fidelity concepts, however, these were somewhat difficult to apply. The present one is 'artificial', i.e. it does not follow, primarily, the classificatory hierachy.

To use the key satisfactorily, certain rules must be observed:

(i) The vegetation sample to be 'keyed out' must appear homogenous, and not a mosaic.

(ii) The area of sample should be not less than 5 sq.m., or greater than 20 sq.m.

(iii) As complete a list as possible of all the spedies present (including bryophytes and Lichens) should be made.

If these points are observed, the vegetation should 'key out' with relative ease.

Heath vegetation, consisting as it does of rather 'social' species, lends itself to the refinement that, on occasions, one species only is used to make the dichotomy. Although this might prove misleading in one or two cases, in general it is perfectly admissable. To ensure that the correct vegetation type is detected, reference should be made to the vegetation tables (Appendix V), and to the descriptions in this section.

In all cases, a constancy table for the Identifying species of the communities and complex is given. Map.1. gives the 10 km squares from which releves were made.

V.2. Community descriptions.

I. The Erica cinerea Heath has its distribution centered on the South and West of England and Wales; although some of the component vegetation is found in Western Scotland. It is a particularly Eu-Atlantic vegetation type, being virtually confined to Britain, Ireland and extreme Western France. Besides being synonymous with the Alliance Ulicion Duvigneaud, 1949, it is also synomous with the Calluna - Erica cinerea - Ulex gallii - Potentilla erecta series of eu-oceanic vegetation (Coombe & Frost, 1956).

Because it is so oceanic a heathland, and as Britain is the focus of Atlantic heathland development, there is much variety within this unit, and consequently few defining species i.e. Erica cinerea, Calluna vulgaris and Potentilla erecta. In addition species such as Ulex gallii and (in the South) Agrostis setacea are typically confined to this Heath. Map 2 shows the distribution of this Heathland type, and Fig.1. illustrates the hierachy of complexes and communities.

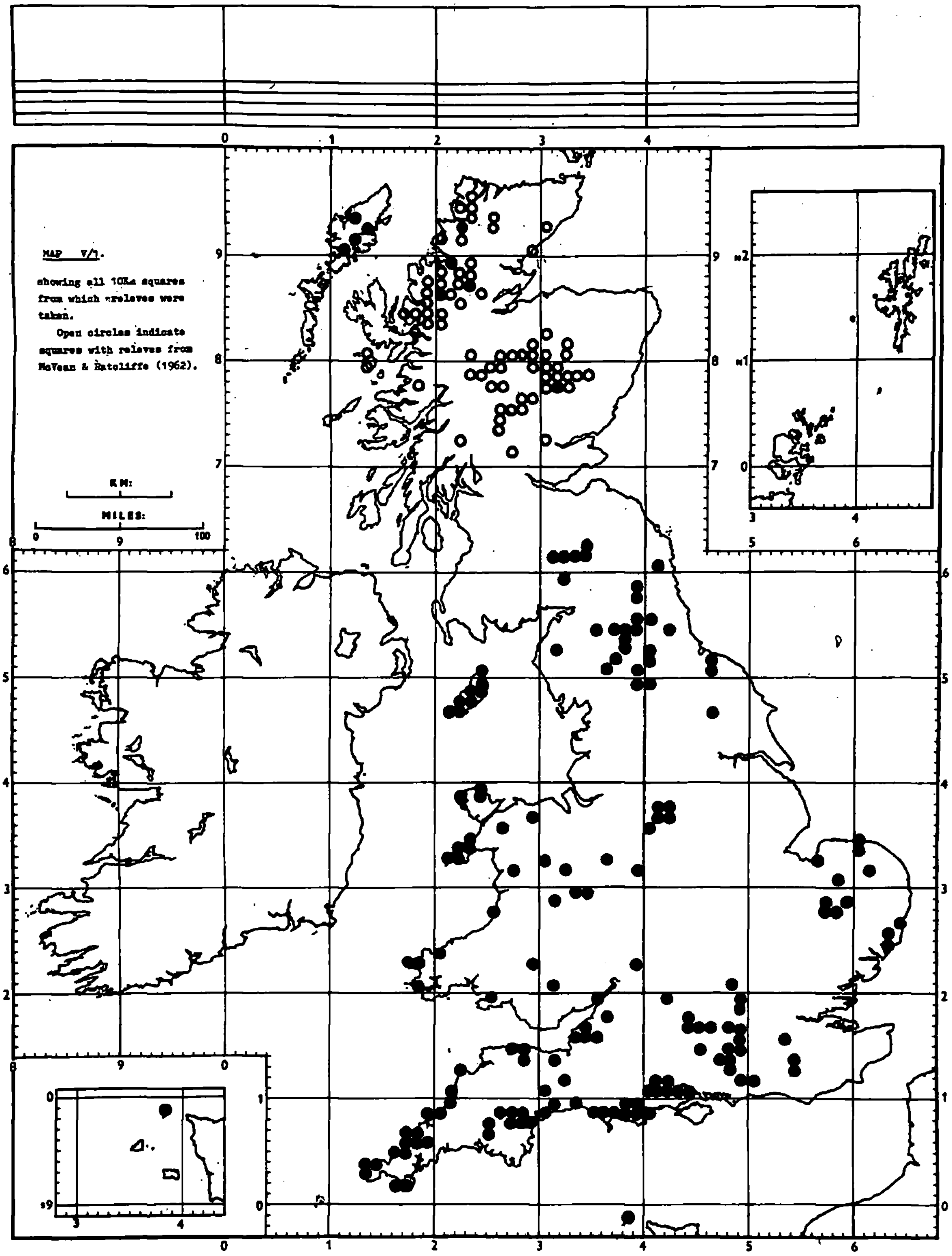
I.1. Thymus drucei Complex.

This complex is the most widespread of all within the Erica cinerea Heath, circumscribing vegetation from S.W. Cornwall to the Outer

MAP V/1

Showing the 10Km squares (National Grid system) from which releves were taken during the Heathland survey.

N.B. open circles denote 10Km squares from which data, obtained by McVean & Ratcliffe (1962) only, has been used in the construction of the vegetation tables (Appendix V)



MAP V/1.

showing all 10Km squares from which releves were taken.

Open circles indicate squares with releves from McVean & Ratcliffe (1962).

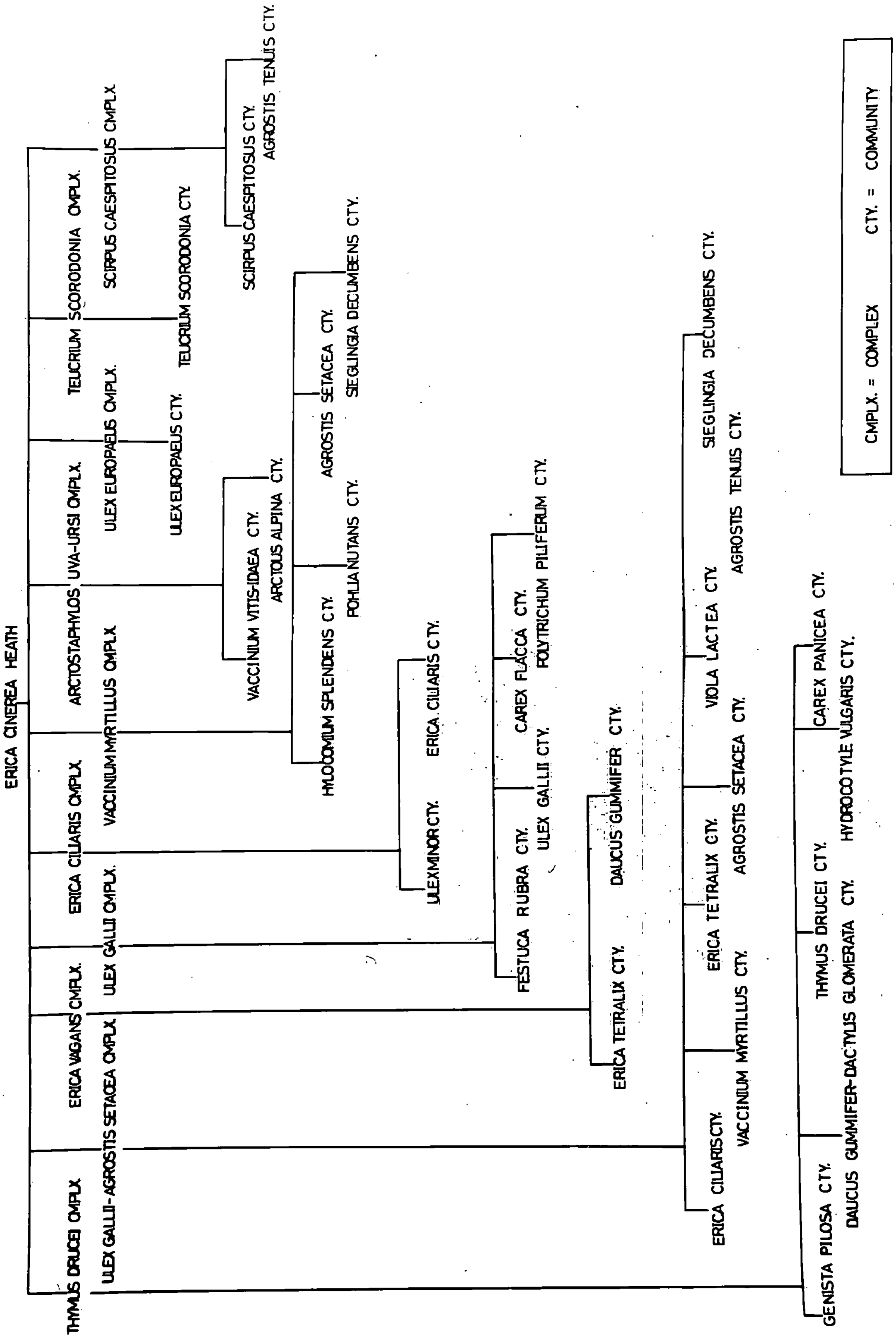
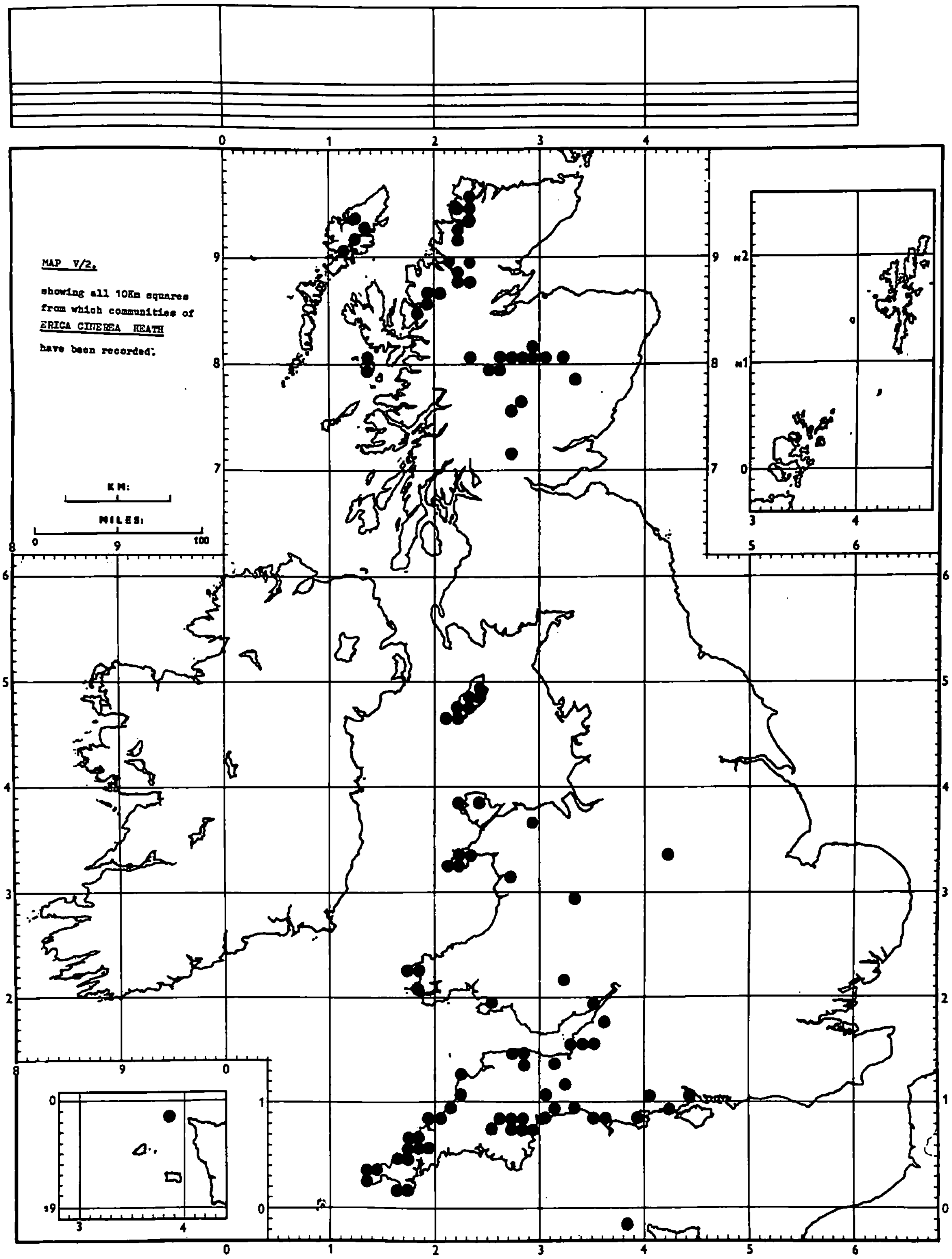

ERICA CINEREA HEATH
THYMUS DRUCEI CMPLX.
ERICA VAGANS CMPLX.
ERICA CILIARIS CMPLX.
ARCTOSTAPHYLOS UVA-URSI CMPLX.
TEUCRIUM SCORODONIA CMPLX.
ULEX GALLII-AGROSTIS SETACEA CMPLX.
ULEX GALLII CMPLX.
VACCINIUM MYRTILLUS CMPLX.
ULEX EUROPAEUS CMPLX.
SCIRPUS CAESPITOSUS CMPLX.
TEUCRIUM SCORODONIA CTY.
ULEX EUROPAEUS CTY.
SCIRPUS CAESPITOSUS CTY.
AGROSTIS TENUIS CTY.
VACCINIUM VITIS-IDAEA CTY.
ARCTOUS ALPINA CTY.
HYLOCOMIUM SPLENDENS CTY.
POHLIA NUTANS CTY.
AGROSTIS SETACEA CTY.
SIEGLINGIA DECUMBENS CTY.
ULEX MINOR CTY.
ERICA CILIARIS CTY.
FESTUCA RUBRA CTY.
ULEX GALLII CTY.
CAREX FLACCA CTY.
POLYTRICHUM PILIFERUM CTY.
ERICA TETRALIX CTY.
DAUCUS GUMMIFER CTY.
ERICA CILIARIS CTY.
VACCINIUM MYRTILLUS CTY.
ERICA TETRALIX CTY.
AGROSTIS SETACEA CTY.
VIOLA LACTEA CTY.
AGROSTIS TENUIS CTY.
SIEGLINGIA DECUMBENS CTY.
GENISTA PILOSA CTY.
DAUCUS GUMMIFER-DACTYLIS GLOMERATA CTY.
THYMUS DRUCEI CTY.
HYDROCOTYLE VULGARIS CTY.
CAREX PANICEA CTY.
CMPLX. = COMPLEX
CTY. = COMMUNITY

Fig. V/1.

MAP V/2

Showing 10Km squares from which communities of the Erica cinerea Heath have been recorded, during the Heathland survey. (See Map V/1 for the full area covered)



MAP V/2.
showing all 10Km squares from which communities of ERICA CINEREA HEATH have been recorded.
KM:
MILES:
0
9
100

No. of relevés	36	40	33	7	*
Community	a	b	c	d	e
Erica cinerea	V	V	V	III	V
Calluna vulgaris	V	IV	V	V	V
Potentilla erecta	IV	III	IV	V	IV
Viola riviniana	III	II	III	II	IV
Siegling ia decumbens	II	I	I	III	V
Festuca ovina	V	V	IV	II	V
Lotus corniculatus	IV	III	IV	III	V
Thymus drucei	IV	III	IV	IV	V
Hypochoeris radicata	III	III	IV		II
Plantago lanceolata	II	III	III		V
Holcus lanatus	II	III	III	III	
Polygala vulgaris	I	I	I		
Genista pilosa	V				
Carex pilulifera	II		I		II
Scilla verna	III	I	II		
Daucus gummifer	I	IV			
Dactylis glomerata		IV			
Jasione montana	I	I	I		
Anthyllis vulneraria	III	III			
Agrostis tenuis	I	III	II		
Hydrocotyle vulgaris				V	
Brachypodium sylvaticum				IV	
Primula veris				IV	
Molina caerulea				III	IV
Carex panicea					V
Agrostis canina	I				V
Carex pulicaris	I				IV
Hypericum pulchrum					IV
Linum catharticum	I				IV
Succisa pratensis					IV
Hylocomium splendens					IV
Pseudoscleropodium purum					IV
Frullania tamarisci					IV
Anthoxanthum odoratum	I	I	I		V
Festuca rubra		I	II	II	V
Euphrasia officinalis agg.					IV
Plantago maritima	III	II	II		IV
Polygala serpyllifolia	I		I		IV

* See McVean and Ratcliffe, 1962, Table 11 a.

Hebrides. All communities are confined to the Coastal fringe of the land. Their species composition is shown on page 87.

I.1a. Genista pilosa community.

Identifying species; G. pilosa, Scilla verna, Carex pilulifera.
Distribution; N. W. coast of Cornwall, between Perranporth and Porth Towan, the cliffs of Lizard Peninsula, Cornwall and cliffs at St. David's Head, Pembrokeshire.
Variants; (i) Hypnum ericetorum variant, differential species - Agrostis setacea, H. ericetorum, (ii) Campanula rotundifolia variant, differential species - C. rotundifolia, Carex flacca, Pteridium aquilinum, Anthoxanthum odoratum, Agrostis tenuis, (iii) Carex flacca variant, differential species - C. flacca, Plantago maritima, Serratula tinctoria, Betonica officinalis, Hieracium sabauda.
Ecological Notes; The community is found in the strictly maritime, "wind-trimmed", cliff heath of S. Cornwall and Wales. Height of the vegetation rarely exceeds 15 cm. Species diversity is usually fairly high for heathland vegetation, including a number of characteristically maritime and South Atlantic species. The three variants occupy rather different habitats.

The Hypnum ericetorum variant is found on the disturbed cliff tops and slopes in the Perranporth-Chapel Porth area of Cornwall. Tin and other metalliferous ore mining has been extensive in this region, and the disturbed cliffs afford the rather bleak conditions necessary for this variant of the three, it is the variant poorest in species.

St. David's Head has the community expressed as the Campanula rotundifolia variant. The presence of species such as Agrostis tenuis, Anthoxanthum odoratum and Pteridium aquilinum indicate the extent to which this variant is transitional between typical maritime cliff heath (with ericoids dominant) and acidic grasslands (ericoids poorly represented, if at all). It would also appear that Genista pilosa is becoming rarer, as many records speak of it being "abundant on St. David's Head", which it now most certainly is not.

Most widespread of all the variants is the Carex flacca variant, occupying rather steeply sloping (15^o - 25^o) cliffs, usually with a South or south-westerly exposition. These areas are usually rather damper, because they collect run-off from the more gentle sloping cliffs above them. Also, they are invariably positioned to experience the maximum effect of salt spray. This latter fact may account for the greater abundance and vigour of Plantago maritima in this variant.

Four sub-variants are distinguisable. The Ulex gallii sub-variant (differential species - U. gallii), with the shrub covering about 30% - 40% of the vegetation, occurs in rather more sheltered areas than the typical variant. It is also less subject to the prolonged effects of salt-spray exposure. The Hieracium glandulosi sub-variant (differential species H. glandulosi) supports some of the most species rich forms of the variant, and, indeed, the community. This sub-variant is expressed in a wet and dry form, the common feature that both share being a substrate of loose, calcareous, sand, with an A_h horizon of 1 mm, or even non existent. The wet form is characterised by the presence of species such as Schoenus nigricans, Carex pulicaris, Hypnum ericetorum, Agrostis canina, Primula vulgaris, Brachypodium sylvaticum. That there is a regular water through-flow is evidenced by a small marsh developed at the foot of the cliffs where this vegetation is found.

Wind-blown sand, piling against cliffs, accounts for the habitat of the 'dry' form. The resultant system acts, for all purposes, as a sand dune. Several dry calcicolous species characterise this form, viz. Linum catharticum, Carlina vulgaris, Poterium sanguisorba, Carex caryophyllea.

The cliffs of the Lizard peninsula form the site for the expression of a third sub-variant; Erica vagans sub-variant (differential species - E. vagans, Sarothamnus maritimus, Genista tinctoria ssp. littoralis). It is assumed that the unusual phytogeographical background of the Lizard peninsula is responsible for the expression of this sub-variant, rather than any particular environmental factor. It is interesting to note that in the sub-variant two sub-specific dwarf legumes are found - and the only area where these occur is the Lizard (Perring and Sell, 1968), although both have other dwarf forms occuring elsewhere.

The relationship of this Community with others in the complex is seen by the Daucus gummifer sub-variant (differential species - D. gummifer, Jasione montana). These differential species are also identifying species of the Daucus gummifer - Dactylis glomerata community, representing the more widespread maritime heath vegetation, and thus this sub-variant links the Genista pilosa community with that community.

This community depends very much for its definition and distribution on the distribution of G. pilosa itself. Evidence is, regretably, not available from other areas of Britain where the plant occurs to determine the similarity or disimilarity of such vegetation to the Genista pilosa community. However, it may be assumed that as near-extinct Sussex and now extinct Suffolk stations recorded it as occuring in the form of an "ascending shrub", rather than the prostrate form from Cornwall and Pembroke, the vegetation from these areas is comparable to the Calluno-Genistion of the Netherlands and N. W. Germany.

The similarities of this alliance and the Calluna vulgaris Heath have been mentioned, and the fact that Sussex and Suffolk both fall into the distributional range of that Heath gives added weight that the Genista pilosa vegetation of these areas is not related to the Genista pilosa community. There is, however, a further distributional area of G. pilosa, Merionethshire. Price-Evans (1932), describes the habitat as follows; "The plant assumes a prostrate habitat, clinging closely to the surface of the rock...." This would seem to indicate that although the maritime species are unlikely to be present, the vegetation surrounding G. pilosa here may be comparable to the Genista pilosa community. Price-Evans records difficulty in finding the plant - I was unable to locate it on Mynydd y Gader in July 1969.

It seems surprising that as the coastal form of G. pilosa being so different, and the geographic disparity of an isolated area from any other continuous distribution across N. Europe should have failed to arouse the interests of systematists. Flora Europaea affords no differention within the taxon. Perhaps, in this case, the Phytosociological situation points to the need for a systematic reappraisal of Genista pilosa in its Coastal sites.

I.1.b. Daucus gummifer - Dactylis glomerata Community.

Identifying species; D. gummifer, D. glomerata, Jasione montana, Anthyllis vulneraria, Agrostis tenuis.

Distribution; Sea cliffs from S. W. Cornwall, N. W. Devon to W. Pembrokeshire.

Variants; (i) Genista tinctoria variant, differential species G. tinctoria, Betonica officinalis, Serratula tinctoria, Scilla verna, Plantago maritima, Carex flacca, (ii) Rumex acetosa variant, differential species - R. acetosa, Armeria maritima, (iii) Cladonia rangiformis variant, differential species C. rangiformis, Hypnum ericetorum, Campylopus introflexus, Ulex europaeus, Cladonia crispata, C. squamosa, C. uncialis, Parmelia physodes, (iv) Anthoxanthum odoratum variant, differential species - A. odoratum, Leontodon taraxacoides, Leucanthemum vulgare, Koeleria cristata. Ecological Notes. Although occuring in the same geographical area as the last community, this is distinguished by a higher number of grassland species present. Ericoid cover is usually 50% or less. The vegetation is less wind trimmed than that of I.1.a. Physiognomically the Genista tinctoria variant of this community is related to the Carex flacca variant of the Genista pilosa community, i.e. both have dwarf leguminous shrubs as a component, both are characterised by C. flacca and associated species and both are sited in areas exposed to direct sea salt spray. A Rumex acetosa sub-variant (differential species - R.acetosa, Armeria maritima) is found on more rocky, drier cliff faces. This links the variant with the Rumex acetosa variant itself, again typical of exposed, steep, rocky cliffs, with poor soil development. In richer, more sheltered sites, the variant is expressed as the Ulex europaeus sub-variant. (differential species U. europaeus, Silene maritima). U. europaeus cover varies between 70% - 100%.

In addition, U. europaeus is a component of the Cladonia rangiformis variant, found in the Channel Islands. This variant is rich in Lichens and bryophytes, notable among which are C. rangiformis and Campylopus introflexus. The former, although boreal in distribution, is essentially a Southern species - in Britain, its distribution is chiefly southern, being frequently found in sea-cliff associations of various kinds. The latter named species has been apparently introduced into Britain since 1947 (Richards, 1963), from Brittany. It is a native of the Southern hemisphere, and the warmer parts of America. The Southern Mediterranean status of the variant is thus illustrated.

The Anthoxanthum odoratum variant is found in the more northerly sector of its distributional range (e.g. Pentire Point, Wadebridge and Widemouth Bay, Bude). As with the Rumex acetosa variant, this is typical of steep cliffs with little soil development. More than others, this variant has many more grass species, and ericoids are poorly represented.

I.1.c. Thymus drucei Community.

Identifying species; (see those of the Complex)

Distribution; S, W & N. coasts of Cornwall, Pembrokeshire coast, S. & W. Coastal cliffs of the Lleyn Peninsula and S. W. coast of the Isle of Man.

Variants; (i) Pedicularis sylvatica variant, differential species - P. sylvatica, (ii) Erica tetralix variant, differential species - E. tetralix, Betonica officinalis, Plantago maritima, (iii) Hypnum ericetorum variant, differential species H. ericetorum, (iv) Agrostis tenuis variant, differential species - A. tenuis, Anthyllis vulneraria.

Ecological Notes; As the type 'community' for the Complex, this, naturally, has the widest distribution. It has been possible to note several developmental stages in the formation of this community. At Zennor Head, for example, bare rock is initially colonised by a bryophyte carpet, of the following species: Polytrichum piliferum, Rhacomitrium canescens, Cladonia furcata, with isolated plants of Sedum anglicum and Aira caryophyllea.

A more complete vegetation with grasses and herbaceous species then develops, as noted in the relevé below:-

Aira caryophyllea	+	Erica cinerea	3.3
Armeria maritima	1.2	Festuca ovina	+.2
Anthyllis vulneraria	1.1	Hypochoeris radicata	+
Betonica officinalis	+.2	Holcus lanatus	2.1
Calluna vulgaris	+	Plantago lanceolata	+
Cerastium atrovirens	+	Sedum anglicum	+
Cladonia furcata	+	Silene maritima	+
Dactylis glomerata	1.2		

This is obviously rather close to the usual cliff heath, which develops from it.

Information of this kind is also found in some of the three 'forms' of the Anthoxanthum odoratum sub-variant (differential species - A. odoratum), - Agrostis tenuis variant. One of the forms (distinguished by Campanula rotundifolia, Viola canina and Carex pilulifera) is geographical in nature, located only on the Lleyn peninsula. The other two reflect early developmental stages. Plain rock development is mediated through bryophytes, or by direct colonisation of the rock by vascular plants. Such a situation is represented by the form distinguished by Koeleria cristata, Armeria maritima and Aira caryophyllea. Development in areas more sheltered and with some prior humus accumulation, is accomplished by the form distinguished by Rumex acetosa and Teucrium scorodonia.

Another site that yielded information of this kind was Widemouth Bay. Here, freshly exposed rock is colonised by a mixture of the following species; A. maritima, Silene maritima, Jasione montana, Festuca ovina, Sedum anglicum, Koeleria cristata. Areas that have been recently colonised are thus characterised by the following species: A. maritima, S. maritima, S. anglicum, K. cristata and A. caryophyllea.

Where colonisation has accumulated some humus and soil development, Anthyllis vulneraria is frequent. This species is rather variable, and the particular infra taxon found in this community discussed, is A. vulneraria ssp. corbierei.

Besides the sub-variant mentioned above, the Agrostis tenuis variant has two others (i) Luzula campestris sub-variant (differential species - L. campestris) and (ii) Koeleria cristata sub-variant (differential species K. cristata, Scilla verna, Plantago maritima). The former typifies a more sheltered, grass-heath cliff vegetation. Rabbit grazing tends to keep this sub-variant from becoming dominated by ericoids. The latter sub-variant is typical of extremely exposed sites on cliff tops, and also areas which are regularly affected by salt sea spray.

The effect of rabbit grazing on the variant in general tends to keep the number of grass species high, and ericoid growth is reduced to very low growing shrubs. This is most noticable at Pentire Point, Newquay, where the Northside and Central part of the headland are subject to rabbit grazing, and anthropogenic effects (trampling, etc.) The south side, however, is more sheltered, and is not subjected to either effect. Whilst the Thymus drucei community is found on the N. and central areas, the South side supports a dense growth of Ulex europaeus (height c. 0.75 - 1.5 m), with the following species associated: Erica cinerea, Teucrium scorodonia, Dactylis glomerata, Phragmites communis and Cirsium arvense. This illustrates the important effects of both climatic and biotic factors in the maintenance of the coastal heath communities.

The Hypnum ericetorum variant is confined to St. David's Head, occuring as a rather atypical maritime heath. It lacks many of the defining species of the Complex and community. Also, the ericoids are more obvious and dominant (height 40 - 45 cms), not wind trimmed.

Lands' End forms the site for the most unusual variant - Erica tetralix variant. E. tetralix is extremely rare in maritime heath

The steeply sloping cliffs where the variant is found are exposed, and have a thin clay layer over the parent rock. This has allowed development of a peat of 5 - 6 cm. depth in places. E. cinerea, therefore, has not developed to its full potential, but E. tetralix has developed to the full in these ideal conditions.

The fourth variant is the Pedicularis sylvatica variant, found in W. Cornwall and Pembroke. In the extreme west conditions at Lands' End Ulex gallii is found in this variant, but because of wind trimming is rarely of a height greater than 6 cm. Besides exposure, rabbit activity is also high in this variant.

I.1.d. Hydrocotyle vulgaris Community.

Identifying species; H. vulgaris, Brachypodium sylvaticum, Primula vulgaris, Molina caerulea.

Distribution; N. W. Cornwall, W. Pembrokeshire.

Variants; None.

Ecological Notes; In some respects similar to the Schoenus nigricans form /Hieracium glandulosi sub-variant, described under I.1.a., this is found on exposed W. or S.W. facing cliffs, near seepage lines. Water is always at or near the surface, and the sites are all exposed to direct sea spray. To explain H. vulgaris and M. Caerulea occuring in such a situation is not difficult, but species such as B. sylvaticum and P. vulgaris may require further investigation. However, both these species are recorded from other types of coastal heaths (B. sylvaticum from the Lizard, I.3.b., and P. vulgaris from Thymus drucei community, Fleshwick Bay, Isle-of-Man)

I.1.e. Carex panicea Community.

Synonomn; Herb rich facies of Callunetum vulgaris, Mc.Vean & Ratcliffe, 1962.

Identifying species; Carex panicea, C. pulicaris, Agrostis canina S.L., Molinia caerulea, Hypericum pulchrum, Linum catharticum, Succisa pratensis, Hylocomium splendens, Festuca rubra, Pseudoscleropodium purum, Frullania tamarisci, Anthoxanthum odoratum, Euphrasia officinalis, Plantago maritima, Polygala serpyllifolia.

Distribution; Wester Ross, W. Inverness, Rhum.

Ecological Notes. McVean and Ratcliffe believe this to be merely a facies of their Callunetum vulgaris, and not a separate unit. They suggest a link between this and the Agrosto-Festuretum (McVean and Ratcliffe, 1962). Coarse management through burning, grazing, etc., is leading to a decline in the occurence of this community. Synsystematically, its inclusion within this complex is correct, and the fact that the Callunetum vulgaris (= Hylocomium splendens community, I.6.a.) is also a member of the Erica cinerea Heath, serves to re-inforce this view.

I.2. Ulex gallii - Agrostis setacea complex.

This heath vegetation is restricted to inland areas of the S. W. Peninsula, extending east to Weymouth and north to the Quantocks. Typically occupying dry areas, wet variants can nevertheless be detected for most communities. A summary of the defining species of the complex is shown on page 98.

I.2.a. Erica ciliaris community.

Identifying species; E. ciliaris.

Distribution; A triangle of mid-Cornwall from Falmouth to Newquay and Camborne.

Variants; (i) Carex panicea variant, differential species - C. panicea, Polygala vulgaris, Calypogeia fissa, Cuscuta epithymum, (ii) Diplophyllum albicans variant, differential species - D. albicans, (iii) Erica tetralix variant, differential species - E. tetralix.

Number of relevés	16	20	30	16	15	5	6
Community	a	b	c	d	e	f	g
Ulex gallii	V	V	V	V	V	5	V
Agrostis setacea	V	V	V	V	I	2	IV
Erica cinerea	V	V	V	V	V	5	V
Potentilla erecta	III	III	III	II	IV	I	V
Calluna vulgaris	V	V	V	V	V	5	V
Molinia caerulea	V	IV	V	V	I		I
Erica ciliaris	V						
Vaccinium myrtillus		V					II
Erica tetralix	II	III	V	III			
Viola lactea	I			I	V		
Hypochoeris radicata					II		
Agrostis montana					II		
Viola canina					III		
Hieracium sabauda					II		
Sieglingia decumbens			I		III		V
Carex pilulifera	I		I		IV	2	
Dactylis glomerata						3	
Rumex acetosa						2	
Festuca ovina						2	
Rosa pimpinellifolia						2	
Viola riviniana						2	
Thymus drucei						2	
Hypnum ericetorum	II	III	II	II		2	
Agrostis tenuis		I	I		I	4	
Festuca rubra							V
Pleurozium schreberi		III					IV
Rhytidiadelphus squarrosus							III

Ecological Notes. The community distribution is obviously tied rather closely to the distribution of E. ciliaris, and the exact status of this species is discussed more fully in Section I.5. Within the community range, nearly every site has been disturbed by the mining industry, and the community is well developed on mine spoil tips (e.g. Newlyn East). The only apparent exception to this rule is the area of heathland known as Carrine Common (Truro), about which the County Archivist writes (Pers. Comm). "In the tithe appointment of 1842 it is described as a common of 33 a. 1r. 20 p., but the state of cultivation is not indicated." The Estate Agent of the Earl of Falmouth, to whom the land belongs, jointly with other landowners in undivided shares, further states that; "In the last Century, certain people were given consent to enclose this area.. the area has remained one of heathland over which there appears to be no rights of common, and has remained in its present state for many years."

It seems particularly interesting that this area should be so well documented as unchanged, because all other sites visited in Cornwall are associated with disturbance, and it is possible to speculate that this site may have more in common with the vegetation of E. ciliaris in W. France and Lusitania, where it is at its 'optimum', than the other sites.

Where the community is subject to fire, the early regeneration phases are dominated by Agrostis setacea, Carex pilulifera, Viola spp., Calypogeia fissa, Cuscuta epithymum. E. ciliaris seems to regenerate faster than other ericoids or Ulex gallii.

In the communities of more drastically disturbed habitats - i.e. tin mines, the Diplophyllum albicans variant is found. D. albicans is a plant often associated with mine soil, rich in heavy metals, and is discussed under Section II.3.b.

More sheltered areas support the Erica tetralix variant, but this reches its best development in water-logged areas, where peat reaches 6 - 8 cm. in depth. The latter sites develop the Gymnocolea inflata subvariant (differential species - G.inflata, Cladonia impexa, C.arbuscula, Zygogonium ericetorium, Pedicularis sylvatica). This shows E. ciliaris as a 'wet heath' species, the rôle most usually cast for it (e.g. Moore,1968) Certainly, this is not the situation in Cornwall, where wet habitats are the exception, not the rule.

I.2.b. Vaccinium myrtillus community.

Identifying species; V. myrtillus.

Distribution; Quantock hills, Blackdown hills of Devon/Somerset border, Gittisham Hill (Sidmouth), Trinity hill (Lyme Regis), Blackdown hill (Abbotsbury). All these sites are above 325 m. O.D.

Variants. (i) Deschampsia flexuosa variant, differential species - D. flexuosa, Pleurozium schreberi, (ii) Erica tetralix variant, differential species - E. tetralix, Calypogeia mülleriana.

Ecological Notes. As noted in the Distributional data, this community is found on some of the highest land in the Devon/Mid-Somerset region. The chief reason for this would seem to be the distribution of the defining species - V. myrtillus. Matthews (1937) lists it as a member of the Continental Northern element. In Central and North Europe, it is a common woodland plant. Thus, if it is to occur in heathland, it will do so only if the marcoclimate is oceanic (cool and moist). In Southern Britain, this type of climate is found only on the summits of these hills. The lowest sites, in altitude, are those exposed to the channel on the South Coast, where the maritime climate doubtless has an influence.

The two variants correspond to the depth of the peat, and the degree of moisture of this, i.e. the Erica tetralix variant is characteristic of the moister, more southerly sites, whereas the Deschampsia flexuosa variant is found in the drier, more northerly areas.

This latter variant has a Cladonia spp. sub-variant (differential species C. arbuscula, C. pyxidata, C. chlorophaea). Typically associated with dense vigorous Calluna growth, and reduced Ulex gallii, the sub-variant usually indicates land recovering from burning.

Landscape of the sites of the Communities varies little - all are concentrated on "hill-tops", due in the case of the Devon/Dorset sites to the capping of chalk or limestone hills by Pliocene formations, and in the N. Devon and Somerset sites to the 'wild' state of the sandstone hilltops, although the sides are now usually cultivated. In the case of the Devon Blackdowns, this applies now to much of the hill top. The Quantocks, however, still have heathland as hill-top vegetation with the sides of hills sometimes afforested. Some of the steep-sided valleys facing North have an Oak-wood flora, referable to the alliance Quercion robori-petraeae Br.Bl. 1932. Two lists from Bincombe Wood (G.R. 31/1735) show the typical flora of these woodlands:

	A	B
Tree cover (%)	90	90
Exposition	NE	NE
Slope	20	25
Phanerogam % cover	70	85
Cryptogam % cover	40	30
Releve area	25	25
Quercus petraea	5.1	5.1
Calluna vulgaris	4.4	+
Vaccinium myrtillus	2.2	4.4
Melampynum pratense	+	
Luzula sylvatica	+.2	2.2
Carex pilulifera	+.2	
Deschampsia flexuosa	1.2	2.2
Hypnum cupressiforme	2.2	3.3
Lephocolea bidentata	2,2	2.2
Pteridium aquilinum	+	+
Polytrichum formosum	2.2	3.2
Betula spp.(seedlings)	r	
Quercus petraca(seedlings)	1.2	r
Dicrenella heteromalla	+.2	+
Agrostis tenuis	+	
Ilex aquifolium(seedlings)	r	1.2
Dicranum majus		2.2
Rubus caesius		+
Thuidium tamariscinium		2.2
Dryopteris dilatata		+

The height of trees in these woods is from 18 - 25 m. in the mid-valley, reducing to 5 - 8 m. near the valley head. These woods terminate in the upper reaches to Oak scrub, and where this abutts on to the heathland, there is an extensive band of Ulex gallii (see Fig.2.) This is a limes convergens situation, sensu van. Leeuwan, 1966. (see also Section III).

Because the typical natural woodland break is "the biological culminating point of the limes divergens situation" (van. Leeuwan, 1966), it seems strange that a woodland should end with a limes convergens situation. However, it may be used as evidence to substantiate the fact that, as limes convergens situations are frequently associated with anthropogenic and other agents of disturbance, the heathlands of the Quantocks are anthropogenic in origin, and held in place by man's direct and indirect interference.

I.2.c. Erica tetralix community.

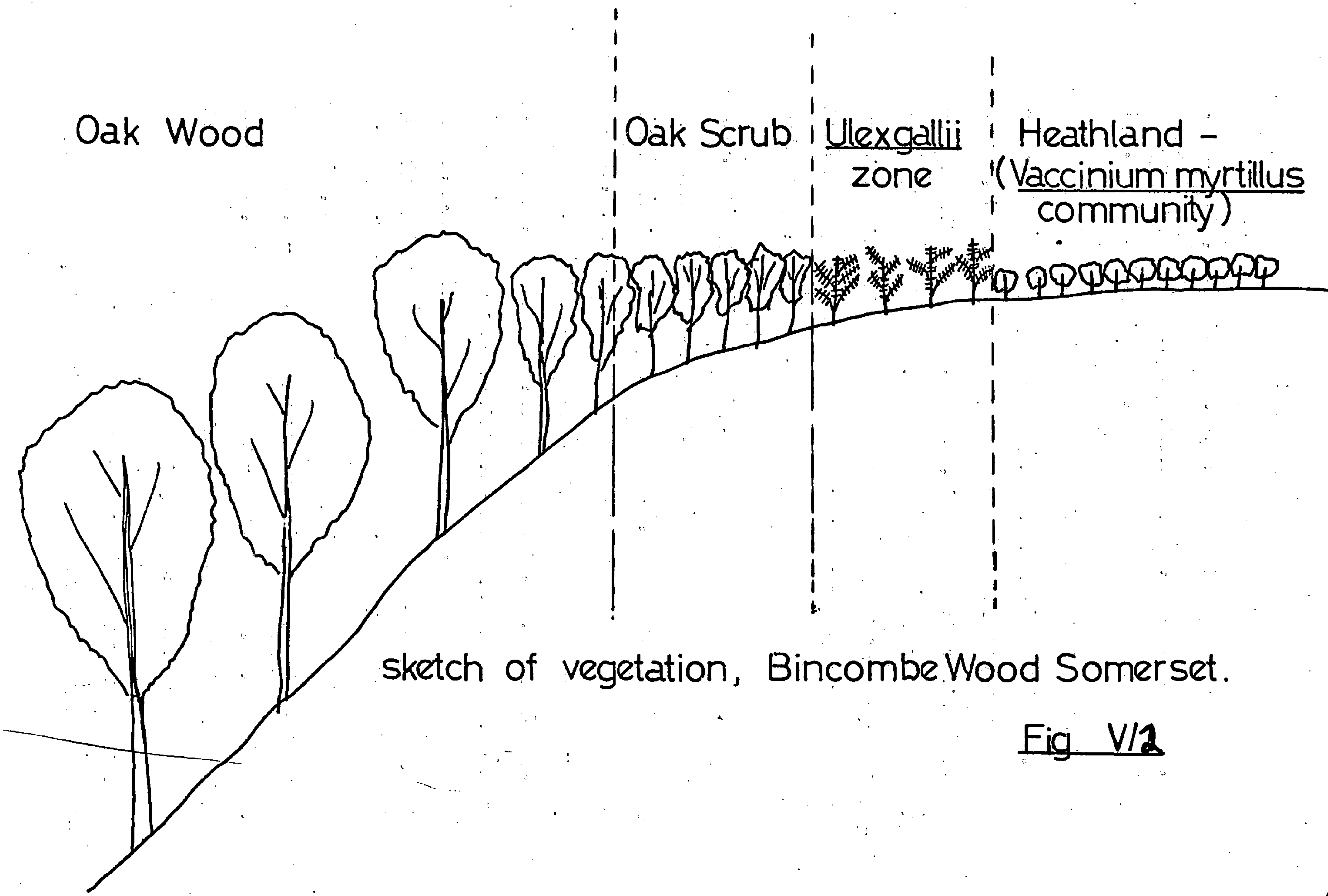
Identifying species; E. tetralix.

Distribution; West Penwith, Wendron Moors, Hensbarrow Downs (Cornwall), Woodbury, Lympstone, Hawkerland Commons, and parts of Dartmoor (Devon).

Variants;(i) Sieglingia decumbens variant, differential species - S. decumbens, Carex binervis, Cuscuta epithymum, (ii) Cladonia spp. variant, differential species - C. floerkeana, C. squamosa, C. crispata, C. degenerens, C. coccifera, Polygala serpyllifolia.

Ecological Notes; Fairly widespread throughout Devon and Cornwall, this community is divisible into two ecological units - (a) the 'typical' community, found in relatively dry areas, with peat depth usually within the range 0.5 - 2 cm. and (b) a wetter heath, comprising the two variants noted above, with a peat layer of 5 - 10 cm. in depth, or, if shallower, then the peat developed over a clay substratum. Geographically (a) is the eastern expression of the community, (b) the Western.

The Sieglingia decumbens variant is developed in the Penwith area of Cornwall, in association with land that has been mined. Through-



sketch of vegetation, Bincombe Wood Somerset.

Fig V/2

out this area there is plenty of such land - and many small settlements owe their name to the Cornish word for mine - 'Wheal'. The disturbance in these sites has broken the heath podsol, and allowed more exacting species to flourish. An Agrostis tenuis sub-variant (differential species - A. tenuis, Dactylisglomerata, Carex hostiana, Polygala serpyllifolia, Galium saxatile), is found in the most disturbed areas, and on the edges of paths and trackways. Where growth is lushest, and the peat is moist, the Calypogeia arguta sub-variant (differential species - C. arguta), is found.

The Cladonia spp. variant has a Carex binervis sub-variant (differential species - C. binervis, C. hostiana, C. panicea, Gymnocolea inflata). This is characteristic of the wettest heaths, found in the hilly N. W. Penwith area. Peat depth here is 8 - 10 cm. The heaths are regularly burnt, with the result of a rather impoverished flora.

N. E. Cornwall and S. E. Devon is the site for the 'typical' community - rich in Cladonia spp. and also Zygogonium erictorum. As, in summer, this latter species forms papery mats and sheets, it is probable that these heaths are "Winter wet - summer dry".

The typical community is often found in association with other vegetation types on some of the "moors" of Mid-Cornwall. A table of five relevés, taken from dry 'moor', through wetter sites, to a flowing stream, is given on page 104, showing the types of communities that are juxtaposed. It must be stressed that the dynamic system, as viewed in the field, is a typical limes divergens situation, and the relevés represent reference points within this. Relevés 1, 2 are closest to the Erica tetralix community, those of 3 and 4 show closest affinity to communities of the order Sphagnetalia Magellanici, Moore 1968. 5 is taken around the stream-side. Data is from Rosenannon Moor (G.R. 10/957669).

	1	2	3	4	5
Molinia caerulea	3.3	3.3	4.4	4.4	1.2
Erica tetralix	3.3	3.3	1.1	1.1	
Sphagnum quinquefarium	2.3	3.3	3.3	+	
Succisa pratensis	+	1.1	+	+	
Potentilla erecta	1.1	1.1	1.2	1.2	
Dactylorhiza ericetorum	1.1	+	+		
Pedicularis sylvatica	1.1	2.1	1.2		
Agrostis setacea	3.3	1.2			
Calluna vulgaris	2.1	1.1			
Ulex gallii	2.1	1.2			
Erica cinerea	1.1				
Leucobryum glaucum	2.3				
Polygala serpyllifolia	+				
Serratula tinctoria	+				
Sieglingia decumbens	1.2				
Anagallis tenella			1.2	1.2	
Calypogeia mülleriana			2.3	+	
Carex echinata			+	+	
C. panicea		+	1.1	1.1	
Cephalozia connivens			+	+	
Luzula multiflora			+		
Sphagnum contortum			1.3	3.3	
Schoenus nigricans		+	3.3	2.2	
Hypnum ericetorum		1.3			
Hypericum elodes			+		4.4
Sphagnum palustre			2.3		
Breuteilia chrysocoma				1.3	
Drosera rotundifolia				1.2	
Eriophorum angustifolium				1.2	
Juncus articulatus				+	
Rhynchospara alba				1.2	
Zygogonium ericetorum				+	
Riccardia pinguis				+	
Drepanocladus intermedius				2.3	
Eleocharis quinqueflora				1.2	

Degredation of this community by over burning, coupled with a heavy grazing pressure, gives rise to a very unusual form of the vegetation, dominated by Molinia caerulea and E. tetralix. This vegetation has been noted at Hensbarrow Downs (Cornwall), Bursldon Moor (Devon) and the Gower peninsula (Glamorgan). In some cases, where this degraded vegetation is subject to a fluctuating water table, or adjacent to stream sides, rich vegetation reminiscent of anthropogenic water meadows (Molinietalia) is produced. Table I.2.x (page 106) gives floristic data for some sites of this degraded community. (Details concerning the relevés may be found in Appendix VI).

I.2.d. Agrostis setacea community.

Identifying species; - as the complex.
Distribution; Central Cornwall, S. W. Devon.
Variants; (i) Erica tetralix variant, differential species E. tetralix, Hypnum ericetorum, Parmelia physodes.
Ecological Notes; Found on the drier sites, i.e. old mine workings in Cornwall, dry gravels of S. W. Devon. The Erica tetralix variant is found in areas where there is an admixture of clay with the sand and gravel, which impedes drainage. It is interesting to note that this community, with its variant, is found on the recent (Eocene and Oligocene) sands and gravels of S. Devon, whereas the Erica tetralix Community is found on the Triassic and Permian marls and sandstones of S. E. Devon, suggesting a possible explanation for the existence of two closely related vegetation units in the same geographical area.

I.2.e. Viola lactea community.

Identifying species; V. lactea, V. canina, Hypochoeris radicata, Agrostis montana, Carex pilulifera, Sieglingia decumbens, Hieracium sabauda.
Distribution; restricted to sheltered coastal valleys between Perranporth and Porth Towan, Cornwall.

TABLE I.2.x.

Degraded Wet Heath in the South West.

Relevé Number	33	1	15	32	2	3
	2	41	4	2	41	41
Exposition	NW	W	W	NN	E	W
Slope	5	2	5	5	3	2
Phanerogam % Cover	100	100	100	100	95	95
Cryptogam % Cover	10	40	80	20	15	15
Relevé area (m^2)	10	10	10	10	10	10
No. of species	14	20	19	12	8	11
Calluna vulgaris	2.2	2.2	2.2	1.2	+	1.2
Erica tetralix	1.2	2.2	2.2	3.3	1.2	2.2
Molinia caerulea	1.2	4.3	4.2	3.3	4.4	4.4
Potentilla erecta	3.3	1.1	+	1.2	1.2	1.2
Agrostis setacea	2.2		1.2	2.2	1.2	2.2
Ulex gallii	+	2.2	1.2	1.2	+	1.2
Carex panicea	+	1.2	1.2	+		
C. binervis	2.2	1.2	+ 2			
Hypnum ericetorum		4.3	3.3			
Sieglingia decumbens	1.2	+	+			
Calypogeia müllerina		+	1.3			
Lophozia ventricosa	1.2	+				
Anthoxanthum odoratum	+		+		+	+
Pedicularis sylvatica		+			+	1.2
Zygogonium ericetorum				2.3		
Sphagnum quinquefarium		3.3				
Diptophyllum albicans		1.3		1.2		

Additional species:

^{1}41, Cephalozia connivens +, Narthecium ossifragum +, Serratula tinctoria 1.1, Sphagnum palustre 2.3, S. tenellum +, Succisa pratensis 1.1, ^{32}2, Erica cinerea 1.2, Agrostis tenuis 1.2,

^{33}2, Calypogeia fissa 2.3, Dryopteris diltata +, Hypochoeris radicata +, ^{15}4, Bryum pseudotriqretrum 1.2, Campylopus fragilis + Carex nigra +, Cephalozia bicuspudata 1.3, Cirsium dissectum +, Festuca ovina +.2, Juncus conglomeratus 1.2, ^{34}1, Carex hostiana 1.2, Luzula multiflora +, Minium hornum 2.3.

Variants; (i) Betonica officinalis variant, differential species - B. officinalis, Thymus drucei, Carex flacca; (ii) Hypericum humifusum variant, differential species - H. humifusum.

Ecological Notes; Although a very restricted area, this community is floristically rich, and also provides a habitat for a species of rather restricted distribution - Euphrasia virgursii.

The community is mostly found on fairly steep slopes (15° - 20°), with a very thin peat layer (0.5 - 1.5 cm) over the loose substrate. Damper areas support the Betonica officinalis variant, drier the Hypericum humifusium variant.

The first named variant has two sub-variants - (a) Campulopus introflexous sub-variant (differential species - C. introflexous, Cladonia impexa, C. rangiformis, Polygala serpyllifolia), found in areas with more open plant cover. The Southern/Oceanic nature of this sub-variant is similar to that described for the Cladonia rangiformis sub-variant, under I.1.b. (b) Plantago maritima sub-variant (differential species - P. maritima, Serratula tinctoria), indicates a more exposed site of community development.

South facing, dry slopes form the optimum habitat of the Hypericum humifusum variant. A Holcus lanatus sub-variant (differential species H. lanatus, Agrostis tenuis) indicates excessive disturbance of the podsol (i.e. near paths, trackways, etc.)

I.2.f. Agrostis tenuis community.

Identifying species; A. tenuis, Dactylis glomerata, Rumex acetosa, Festuca ovina, Rosa pimpinellifolia, Carex pilulifera, Viola riviniana, Thymus drucei, Hypnum ericetorum.

Distribution; N. Cornish Coast.

Variants; None.

Ecological Notes; A poorly defined community, within which two residues may be distinguished - (i) characterised by C. pilulifera and H. erictorum, is a grass-rich residue of the Genista pilosa community (I.1.a.) and (ii) characterised by Dactylisglomerata and Rosa pimpinellifolia, being a residue of the Dactylis glomerata - Daucus gummifer community (I.1.b.)

The community is rather species-poor, an unusual feature in maritime heaths. This, coupled with its ill-defined nature suggests that it may be merely an aggregation of relevés which are degredation products of communities I.1.a. and I.1.b. More detailed investigation is therefore needed to determine its true nature.

I.2.g. Sieglingia decumbens community.

Identifying species; S. decumbens, Festuca rubra, Agrostis tenuis, Rhytidiadelphus squarrosus, Pleurozium schreberi.

Distribution; Dartmoor, above 365 m.

Variants; (i) Carex binervis variant, differential species - C. binervis, Nardus stricta, (ii) Anthoxanthum odoratum variant, differential species, A. odoratum, Cuscuta epithymum, Galium saxatile.

Ecological Notes; This community is the result of over grazing of heath and grass-heath by sheep and horses. It is analagous to the Festuca rubra community/Ulex gallii complex (I.4.a.) The two variants noted reflect essential differences in the soil - the Carex binervis variant occuring on heavy, rather poor soils, the Anthoxanthum odoratum variant on lighter, humus rich soils. The latter has a Vaccinium myrtillus sub-variant (differential species - V. myrtillus), indicating a transitional form of vegetation between this community and the Vaccinium myrtillus Community (I.2.a.)

It is suggested that in its early stages of development, from hill grassland, the community is found as isolated Ulex gallii bushes, within the grassland mosaic. (Species composition varies, but usually includes A. odoratum, Agrostis tenuis, Sieglingia decumbens). Once established, the bushes spread rapidly. Intensive grazing is thus concentrated on a diminishing area, tending to reduce the species diversity. Once established, the U. gallii bushes are able to acidify the soil in the same way as ericoid shrubs (discussed for U. europaeus in Grubb, 1968). The combination of reduced species diversity and soil acidification thus form a self-accelerating process.

I.3. Erica vagans complex.

Of restricted distribution (Lizard peninsula, Cornwall), this complex is unique in Britain, because of the presence and abundance of E. vagans, the dominant ericoid of the Lizard heaths. The reasons for this are not particularly clear. As Coombe and Frost (1956) point out, E. vagans is not confined to Serpentine rock, which outcrops in the area, although the rock has been suggested as the reason for the existence of E. vagans and several other species confined to the Lizard. One interesting point, however, does emerge. In climate, although the Lizard is highly oceanic, there are distinct mediterranean tendencies, which could explain the strong Lusitanian element in the flora (Coombe and Frost, loc.cit.) The component defining species are shown on page 110.

I.3.a. Erica tetralix community.

Synonymy. This encompasses the Erica vagans - Shoenus nigricans heath (Tall heath) and the Agrostis setacea heath (Short heath) of Coombe and Frost, 1956.

Identifying species; E. tetralix, Ulex gallii, Molina caerulea, Carex panicea.

No. of releves.	15	7		15	7
Community.	a	b		a	b
Erica vagans	V	V	Carex panicea	IV	
Carex flacca	V	V	Sanguisorba officinalis		III
Shoenus nigricans	V	V	Viola riviniana	I	IV
Erica cinerea	III	V	Betonica officinalis	II	V
Potentilla erecta	IV	IV	Brochypodium sylvaticum		V
Calluna vulgaris	II	III	Daucus gummifer		V
Hypnum ericetorum	III	I	Filipendula vulgaris		V
Sieglingia decumbens	II	III	Agrostis montana		III
Erica tetralix	V		Dactylis glomerata		III
Ulex gallii	IV		Ulex europaeus		IV
Molinia caerulea	V		Holcus lanatus		III

Distribution; Southern half of the Lizard peninsula.

Variants; (i) Anagallis tenella variant, differential species - A. tenella, Serratula tinctoria, Succisa pratensis, Campylium stellatum. (ii) Genista anglica variant, differential species - G. anglica, Carex pulicaris, (iii) Agrostis setacea variant, differential species - A. setacea. N.B. (i) and (ii) = Tall heath, (iii) = Short heath.

Ecological Notes; In many respects, physiognomally, this is closer to bog than heath - due largely to the dominance of Schoenus nigricans. This species, with Molinia caerulea forms tussocks, which have area of flat 'pan' peat surrounding them. Thus, the resulting vegetation has something akin to the 'hummock-hollow' differentiation of ombrotrophic raised bogs. Peat depth varies from 12 - 15 cm. on the hummocks, to 4 cm. for the 'pans'. There is characteristic species differentiation with respect to the two systems - species more often located on tussocks are Succisa pratensis, E. vagans, Serratula tinctoria and those on the 'pans' Anagallis tenella, Carex panicea, Zygogonium ericetorum, Campylium stellatum, in addition to several species of Cyanophyta which develop in late summer. Despite this differentiation the vegetation can be treated as a unit because in many areas the differentiation is minimal.

The Agrostis setacea variant, found chiefly in the Northern range of this community, is physiognomically and floristically allied to the Erica tetralix community/Ulex gallii - Agrostis setacea complex. (I.2.c.) Here peat depth is shallow (3 - 5 cm.), and the heaths are frequently fired. As a result, the species diversity is usually low, and much of the vegetation is of rather an open nature, with incomplete cover.

The most widely distributed variant is the Anagallis tenella variant, found on the vast heathland expanses of Goonhilly, Crousa and Lizard Downs. Two sub-variants have been noted. An extreme wet vegetation is formed by the Carex demissa sub-variant (differential species - C. demissa, C. hostiana, C. pulicaris, Juncas articulatus, Drepanocladus intermedius, Sphagnum contortum, Sanguisorba officinalis, Agrostis montana, Scorpidium scorpidiodes). This is the most bryophyte rich form of the community. Where there is water movement through the heath, open stands of Phragmites australis can be found.

A second sub-variant, the Zygogonium ericetorum sub-variant (differential species - Z. ericetorum, Genista anglica, Juncus maritimus, Riccardia pinguis) is rather more typical of drier situations. G. anglia also occurs in the Genista anglica variant, which is characterised by an almost complete loss of tussock-pan structure, and thus is typical of the driest sites.

One peculiar feature of this heath is the occurence, in burnt areas, of species such as Plantago maritima, Festuca rubra, etc. Coombe and Frost (1956) note other such species, i.e. Poa annua, Cirsium vulgare. They see this as "a testimony as much to the efficiency of dispersal of some of the weed species as to their failure to grow in unburnt heath." However, this phenomenon is equally interesting in the light of comments by van Leeuwan (1966) that reclaimed inland heath from the Netherlands, under "wrong agricultural measures", develops a flora not unlike "trodden" areas and salt marshes. Thus, both cases exhibit an influx of salt-marsh, or 'tread' species under heavy pressure.

I.3.b. Daucus gummifer community.

Synonymy; Rock heath + Mixed heath (pro parte) of Coombe and Frost, (1956)
Identifying Species; Sanguisorba officinalis, Viola riviniana, Betonica officinalis, Brachypodium sylvaticum, D. gummifer, Filipendula vulgaris, Agrostis montana, Dactylis glomerata, Ulex europaeus, Holcus lanatus.
Distribution; Coastal cliffs of the Lizard peninsula.
Variants; (i) Carlina vulgaris variant, differential species - C. vulgaris, Pimpinella saxifraga, Lotus corniculatus, (ii) Geranium sanguineum variant; differential species - G. sanguineum.
Ecological Notes; There is a considerable physiognomical relationship between this community and the Daucus gummifer-Dactylis glomerata community/Thymus drucei complex (I.1.b.) This latter community is found within the distributional area of the Daucus gummifer community, as also is the Erica vagans variant/Genista pilosa community (I.1.a.)

The two variants develop to their maximum in sheltered south facing gulleys, running inland from the cliffs. Species typical of the exposed cliffs (Plantago maritima, Koeleria cristata) are not found in these variants, but in the more exposed sites of the community.

One of the most striking features of this community is the abundance of species usually confined to calcareous grasslands, i.e. Filipendula vulgaris, Carlina vulgaris, Pimpinella saxifraga, Geranium sanguineum, etc., in heath vegetation.

Steele (1955) notes that the brown earth soils over serpentine are not rich in exchangeable calcium, because Magnesium predominates. These species are thus apparently rather an anomaly. However, they are all found in other situations where heath develops of calcium-rich soils (limestone heath of the Mendips, and heath on Craig Breidden), suggesting that they may be tolerant over a rather wide pH soil spectrum.

Although E. vagans is not now found outside the Lizard, there are several older records. Those from Zennor and Lands End are rather unsubstantiated and doubtful. That of Connor Downs (Turner, 1805 and Davey, 1909) does seem more probable, although relatively little data concerning the accompanying vegetation is abailable. Davey (loc.cit) gives the following note; ".... a tongue of the Lizard Flora, represented by E. vagans and F. vulgaris runs out to the sand hills". Thus this area must have supported a further variant to this community - now destroyed because of intensive use of the dunes by the Ministry of Defence.

I.4. Ulex gallii Complex.

Similar in some ways to the Ulex gallii - Agrostis setacea complex (I.2.), the creation of two separate complexes was made because of the presence in the latter of A. setacea and Molinia caerulea, the absence of these in the Ulex gallii complex, with additional species A. tenuis and Sieglingia decumbens present. The distribution of the complex ranges from the Mendip Hills of Somerset through Wales, N. W. England and the Isle of Man. Details of its species components are reproduced on page 114.

I.4.a. Festuca rubra community.

Synonymy; The 'upper Ffridd' (Price-Evans, 1932), pp.

Calluna vulgaris - Heath moss sociation (Edgell, 1969), pp.

Identifying species; F. rubra, Anthoxanthum odoratum, Galium saxatile.

Distribution; S. Gloucestershire, N. W. Wales, Isle-of-Man.

No. of relevés	22	21	5	7
Community.	a	b	c	d
Potentilla erecta	IV	IV	5	
Ulex gallii	V	V	5	V
Erica cinerea	V	V	3	V
Calluna vulgaris		V	5	V
Agrostis tenuis	V	IV	2	V
Sieglingia decumbens	V	II	3	
Anthoxanthum odoratum	II		1	
Galium saxatile	IV			
Festuca rubra	V		5	
Carex flacca			5	
Agrostis stolonifera			5	
Thymus drucei			4	
Filipendula vulgaris			4	
Helianthemum nummularium			2	
Galium verum			4	
Hypericum pulchrum			4	
Viola canina	I		2	
Polytrichum piliferum				V
Deschampsia flexuosa				V
Cladonia floerkeana				IV
C. chlorophaea				IV
C. crispata				III
C. coccifera				III
Lecidia quadricolor				III
Polytrichum juniperinum				IV
Cephaloziella starkei				IV
Pohlia nutans				III

Variants; (i) Agrostis montana variant, differential species - A. montana, Carex pilulifera (ii) Hypnum ericetorum variants, differential species, H. ericetorum.

Ecological Notes; In general, a community typical of upland situations, though some of its sites are lowland. The Agrostis montana variant is found at low altitudes (50 - 180 m). There is a Campanula rotundifolia sub-variant (differential species - C. rotundifolia, Viola canina), found on the exposed coastal plateau heaths of the Lleyn peninsula.

Early colonising vegetation which precedes this community was noted at Mynydd Mawr. A list of species typical of this is; Sedum anglicum, Festuca ovina, Polytrichum piliferum, Erica cinerea, Cladonia pyxidata, C. macilenta S.L.

The more upland sites for this community are distinguished by the presence of the Hypnum ericetorum variant.

Degredation of this community can give rise to various forms of Grass Heath (sensu Tansley, 1939). Table I.4.x. (page 116) shows four releves taken from South Glos., illustrating the species composition of such areas.

I.4.b. Ulex gallii community.

Identifying species; - as complex.

Distribution; N. Somerset, W. Wales, Isle-of-Man.

Variants; (i) Molinia caerulea variant, differential species - M. caerulea, (ii) Ulex europeeus variant, differential species - U. europoeus, Pteridium aquilinum, (iii) Scirpus caespitosus variant, differential species - S. caespitosus, Zygogonium ericetorum, Carex nigra, C. panicea.

Ecological Notes; The Molinia caerulea variant is found distributed throughout the range of the community, though in areas with a good peat depth (more than 10 cm.) or where peat overlays clays and marls, a Hypnum ericetorum sub-variant is found in the more sheltered areas (woodland ridges, etc.)

Anglesey, particularly Holyhead mountain, supports the Ulex europaeus variant, indicating the extent of interference with the area. Much has been, or is being quarried for roadstone, or used as official and unofficial dumping ground. A result of the latter activity is the increase in fires, which again favours the development and maintenance of this variant.

The Scirpus caespitosus variant appears to be the result of drastic over-burning of the typical community in the Isle-of-Man. The phanerogam percentage cover is down to 80 - 85%, and the species list is very depauperate. Found particularly in the hill districts of the

TABLE I.4.x.

Grass Heath - South Gloucestershire.

Relevé No.	2	3	5	6
Exposition.	34	34	34	34
Slope	-	-	S	SW
Phanerogam % cover	100	100	100	100
Cryptogam % cover	-	-	60	-
Relevé area (m^2)	10	10	10	10
No. of species.	8	11	12	9
Calluna vulgaris	5.5	4.4	3.3	
Dicranum scoparium	5.5	1.3	4.4	
Agrostis tenuis			3.3	2.3
Festuca rubra	3.3	3.3	3.3	5.5
Potentilla erecta		+	+	
Sieglingia decumbens	+	1.2		1.2
Luzula campestris	+	+	+	+
Galium saxatile	1.3	+	3.3	4.4
Campanula rotundifolia		1.1		2.1
Pilosella officinarum		+	+	
Rumex acetosella				2.3
Deschampsia flexuosa		+		

Additional species:-

2/34: Pteridum aquilinium (+), Hieracium tridentata (r)$\frac{7}{8}$

3/34: Ulex gallii (+)

5/34: Festuca ovina (2.3); Solidago virgaurea (+)
Holcus lanatus (+); Hypochoeris radicata (r)

6/34: Lotus corniculatus (+); Plantago lanceolata (+).

west of the Rushen and Glenfaba sheadings (hills such as South Barrule, Cronk Fedjaling, etc.) The more northerly hills have a hill grassland/ blanket bog vegetation cover.

I.4.c. Carex flacca community.

Synonymy; Limestone Heath (Moss, 1903, Tansley, 1911)

Identifying species; Festuca rubra, Viola canina, C. flacca, Thymus drucei, Filipendula vulgaris, Helianthemum nummularium, Galium verum, Hypericum pulchrum, Agrostis stolonifera.

Distribution: N. Somerset, S. Pennine region.

Variants: Lotus corniculatus variant, differential species - L. corniculatus, Helictotrichon pratense, Crataegus monogyna(seedlings). Betonica officinalis, Brachypodium pinnatum, Cirsium acaule.

Ecological Notes; One of the most characteristic types of heathland vegetation, developed over leached limestone grassland. The Community has a completely homogenous mixture of 'calcifuge' and 'calcicole' species. It is an extremely species-rich vegetation - the richest(and that of earliest stage of development), being represented by the Lotus corniculatus variant. Later, full growths of Ulex gallii and the ericoid species decreases the species diversity. This community develops on steeply sloping hills, which are covered initially with the Helictotricho-caricetum flaccae, Shimwell, 1969.

When there is no slope, and well developed Brown earth soils, a 'limestone heath' can also develop, but with an even richer species assemblage. The two lists given below were taken from Burrington Coombe, N. Somerset, (G.R. 31/471585), sited on the edge of steep cliffs:

	(i)	(ii)		(i)	(ii)
Agrostis montana	2.2	2.3	Koeleria cristata		+
A. tenuis	+	+	Leontodon taraxacoides	+	
Anthoxanthum odoratum	2.2	1.2	L. autumnalis	+	
Briza media	+	+	Lingustrum vulgare		+
Carex flacca	+	+	Lotus corniculatus	1.1	+
Cirsium acaule		+	Luzula multiflora		+
C. palustre	+	+	Pilosella officinarum	+	
C. vulgare	+	+	Plantago lanceolata	+	+
Crataegus monogyna		+	Polygala serpyllifolia	+	+
Crepis capillaris	+		Potentilla erecta	+	+
Dactylis glomerata	+	+	Poterium sanguisorba	+	1.1
Dicranium scoparium	+.2	+.2	Prunella vulgaris	+	+
Erica cinerea	3.3	3.3	Pseudosderopodium purum	+	2.3
Festuca ovina	+	+	Pteridium aquilinium	3.3	2.7
F. rubra	2.2	2.2	Scabosia colombaria	+	
Frageria vesca	+	+	Senecio jacobaea	+	
Galium mollugo	+		Sieglingia decumbens	3.3	2.2
G. verum	+	1.1	Teucrium scorodonia	2.2	1.1
Helictotrichon pratense	1.1	+	Thymus drucei	+	
Hieracium vulgatum S.L.		+	Tragopogon pratensis	+	
Hypericum pulchrum	+		Ulex europaeus	+.2	3.3
Hypochoeris radicata	+		Viola canina	+	1.1
Holcus lanatus	1.2	+	V. hirsta	+	+
Hypnum ericetorum		+.2	Viburnum lanata(seedling)		1.1

Although they lack Ulex gallii, Calluna vulgarism typical of the complex, and Filipendula vulgaris, Helianthamum nummularium, from the community, the affinity to these is obvious, and it is the topography of the site, coupled with the well-developed soil structure that precludes full development of the community. Evidence from other areas suggests that eventually a grassland with E. cinerea, and dominated by Pteridium aquilinum develops.

I.4.d. Polytrichum piliferum community.

Identifying species; P. piliferum, P. juniperinum, Deschampsia flexuosa, Cladonia floerkeana, C. chlorophaea, C. crispata, C. coccifera, Lecidia quadricolor, Cephaliziella starkei, Pohlia nutans.

Distribution: Shropshire.

Variants: (i) Digitalis purpurea variant, differential species - Jasione montana, D. purpurea, Sarothamnus scoparius, (ii) Cladonia squamosa variant, differential species - C. squamosa, C. pityrea, Pteridium aquilinium.

Ecological Notes: Of rather restricted distribution, the community is found on the steeply sloping South faces of the Salopian hills, (Stiperstones, Long Mynd, etc.). In the Erica cinerea aspect , the community is very pronounced, as the slopes of the hills are red with this community, whilst the tops and plateaux are olive brown with the Pohlia nutans complex/Calluna vulgaris Heath.

The Digitalis purpurea variant is rather common, characteristic of the more 'open' areas(as Jasione montana shows), and those under the pressure of sheep grazing. On the steepest slopes several herbaceous species are found as the Teucrium scorodonia sub-variant.(differential species - T. scorodonia, Festuca ovina, Aira praecox, Rumex acetosella, Galium saxatile).

I.5. Erica ciliaris complex.

This complex, geographically restricted to East Dorset, is particularly interesting from two standpoints, (i) it is characterised by an extremely local species, and (ii) it represents the easternmost distribution of the Erica cinerea Heath.

At this point, it is perhaps pertinent to comment on the distribution of E. ciliaris. Perring, Sell and Walters (1962) show the distribution as E. Dorset, Dartmoor and S. W. Cornwall, and apparently declining in all those areas. Some mention of the Cornish sites has been made under I.2.a., and, as noted, the species is chiefly found on disturbed mine workings. It was formerly much more extensive, as Davey (1909) records "from a little to the W. of Newquay to St.Agnes that prettiest of heaths, Erica ciliaris may be found at intervals along the waysides and wastrels...." This is especially pertinent in the light of observations made earlier, i.e. that it is more or less confined to disturbed areas.

The stations of the species on Dartmoor have always been rather anomalous, as the general height (O.D.) of the Dorset and Cornish sites varies from 10 - 100 m., whereas on Dartmoor, Fraser and Martin (1939) record it as occuring at several sites, ranging between 350-400 m. An exception to this was Bovey tracey heath, but this and several other records appear in doubt. The only site it may still be found is Warren House Inn (G.R. 20/7281), where it occurs just within the bounds of a Forestry Commission plantation. No relevés have been made in this area, although the surrounding vegetation forms part of the Agrostis Setacea Community (I.6.c.) The whole area has been extensively mined and disturbed.

In Dorset, E. ciliaris is found concentrated on the North-west Purbeck heaths. Its distribution is thus rather irreconcilable with any major 'factor'. Good (1948) states "The particular interest in E. ciliaris is that its local geographical limits follow no obviously recognizable edaphic or climatic boundary, and are therefore set by some unusually subtle factor or combination of factors."

As in Devon and Cornwall, many sites of occurence are typically 'disturbed', i.e. ditch sides, disused areas quarried for clay and gravel. Therefore, it seems certain that in Britain, E. ciliaris is to be found in situations of the limes convergens type. However, there are a number of sites in Dorset not disturbed, from both wet and dry heathland, where it may be found. This can be reconciled with Good's statement and the fact that the vegetation of this part of Dorset is a major sharp boundary zone of vegetational change (Oceanic/Continental influences). The most obvious manifestation of this is the clear line of demarcation between Ulex gallii and U. minor (Proctor, 1967). The idea that major boundary areas might create these "subtle conditions" for the support of local species, has been advanced in Bellamy et. al (1969). A further point of interest is that Gentiana pneumonanthe, another species of restricted distribution is not only found in this area, but as a component of these same E. ciliaris communities.

The foregoing comments may help to clarify the position of such species as E. ciliaris, with restricted distributions. What is needed to complement these observations is an investigation to attempt to define the peculiar "subtle conditions" of boundary areas, as also discussed in Section III.

The table below notes the defining species of this complex:

No. of releves Community	17 a	8 b	No. of releves Community	17 a	8 b
Calluna vulgaris	V	IV	E. cinerea	II	I
Potentilla erecta	III	V	E. tetralix	IV	IV
Molinia caerulea	V	V	Ulex minor	V	
Erica ciliaris	V	V	Agrostis setacea	IV	

I.5.a. Ulex minor community.

Identifying species; U. minor, Agrostis setacea.

Distribution: Heaths around the South of the Poole Basin.

Variants: (i) Scirpus caespitosus variant, differential species - S. caespitosus, Carex panicea.

Ecological Notes: This community, besides having a variant of S. caespitosus, has this divided into three sub-variants. Such fragmentation of vegetation units may be taken as a further indication of the boundary nature of the community (cf. Section III.4.2.b.)

The Zygogonium ericetorum sub-variant, (differential species - Z. ericetorum, Rhychospora alba, Drosera intermedia, Polytrichum commune, Eriophorum angustifolium, Campyolopus flexuosus, Pedicularis sylvatica), is typical of wet heath communities (see also the Erica tetralix Heath). Moore(1968) notes the provisional association Ericetum ciliaris, with data from Van den Bergen. This is within the alliance Ericion tetralicis Schwick, 1933, and perhaps is more typical of the E. ciliaris vegetation in Western France, as there are basid similarities to the Ulici-Ericetum ciliaris Br.Bl. 1966, from the Basque country. Thus the sub-variant perhaps represents the closest E. ciliaris vegetation to that of continental Europe.

Agricultural land, in close proximity to heath vegetation, obviously has a considerable effect in terms of improved nutrient status and altered water regimes. One result of nutrient influx into heath vegetation is the Linum catharticum sub-variant (differential species - L. catharticum, Hypericum pulchrum, Sieglingia decumbens, Schoenus nigricans) Where the vegetation is well defined, a structure not unlike the Erica tetralix community/Erica vagans complex (I.3.a.) is found, i.e. tussock-pan differentiation. Anagallis tenella and Campylium stellatum were noted in some of the 'pans', and Genista anglica observed on some tussocks.

The Ulex europaeus sub-variant (differential species - U. europaeus, Myrica gale, Succisa pratensis) is found in degraded sites, both wet from the drainage of valley bog. (sensu Tansley, 1939) or dry at the roadside edges of heathland.

I.5.b. Erica ciliaris community.

Identifying species; - as complex.

Distribution; as I.5.a.

Variants; (i) Lythrum salicaria variant, differential species - L. salicaria, Myrica gale, Succisa pratensis, Salix atro-cinerea, Agrostis canina, Galium palustre, Hypochoeris radicata, Carex demissa.

(ii) Narthecium ossifragum variant; differential species - N. ossifragum, Gentiana pneumonanthe, Sphagnum recurvum, Cladonia arbuscula.

Ecological Notes; This community is formed of two apparently different types of habitat, but they are related, i.e. variant (i) represents degraded and (ii) represents unaffected valley bog.

The degradation, observable in the Lythrym salicaria variant, has produced a vegetation which approximates, in many respects, to both associations in the order Molinietalia, W. Koch, 1926, and the alliance Salicion cinereae Th. Müll. et Görs, 1958. Molinietalia represents anthropogenic wet-meadowland, and the Salicion cinereae the secondary pioneer scrub which typically develops from the meadowlands. Thus the synsystematic position of the variant is rather ill-defined and anomalous, but the presence of species such as E. ciliaris, E. cinerea, E. tetralix, Potentilla erecta, etc., indicates the primary affinity should be towards associations of the Calluno-Ulicetalia.

Although the hybrid of E. ciliaris and E. tetralix(= E.X. Watsonii) is fairly abundant in all the E. ciliaris vegetation types, it is particularly abundant in this variant.

The Narthecium ossifragum variant has two sub-variants, (a) Eriophorum angustifolium sub-variant (differential species - E. angustifolium), and (b) Schoenus nigricans sub-variant (differential species - S. nigricans). This latter sub-variant is found in the drier parts of bog, whereas the former is found in the wettest areas.

I.6. Vaccinium myrtillus complex.

Communities of this complex represent intermediary forms between the Erica cinerea Heath and the Vaccinium myrtillus Heath. In the South West of England they are found on high ground of Dartmoor, Exmoor and the Mendips (350 m O.D. or higher). In Scotland they have a much greater additional range (0 - 763 m O.D.), but attain their optimum between 753 - 457 m O.D.

The table on page 124 gives the major species complement of the complex.

I.6.a. Hylocomium splendens Community.

Synonymy; Callunetum vulgaris, McVean and Ratcliffe, 1962.
Identifying species; Cladonia impexa, H. splendens, Listera cordata, Vaccinium vitis-idaea, Rhytidiadelphus loreus, Scirpus caespitosus.
Distribution; Cairngorms, Western Highlands.
Ecological Notes; Described initially by McVean and Ratcliffe (1962), the community nevertheless forms part of the Vaccinium myrtillus complex. This community, with the others in the complex, are included in the Erica cinerea Heath, on the basis of floristic composition and phyto-geographical position.

Whilst the community is related to similar heaths of West Norway and Southern Sweden (Hylocomieto-Callunetum, Damman, 1957), it

Relevé number.	*	22	6	7
Community	a	b	c	d
Vaccinium myrtillus	IV	V	V	V
Hypnum ericetorum	V	III	V	V
Pleurozium schreberi	IV	II	III	IV
Deschampsia flexuosa	IV	III	II	IV
Calluna vulgaris	V	V	V	V
Potentilla erecta	IV	IV	V	V
Erica cinerea	III	IV	V	III
Dicranum scoparium	V	III	II	V
Festuca rubra		III	III	III
Agrostis tenuis	I	IV	IV	V
Hylocomium splendens	V			
Vaccinium vitis-idaea	III			
Listera cordata	III			
Rhytidiadelphus loreus	III			
Scirpus caespitosus	III			
Cladonia impexa	IV			
Agrostis setacea			IV	
Carex binervis			IV	
Luzula multiflora			V	
Cladonia arbuscula		I	III	
Sieglingia decumbens				IV
Polytrichum commune				III
Juncus squarrosus		I		III
Pohlia nutans		III		

(* See McVean and Ratcliffe, 1962).

is not truly relatable to the heaths of North-West Germany, which is more closely allied to the Calluna vulgaris Heath.

I.6.b. Pohlia nutans community.

Synonymy; Part of this community is synonymous to the Callunetum of Heath, Luckwill and Pullen (1937) and part to the Callunetum vulgaris of Watson (1932).

Identifying species; P. nutans.

Distribution; Exmoor, Quantock and Mendip Hills.

Variants; (i) Erica tetralix variant, differential species - E. tetralix, Molinia caerulea, (ii) Carex binervis variant, differential species, C. binervis.

Ecological Notes; Found between 250 - 550m, O.D., this community is the typical Somersetshire high-level moorland, or heather moor.

The Erica tetralix variant highlights the damper areas, or those with a peat depth of greater than 8 cm. Burning produces, in the earlier phases of regeneration, rather a cryptogam-rich vegetation - the Nardus stricta sub-variant (differential species - N. stricta, Scirpus caespitosus, Cladonia chlorophaea, C. crispata, C. floerkeana, Calypogeia arguta, Cephalozia bicuspidata, Agrostis setacea, Campylopus flexuosus). A thin peat layer (3 - 4.5 cm) coupled with sheep or cattle grazing produces the Carex binervis variant. Heaviest grazing pressure appears to lead to the development of the Anthoxanthum odoratum sub-variant (differential species - A. odoratum), whereas conditions not so pressured are distinguished as the Cladonia crispata sub-variant (differential species - C. crispata, C. floerkeana, Melampyrum pratense, Polytrichum juniperinum, Galium Saxatile).

I.6.c. Agrostis setacea community.

Identifying species; A. setacea, Carex binervis, Luzula multiflora, Cladonia arbuscala.

Distribution; Dartmoor.

Variants; None.

Ecological Notes; Found on disturbed ground Dartmoor. The community is notably poor in bryophytes, but relatively rich in herbaceous species, a result of the podsol disturbance, typical of the sites where it is found. There are superficial resemblances between this community and the Carex binervis variant/Pohlia nutans community (I.6.b.) q.v.

I.6.d. Sieglingia decumbens Community.

Identifying species; S. decumbens, Polytrichum commune, Juncus squarrosus.

Distribution; Dartmoor, Isle-of-Man.

Variants; (i) Scirpus caespitosus variant, differential species - S. caespitosus, Rhytidiadelphus loreus, Molinia caerulea.

Ecological Notes; The product of degredation of Heather Moor. Sheep grazing is pronounced, and Manx sites often suffer from over-grazing. Wetter conditions give rise to the Scirpus caespitosus variant, which may also be a degenerate form of wet Molinia caerulea grasslands.

I.7. Arctostaphylos ava-ursi Complex.

This complex has been structured entirely from the material published in McVean and Ratcliffe (1962). The tables have, however, been "ordered". Notes on the communities will serve only to highlight important points. Details of the species complement of the Complex is reproduced below;

Community:	a	b	Community:	a	b
Ardostaphylos uva-ursi	V	V	Pyrola media	IV	
Calluna vulgaris	V	V	Viola riviana	IV	
Erica cinerea	V	IV	Arctous alpina		IV
Deschampsia flexuosa	V	IV	Scirpus caespitosus		V
Potentilla erecta	IV	IV	Rhacomitrium lanuginosum		V
Dicranum scoparium	IV	III	Diplophyllum albicans		IV
Hylocomium splendens	IV	III	Cladonia uncialis		V
Hypnum ericetorum	IV	V	Sphaerophorus globosous		IV
Pleurozium schreberi	IV	III	Lycopodium selago		IV
Vaccinium vitis-ida ea	V		Frullaniana tam$_a$risci		IV
Genista anglica	IV		Cornicularia aculeata		III
Lathyrus montana	V		Cladonia arbuscula		IV
Lotus corniculatus	IV				

I.7.a. Vaccinium vitis-idaea community.

Synonymy; Arctostaphyleto-Callunetum, McVean and Ratcliffe, 1962.

Identifying species; V. vitis-idaea, Genista anglica, Lathyrus montanus, Lotus corniculatus, Pyrola media, Viola riviniana.

Distribution; Cairngorms, E. Highlands.

Ecological Notes; The authors regard this as "perhaps a mere facies of the Callunetum vulgaris". However, there is sufficient distinction between these communities, which emerges as the tables are 'ordered'.

1.7.b. Arctous alpina Community.

Synonymy; Juniperetum nanae + Rhacomitreto - Callunetum Arctostaphyletosum - McVean and Ratcliffe, 1962.

Identifying Species; A. alpina, Scirpus caespitosus, Rhacomitrium lanuginosum, Diplophyllum albicans, Cladonia uncialis, C. arbuscula, Sphaerophorous globosous, Lycopodium selago, Frullania tamarisci, Cornicularia aculeata.

Distribution; N. W. Scottish Highlands.

Variants; (i) Juniperus nana variant, differential species - J. nana.

Ecological Notes; The additional range of this community is from 305 - 763 m O.D. and the community is typically found in rather exposed habitats.

Within the Juniperus nana variant, there is a Pleurozia purpurea sub-variant (differential species - P. purpurea, Herberta sp., Cladonia impexa), synonymous to the facies hepaticosum, found only on exposures to the North and East. The soil development is a raw humus overlaying a substrate of large rock fragments.

I.8. Ulex europaeus Complex.

There is just one component community within this complex. Details of the species complement are:

No. of relevés:	10	No. of relevés:	10
Ulex europaeus	V	Potentilla erecta	V
Erica cinerea	V	Agrostis setacea	V
U. minor	IV	Calluna vulgaris	V
Molinia caerulea	V		

I.8.a. Ulex europaeus community.

Identifying species; as complex.

Distribution; Heaths in S. W. Hampshire.

Variants; (i) Erica tetralix variant, differential species - E. tetralix, U. gallii, Carex pilulifera, Polygala serpyllifolia, (ii) Serratula tinctoria variant, differential species, S. tinctoria.

Ecological Notes; A most interesting community, because, with the Erica ciliaris complex (I.5.), this represents an eastern intrusion of the Erica cinerea Heath into land occupied by Calluna vulgaris Heath.

With reference to its most obvious defining species, (U. europaeus), Tubbs and Jones (1964), note the following about its New Forest distribution, "In detail the gorse stations are shown by our field notes to fall into four categories:-

(A) (1) ditches, track edges.
(2) abandoned gravel workings.
(3) edges of grass 'leys'.
(4) tumuli
(5) railway cuttings.
(6) ground disturbed by the military.

(B) Areas of gorse were found to be characteristic of heath edges close to settlements which used to turn out substantial stock herds.

(C) Sites that have been cultivated or enclosed at some time.

(D) It was estimated that approximately one quarter of the area of gorse in the New Forest does not fall into the categories so far listed." They further suggest reasons for these four categories, based on the fact that U. europaeus is more exacting in terms of nutrients etc., than Calluna vulgaris, Erica spp. etc., "(A) Mass disturbance has inverted the soil horizons, thus releasing some nutrients trapped by podsolization. (B) Heavy dunging of these areas would increase the nutrient status, (C) former night folding and ploughing of the soil would similarly increase nutrients, and (D) no obvious explanation." (underlining mine).

In terms of sociological position, their categories (A) - (C) are more properly part of the alliance Ulici-Sarothamnion, Doing 1962, and thus not part of the 'Heath' scheme. (D) sites, however, represent areas where this Ulex europaeus community is developed. Also, these areas show evidence of podsolization. The Erica tetralix variant does not form part of Tubbs and Jones. (D) category, being a more typical heathland vegetation. Its interesting feature, however, is the co-occurence of U. minor and U. gallii in the same relevés.

The Seratula tinctoria variant, with its Sieglingia decumbens sub-variant (differential species - S. decumbens. Hieracium tridentata), do form part of the (D) category. This is best developed in the Beaulieu Heath/Hatchet Pond area, G.R. 40/4001.

As the case with the Erica ciliaris complex (I.5.) this is sited in a major phytogeographical boundary, and therefore the unusual community could be explained by this factor (de Smidt, pers.comm).

In this connection, it is interesting to note that Serratula tinctoria occurs in heath situations only in the Maritime heaths. (Thymus drucei complex), and this complex. However, where woodland abutts onto heath or poor grassland, S. tinctoria is found on the boundary between them. This species is, therefore, characteristically a 'boundary' species, reinforcing the arguments advanced above.

I.9. Teucrium scorodania complex.

As with the previous, the complex has only one component community. The defining species are shown in the Table reproduced below:

No. of relevés:	10.	No. of relevés:	10.
Erica cinerea	V	Calluna vulgaris	IV
Agrostis tenuis	V	Deschampsia flexuosa	IV
Teucrium scorodonia	V	Dicranum scoparium	V
Campanula rotundifolia	III	Pleurozium schreberi	IV
Solidago virgaurea	III	Hypnum ericetorum	IV
Hypericum pulchrum	III	Potentilla erecta	II
Viola hirta	IV	Galium saxatile.	III
Rubus fruticosus S.L.	II		

I.9.a. Teucrium scorodonia community.

Identifying species: as complex.

Distribution; Confined to Dolerite cliffs at Craig Breiddon, Montgomeryshire.

Variants; (i) Agrostis stolonifera variant, differential species - A. stolonifera, Pseudoscleropodium purum, Oxalis acetosella, with seedlings of Quercus spp., Sorbus aucuparia, Fagus sylvatica, (ii) Festuca ovina variant, differential species - F. ovina, Vaccinium myrtillus.

Ecological Notes; Many species present in this Community could be described as calciphilous - although this is true, the community is a completely homogenous mixture of calcicoles and calcifuges. In physiognomy, there is much similarity between this community (particularly the Festuca ovina variant), and the 'limestone heath' (I.4.c.) or 'rock heath' (I.3.b.)

The Agrostis stolonifera variant is located on the upper slopes, where the tree seedling are capable of development to meet the full growth of forest-crowning the hill.

The Festuca ovina variant has two sub-variants (a) the Luzula campestris sub-variant (differential species - L. campestris, Cladonia furcata, C. pityrea, C. arbuscula, C. chlorophaea), and (b) the Geranium sanguineum sub-variant, (differential species - G. sanguineum, Eurhynchium striatum, Scabiosa columbaria, Pilosella peleteranum, Crataegus monogyra (small bushes), and Helianthemum nummularium).

The first of these is typical of the more exposed and rather young developing heath, whilst the second illustrates the richest development of this unusual vegetation.

An unusual and restricted community such as this, and the preceding, is almost certainly the result of their position in phytogeographic boundary zones. Although the major vegetation type of the area is the Vaccinium myrtillis heath, there are communities of other 'Heaths' in this area, in addition to a small number of relevés unassignable to any of four 'Heath' units, reproduced as Table I.9.x., shown below.

TABLE I.9.x.

Releve number:	59	54	58	57	53	55	56	52
	40	40	40	40	40	40	40	40
Exposition:	SW	S	SW	S	SW	S	SW	S W
Slope:	5	35	30	25	30	30	25	35
Phanerogam % area	85	90	85	85	90	90	100	90
Cryptogam % area	50	25	20	15	40	30	10	5
No. of species	13	12	20	12	15	12	15	18
Erica cinerea	+	4.4	3.3	1.2	4.4	4.4	4.3	4.4
Calluna vulgaris	5.4	3.3	4.4	5.4	4.4	2.2	1.2	3.4
Deschampsia flexuosa	1.3	2.2	1.2	+	1.2	1.1	1.2	2.1
Dicranum scoparium		2.2			1.1	+	+	
Vaccinium myrtillus	1.2	1.3	r				2.2	+
Parmelia physodes	+		+		1.2			
Polytrichum piliferum			+.2	+	+			+
Cladonia floerkeana	+		+	2.2	1.1	+		+
C. chlorophaea			+	2.2	+	+	+	
C. crispata	3.3		2.2	+	+.2	+	+	1.1
Lecidia quadricolor	2.3	2.3	1.2	+		1.3	+	+
C. coccifera	+	+	1.2		+			+
Pohlia nutans	1.1		+			+		+
Pteridium aquilinum		2.1		+	+			
Sorbus aucuparia		+			+	+		
Cladonia furcata			1.2	+			+	
C. squamosa					+		1.2	
Polygala serpyllifolia						1.2		+
Sarothamnus scoparius						+		1.2
Digitalis purpurea							+	+
Agrostis tenuis							+	+
Galium saxatile			r				+	+
Erica tetralix				+2	+2			
Cephalozia bicuspidata			+					+

Additional species; $^{50}40$ Lophozia bicrenata 1.2; $^{43}40$ Betula spp (seedlings) +: Cladonia gracilis 1.2; $^{49}40$ Cladonia pityrea +; C. fimbriata +; Festuca rubra +; $^{42}40$ Gymnocolea inflata 1.2; Jasione montana 1.2; $^{44}40$ Cladonia impexa +; $^{46}40$ Hypnum ericetorum +; $^{41}40$ Polytrichum juniperinum +; Calypogeia mülleriana +:

Further evidence of the unusual phytogeographical position of this area is given by the occurence of three 'restricted' species on Craig Breidden -(Potentilla rupestris, Lychnis visceria and Veronica spicata). Certainly an attempt to understand the nature and function of this vegetation must start from the standpoint of its peculiar phyto-geographic position.

I.10. Scirpus caespitosus complex.

Confined to the North-west of Scotland, this is related to the Trichophoreto-Eriophoretum typicum and Molinieto-Callunetum associations (McVean and Ratcliffe, 1962), arising where the peat layer is less than 20 cm., or where excessive drying out of peat occurs. The species complement is shown below:

No. of releves:	10	10	No. of releves:	10	10
Community:	a	b	Community:	a	b
Calluna vulgaris	V	V	Pleurozium schreberi	IV	III
Cladonia uncialis	III	II	Hypnum ericetorum		IV
C. arbuscula	IV	II	Erica cinerea	IV	V
Rhacomitrium lanuginosum	III	II	Molinia caerulea	V	IV
Scirpus caespitosus	V	IV	Erica tetralix	IV	II
Dicranium scoparium	IV	II	Agrostis tenuis		V
Hylocomium splendens	VI	III	Polygala serpyllifolia		IV
Rhytidiadelphus loreus	III	IV	Sieglingia decumbens		V
Potentilla erecta	V	V			

I.10.a. Scirpus caespitosus community.

Identifying species: as complex.

Distribution: N. W. Scottish Highlands.

Variants: (i) Diplophyllum albicans variant, differential species - D. albicans, Narthecium ossifragum, Cladonia papillaria, C. chlorophaea, C. floerkeana, Eriophorum angustifolium, Carex panicea. (ii) Carex binervis variant, differential species- C.binervis, Sphagnum rubellum.

Ecological Notes; The Diplophyllum albicans variant, is typical of 'high western' situations. The relevés were described from a sea-level site near Ullapool, Wester Ross. Peat depth is 10 - 20 cm. deep, over Torridonian sandstone. There is some degree of erosion of the peat surface. It seems highly probable that this vegetation is here the climatic climax.

A pronounced Juncus squarrosus sub-variant (differential species J. squarrosus, Narthecium ossifragum, Nardus stricta, Sphagnum tenellum, Blechnum spicant) is found in the Carex binervis variant. Typical of grazed forms of this community, it has a peat layer of 15 - 20 cm., and is usually rather moist. The non-grazed form of the variant shows many characteristics of deep peat vegetation. One particularly interesting relevé - 3/105 should be noted. From the Beinn Eighe Nature reserve, the relevé is primarily bryophytic in nature, showing many 'high western-montane' species, e.g. Pleurozia purpurea, Herberta hutchinsae, Orthothecium rufescens.

I.10.b. Agrostis tenuis community.

Identifying species; A. tenuis, Sieglingia decumbens, Polygala serpyllifolia.

Distribution; Outer Hebrides.

Variants; (i) Carex pulicaris variant, differential species - C. pulicaris C. panicea, Viola canina, Hypericum pulchrum, Blechnum spicant, Dactylorhiza ericetorum, Leucobryum glaucum, Pilosella officinarum. (ii) Carex flacca variant, differential species - Nardus stricta, Festuca vivipara, Euphrasia micrantha, C. flacca.

Ecological Notes; The only community to be described from the 'atlantic' province, this has some similarities with the Carex panicea community/ Thymus drucei complex. (I.1.e.) The Carex pulicaris variant is found usually on rather steep slopes where the blanket peat becomes very thin.

This allows several herbaceous species to act as components of the community.

The Carex flacca variant is found in areas of sheep grazing, accompanied by water seepage through the peat. A Carex hostiana sub-variant (differential species C. hostiana, Scapania gracilis) has been described for particularly damp areas.

Although this community is widespread, it is found as 'islands' surrounded by blanket peat. Near the sea, wind effects are sufficient to maintain this type of community, preventing the establishment of many species of the Trichophoreto-Eriophoretum typicum, the most widespread and abundant community in this province.

II. Calluna vulgaris Heath.

Analagous to the Calluno-Genistion, this 'Heath' is the continental vegetation type - as noted in Section I, compared to the Erica cinerea Heath, the communities of this Heath are species poor - being found chiefly on the sandy Tertiary deposits of the South and East of England. Species characteristic of the Heath are; Calluna vulgaris, Hypnum ericetorum, Dicranum scoparium, Parmelia physodes. Map 3 shows the distribution of this heathland type, and Fig.3. illustrates the hierachy of the complexes and communities.

I.1. Ulex minor complex.

Spreading from East Dorset to Kent, this complex forms the bulk of lowland heath found on the Eocene deposits known as the Bagshot Beds. The complex is synonymous with the Callunetea of Fritsch and Parker (1913) and Summerhayes and Williams (1922).

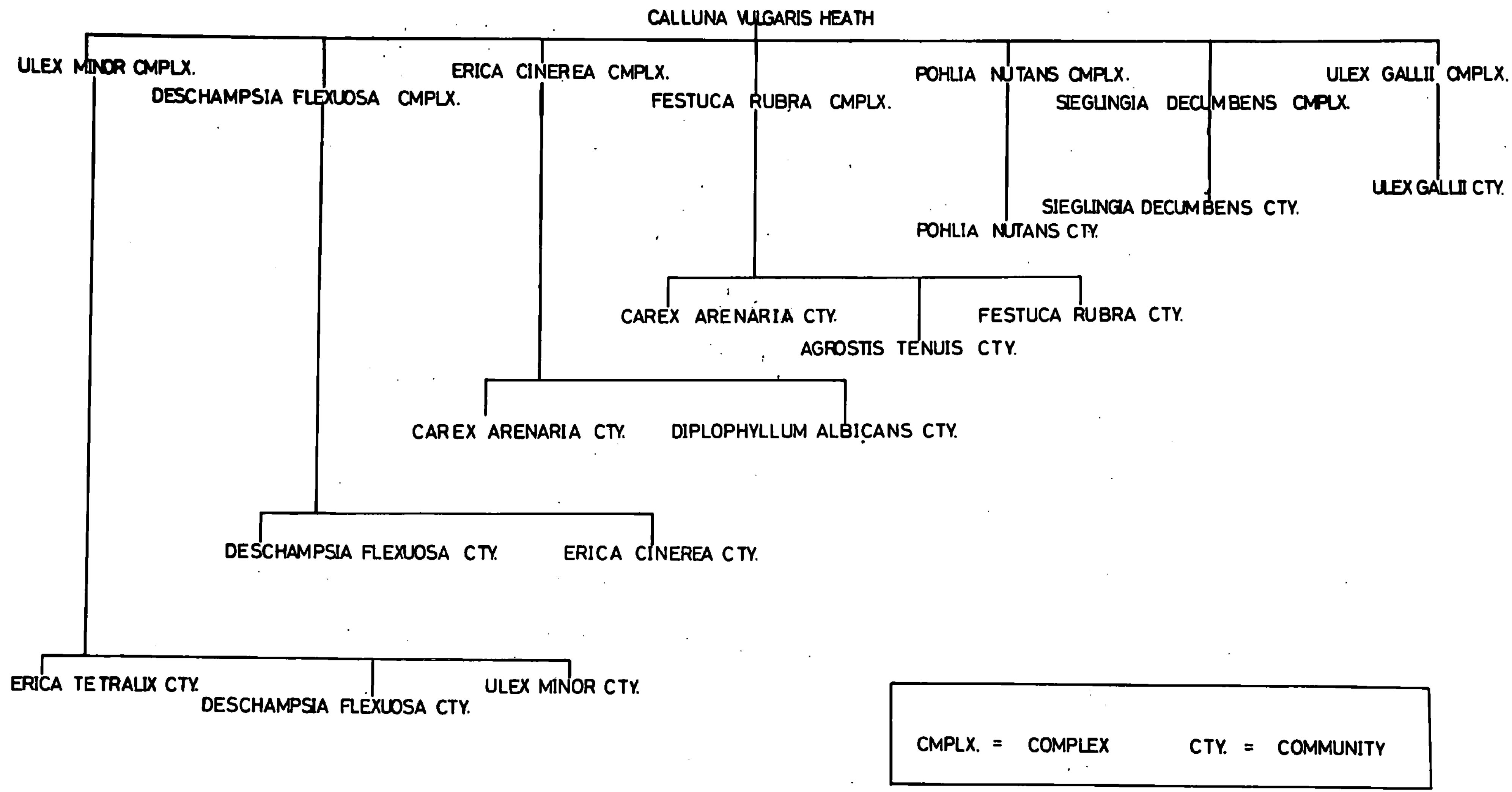
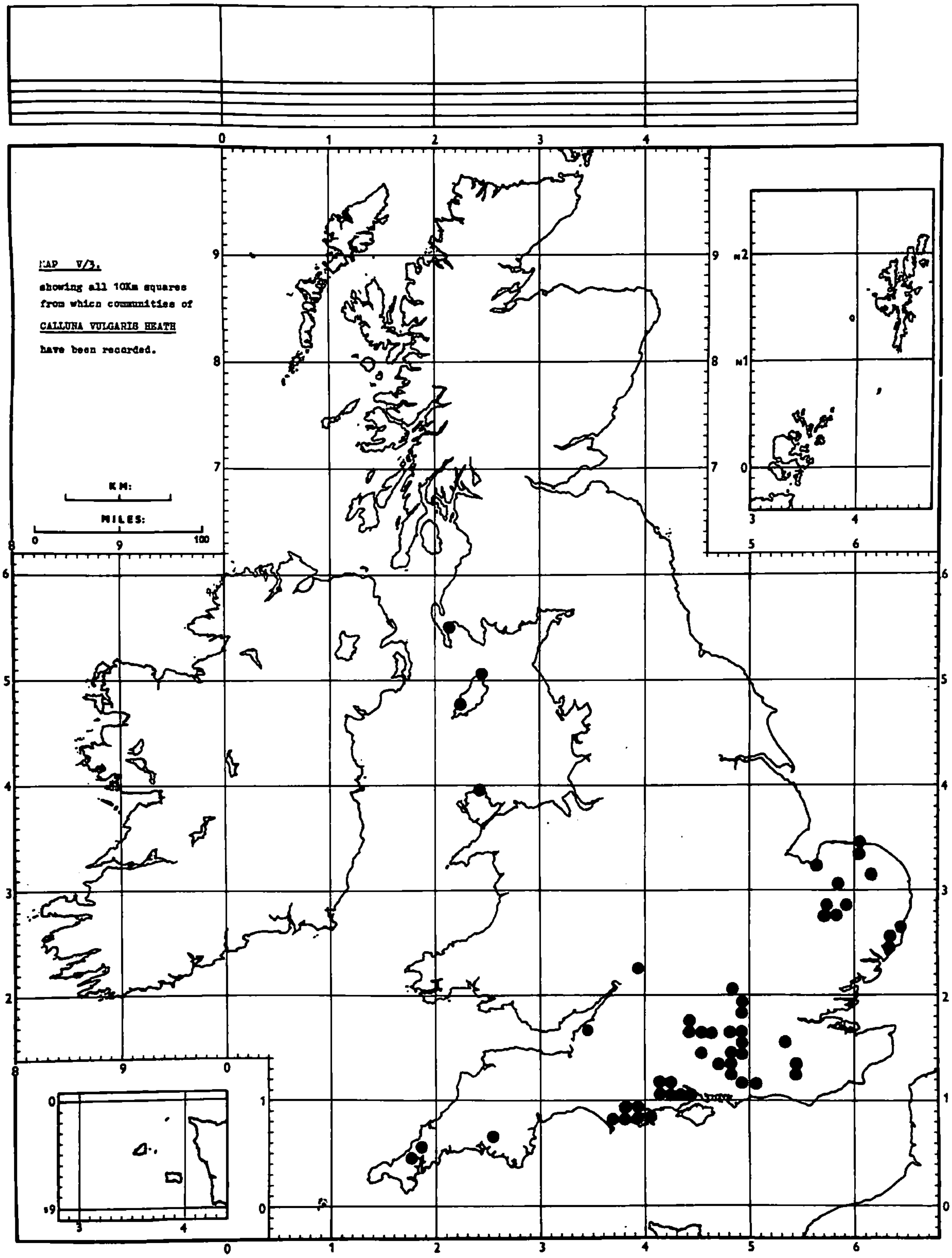

CALLUNA VULGARIS HEATH
ULEX MINOR CMPLX.
DESCHAMPSIA FLEXUOSA CMPLX.
ERICA CINEREA CMPLX.
FESTUCA RUBRA CMPLX.
POHLIA NUTANS CMPLX.
SIEGLINGIA DECUMBENS CMPLX.
ULEX GALLII CMPLX.
ULEX GALLII CTY.
SIEGLINGIA DECUMBENS CTY.
POHLIA NUTANS CTY.
CAREX ARENARIA CTY.
AGROSTIS TENUIS CTY.
FESTUCA RUBRA CTY.
CAREX ARENARIA CTY.
DIPLOPHYLLUM ALBICANS CTY.
DESCHAMPSIA FLEXUOSA CTY.
ERICA CINEREA CTY.
ERICA TETRALIX CTY.
DESCHAMPSIA FLEXUOSA CTY.
ULEX MINOR CTY.
CMPLX. = COMPLEX
CTY. = COMMUNITY

fig V/3

MAP V/3

Showing 10Km squares from which communities of the Calluna vulgaris Heath have been recorded during the Heathland survey. (See Map V/1 for the full area covered)


MAP V/3.
showing all 10Km squares
from which communities of
CALLUNA VULGARIS HEATH
have been recorded.
KM:
MILES:
0
100

Number of relevés.	56	17	9
Cummunity.	a	b	c
Calluna vulgaris	V	V	V
Erica cinerea	V	V	V
Molinia caerulea	V	IV	III
Ulex minor	V	V	V
Hypnum ericetorum	II	I	II
Cladonia impexa	II	I	II
Parmelia physodes	II	I	II
Dicranum scoparium	I	II	III
Erica tetralix	V		
Deschampsia flexuosa	I	V	
Betula species (seedling)	I	II	

II.1.a. Erica tetralix community.

Identifying species; E. tetralix.

Distribution; The range of the complex, most common in the New Forest area.

Variants; (i) Leucobryum glaucum variant, differential species - L. glaucum, (ii) Betula spp. variant, differential species - Betula spp. (seedlings), Quercus spp. (seedlings), Deschampsia flexuosa, (iii) Pteridium aquilinum variant, differential species - P. aquilinum, Ulex europaeus, (iv) Agrostis setacea variant, differential species - A. setacea.

Ecological Notes; A widespread community, which, although defined by the presence of E. tetralix, is not a 'wet heath' (sensu Tansley, 1939). Peat depth is usually between 3 - 5 cm. over a substrate of sand, or gravel fragments.

Of the four variants, the most widespread is the Agrostis setacea variant, which becomes rarer in Kent, Sussex and Surrey, as its distribution is primarily South Western. Four sub-variants are distinguished, (a) the Pteridium aquilinum sub-variant (differential species P. aquilinum), (b) Ulex europaeus sub-variant (differential species - U. europaeus, (c) Zygogonium ericetorum sub-variant (differential species - Z. ericetorum) and (d) Campylopus brevipilus sub-variant (differential species C. brevipilus).

The first two represent areas which have been affected by man's disturbance - Ulex sites in particular. Those from the New Forest fall into the categories A, B & C of Tubbs and Jones (1964) (see also the Ulex europaeus community - I.8.a.) Sub-variants (c) and (d) are indicative of much damper conditions, as also is the Leucobryum glaucum variant. These vegetation units approximate to those of the Zygogonium ericetorum complex/Erica tetralix Heath (IV.1.)

Relatively undisturbed sites, close to woodlands, show the Betula spp. variant, with both Betula and Quercus spp. seedlings, thus illustrating the considerable ability of these species to regenerate in this community. Where planted near to heath, seedlings of Castnea sativa can be found in this variant.

If disturbance has broken the podsol (gravel pits, trackways, heath/road junctions, etc), the Pteridium aquilinum variant is found. This is largely confined to the heaths of the upper and lower greensands in N. Sussex and Kent.

II.1.b. Deschampsia flexuosa community.

Identifying species; D. flexuosa, Betula spp. (seedlings).

Distribution; S. E. Berks., Surrey, N. W. Sussex, Ashdown Forest.

Variants; (i) Festuca rubra variant, differential species - F. rubra.

(ii) Vaccinium myrtillus variant, differential species - V. myrtillus, Quercus spp. (seedlings), Pteridium aquilinum.

Ecological Notes; Depth of peat is negligable in most areas where this community is found (0.5 - 2 cm). The Festuca rubra variant is typical of the driest areas. At one site (Owlsmoor, Berks.) this variant had a large number of Agricultural grassland species present (e.g. Holcus lanatus, Lotus uliginosus, Trifolium dubium, Cynosurus cristatus,) because the land had been cultivated until relatively recently. A further conseqsequence of this anthropogenic interference was the occurence of patches of Sarothamnus scoparius in this area.

Many heaths once abundant in the South Greater London area are now mere vestiges of a widespread heath vegetation. A large number of commons exist in this area, some of which are still primarily heath (Wimbledon Common), but most are acid grassland areas, with perhaps occasional 'islands' of Calluna vulgaris vegetation. One rather well-developed site of this nature is Westend Common, Caterham, described and entered in the table for this community as relevé 24/17.

The Vaccinium myrtillus variant has an Agrostis setacea sub-variant (differential species - A. setacea), localised on Chobham ridges - the furthest east A. setacea is found in Britain. V. myrtillus itself is found fairly extensively in the heaths of the Bagshot Beds - rather an anomaly in terms of its general distribution, which is North and Western (see Map.4.) However, whilst it occurs in open heath to the North and West of Britain, in the South and East of England it is found only in heath and at woodland edges or areas which have a good cover of Pteridium aquilinum.

II.1.c. Ulex minor community.

Identifying species; - as complex.

Distribution; Dorset, Lwr. Greensand of Surrey and Sussex.

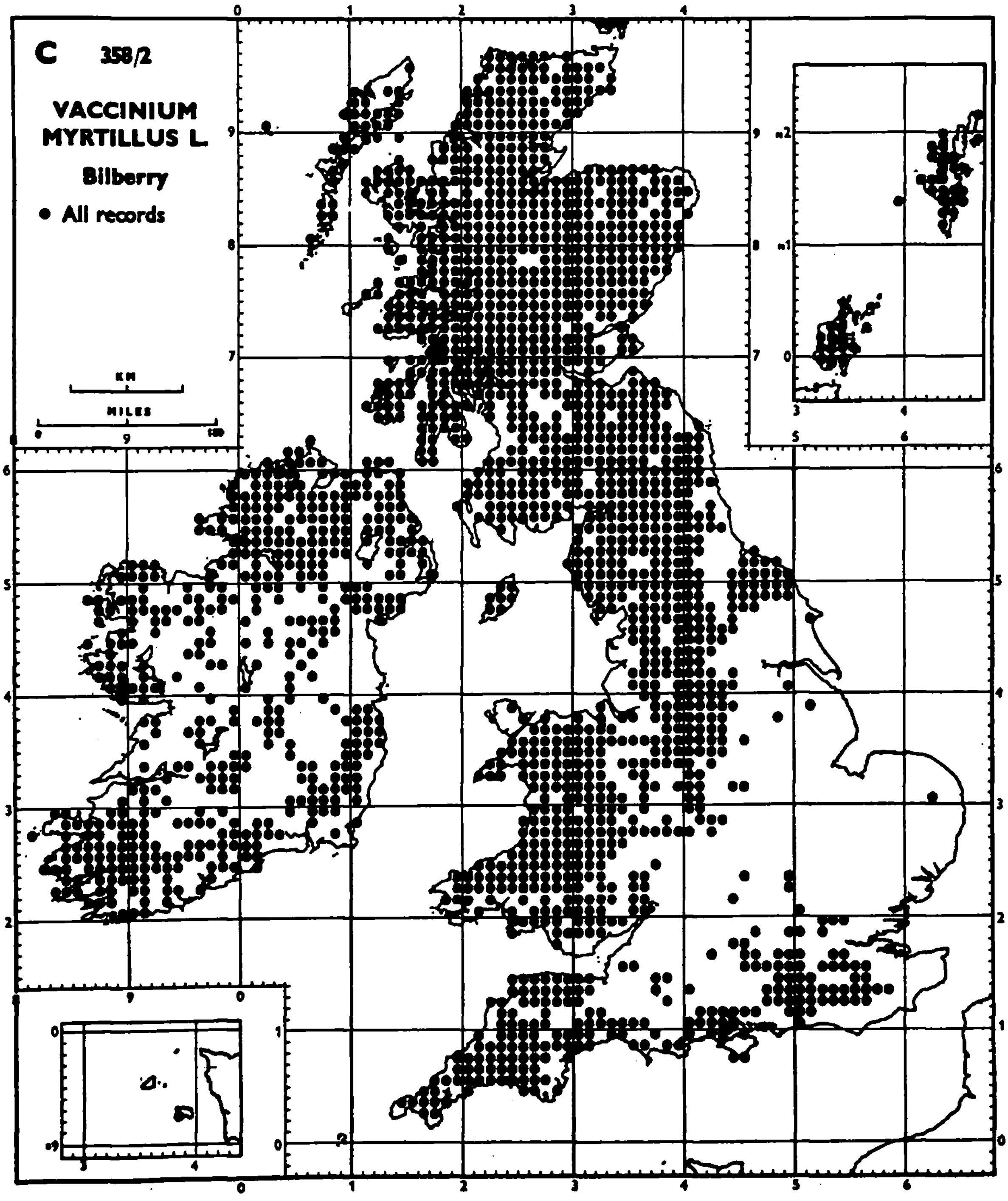
Variants; (i) Agrostis setacea variant, differential species A. setacea.
(ii) Ulex europaeus variant, differential species - U. europaeus.

Ecological Notes; Again this community has a very thin peat layer (1.5 - 2 cm.) with the exception of one relevé from Studland Heath, Dorset, which had a depth of 7 cm. This was due to the area having been rather densly

MAP V/4

Showing the distribution of Vaccinium myrtillus.

(Reproduced from 'Atlas of the British Flora' by kind permission of the publishers - Thomas Nelson & sons Ltd.)


C 358/2
VACCINIUM MYRTILLUS L.
Bilberry
● All records
KM
MILES

covered by Pteridium aquilinum, the lightly humified leaves of which added considerably to the completely humified peat.

The two variants are geographically exclusive - the Agrostis setacea variant is confined to Dorset, the Ulex europaeus variant to the greensand of Sussex. The latter is produced by heavy burning, trampling or other anthropogenic influences. It is related to associations of the Ulici-Sarothamnion (Doing, 1962, 1963). As noted by Doing, these form the first degradation phase of woodlands, which give way to the associations of the Calluno-Genistion as the second degredation phase.

This variant could, therefore, be regarded as representing an intermediate stage of degredation - or, alternatively an initial stage in the development of secondary woodland. An interesting feature is the behaviour of Ericoid species in this variant, which become elongated and 'straggly' - reaching 0.75 - 1.25 m. in height.

II.2. Deschampsia flexuosa complex.

Located on sands and gravels of Eocene deposits of the N. W. London basin, and Greensands on the West of the Weald. The component species are noted below:

Number of relevés:	12	17
Community:	a	b
Calluna vulgaris	V	V
Deschampsia flexuosa	IV	IV
Dicranum scoparium	IV	IV
Hypnum ericetorum	III	IV
Parmelia physodes	III	I
Erica cinerea	V	

II.2.a. Erica cinerea community.

Identifying species; E. cinerea.

Distribution; Confined chiefly to Upper and Lower Greensands, in the Farnham-Ambersham region.

Variants; (i) Pteridium aquilinum variant, differential species - P. aquilinum, Cladonia floerkeana, (ii) Quercus spp. variant, differential species - seedlings of Quercus spp., Pinus sylvestris.

Ecological Notes; This community is typically species poor, with little depth of peat (1.5 - 2.5 cm.), and is often found as an early stage in the development of burnt heathland, accompanied by a dense cover of algae (chiefly cyanophyta) and crustaceous lichens on the peat surface.

One exception to the species-poor description is the Pohlia nutans sub-variant (differential species - P. nutans, Cladonia gracilis, C. pyxidata, C. uncialis, Cornicularia aculeata) of the Pteridium aquilinum variant, found as heath glades in Birch Woodland, in the extreme West of Surrey.

The Quercus spp. variant is rather distinct, being found at the edge of Pinus plantations. Here, the Erica cinerea community is found as a band 2 - 2.5 m. wide, from the edge of the Pinus shade area to the typical Ulex minor community (II.1.a.) This is a case of a limes convergens situation (See Section III). It is interesting to note that this would not be easily detected by the differential profile technique, because the chief vegetational change is caused by a difference in the relative abundance of the two dominant species (Erica cinerea/Calluna vulgaris) rather than major changes in species composition.

II.2.b. Deschampsia flexuosa community.

Identifying species; - as the complex.

Distribution; Berks. and Bucks.

Variants; (i) Betula spp. variant, differential species - B. spp. (seedlings), (ii) Quercus spp. variant, differential species - Q. spp. (seedlings), Festuca rubra.

Ecological Notes; The Betula spp. variant is confined to the Bagshot Beds North and East of Newbury. Once rather extensive heathland, this area now has dense stands of woodland (dominant species: Betula pendula and B. pubescens). Those areas not wooded are represented by this variant. A Vaccinium myrtillus sub-variant (differential species - V. myrtillus, Pteridium aquilinum, Quercus spp. (seedlings)), is found where dense stands of P. aquilinum are located. The same comments concerning V. myrtillus made under community II.1.b. also apply here.

As the Newbury Commons are represented by the Betula spp. variant, so the Buckinghamshire heathland, such as remains, is represented by the Quercus spp. variant.

Within this variant, there are three recognizable sub-variants, (i) the Polytrichum commune sub-variant, (differential species - P. commune, Cladonia fimbriata, Carex pilulifera, Juncus conglomeratus, Fagus sylvatica-less than 2 m. high) found in Acid Beech woods on the clay and gravel tops of the Chiltern Ridge, (ii) the Luzula campestris sub-variant (differential species - L. campestris, Agrostis tenuis, Sieglingia decumbens, Galium saxatile) characteristic of the grassy heaths adjacent to woodlands on the upper Eocene gravels of S. Bucks., and (iii) the Potentilla erecta sub-variant (differential species - P. erecta, Holcus mollis, Crataegus monogyna, Rubus discolores, Agrostis tenuis), characteristic of woodland edges in Oak/Birch woodland in lowland Bucks.

It is interesting to note that van Leeuwan (1966) describes communities of Woodland edges as "the biological culminating-point of the limes divergens". In Section III.4.2. it was noted that under classificatory techniques the limes divergens situation yields a highly fragmented set of species groups. Applying these statements to the latter-named sub-variant, their accuracy can be established because there are two well defined further "forms" that can be distinguished. These two forms are defined as follows:- (a) by Sieglingia decumbens, Pseudoscleropodium purum, Succisa pratensis and (b) by Lonicera peridymenum, Hieracium tridentata. Thus the extreme variability of vegetation at the periphery of woodlands is shown.

II.3. Erica cinerea complex.

This complex encompasses two communities from rather different habitats, (a) sand dune vegetation from the Isle of Man and S. W. Scotland, and (b) vegetation of metalliferous mine waste tips in the Isle of Man, N. Wales and Cornwall. The one uniting feature of these two communities is the open, unstable nature of the substrate. The relation of this complex to the following, by the unstable substrate and floristic composition are the reasons for including in this Heath type. In distribution, the complex is responsible for the Western sites of the Heath. (See Map 3.) Vascular plant colonisation of the substrate is direct, and not mediated through a bryophyte and lichen initial community.

II.3.a. Carex arenaria community.

Identifying species; C. arenaria, Polytrichum piliferum, Agrostis tenuis.

Distribution; as above.

Variants; (i) Cornicularia aculeata variant, differential species - C. aculeata, Cladonia uncialis, C. spp. (ii) Rosa pimpinellifolia variant, differential species - R. pimpinellifolia, Festuca ovina, Jasione montana, Lotus Corniculatus, Luzula campestris, Aira praecox, Ononis repens. (N.B. cf. the Emptero-Genistetum Caricetosum arenariae, Westhoff 1947). (iii) Cladonia coccifera variant, differential species - C. coccifera, Pinus sylvestris (seedlings), (iv) Potentilla erecta variant, differential species P. erecta, Luzula multiflora, (v) Erica tetralix variant, differential species - E. tetralix, Diplophyllum albicans, Juncus squarrosus, Mylia taylori, Polytrichum commune.

Ecological Notes; Confined to Northern sand dunes, the driest, most acidic of which support the Cornicularia aculeata variant, and the Cladonia coccifera variant. The latter has as a diferential species Pinus sylvestris seedlings, which result from natural regeneration from Forestry Commission plantations, illustrating the ability of Pinus to colonise early developing podsolic soils.

Towards the Western edge of the Ayreland dune system (Isle of Man), the dune sand becomes more calcareous, and the attendant vegetation includes a number of species more typically calcicolous (e.g. Rosa pimp-inellifolia, Ononis repens, Camptothecium sericeum, Thymus drucei). This is expressed as the Rosa pimpinellifolia variant, which is further divided into a Plantago coronopus sub-variant (differential species - P. coronopus, Hypochoeris radicata, Usnea sub-florida), found in the more open, earliest colonised areas. The Rosa plants are less than 5 cm. high, and the whole area is severely wind-trimmed. Dune slacks are represented by the Erica tetralix variant. The occurence of Carex arenaria, typically a species of dry dune grassland and heath, in these slacks, may be regarded as unusual. However, Tyler and Crawford (1969), showed that C. arenaria, together with a number of recognised 'helophytes', is tolerant of flooding, and this explains the anomaly.

II.3.b. Diplophyllum albicans community.

Identifying species; D. albicans.

Distribution; (see notes under complex).

Variants; (i) Agrostis stolonifera variant, differential species - A. stolonifera, (ii) Agrostis tenuis variant, differential species - A. tenuis, Calypogeia trichomanes, Cladonia squamosa, (iii) Usnea sub-florida variant, differential species U. sub-florida.

Ecological Notes: Large areas of rubble left after surface mining operations for heavy metals is colonised more or less immediately by this community. As Jain and Bradshaw (1966) have indicated, plants tolerant of heavy metal ions are usually confined solely to sites such as these spoil heaps. Therefore, it could be argued that this community is even more rigidly defined, because species such as Agrostis tenuis, A. stolonifera and even Calluna vulgaris will be the 'tolerant' ecotype, i.e. genetically distinct.

Varieties of some species are sometimes used as Trennarten, and sub-species frequently, a good example being the definition of Gentiano-Pimpinelletum Tx. ex Westhoff (1962), 1967, described in Tüxen (1967). This poses the question, "should physiologically distinct ecotypes be used as Trennarten, even if they are morphologically identical to the non-tolerant forms?" This question is not simply answered, chiefly because unless experimentation is undertaken, tolerance/non-tolerance is not detectable. Certainly, physiological changes are more valuable ecological indicators than simple morphological variation, which may be insignificant ecologically.

A special case of the latter, which has occured in heathlands, is Calluna vulgaris var. incana Reichb. (= C. vulgaris var hirsuta, S.F. Gray), which, although quite distinct, shows no particular ecological preference, occuring rather randomly (not specifically near to the sea, as Clapham, Tutin and Warburg (1962) state).

Therefore, it seems necessary that consideration of the status of sub-species and varieties, or the existence of non-distinct forms, in constructing Phytosociological tables, is very necessary to ensure the system does not become unwieldly, or cease to reflect environmental distinctions.

The Usnea sub-florida variant of this community is analagous to the Plantago Coronopus sub-variant/Rosa pimpinellifolia variant of the previous community.

Both Armeria maritima and Plantago maritima have been found on Cornish inland sites of this community. This raises points similar to those discussed in Section I.III.a. As noted there, this may be merely an indication of the dispersive capacity of the plants. However, as both the habitats of the mine tips, and typical maritime habitats of A. maritima and P. maritima can be included as limes convergens situations, the behaviour of these species seems better explained in those terms.

The Agrostis tenuis variant is most widespread of the variants, and has a Cladonia chlorophaea sub-variant (differential species - C. chlorophaea, Pohlia nutans), found on the higher more exposed soil heaps of the Glen Rushen mines, Isle-of-Man.

Although the relevés are generally species-poor 34/71, has a larger number of species than average. This site was the edge of mine tip sloping into a now dried pool, which provided several additional, rather anomalous species, i.e. Equisetum fluviatile, Sphagnum spp., Erica tetralix.

II.4. Festuca rubra complex.

Concentrated chiefly in East Anglia, but with extensions to South-West England, the complex exhibits extreme Continental affinity. Some of the component communities parallel the Inland heaths of the Netherlands, and N. W. Germany. Details of the species complement is shown below:

Relevé number: Community:	20 a	6 b	5 c	Relevé number:	20 a	6 b	5 c
Calluna vulgaris	V	V	5	Pleurozium schreberi	II	IV	1

Relevé number:	20	6	5	Relevé number:	20	6	5
Community:	a	b	c	Community:	a	b	c
Dicranum scoparium	IV	III	5	Campanula rotundifolia		II	
Hypnum ericetorum		II	3	Rumex acetosella	II		
Festuca rubra	II	V	4	Carex arenaria	V		
Parmelia physodes		I	3	Agrostis tenuis	I	IV	2

II.4.a. Carex arenaria community.

Synonymy: Callunetum, Farrow, 1915, 1925.

Identifying species; C. arenaria.

Distribution; Norfolk, Suffolk, Dorset.

Variants; (i) Pteridium aquilinum variant, differential species - P. aquilinum, (ii) Sarothamnus scoparius variant, differential species - S. scoparius, Holcus lanatus, Senecio jacobaea, Galium verum, Poa pratensis, (iii) Erica cinerea variant, differential species - E. cinerea.

Ecological notes: Typical of sand dunes - coastal in Dorset, but inland in the Breckland region of Norfolk and Suffolk, although Farrow (1915) notes that these were short dunes of the old shore line of the Wash Bay, before the present Fen land infilling took place.

A large area of Breckland heath is formed by vegetation with Calluna vulgaris and Pteridium aquilinum in dynamic balance - this subject being much discussed by Watt (1940 et.seq.).

The Pteridium aquilinum variant of this community is therefore rather extensive, and has two sub-variants, (i) Ulex gallii sub-variant (differential species - U. gallii), found on the Coastal heath of the Suffolk Sandlings and (ii) Deschampsia flexuosa sub-variant (differential species D. flexuosa, Quercus spp. (seedlings)), found at Woodland edges.

Thetford Heath, Norfolk, is characterised by the prescence of 'stone stripes', which are old Solifluxion ridges. The effect of these is to have strips of grass heath (Farrow, 1915), representing a furrow of richer soil, alternating with strips of this community, representing the ridges of poor, more open soils.

The above variants characterise the inland dune heath of the Breckland, which is essentially similar to that of the Netherlands, with the exception that Corynephorus canescens common to the Netherlands heath, is absent from the Brecklands. It is, however, present on Coastal dunes in Norfolk - its only occurence in Britain.

Dune heath from Dorset forms the Erica cinerea variant, which has two sub-variants; (a) Ammophila arenaria sub-variant (differential species - A. arenaria, Polygala vulgaris), from open heath of the fore-dunes, and (b) Cuscuta epithymum sub-variant (differential species - C. epithymum), characteristic of the older forms of dune heath.

Initially, colonisation of the dunes is mediated through a grass-lichen vegetation. A relevé from such vegetation (Studland Heath, Dorset, G.R. 40/037858) is given below:

Area= 2 sq.m. Cover = 60%

Agrostis tenuis	3.3	Cornicularia aculeata	3.2
Jasione montana	2.1	Calluna vulgaris	r
Festuca rubra	+		

II.4.b. Agrostis tenuis community.

Synonymy; Grass Heath, Farrow (1915, 1925).

Identifying species; A. tenuis.

Distribution; Breckland of East Anglia.

Variants; (i) Lotus corniculatus variant, differential species - Pseudoscleropodium purum, L. corniculatus, Cerastium arvense, Rhytidiadelphus squarrosus, (ii) Sieglingia decumbens variant, differential species S. decumbens.

Ecological Notes; Found in rather richer areas, and distinguished from the preceding community by the abundance of several grasses and herbaceous species. The Lotus corniculatus variant was noted in an area where former heathland is now being used for arable crops, the remaining heath forming a belt, approximately 10 m. wide, between the field edge and the road. Arable weeds such as Poa pratensis, Lolium perenne are common in this heath.

Within the Sieglingia decumbens variant, two sub-variants are found; (a) the Potentilla erecta sub-variant (differential species - P. erecta, Nardus stricta, Quercus spp. (seedlings), Cladonia arbuscula), and (b) the Holcus lanatus sub-variant (differential species - H. lanatus, Pseudoscleropodium purum).

The former is typical of woodland ridges and edges in West Norfolk, now the only remnants of a large area of heath, which extended between Norwich and Aylsham. Cultivation and afforestation now account for almost the whole of the former heathland. Typical 'grass heath' is demonstrated by the latter sub-variant. Where trampling pressures are low, the vegetation can reach a height of 1 - 1.5 m.

II.4.c. Festuca rubra community.

Identifying species; as complex.

Distribution: Dartmoor.

Variants; (i) Cladonia impexa variant, differential species - C. impexa, C. uncialis, Cornicularia aculeata, Polytrichum gracile, Vaccinium myrtillus.

Ecological Notes: Found on waste tips from china clay mining operations. The plant cover is generally stunted, rarely more than 5 cm. high. The substrate is essentially similar to a coarse sand, directly colonised by grasses, Calluna bushes as well as bryophytes and lichens.

A Luzula campestris sub-variant (differential species L. campestris, Anthoxanthum odoratum) distinguishes the more grassy areas of the variant.

Direct colonisation of spoil waste, particularly china clay debris in Cornwall, is rather common. In the St. Austell area, the spoil heaps are often huge conical mounds, the lower slopes of which are colonised by species such as Ulex gallii, Erica cinerea, Calluna vulgaris, Agrostis tenuis and Potentilla erecta. These facts are of obvious importance in determining the nature of recolonisation that should be attempted in such areas.

II.5. Pohlia nutans complex.

There is only one component community, a list of definitive species is given below:

Number of relevés:	7	Number of relevés:	7
Calluna vulgaris	V	C. crispata	IV
Parmelia physodes	IV	C. floerkeana	V
Pohlia nutans	V	C. chlorophaea	III
Cladonia squamosa	III		

II.5.a. Pohlia nutans community.

Identifying species; as complex.

Distribution; N. E. Norfolk.

Variants; (i) Erica tetralix variant, differential species - E. tetralix Molinia caerulea, (ii) Cladonia coccifera variant, differential species - C. coccifera.

Ecological Notes; Confined to the heaths of N. E. Norfolk, and rather similar to some heaths of the Veluwe, Netherlands (Stoutjesdijk, 1959).

There is an extreme wet form of the Erica tetralix variant, the Scirpus caespitosus sub-variant, differential species - S. caespitosus, Gymnocolea inflata, Campylopus atrovirens), and an intermediate form - the Cladonia coccifera sub-variant (differential species - C. coccifera).

The heaths are rather species poor. Peat depth varies from

1.5 - 2.5 cm. in the driest areas to 7.5 - 10 cm. in the really wet areas.

II.6. Sieglingia decumbens complex.

Again, there is only one component community. The constancy for the identifying species is shown below:-

No. of relevés:	5	No. of relevés:	5
Calluna vulgaris	5	Cirsium acaule	4
Potentilla erecta	5	Lotus corniculatus	4
Carex flacca	4	Hielianthemum nummularium	3
Sieglingia decumbens	5	Viola canina	3

II.6.a. Sieglingia decumbens community.

Identifying species; as complex.

Distribution; North East Gloucestershire, North Somerset.

Variants; (i) Campanula rotundifolia variant, differential species - C. rotundifolia, Pohlia nutans, Galium saxatile, Cladonia macilenta, Antennaria dioica, Hypnum ericetorum, Festuca ovina, Agrostis tenuis, Anthoxanthum odoratum, Bromus erectus, (ii) Brachypodium pinnatum variant, differential species - B. pinnatum, Frageria vesca, Holcus lanatus, Agrostis montana, Poterium sanguisorba, Teucrium scorodonia.

Ecological Notes; Heath developed over both Jurassic and Carboniferous limestone. In the case of the Campanula rotundifolia variant, the heath owes its development to a thin cover of sand over the limestone (Harford sand). This formation occurs sporadically along the Cotswold ridge, but only one site today remains unploughed - Cleeve Common, Cheltenham.

The Brachypodium pinnatum variant is developed from steeply sloping calcareous grassland (see also community I.4.c.), which is subject to considerable leaching. Formerly rather widespread, this vegetation is now restricted, as many of its former sites of occurence have been reclaimed for agriculture, or afforested.

II.7. Ulex gallii complex.

Another complex with only one component community, the species constancy table of which is shown below:-

No. of relevés:	15	No. of relevés:	15
Erica cinerea	V	Cladonia chlorophaea	III
Ulex gallii	V	Dicranum scoparium	III
Calluna vulgaris	V	Hypnum ericetorum	III

II.7.a Ulex gallii community.

Identifying Species; as complex.

Distribution; Suffolk sandlings, N. E. Isle of Man.

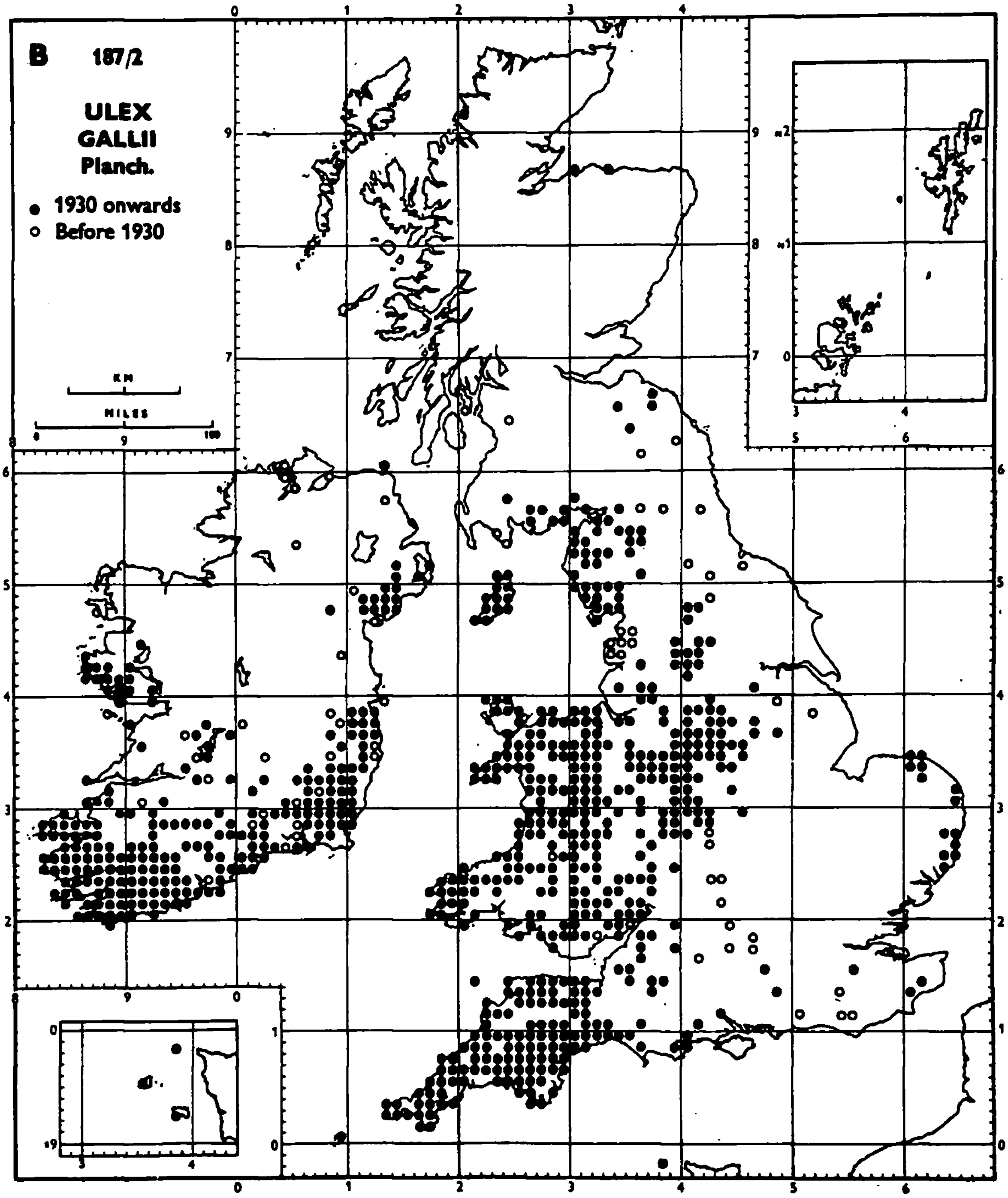
Variants; (i) Campylopus flexuosus variant, differential species C. flexuosus, (ii) Carex arenaria variant, differential species - C. arenaria (iii) Festuca rubra variant, differential species - F. rubra Agrostis tenuis, Parmelia physodes, Ulex europaeus.

Ecological Notes; Ulex gallii is a species of predominantly western distribution (Map.5.) and thus it is surprising to find it occuring in East Anglia. However, in this region, it is found outside the community only rarely. The problem is therefore one of community distribution, not merely species distribution. It is interesting that apart from this one community/complex, and the Ulex gallii sub-variant/Pteridium aquilinium variant (II.4.a.i.x), within the Calluna vulgaris Heath, no other unit is defined by U. gallii. The Erica cinerea Heath, however, whose geographical area coincides with that of U. gallii, (cf. Maps 2 & 5), has a wide variety of units defined by it.

U. minor is apparently rare in East Anglia (Petch and Swan, 1968),

MAP V/5

Showing the distribution
of Ulex gallii.
(Reproduced from 'Atlas of the
British Flora' by kind
permission of the publishers
Thomas Nelson & sons Ltd.)


B 187/2
ULEX
GALLII
Planch.
● 1930 onwards
○ Before 1930
KM
MILES

U. gallii being the commonest species. This prompts the question of why U. gallii should occur as an 'Outlier' in an area that theoretically should be colonised by U. minor, and what significance this Community has?

A clue may perhaps be derived from that fact that the community should be considered as a whole - and the occurence of it on the Isle-of-Man rationalises the presence of U. gallii. This, then, can be regarded as the most 'continental' community in which U. gallii is found - although a more detailed examination of the community will be necessary to determine the nature of the operative environmental factors in this case.

The Campylopus flexuosus variant, rather typical of recently burnt areas, has a Cladonia unicialis sub-variant (differential species - C. unicialis, Polytrichum juniperinum, Lecidia spp.), typical of more severe burns, usually with an incomplete Phanerogam cover.

In the Isle-of-Man, this community is found as the Carex arenaria variant, on a substrate of blown dune sand, unlike the East Anglian sites, which have a substrate of recent deposits.

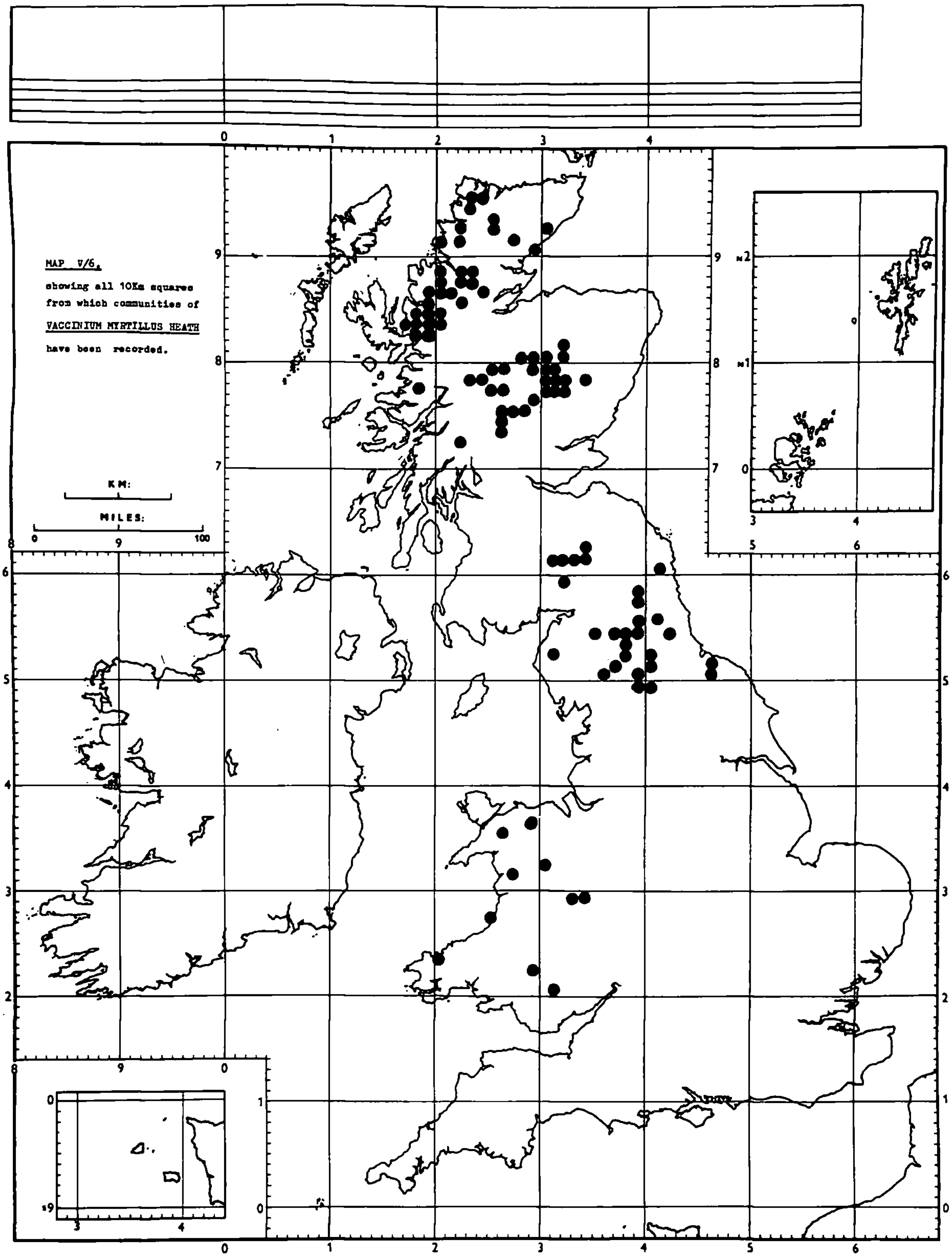
Disturbed sites are represented by the Festuca rubra variant. Near woodlands, where seedlings can easily establish themselves, the Carex pilulifera sub-variant is found (differential species - C. pilulifera, Quercus spp. (seedlings).

III. Vaccinium myrtillus Heath.

Found in Northern Britain and upland Wales, this heath represents the Boreal aspect of the British heath formation; and has strong resemblences to the Myrtillion boreale Böcher, 1943. Species typical of this Heath are; V. myrtillus, Calluna vulgaris, Deschampsia flexuosa, Dicranum scoparium, Hypnum ericetorum, Potentilla erecta, Pleurozium schreberi. Map 6, shows the 10 km. squares in which the

MAP V/6

Showing 10Km squares from which communities of the Vaccinium myrtillus Heath have been recorded, during the Heathland survey. (See Map V/1 for the full area covered)


MAP V/6.
showing all 10Km squares
from which communities of
VACCINIUM MYRTILLUS HEATH
have been recorded.
KM:
MILES:
0
100

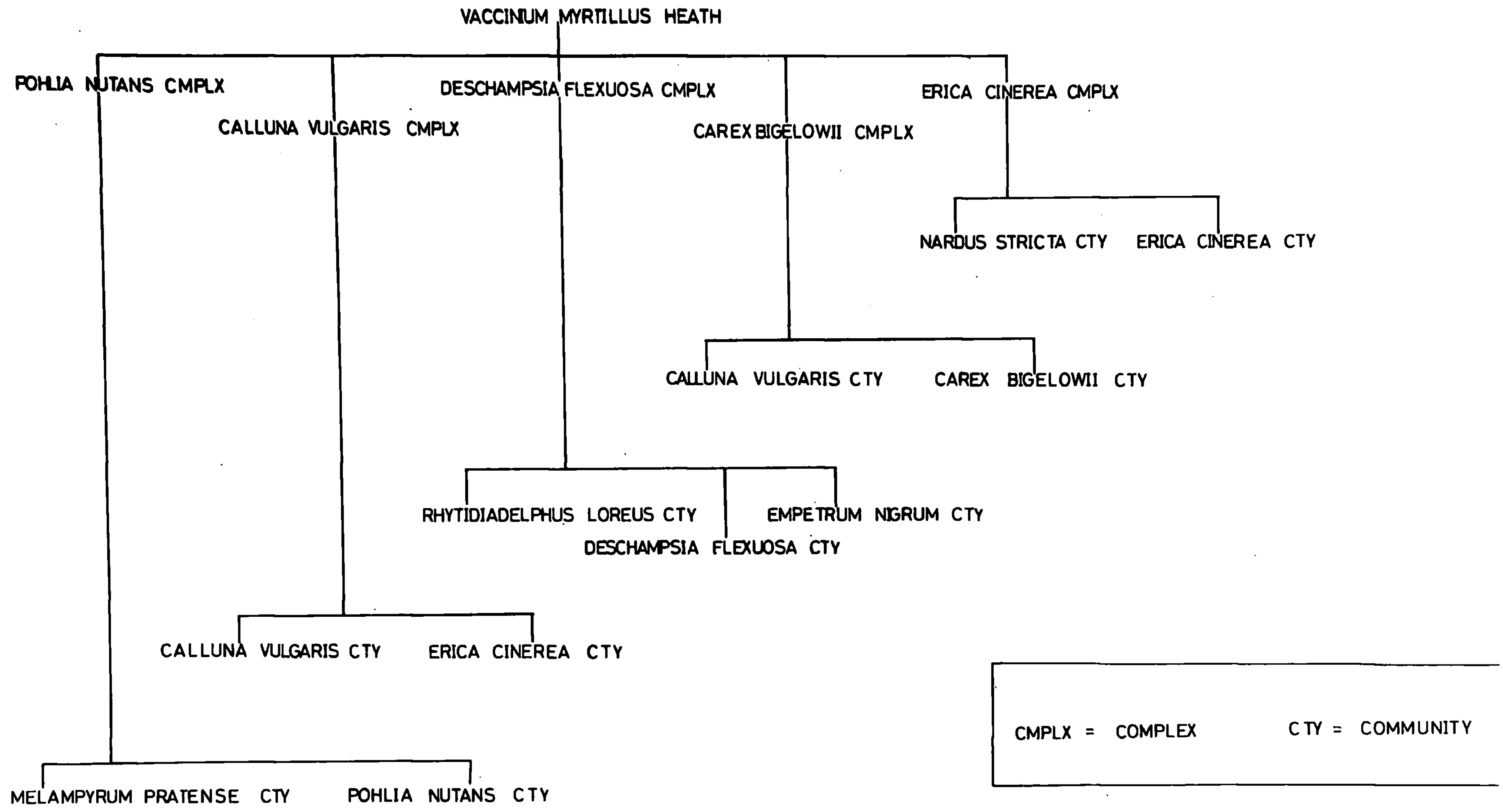

VACCINIUM MYRTILLUS HEATH
POHLIA NUTANS CMPLX
CALLUNA VULGARIS CMPLX
DESCHAMPSIA FLEXUOSA CMPLX
CAREX BIGELOWII CMPLX
ERICA CINEREA CMPLX
NARDUS STRICTA CTY
ERICA CINEREA CTY
CALLUNA VULGARIS CTY
CAREX BIGELOWII CTY
RHYTIDIADELPHUS LOREUS CTY
DESCHAMPSIA FLEXUOSA CTY
EMPETRUM NIGRUM CTY
CALLUNA VULGARIS CTY
ERICA CINEREA CTY
MELAMPYRUM PRATENSE CTY
POHLIA NUTANS CTY
CMPLX = COMPLEX
CTY = COMMUNITY

fig V/4

Heath is found, and Fig.4., gives the hierachy of complexes and communities.

III.1. Pohlia nutans complex.

Confined to the Shropshire uplands (Stiperstones, Long Mynd, etc.). The component species are shown below:

No. of relevés: Community:	33 a	14 b	No. of relevés: Community:	33 a	14 b
Vaccinium myrtillus	V	V	Pteridium aquilinium	IV	
Pohlia nutans	V	V	Sorbus aucuparia(seedling)	II	
Calluna vulgaris	V	V	Blechnum spicant	II	
Deschampsia flexuosa	V	V	Lepidozia reptans	II	
Dicranum scoparium	IV	III	Gymnocolea inflata	II	
Hypnum ericetorum	V	IV	Lophocolea bidentata	II	
Parmelia physodes	IV	II	Empetrum nigrum	II	
Potentilla erecta	II	II	Cephaloziella starkei	I	
Pleurozium schreberi	II	II	Campylopus flexuosus	II	
Melampyrum pratense	IV		Calypogeia fissa	I	
Calypogeia mülleriana	III	II	Polytrichum juniperinum	I	

III.1.a. Melampyrum pratense community.

Synonymy; Callunetum, Leach, 1931.

Identifying species; M. pratense, Calypogeia mülleriana, C. fissa, Pteridium aquilinum, Sorbus aucuparia (seedlings), Blechnum spicant, Lepidozia reptans, Gymnocolea inflata, Lophocolea bidentata, Empetrum nigrum, Cephaloziella starkei, Campylopus flexuosus, Polytrichum juniperinium.

Distribution; as complex.

Variants; (i) Cladonia chlorophaea variant, differential species - C. chlorophaea, C. crispata, C. floerkeana, Lecidia quadricolor.

(ii) Galium saxatile variant, differential species - G. saxatile, Agrostis tenuis, Oxalis acetosella, Holcus mollis.

Ecological Notes; Found on the plateaux of the Salopian Hills, which form a distinct buffer to the Midland and Cheshire plains. Most of the heath is lichen rich, the Cladonia coccifera sub-variant (differential species - C. coccifera, C. squamosa, C. impexa, C. macilenta), to the Cladonia chlorophaea variant. This has two 'forms', (i) denoted by the presence of Vaccinium vitis-idaea is indicative of more exposed habitats and (ii) denoted by Polytrichum commune and Betula spp. (seedlings) indicative of areas of heat that are regenerating Birch wood.

Also in this area is the Polytrichum piliferum community (I.4.d.), and a transition between it and the present community is the Erica cinerea sub-variant (differential species - E. cinerea).

At the tops of steep, scarp slopes, small patches (sensu Watt, 1947) of the Galium saxatile variant are found, unusual because of the presence of a number of herbaceous species, more particularly the typically woodland Oxalis acetosella.

III.1.b. Pohlia nutans community.

Identifying species; as complex.

Distribution; Shropshire, Radnorshire.

Variants; (i) Vaccinium vitis-idaea variant, differential species - V. vitis-idaea, Carex nigra, Eriophorum angustifolium, Calypogeia mülleriana, (ii) Cladonia chlorophaea variant, differential species C. chlorophaea.

Ecological Notes; The Vaccinium vitis-idaea variant represents small marshy hollows, found in the heath, with a richly developed sedge component.

In general, this community is species poor, and the Cladonia chlorophaea variant is a much reduced vegetation, analagous to the Cladonia chlorophaea variant of the previous community. Similarly, its Cladonia coccifera sub-variant is species-poor compared to its counterpart in the previous Community.

One aspect of vegetation unique to this community is the Nardus stricta sub-variant (differential species N. stricta, Juncus squarrosus, Cladonia arbuscula), to the above variant, representing over-grazed hill areas. Species such as N. stricta and J. squarrosus are typical dominants of nutrient-poor hill grassland, and thüs this sub-variant indicates an intermediate vegetation type between Heather Moor and Hill grassland.

III.2. Calluna vulgaris Complex.

Found on the Pennine Hills, across N. England from West York and Durham to Westmorland. The defining species are noted below:

No. of relevés:	28	10	No. of relevés:	28	10
Community:	a	b	Community:	a	b
Calluna vulgaris	V	V	Agrostis tenuis	III	III
Deschampsia flexuosa	III	III	Sieglingia decumbens	I	IV
Hypnum ericetorum	V	V	Lophocolea bidentata	II	I
Nardus stricta	II	V	Potentilla erecta	II	I
Rhytidiadelphus squarrosus	I	I	Plagiothecium undulatum	III	
Parmelia physodes	II	I	Erica tetralix	II	IV
Dicranum scoparium	III	II	Erica cinerea		V
Pleurozium schreberi	IV	I			
Galium saxatile	II	IV			

III.2.a. Calluna vulgaris community.

Synonymy: Callunetum of Lewis (1903) and Adamson (1918).

Identifying species; - as complex.

Distribution; N. W. York, Durham, Northumberland, Westmorland.

Variants; (i) Erica tetralix variant, differential species - E. tetralix. (ii) Pohlia nutans variant, differential species - P. nutans. (iii) Festuca ovina variant, differential species - F. ovina, Empetrum nigrum, Lophozia floerkii, Ptilidium ciliare, Hylocomium splendens, Cladonia arbuscula, Campanula rotundifolia, Rhytidiadelphus loreus, Cetraria islandica, Polygala vulgaris, Thymus drucei, Carex capillaris, (iv) Luzula multiflora variant, differential species - L. multiflora.

Ecological Notes; This community represents the most typical Pennine heather moor, and there are a number of distinct variants. Damper areas are indicated by the Erica tetralix variant, which has a Carex binervis sub-variant (differential species - C. binervis, Juncus articulatus), found as a rather degraded heather moor in South Northumberland. The vegetation seems fairly frequently burnt - and is similar to the degraded vegetation depicted in Table I.2.x. (q.v.)

The species rich Festuca ovina variant is found in Teesdale (Co. Durham). This area is particularly interesting because of the juxtaposition of metamorphosed, granular, limestone (which supports Calcareous grassland), and varying humic soils. The result is this unusual 'species-rich heather moor' (Bellamy et. al., 1969), which supports a number of calcicoles, as well as a large number of bryophytes. Although the defining species of the variant are the commonest species of this vegetation, there are many more species found sporadically through it, and thus not included in the relevés.

Crags of the lower carboniferous Fell sandstone in Northumberland support the Luzula multiflora variant. This has two sub-variants; (a) the Leucobryum glaucum sub-variant (differential species - L. glaucum Festuca rubra, Anthoxanthum odoratum), found where the rock outcrops in the Coquet valley and (b) the Pteridium aquilinum sub-variant (differential species P. aquilinum, Campylopus flexuosus, Betula spp. (seedlings)), found on the West Scarp of the outcrop, west of Alnwick. This latter area is under pressure from both man and sheep-grazing, and seems likely to become transformed into an area dominated by P. aquilinum.

III.2.b. Erica cinerea community.

Identifying species; E. cinerea, E. tetralix.

Distribution; Durham, Northumberland, Westmorland.

Variants; (i) Empetrum nigrum variant, differential species - E. nigrum, Festuca rubra, Viola canina.

Ecological Notes; Confined to West or Soüth facing slopes of the millstone grit formation of the Pennines. The Empetrum nigrum variant was found on the slopes of a disused railway cutting, with a rather incomplete phanerogam cover. The vegetation height was only 5 cm., compared to 25 - 35 cm. for corresponding adjacent moorland.

III.3. Deschampsia flexuosa complex.

Rather wide ranging, this complex is found in upland N. Wales, Southern Pennines, North York. Moors, Southern Scotland and Cumberland. The species constancy table is shown below:-

Number of relevés:	20	25	32	6
Community:	a	b	c	d
Vaccinium myrtillus	V	V	V	V
Calluna vulgaris	V	V	V	V
Deschampsia flexuosa	V	IV	V	V
Hypnum ericetorum	V	V	V	II
Nardus stricta	IV	IV	II	II
Parmelia physodes	II	II	II	
Dicranum scoparium	IV	III	IV	
Pleurozium schreberi	V	III	IV	I
Potentilla erecta	V	I	III	I
Rhytidiadelphus loreus	IV		I	
Cladonia arbuscula	III	I	I	
Hylocomium splendens	III		I	
Sieglingia decumbens	III	II		
Agrostis tenuis	IV		I	
Galium saxatile	III	II	III	
Empterum nigrum		V		I
Pteridium aquilinum	I		II	V
Pohlia nutans		II	I	V

II.3.a. Rhytidiadelphus loreus community.

Identifying species; R. loreus, Cladonia arbuscula, Hylocomium splendens, Sieglingia decumbens, Agrostis tenuis, Galium saxatile.

Distribution; Southern uplands of Scotland.

Variants; (i) Carex binervis variant, differential species C. binervis, (ii) Blechnum spicant variant, differential species B. spicant.

(iii) Campanula rotundifolia variant, differential species - C. rotundifolia, Cladonia pyxidata.

Ecological Notes; The 'heather moor' of the Southern uplands is quite species rich and rather varied. The Carex binervis variant is found in rather wet areas, and has two sub-variants (a) the Polytrichum commune sub-variant (differential species - P. commune), and (b) the Molinia caerulea sub-variant (differential species M. caerulea).

Within the Blechnum spicant variant, there is a Luzula sylvatica sub-variant (differential species - L. sylvatica, Plagiothecium undulatum, Lophocolea bidentata, Cladonia uncialis). This is closely allied to the 'Luzula sulvatica grassland nodum' of McVean and Ratcliffe, 1962., and is rather a plentiful vegetation in the Selkirk/Dumfries area.

The Campanula rotundifolia variant is indicative of rather more nutrient rich areas, and has two sub-variants which reflect this, (a) the Thymus drucei sub-variant (differential species - T. drucei, Viola riviniana, Teucrium scorodonia, Erica cinerea, Succisa pratensis), found on steep, rockly slopes of the Etterick hills and (b) the Peltigera canina sub-variant (differential species P. canina).

II.3.b. Empterum nigrum community.

Identifying species; E. nigrum.

Distribution; N. York moors and Durham to Cumberland.

Variants; (i) Rhytidiadelphus loreus variant, differential species - R. loreus, Ptilidium ciliare, Cladonia arbuscula, Festuca ovina, Galium saxatile, (ii) Juniperus communis variant, differential species - J. communis, Pteridium aquilinum, (iii) Erica cinerea variant, differential species E. cinerea, (iv) Gymnocolea inflata variant, differential species - G. inflata, Cladonia uncialis, C. pyxidata, (v) Juncus squarrosus variant, differential species - J. squarrosus, Cladonia chlorophaea.

Ecological Notes; The first named variant typifies rather rich areas of Pennine moorland, with a number of herbaceous species and bryophytes.

A number of areas in the Northern Pennines support the Juniperus communis variant, with varying degrees of species richness in terms of cryptogams. Similar vegetation types are found on the vast "Luneberger Heide" in Northern Germany.

The North York moors support the Erica cinerea variant, with two sub-variants, (a) the Sieglingia decumbens sub-variant (differential species - S. decumbens, Galium saxatile, Polytrichum juniperinum), in richer, grazed areas and (b) the Pohlia nutans sub-variant (differential species - P. nutans, Cladonia coccifera, C. floerkeana, Juncus squarrosus, Agrostis tenuis), found in flat, damp lichen-rich areas.

The whole community is subject to fairly heavy grazing pressure, and also burning rather frequently.

III.3.c. Deschampsia flexuosa community.

Identifying species; as complex + Agrostis tenuis, Galium saxatile.

Distribution; Brecon and Pembroke to Cumberland and Northumberland.

Variants; (i) Carex pilulifera variant, differential species1 - C. pilulifera, Anthoxanthum odoratum, Carex binervis, Hylocomium splendens. (ii) Pteridium aquilinum variant, differential species - P. aquilinum. (iii) Molinia caerulea variant, differential species - M. caerulea, (iv) Cladonia arbuscula variant, differential species - C. arbuscula, Rhytidiadelphus loreus, (v) Vaccinium vitis-idaea variant, differential species V. vitis-idaea, Pohlia nutans, Pteridium aquilinum. (vi) Erica cinerea variant, differential species1 E. cinerea.

Ecological Notes; The most widespread and varied community within the Vaccinium myrtillus Heath. In South Wales, some of the roadsides have been quarried, or the road is cut through areas of slate. The loose rock aggregates support the Diplophyllum albicans sub-variant (differential species - D. albicans, Betula spp. (seedlings), Festuca rubra) of the Pteridium aquilinum variant, which is comparable to the Diplophyllum albicans community (III.3.b.)

Exposed areas, which are lightly grazed, have the Carex pilulifera variant, whilst those with virtually no grazing, and a peat depth of 10 - 15 cm., support the Molinia caerulea variant. This latter variant, in the Brecon Beacons area of South Wales is usually additionally differentiated by the presence of Ulex gallii.

Upland areas of mid-west Wales have the Cladonia arbuscula variant. Two sub-variants have been noted (a) the Carex binervis sub-variant (differential species - C. binervis, Lophozia floerkii, Polytrichum formosum), found in an area of planted conifers and (b) the Diplophyllum albicans sub-variant, found in extremely exposed montane situations.

Both the Vaccinium vitis-idaea and Erica cinerea variants are found on the North York moors, in dry, exposed situations. The latter variant, however, is restricted to sites with less than 1.5 cm. depth of peat, whereas the former varies rather more in peat depth, but has never less than 5 cm. depth.

Some of the extremely steep slopes in the Cumbrian mountains support this community, but in a form with the dominant plant being Cryptogramma crispa. This has been recorded once as relevé 11/70.

III.3.d. Pteridium aquilinium community.

Synonymy; Callunetum vulgaris, Jeffereys, 1916.

Identifying species; P. aquilinium, Pohlia nutans.

Distribution; Lowland, Co. Durham.

Variants - None.

Ecological Notes; A rather degraded form of the complex, found on the millstone grit outcrops of lowland Co. Durham. This was formerly a much more extensive community, as Jeffereys (1916) notes. He also indicated that most of the community was becoming transformed to his 'Pteridetum'. On some of the slopes, Vaccinium myrtillus forms large, almost mono-cultural patches - Jeffereys made this a separate association, the Vaccinetum myrtilli. He did note, however, that "(it) is a mere aspect of the Callunetum." There is no floristic distinction between these associations he described, and both are assimilated within this one community.

III.4. Erica cinerea complex.

Chiefly from North Wales and Cumberland. The species constancy table is given below:

Number of relevés:	9	12
Community:	a	b
Calluna vulgaris	V	V
Vaccinium myrtillus	V	V
Erica cinerea	V	V
Hypnum ericetorum	V	V
Dicranum scoparium	V	IV
Pleurozium schreberi	IV	IV
Potentilla erecta	IV	III
Deschampsia flexuosa	V	V
Parmelia physodes	II	V
Nardus stricta	V	

III.4.a. Nardus stricta community.

Synonymy: Callunetum, Price-Evans, 1932.

Identifying species; N. stricta.

Distribution; N. Wales.

Variants. (i) Carex binervis variant, differential species - C. binervis, Rhacomitrium lanuginosum, (ii) Erica tetralix variant, differential species - E. tetralix, Plagiothecium undulatum, (iii) Sieglingia decumbens variant, differential species - S. decumbens, Agrostis tenuis, Cladonia arbuscula.

Ecological Notes; The chief 'heather moor' community of the North Welsh mountains. Some of the rocky crags support the Carex binervis variant, which is rich in bryophytes and herbaceous species. Damp, boggy areas are colonised by the Erica tetralix variant, which gives way in extreme conditions to Erica tetralix bog (Price-Evans, 1932).

Vegetation of some mountain slopes in the Snowdon area, and the managed heather moor of the Llynld Hiraethog (Denbigh) is characterised by the Sieglingia decumbens variant.

II.4.b. Erica cinerea community.

Identifying species; as complex.

Distribution; Shropshire, Cumberland.

Variants; (i) Pohlia nutans variant, differential species P. nutans, Cladonia fimbriata, (ii) Ulex europaeus variant, differential species - U. europaeus, (iii) Pteridium aquilinium variant, differential species - P. aquilinium, (iv) Agrostis tenuis variant, differential species - A. tenuis, Polygala vulgaris.

Ecological Notes; This community is chiefly confined to Cumberland - although tongues are found in Shropshire and Co. Durham.

The Pohlia nutans variant is found on exposed northerly slopes in Cumberland, not including the Cumbrian mountain area. Both the Ulex europaeus variant and the Pteridium aquilinium variant represent phases of Anthropogenic degradation of the heathland. They are established in rather different ways - U. europaeus prefering to colonise heath with a broken podsol, P. aquilinium being able to compete with Calluna vulgaris in open heathland (see Watt, 1940, et.seq.)

The Agrostis tenuis variant is developed at the edge of a Forestry Commission plantation, and represents a remnant of a formerly very extensive heather moor. Because of the small amount of heath left, herbaceous species are able to take part more freely in the community structure.

III.5. Carex bigelowii Complex.

Comprising two communities, this complex has been constructed from vegetation units described by McVean and Ratcliffe, 1962. As they have given environmental detail in their publication, this is not repeated here.

Synonymy; (a) Calluna vulgaris community.

(i) Anastrepta orcadensis variant.

a) Chamaepericlymenum suecicum sub-variant = Vaccineto-Callunetum hepaticosum (13a), (b) Pleurozia purpurea sub-variant = Vaccineto-Callunetum suecicosum (13b).

(ii) Ochrolechia frigida variant = Cladineto-Callunetum,

a) Juniperus nana sub-variant = Arctoeto-Callunetum + Loiseleuria Empetrum provisional nodum + Rhacomitreto-Callunetum + Western Calluna - Arctostaphylos communities.

(iii) Blechnum spicant variant = Vaccinetum chionophilum + Cladineto-Vaccinetum sylvaticum (20a).

(b) Carex bigelowii community.

typical = Vaccineto-Empterum & Empterum-hypnaceous moss communities + Hepatic-rich Vaccineto-Empetretum + Vaccinium - Nardus communities.

(i) Ochrolechia frigida variant = Cladineto-Vaccinetum typicum + Cladineto-Vaccinetum empetrosum.

(ii) Alchemilla alpina variant = Festuceto-Vaccinetum.

(iii) Anastrepta orcadensis variant = Rhacomitreto - Empetretum.

A constancy table for the species complement of the communities is shown on the following page.

Community:	a	b	Community:	a	b
Carex bigelowii	IV	V	C. gracilis	III	IV
Empetrum hermaphroditum	V	V	Ptilidium ciliare	III	IV
Vaccinium myrtillus	IV	V	Vaccinium vitis-idaea	III	IV
Deschampsia flexuosa	IV	IV	Rhytidiadelphus loreus	III	III
Dicranum scoparium	III	III	Potentilla erecta	II	I
Hylocomium splendens	III	III	Calluna vulgaris	V	
Hypnum ericetorum	III	II	Cladonia bellidiflora		II
Pleurozium schreberi	IV	IV	C. rangiferina		IV
Rhacomitrium lanuginosum	IV	V	C. pyxidata		III
Cladonia uncialis	IV	IV	Cetraria islandica		III
C. arbuscula	IV	V	Cornicularia aculeata		V

IV. Erica tetralix heaths.

Unlike the previous three Heath categories, which are characteristic of dry lowland and upland heath, this is equated with the 'wet heath' of Tansley (1939) and the alliance Ericion tetralicis, Schwick, 1933. Map 7 shows the distribution of this Heath type, and Fig.5. illustrates the hierachy of complexes and communities.

IV.1. Zygogonium ericetorum complex.

This represents the main wet heath vegetation of Southern Britain from Dorset and Berkshire to Kent. In many ways it acts as a transition between the dry heath and valley bog (Tansley, 1939), and, as noted in Section III, is usually of the limes divergens type.

The species constancy table is shown below:

Number of relevés:	26	8	Number of relevés:	26	8
Community:	a	b	Community:	a	b
Zygogonium ericetorum	IV	IV	Calluna vulgaris	V	V
Erica tetralix	V	IV	Sphagnum compactum	IV	
Molinia caerulea	V	IV	Scirpus caespitosus	IV	

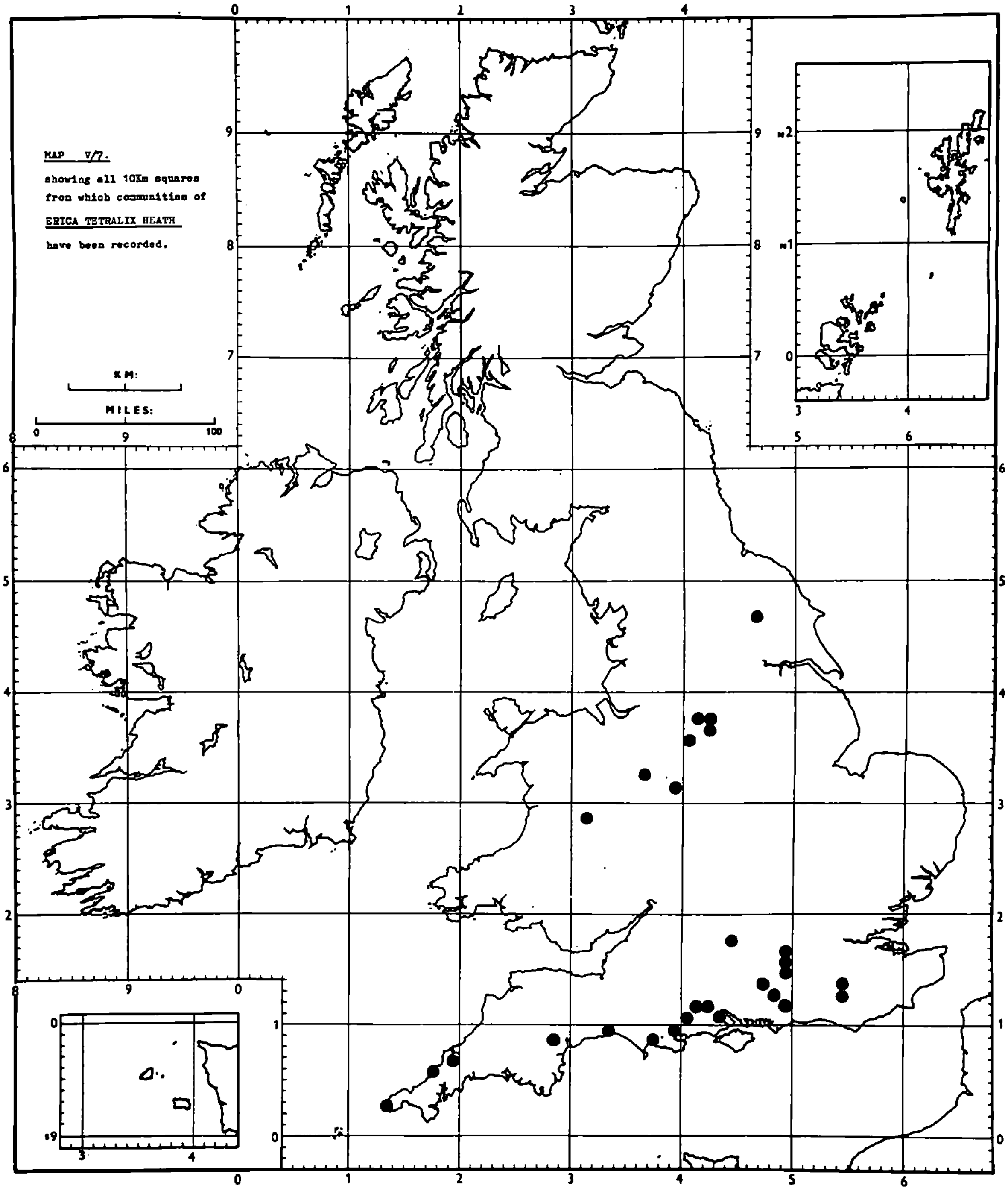
IV.1.a. Sphagnum compactum community.

Identifying species; S. compactum, Scirpus caespitosus.

Distribution; as complex.

MAP V/7

Showing the 10Km squares from which communities of the Erica tetralix Heath have been recorded, during the Heathland survey. (See Map V/1 for the full area covered.)


MAP V/7.
showing all 10Km squares
from which communities of
ERICA TETRALIX HEATH
have been recorded.
KM:
MILES:

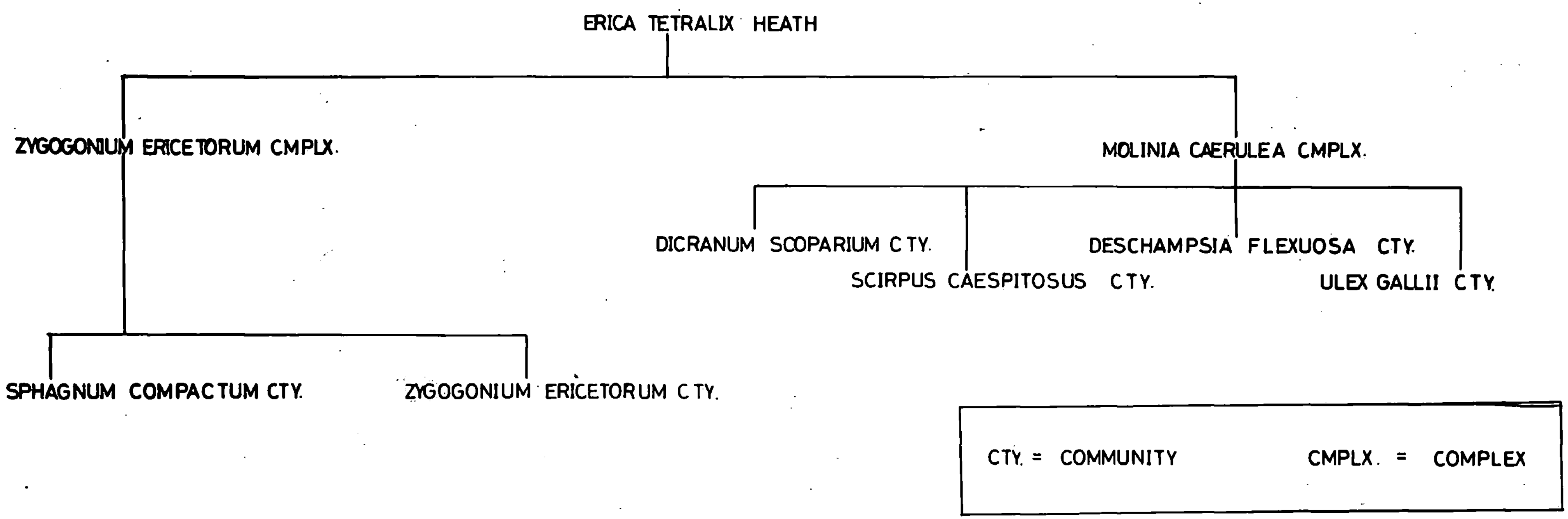

ERICA TETRALIX HEATH
ZYGOGONIUM ERICETORUM CMPLX.
MOLINIA CAERULEA CMPLX.
DICRANUM SCOPARIUM CTY.
SCIRPUS CAESPITOSUS CTY.
DESCHAMPSIA FLEXUOSA CTY.
ULEX GALLII CTY.
SPHAGNUM COMPACTUM CTY.
ZYGOGONIUM ERICETORUM CTY.
CTY. = COMMUNITY
CMPLX. = COMPLEX

fig V/5

Variants; (i) Rhynchospora alba variant, differential species - R. alba, (ii) Cladonia impexa variant, differential species - C. impexa, (iii) Campylopus brevipilus variant, differential species - C. brevipilus, Potentilla erecta, Agrostis setacea, (iv) Gymnocolea inflata variant, differential species - G. inflata.

Ecological Notes; Together the Rhynchospora alba variant and the Cladonia impexa variant span the ecological variation within this community that relates to the 'wetness' of the peat. Besides having recognisable sub-variants, there are a number of 'forms' or 'phases' of these variants.

The Rhynchospora alba variant has a Drosera rotundifolia sub-variant (differential species - D. rotundifolia, Eriophorum angustifolium). representing states nearest to the 'valley bog'. Within this is an extreme wet phase, differentiated by Sphagnum cuspidatum, Narthecium ossifragum and a drier phase, with Cladonia arbuscula, Cornicularia aculeata.

The Cladonia impexa variant has two sub-variants, (a) the Sphagnum tenellum sub-variant (differential species - S. tenellum, Parmelia physodes, Hypnum ericetorum, Campylopus atrovirens), from the wettest areas of the variant, and (b) the Cladonia floerkeana sub-variant (differential species - Dicranum scoparium, C. floerkeana, C. pyxidata, C. furcata, Odontoschisma denudatum), from the drier.

Some vegetation described is intermediate between these two variants, with species such as Rhynchospora alba, Cladonia impexa, Cornicularia aculeata, Carex panicea, Sphagnum quinquefarium, Leucobryum glaucum, Parmelia physodes, Campylopus atrovirens, Gymnocolea inflata. The fragmentation and intergradation of the vegetation units thus confirms the existence, in the abstract form, of a limes divergens situation, paralleling the 'concrete' situations of wet heath and bog, discussed in Section III. Fig.6. shows an expanded scheme of the vegetation units discussed above.

Two other variants have been described from this community, one, the Campylopus brevipilus variant represents the aspect of the community after fire. The other, Gymnocolea inflata variant, is found on Greensands of Surrey and Sussex, and on Ashdown Forest. Two sub-variants are represented, (a) the Campylopus brevipilus sub-variant, and (b) the Juncus squarrosus sub-variant. Wetter forms of the latter are are differentiated by the presence of Carex nigra.

IV.1.b. Zygoganium ericetorum community.

Identifying species; as complex.

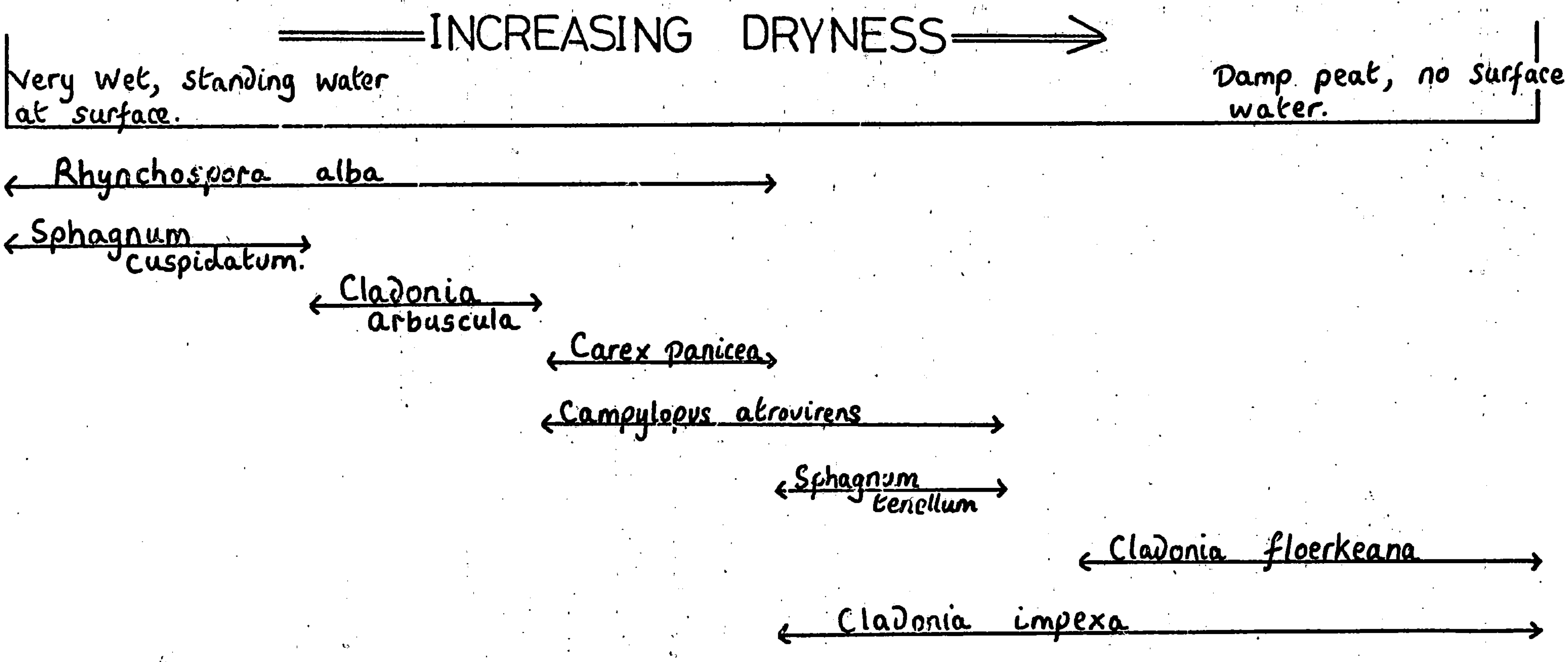
Distribution; N. sussex, Surrey.

Variants; (i) Erica cinerea variant, differential species - E. cinerea.
(ii) Pteridium aquilinum variant, differential species - P. aquilinum,
(iii) Polytrichum juniperinum variant, differential species - P. juniperinum.

Ecological Notes; An extremely species poor community, representing wet heath after burning. The Erica cinerea variant has a Juncus squarrosus sub-variant (differential species - J. squarrosus, Cladonia fimbriata, C. floerkeana), found on exposed South facing ridges. This sub-variant also has many regenerating seedlings of Pinus sylvestris .

IV.2. Molinia Caerulea complex.

Geographically, this is of very wide extent, from Cornwall, the Welsh Marshes to Southern Yorkshire. Details of the component species are shown on the following page.



Ecological amplitude of certain species from the *Rhynchospora alba* & *Cladonia impexa* variants.

Fig. V/6

Number of relevés:	6	10	10	7
Community:	a	b	c	d
Calluna vulgaris	V	V	V	IV
Molinia caerulea	V	V	V	III
Erica tetralix	V	V	IV	V
Dicranum scoparium	V			
Parmelia physodes	IV			
Pleurozium schreberi	IV			
Aulaucomnium palustre	III			
Sphagnum tenellum	IV			
Cladonia impexa	IV			
Scirpus caespitosus		III		
Zygogonium ericetorum		IV		
Juncus squarrosus			V	
Eriophorum angustifolium			V	
Hypnum ericetorum		III	II	II
Deschampsia flexuosa			V	
Pohlia nutans			V	
Scirpus caespitosus			IV	
Carex nigra			III	
Cephalozia bicuspidata			IV	
Ulex gallii				V
Potentilla erecta				V

IV.2.a. Dicranum scoparium community.

Identifying species: D. scoparium, Parmelia physodes, Pleurozium schreberi, Aulaucomnium palustre, Sphagnum tenellum, Cladonia impexa.

Distribution: Shropshire, Radnorshire.

Variants: (i) Nardus stricta variant - differential species - N. stricta, Cladonia arbuscula, Juncus squarrosus, Carex panicea, Potentilla erecta, Ulex gallii, Sphagnum compactum, Rhacomitrium lanuginosum, Cladonia uncialis, (ii) Eriophorum angustifolium variant, differential species - E. angustifolium, Calypogeia trichomanes, Hypnum ericetorum.

Ecological Notes; This community was not found outside the Welsh marches. There is a lowland form - the Eriophorum angustifolium variant, and an upland form (c. 600 m.) - the Nardus stricta variant. The latter approaches some of the vegetation types of the blanket bog type(Tansley, 1939).

IV.2.b. Scirpus caespitosus community.

Identifying species; S. caespitosus, Zygogonium ericetorum.

Distribution; East Yorkshire, Devon.

Variants; (i) Carex nigra variant, differential species - C. nigra, Salix repens, Gymnocolea inflata, Cladonia chlorophaea, Pohlia nutans, (ii) Cladonia impexa variant, differential species - C. impexa, Hypnum ericetorum, Calypogeia mülleriana.
Ecological Notes; Besides an unusual geographic disparity, the community forms a link between the Molinia caerulea complex and the Zygogonium ericetorum complex.

The Carex nigra variant occurs on flat commons (c. 30 m O.D.) in East Yorks. There are two sub-variants; (a) the Juncus squarrosus sub-variant (differential species - J. squarrosus), found in the wetter areas, and (b) the Hypnum ericetorum sub-variant (differential species - H. ericetorum, Betula spp. (seedlings)), from the drier areas. An unusual feature of the latter sub-variant is the occurence of Phragmites australis in some areas, even those that are quite dry.

The Cladonia impexa variant is found at about 240 - 250 m O.D., on the Haldon hills, South Devon. This is the wet heath that accompanies the Agrostis setacea community (I.2.d.), which is the commonest vegetation of the Haldon hills.

IV.2.c. Deschampsia flexuosa community.
Identifying species; D. flexuosa, Juncus squarrosus, Eriophorum angustifolium, Hypnum ericetorum, Pohlia nutans, Scirpus caespitosus, Carex nigra, Cephalozia bicuspidata.
Distribution; Stafford, Derby.
Variants; (i) Eriophorum vaginetum variant, differential species - E. vaginetum, Dicranum scoparium.
Ecological Notes; Found on the Southern Pennines and Staffordshire 'Forests' and 'Chases'. The Eriophorum vaginetum variant represents rather degraded blanket peat vegetation, with the Vaccinium myrtillus sub-variant (differential species - V. myrtillus, Empetrum nigrum).

representing the driest forms of such vegetation. Peat depths in general is between 15 and 20 cm.

IV.2.d. Ulex gallii community.

Identifying species; U. gallii, Potentilla erecta.

Distribution; W. Cornwall.

Variants; (i) Holcus_lanatus_variant, differential species - H. lanatus, Sieglingia decumbens, Festuca ovina, (ii) Schoenus_nigricans_variant - differential species - S. nigricans.

Ecological Notes; The most oceanic of the 'wet heath' vegetation, this community has two distinct variants. Lands End, the most westerly point in Britain, supports the Holcus_lanatus_variant, in which two distinct sub-variants are found; (a) the Hydrocotyle_vulgaris sub-variant (differential species - H. vulgaris, Agrostis canina, Ulex europaeus), and (b) the Erica cinerea sub-variant (differential species - E. cinerea, Cladonia floerkeana, Zygogonium ericetorum).

The former, found on level moorland exposed to the west, is strongly analagous to the Hydrocotyle vulgaris community (I.1.d.), with exception that this sub-variant is not found on slopes, neither does it have water seepage through it, although the peat is unusually moist in this vegetation.

The second sub-variant, occurs on slightly sloping, southerly exposed moorland, and is a much drier community. It is, in fact, rather wet in winter, but during the dry summers, Zygogonium ericetorum and other algae dry to form a papery mat.

The Schoenus_nigricans_variant is found further inland, in areas with a peat depth of 15 - 20 cm. Some areas are 'streamside' communities, from a drier moorland, and these form the Succisa pratensis_ sub-variant (differential species - S. pratensis, Carex panicea, *Pedicularis sylvatica, Dactylorhiza ericetorum, Narthecium ossifragum, Sphagnum quinquefarium*). The variant is sometimes found with a peat depth of only 6 - 8 cm. - but in these cases the substrate is clay, and not sand or gravel.

V.3. Conclusions.

The vegetation units described above show the great variation present in the British Heath Formation. This variation can, however, be encompassed within the existing framework of the Z-M school, i.e. the three alliances Ulicion, Myrtillion and Calluno-Genistion of the Class Nardo-Calluneta, and the alliance Ericion tetralicis of the class Oxycocco-sphagnetea.

At the time of writing, the synsystematics of N. W. European Heath is under consideration by de Smidt (Pers.Comm.), and some revision of existing structure is likely, as vegetation not previously described in European literature, including some of the relevés from this survey are being considered, along with existing literature.

One important point that emerges is that the Z-M phytosociological system can be tailored to local needs and situations, within a rigid international framework. Vegetation keys, for example, can be produced regionally or nationally, without the difficulties from overlapping differential species, that would arise in an international 'key'. Such keys would be of value and use in the application of phytosociology, particularly in developing countries, where identification of vegetation types for agriculture, afforestation, conservation, etc., is of prime importance.

Thus, in conclusion, the application of the Z-M system, is seen to provide a useful classification that can be linked with that of Continental European heathlands, and, in a more general way, that of other continents. In addition, it is seen to be a flexible system, capable of tailoring to a variety of situations.

SECTION VI.

Historical Phytosociology.

VI.1. Introduction.

Many vegetation studies are made solely on the basis of the present state of the vegetation without reference to its origins and former extent. Interpretation of vegetation should also involve some reference to its recent historical background, more especially where such interpretations are made for the purposes of conservation, land use, etc.

Palynological studies have given a general picture of vegetation cover before, during, and after the Last Ice Age, but the nearer in time one approaches to the Twentieth Century, the amount of useful and extractable data declines sharply. Many other sources of information do exist, but are little utilised, e.g. place names, local histories, Archives, Parish registers and old Botanical records!

Historical documentation generally, and the use of relict vegetation, is discussed below, and one area - South Gloucestershire - has been subjected to detailed study using a number of differing techniques.

VI.2. Use of Documents.

The first useful documentary evidence of a general nature on vegetation and the countryside is provided by Leland, who travelled about England for six years during the period 1535 - 1543 (approximately), He made voluminous notes which were not properly assembled until the Eighteenth Century.

The greater abundance of heath and heather moor in the Durham - Newcastle region, now either agricultural or mining country, is given by him as follows: (text by Smith, 1906). "From Duresme over Framgate Bridge to Chester in the Streate partly by a little corn ground, but most by Mountaineose Pasture and Some Mores and Fyrres....Thense to Gateshed vij miles by Mountaineose Ground with pasture, Heth, More and Fyrres."

Then came a lull, until the Eighteenth and Nineteenth Centuries, when many of 'Wastelands' were enclosed. A full review of the literature of this period is found in Darby (1936) pp.466-492. Details of the enclosures can be found in the various enclosure acts of Parliament, which provide a detailed local coverage.

VI.3. Relict Vegetation.

The most useful available form of relict vegetation in Britain, is the hedgerow. In Southern and Midland England, particularly, the hedgerows have been in existence for several centuries.

Hoskins (1967), has shown that hedge banks can be 'aged' by the number of shrub species represented. In addition to this, the hedge bank often provides a haven for species previously important in the natural vegetation. Here, the older the hedgebank, the less likely will the species composition reflect the previous vegetation. Two lists below illustrate this. The first, from Little Newcastle, Pembrokeshire, is from an area that still has some moorland in the vicinity, although the hedgebanks separate sheep pastureland. Non-heathland shrubs are virtually absent - the dominant shrub being Ulex europaeus; (N.B. figures are those of the Braun-Blanquet scale, 1928).

U. europaeus	3.3*	Dryopteris dilatata	+
Erica cinerea	2.3*	Lotus uliginosus	1.2
Blechnum spicant	1.2*	Holcus lanatus	2.2
Dactylis glomerata	3.3	Festuca rubra	+ *
Dryopteris felix-mas	+	Ulex gallii	1.2 *
Rubus discolores	1.2	Calluna vulgaris	1.2 *
Plantago lanceolata	+	Teucrium scorodonia	+ *
Agrostis tenuis	2.2 *	Rumex crispus	+
Potentilla erecta	+ *	Centaurea nigra	+
Hieracium tridentata	1.2		

Area of Plot, 6 sq.m., * = species typically found in surrounding heath vegetation.

The second is taken from Umberleigh, N. Devon. Here there are mesophytic shrubs dominating the hedge bank, and no trace of ericoids. The whole surrounding area is cultivated, and has been for a considerable time. Even so, there are a number of species that are referable to heathland vegetation of the area (indicated by *).

Shrubs; Quercus spp. 3.1*, Corylus avellana 1.1, Rubus glandulosi 2.1 *, Ilex aquifolium 1.1 *, Fraxinus excelsior +.

Bank.

Agrostis tenuis	1.2 *	Geranium robertianum	1.1
Angelica sylvestris	1.2	Hedera helix	2.3
Anthriscus sylvestris	+	Hieracium umbellatum	1.1 *
Arrhenatherum elatius	2.3	Holcus lanatus	1.2 *
Betonica officinalis	+ *	Hypericum pulchrum	+ *
Blechnum spicant	1.2 *	Polypodium vulgare	+
Dryopteris felix-mas	+.2	Pteridium aquilinum	2.2 *
Epilobium lanceolatum	1.1	Rumex crispus	+
Frageria vesca	1.1	Succisa pratensis	+.2 *
Galium aparine	1.2	Teucrium scorodonia	1.2 *
G. saxatile	+ *		

Thus, as qualitative guides to the former vegetation, small relict 'islands' such as hedgerows and roadside banks, are extremely useful.

VI.4. Site study of South Gloucestershire.

VI.4.a. Site Descriptions.

In the period July - August, 1967, the area was visited, and any communities that could be ascribed to Heathland, or a degeneration product of Heathland, were described, using the methods of the Zurich-Montpellier School. Most of the communities were extremely fragmentary, but it has been possible to group them into four types:- (i) Communities of the Class Nardo-Callunetea (the "true heaths"), (ii) Communities of the Class Molinio-Arrhenatheretea R.Tx.1937 (the anthropogenic degradation product, particularly of Wet heaths), and (iii) Communities of mixed identity between (i) and (ii) above, (iv) acidic communities of the class Festuco-Brometea Br.-Bl. et. R.Tx. 1943. The location of sites is shown on Map 1., floristic details in Tables I - IV, and the site descriptions

MAP VI/1

Showing the area of South Gloucestershire under consideration, its river system, location of sites studied, and details of some of the place names.

LEGEND.

▲	'Green' place name.
●	'Heath' " "
■	'Common' " "

Areas enclosed by broken lines indicate the occurence of Pennant Sandstone (Lower Carboniferous).

Scale - 1:25,000

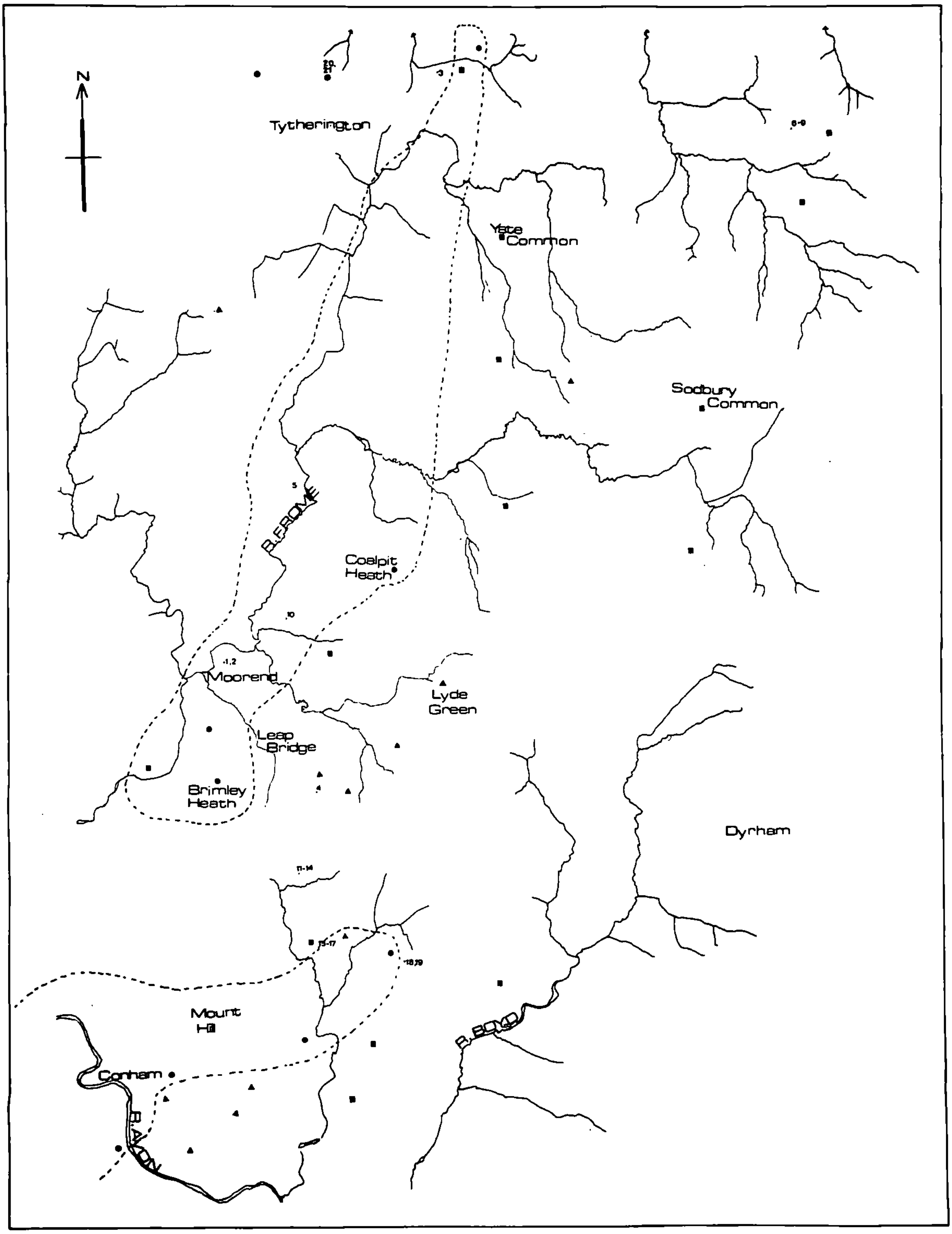

N
Tytherington
Yate
Common
Sodbury
Common
R. FROME
Coalpit
Heath
Moorend
Lyde
Green
Leap
Bridge
Brimley
Heath
Dyrham
Mount
Hill
Conham
R. AVON
R. BOYD

TABLE I.

Communities of the Class Nardo-Callunetea.

SITE NO.	1	14	11	17	12	16
Nardo-Callunetea char.						
Calluna vulgaris	1.3	+	5.5	3.3	4.4	1.3
Galium saxatile	1.3	+	1.3	3.3	+	2.3
Festuca rubra	1.3	3.3	3.3	3.3	3.3	
Agrostis tenuis	2.3	2.3			3.3	3.3
Potentilla erecta	+			+	+	1.3
Ulex gallii	2.2	1.3			+	5.5
Luzula campestris			+		+	+
Festuca tenuifolia				2.3		2.3
Campanula rotundifolia	(+)					1.1
Dicranum scoparium			5.5	4.4	1.3	
Sieglingia decumbens		+	+		1.2	
Deschampsia flexuosa	1.2				+	
Hypochoeris radicata	+			r		
Festuca ovina ssp.ovina		2.2				
Companion species.						
Agrostis stolonifera	+					3.3
Rumex acetosa	1.2					1.2
Holcus lanatus	+			+		
Hieracium sect. tridentata				1.1	r	
Rumex acetosella			+	2.3		
Dicranella varia						+
Leontodon autumnalis					1.1	
Achillea millefolium				1.2		
Galium verum				+		
Raununculus repens				+		
Solidago viraurea			+			
Hieracium sect. umbellatum		+				
Teucrium scorodonia	2.2					
Anthoxanthum odoratum	+					
Lolium perenne	+					
Hieracium sect. vulgatum	+					
Crepis capillaris	+S					
Stellaria graminea	(+)					

TABLE II.

Communities of the Class Molinio-Arrhenatheretea.

SITE NO.	8	6	9	3	7	5	18	19	4
Molinio-Arrhenatheretea char.									
Holcus lanatus	1.1	3.3	3.3	+	3.3	3.3	3.3	+	1.1
Phleum pratense	+	+	+	+	+	+	+	+	1.1
Anthoxanthum odoratum	1.1	1.2	1.1	(+)	1.1		1.2	1.2	+
Agrostis tenuis	1.2	1.2	2.3	2.2			4.4	3.3	1.2
Dactylis glomerata	+	+	+	4.4		3.3	2.2		+
Festuca rubra	+	+		2.2	+	1.2		1.2	
Centaurea nigra	+	1.1	1.1	+	1.1	+			(+)
Plantago lanceolata	+	+	+	+	+	1.1			
Senecio aquaticus		1.1	1.1		1.1				
Rumex acetosa		+				+			
Arrhenatherum elatius			1.1	2.2					
Cynosurus cristatus	+	+	+	+					
Bromus mollis	+	+	1.1						
Hordeum secalinum	+	1.1	2.1						
Briza media	+	+	+						
Poa pratensis	+	+	+						
Molinietalia char.									
Deschampsia caespitosa	3.2	3.3	3.2	3.2	3.2		4.2	4.2	5.2
Prunella vulgaris	+			1.1	+	1.1		+	
Achillea ptarmica								+	1.1
Juncus effusus		2.2	+	2.2	+	1.2			
Angelica sylvestris				+	+	+			
Cirsium palustre	+		+	+					
Juncus conglomeratus	+	+							
Molinion char.									
Ranunculus acris.	2.1	2.1	2.2	1.1	2.2		1.2	+	+
Lotus uliginosus	+	1.1	+	1.2	+		+		1.1
Potentilla erecta			2.3		+	+		1.3	
Trifolium pratense	+	+	2.1				+	+	
Potentilla reptans	+	+	1.1	1.2	1.1	+	+		
Lysimachia nummularia	1.3		+			2.3			
Carex flacca		+	2.2	+	2.2	+			
Species of uncertain alliance.									
Potentilla anserina	+	1.1	1.2	+	1.2				1.1
Agrostis stolonifera		1.2		1.2		1.2			+
Cirsium arvense	3.1	2.1	2.1	+	3.1		r		
Trifolium medium			+			+	+	1.1	
Agrimonia eupatorium	+	+	+	1.1	+	+			
Carex hirta		1.2	2.2		2.2	2.2			
Rubus fruticosus sect. discolores			+	+	+	+			
Ranunculus flammula	+			+		1.2			
Juncus inflexus		1.2		+		1.2			
Cerastium glomeratum		+	+	+	+				

/continued........

TABLE II. (continued).

SITE NO.	8	6	9	3	7	5	18	19	4
<u>Companion species.</u>									
Juncus acutiflorus									+
Sieglingia decumbens								1.2	
Galium palustre			+						(+)
Trifolium repens	+	+							+
Achillea millefolium				1.1			+		
Taraxacum officinale					r		r		
Epilobium parviflorum		+	+			(+)			
Vicia cracca					+	+			
Heracleum sphondylium				+		+			
Rumex crispus			+		+				
Cirsium vulgare		2.1			+				
Carex ovalis	1.2				1.2				
Ononis spinosa	(+)				+				
Epilobium hirsutum		+		+					
Agrostis canina	1.2		1.1						
Lolium perenne		+	+						
Leucanthemum vulgare		+	+						
Succisa pratensis						2.2			
Sarothamnus scoparius						+			
Galium verum				2.2					
Filipendula ulmaria				1.1					
Equisetum arvense				+					
Galium aparine				+					
Betonica officinalis				+					
Conopodium majus				+					
Stachys sylvatica				+					
Urtica dioica			+						
Alopecurus geniculatus		+							
Hypericum hirsutum	+								
H. tetrapterum	+								
Carex ovalis	+								

Also at (3): Acrocladium cuspidatum +, Eurhynchium striatum +, Dicranum majus 2.3, Pseudoscleropodium purum 1.3, Mnium punctatum +.

TABLE III.

Communities of Mixed Identity.

SITE NO.	2	10	15	13.
Nardo-Callunetea char.				
Galium saxatile			2.3	4.4
Campanula rotundifolia			1.1	2.1
Carex pilulifera				1.2
Hypochoeris radicata			2.2	
Luzula campestris			+	
Pilosella officinarum			1.3	
Holcus mollis		4.4	2.3	
Teucrium scorodonia	1.1	2.3		
Deschampsia flexuosa	2.2			
Molinio-Arrhenatheretea char.				
Plantago lanceolata		+	1.2	2.1
Lotus corniculatus			1.2	+
Trifolium pratense			+	
Cirsium palustre			+	
Anthoxanthum odoratum		+		
Holcus lanatus		+		
Centaurea nigra		1.1		
Rumex acetosa		1.1		
char. of both classes.				
Festuca rubra	+	1.1	4.4	5.5
Agrostis tenuis		2.2	3.3	3.3
Sieglingia decumbens				1.2
Potentilla erecta	+			
Companion species.				
Quercus sp. (k)	+	+		
Rubus fruticosus sect. silvatici	+	+		
Agrostis stolonifera			1.2	
Cerastium glomeratum			+	
Agrostis canina	1.1			
Hieracium sect.umbellatum	1.1			
H. sect. vulgatum	+			
Succisa pratensis	+			
Betula pendula (k)	+			
Hieracium sect. tridentata		+		
Achillea millefolium			+	
Rumex acetosella			+	
Ranunculus bulbosus			+	
Solidago virgaurea				+

Also at (10). Stellaria graminea +; Rumex crispus +; Galium aparine +; Urtica dioica +; Taracacum officinale +; Betonica officinalis +; Cirsium vulgare +; Conopodium majus +; Chamaenerion angustifolium +; Lathyrus montanus 1.1; Endymion non-scriptus 1.1; Viola canina +; Allium vineale +; Prunus spinosa +; Crataegus monogyna +; Eurhynchium striatum +;

TABLE IV.

Communities of the class Festuco-Brometea.

SITE NO.	20	21
Mesobromion All. char.		
Helianthemum nummularium	1.3	+
Centaurea nigra	1.1	+
Pimpinella saxifraga	+	+
Poterium sanguisorba	1.2	2.2
Lotus corniculatus	+	1.3
Galium verum	+	+
Achillea millefolium	+	1.2
Cirsium acaule	+	+
Plantago lanceolata	+	+
Brachypodium pinnatum	5.5	
Dactylis glomerata	1.2	
Hypericum perforatum	+	
Helictotrichon pratensis		5.5
Poa pratensis		+
Briza media		+
Centaurea scabiosa		1.1
Scabiosa columbaria		+
Arrhenatheretalia Ord. char.		
Arrhenatherum elatius	1.2	+
Succisa pratensis	+	+
Deschampsia caespitosa	+	
Agrostis tenuis		+
Anthoxanthum odoratum		+
Companion species.		
Trifolium medium	+	
Clematis vitalba	+	
Ulex gallii	+	
Plantago media		+
Agrimonia eupatorium		+
Lathyrus pratensis		+
Heracleum spondylium		r
Potentilla erecta		(+)

wrong place

in the text below;

Sites 1, 2. BURY HILL, Winterbourne, Grid Reference 31/652792.

The area consists of the Old Earthworks of Bury Hill Camp, with pennant sandstone as underlying rock. Much of the vegetation is *Ulex gallii*, *U. europaeus*, scrub, though there is still extensive cattle grazing. Relevés were taken on the slopes of ramparts, 10° - 15° SW, Altitude = 150'.

Site 3. CROMHALL COMMON, Grid Reference 31/683884.

An area of damp meadowland, occasionally cut for hay, beside the Bagstone - Tythennington road. The underlying rocks are Triassic marl beds, the altitude is 170 '.

Site 4. EMERSONS GREEN. Grid Reference 31/669770.

This site is a portion of the once extensive "Greens" in this area of East Bristol, and is preserved in the first 100 yards of a wide "Green Lane", leading to Lyde Green. There is no evidence of interference by cattle, or of the area being cut. The area is underlain by clays and marls of the Upper Coal series, and has an altitude of 200 '.

Site 5. FRAMPTON COTTERELL COMMON. Grid Reference 31/670827.

A small clearing in an area now planted with *Pinus sylvestris*, formerly the site of Iron Ore mining; on the exposed sandstone cliffs adjacent to the site, *Viola canina* and *Blechnum spicant* flourish extensively. Altitude 170 '.

Sites 6 - 9. INGLESTONE COMMON. Grid Reference (6,7) 31/7489 & (8,9) 31/7588

These are aufnahmen taken from the largest group of 'commons' now left in South Gloucestershire. The whole area is more or less level, rather damp pasture land. Some of the area is subject to quite heavy grazing and trampling by cattle. The most northerly sites considered, they are on triassic marls, at an altitude of 275'.

Site 10. IVORY HILL. Grid Reference 31/663800.

Due to road widening, this site is now a mere vestige. The dominant is Pteridium aquilinium. Altitude 250 '.

Sites 11 - 14. RODWAY HILL. Grid Reference 31/6675

11, 13 are level, 12 and 14 are 10° - 15° SW. This site, often quoted as "The last vestige of the forest of Kingswood", consists of an area of grass heath, with bracken dominant on the hill slopes. The underlying rock is pennant sandstone, outcropping in some places. Human influence is very pronounced, as this serves as the first "buffer" for the large population of N. E. Bristol. One of the most interesting points about this site is the occurence of a small spring bog on the spring line. Although several Juncus effusus/J. articulatus marshes are widespread in the area, this is probably the only site with Sphagnum (S. subsecundum) present. Other associated species are Juncus effusus, Hypericum elodes, Hydrocotyle vulgaris, Molinia caerulea, and Epilobium hirsutum. These small acidic bogs were probably also much more widespread before the lands were drained for agriculture. §

Sites 15 - 17. SISTON COMMON. Grid Reference 31/6674.

A large area of Grass Heath, Calluna vulgaris becoming dominant, in some places (cf. the 'commons' in the Surrey Suburbs of London). Cattle occasionally graze the area. As with the last four sites, it is subject to much human influence. In general, the area is gently sloping, overlying the lower coal marls and clays, and has an altitude of 200 '.

Sites 18-19. WEBB'S HEATH. Grid Reference 31/680739.

As with the last site, an area of damp, grassy common land - subject to very little grazing, or human pressure. Geology and altitude as sites 15 - 17.

Sites 20-21. MILBURY HEATH. Grid Reference 31/665900.

Altitude 300 '. This site is a small area of common, about 1.5 km. from Tytherrington. The underlying rock is carboniferous limestone, and the communities are allied to the 'Limestone Heath' vegetation described by Moss (1907) for the Mendips (Carex flacca community, I.4.c.)

The damp, cattle grazed commons can be assigned to the class Molinio-Arrhenatheretea - probably related to the association Junco-Molinetum Prsg., 1951. They are typically found on the Triasic and Carboniferous marls - the type of soils being those most suitable for cultivation. Sandstones and gritstones - harsher to tame and cultivate - support vegetation communities of the class Nardo-Callunetea (Erica cinerea Heath (I)).

IV.4.b. Site Records from Botanical Sources.

The area has been well botanised and documented from a relatively early period, and there have been many Botanical publications, for example, Ellacombe (1883), Swete (1854), White (1879-1887), Riddelsdell (1948). The following list of Heathland sites is taken from these publications, together with their fate. Bromley Heath, Downend (urbanised), Brimley Heath, now the residential district of Cleere Hill, Downend, Coalpit Heath (urbanised), Durdham Downs - a limestone heath - has become progressively more tame, and is now mown regularly. This latter process is, of course, extremely detrimental to the survival of heath plants. Hanham Heath, mostly settled, though some now "tamed" as a green, Kendleshire Common (ploughed up), Lyde Green (ploughed up), Oldland Common (settled), Sodbury Common (much now a golf course), Whiteshill (now a football pitch), Winterbourne Down (settled), and Yate Common (ploughed up in 1946). White (1912) gives reference also to three areas as 'dry, sandy turf' - and seems to mean a type of grass heath vegetation. The sites he quotes are - Brandon Hill (now a park), Leap Bridge and Troopers Hill, both now urbanised. Leap Bridge is interesting as it has one of the few sites for Potentilla argentea. The location of all these sites is also shown on Map. 1.

That areas of South Gloucestershire were once large expanses of heath and scrubland, cannot be doubted, as the wealth of ancient records show, despite the fact that there is virtually no sign of this today. For example, when questioned, several local inhabitants explained that the Milbury Heath site was formerly much more extensive, but due to quarrying, and neglect in some cases, the heath had retracted to the small patch described earlier. Thus it is obviously necessary to know the history of the area involved, and the next section examines the sources for this.

VI.4.c. Historical Sources.

Local historians have been quite active in the region, and the diverse sources consolidated into a few concentrated works, i.e. Braine (1913), Ellacombe (1883) and Payne (1946). The following account is based on these three sources. In some areas, such complete accounts will rarely be available, and the task of constructing the paths of history has to be traced from rather more accounts.

The whole, rather flat area of South Gloucestershire "from the Sodbury Hills to the Severn Marshes, southwards to Lansdown, Bitton and Bristol", was once forested, and used for hunting by the Saxon kings, who had a Royal Palace at Pucklechurch. The whole area was known as "The Royal Forest of Kingswood", and, rather surprisingly, was mentioned in the Domsday Book - presumably as it was "Terra Regis".

In 1228, under Baronial pressure, Henry III dissafforested "all the towns, lands and woods between Huntingford and the Wood of Furzes (Kingswood), to within four miles of Bristol, and soe from Severne side to the browes of the hills by Sodbury, excepting only Allestone Park " (Ellacombe 1883). A portion of 3432 acres within the parishes of SS.Philip and Jacob, Stapleton, Mangotsfield and Bitton was left as a Chase (It is interesting to note that most of the ten relict sites are from this area). During the Civil War, this land was prey to all comers, and ultimately powerful Lords claimed all the land.

By 1800 much of the land was enclosed, virtually the last lands (Longwell Green, Cadbury Heath, Oldland and North Commons) were enclosed by the enclosure act of 1819. Now there are only Inglestone and Sodbury Commons in the North, and a few remnants around Siston common on the East Bristol Fringe to show what remains of the great Kingswood Forest.

After the initial dissafforestation period the area became covered by a Heath type of vegetation - with Erica cinerea, Calluna vulgaris and in the wetter areas, E. tetralix as the major species. This much can be gleaned from White (1912), who wrote "little is now left of the large tracts of Heath which existed at one time in the vicinity of Bristol... The Invasion of human feet over all spaces available for sports and recreating is mainly responsible for the elimination or disappearance of ericetal plants from these Downs and Commons that are readily accessible to the people; and Ericaceae certainly furnish some of the chief sufferers."

This spread of population is due to the Industrial revolution, which not only demanded more space for housing, but also needed more coal and iron. Though the latter was mined in but small quantities, the North Bristol Coalfield, in its heydey, extended over all the Kingswood Forest area. Consequent upon these developments, came the need for increased agricultural production, and much of the former, fallow land, was put to the plough.

Such records as these provide the background and generalised details of the vegetation, and its changes. Detailed Floristic data, however, cannot be derived from such sources.

VI.4.c. <u>Historic Botanical Records.</u>

In Britain, there is a wealth of relatively old Botanical literature, itself often containing even older records. The spread of the data is rather uneven, both in quantity and quality. The Flora's available for the area, White (1912), Riddlesdell (1948), provide much useful information. In both publications a similar form of recording is adopted - species are either described as common, widely distributed, etc., or have a detailed list of localities appended. Where this is done the species is usually fairly restricted, i.e. has a fairly narrow ecological amplitude. As such, these species are often characteristic of a particular hierachical unit in the Zurich-Montpellier school of Phytosociology, and thus lend themselves easily to analysis.

The following method of analysis has been adopted:- Some 32 species were chosen - all characteristic of one of the following four classes of vegetation - <u>Nardo-Callunetea</u>, <u>Molinio-Arrhenatheretea</u>, <u>Querco-Fagetea Br.-Bl. et. Vlieger</u>, 1937, and <u>Sedo-Scleranthetea, Br.-Bl. 1955, em. Oberd.mskr.</u> The first two classes have already been mentioned - the <u>Querco-Fagetea</u> represented the Woodland stage from which the Heaths would be secondarily derived, and the <u>Sedo-Scleranthetea</u> a stage of dry grass sward, precurser of the Heath stage. All three classes, therefore, reflect the dynamic stages of the Heath communities.

For each species the localities were noted (a total of eleven sites), and for each site a percentage presence value of each class was calculated, using the following formula:

$$\% \text{ presence} = \frac{\text{Total spp. recorded per class}}{\text{Total spp. recorded per site}} \times 100$$

Where a species appeared to be characteristic of two classes, it was recorded separately for each class (Note. The affinities of the species was defined using Oberdorfer (1962) and Westhoff (1969)). These percentage values give the proportionality of each class for each site. The raw data is presented in Table V, on page 186, and the percentage values presented in the histograms of Fig.1. The resultant graph forms fall into four fairly distinct groups:-

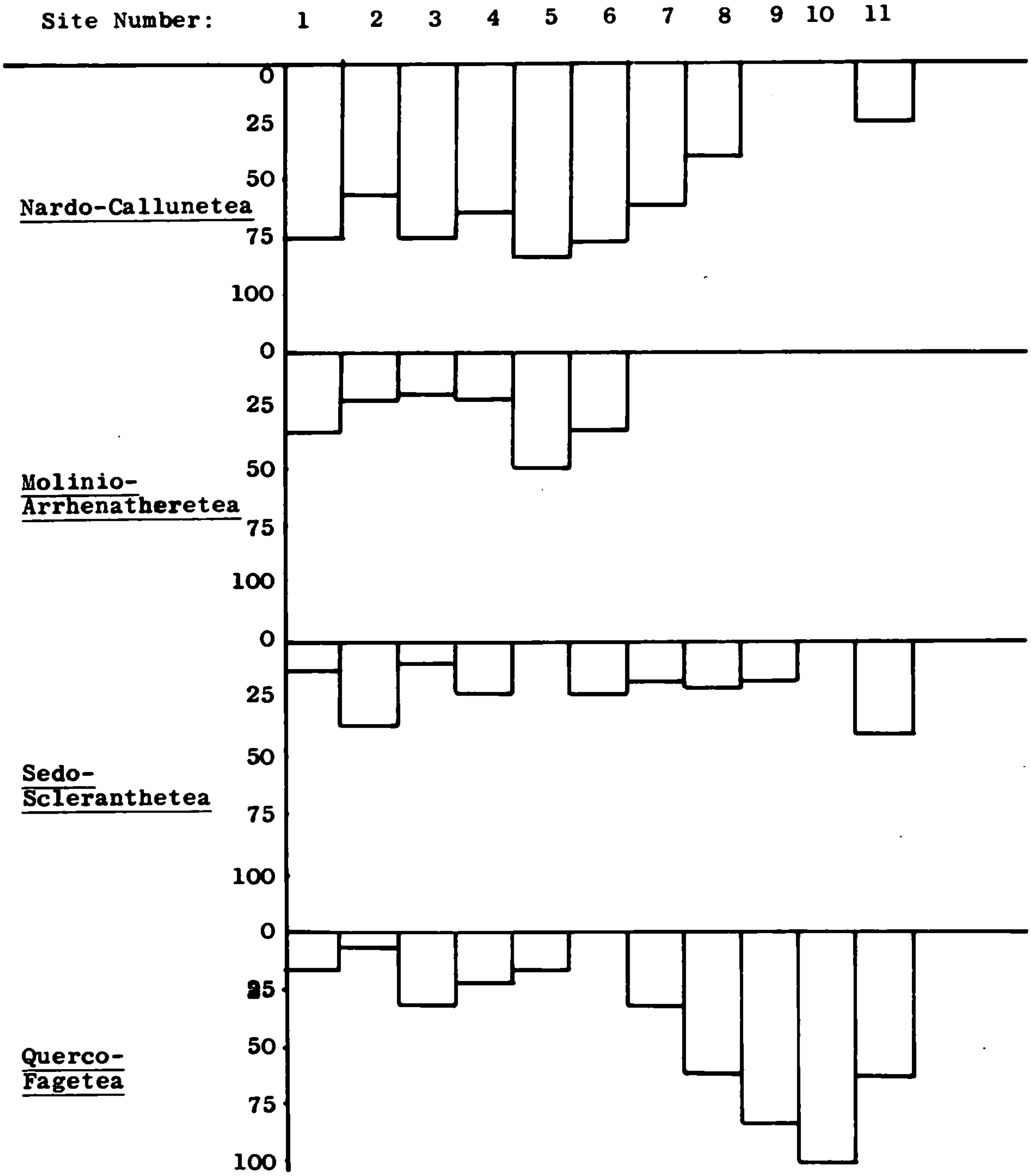
(i) Sites 1-4. In each case, elements of all four classes are present, but the largest proportion in each case is assumed by the Nardo-Callunetea. The vegetation was thus probably Heath-like, with smaller areas of grassland and wood scrub.

(ii) Sites 5-7. In these, also Nardo-Callunetea is proportionally greater, but only two other classes are represented at any one time. Cromhall Common, a low lying, damp pasture area, the dry sandy communities of the S-S are absent. Clifton Downs have been settled, and subject to much human pressure for some considerable period, thus lack the elements of the Querco-Fagetea comes as no surprise; whereas the Glen Frome area, with its steep sided river gorge has Querco-Fagetea elements second to Nardo-Callunetea (see also Site 11.)

(iii) Sites 8-10. These sites are denoted by the predominance of elements of the Sedo-Scleranthetea, and the only class absent from all three is the Molinio-Arrhenatheretea (damp grasslands). Sites 8-9 occur on Pennants sandstone, 10 on Millstone grit.

(iv) Site 11. Here the dominant class is the Querco-Fagetea. As at Glen Frome (7), the site is a river gorge, cut through the Pennant Sandstone, and thus an obvious refuge for woodland communities.

Thus it can be seen that quite an accurate reconstruction of the plant vegetation of the area can be made. It is noticable that the one class represented more than any other is the Nardo-Callunetea - an indication of its former widespread nature.



"N.B. % values are calculated as per text".

Fig. VI/1.

TABLE V.

Distribution of 'Key Species' in Kingswood Forest Area.

SITE NO.	1	2	3	4	5	6	7	8	9	10	11
(A)											
Viola lactea	+										
Polygala oxyterpa				+		+					
P. serpyllifolia	+	+									
Hypericum maculatum			+				+				
Ulex gallii	+	+	+	+	+	+	+				
Genista anglica	+	+		+							
Sarothamnus scoparius								+			
Lathyrus montanus	+		+	+							
Campanula rotundifolia	+		+								
Erica tetralix	+					+	+				
Pedicularis sylvatica	+	+		+		+					
Nardus stricta	+	+									
H olcus mollis	+		+		+						
(B)											
Viola canina	+	+	+	+							
Betonica officinalis	+	+	+	+	+	+					
Salix repens	+										
Luzula multiflora	+										
Sieglingia decumbens	+			+	+	+					
Molinia caerulea	+					+					
(C)											
Achillea ptarmica	+	+			+						
(D)											
Deschampsia flexuosa	+	+	+	+	+		+	+			+
Hieracium sect.umbellatum	+										+
(E)											
Senecio sylvaticus	+		+	+					+		+
Hieracium sect.tridentata	+		+								+
H. sect. sabauda			+	+			+				+
(F)											
Moenchia erecta	+	+				+				+	+
Sagina ciliata		+					+		+	+	
Aira praecox	+	+	+	+		+			+	+	+
Plantago coronopus								+	+	+	
Rumex acetosella								+		+	
Spergularia rubra	+	+		+				+	+	+	
Scleranthus annuus									+	+	

(A) Nardo-Callunetea; (B) Nardo-Callunetea/Molinio-Arrhenatheretea;
(C) Molinio-Arrhenatheretea; (D) Nardo-Callunetea/Querco-Fagetea;
(E) Querco-Fagetea; (F) Sedo-Scleranthetea., character species.
SITES: 1. Yate Common; 2. Siston Common; 3. Ivory Hill; 4. Rodway Hill.
5. Cromhall Common; 6. Clifton/Durdham Downs; 7. Glen Frome/Stapleton;
8. Troopers Hill; 9. Frenchay Common; 10. Brandon Hill; 11. Conham/Hanham.

A second type of analysis was also possible in this area - the tabulation of the distribution of some of the microspecies of the Rubus fruticosus aggregate. (Table VI, page 188). This was possible because of the well documented records in both floras. Many of these microspecies are exceedingly specific to distinct types of habitat. Those included in the table were described to be of 'bushy, rough heathy spots.' The value of this table is that it confirms the data obtained for such areas as Conham, Rodway Hill, Siston Common, Ivory Hill, Yate Common etc., as well as adding many new areas about which less information was available, i.e. Mount Hill, Leap Bridge.

What is of particular interest is that most of the 'species' are from three sections - glandulosi, sylvaticii and appendiculati. This is a fairly clear pointer that in normal phytosociological descriptions, "species" such as R. fruticosus and Hieracium vulgaris s.l., should really be determined to the section, as these may have very different and distinct ecological preferences.

V. Use of Place Names.

Place names have been used by the Historical Geographer to yield much information (Mitchell, 1954) - and can also be utilised with advantage by the 'historical botanist'. The one difficulty in the use of place names, however, is that occasionally some misunderstandings may arise because of incomplete knowledge of the precise meaning of the name. "Heath" is sometimes exceptionally vulnerable in this respect, e.g. Shapwick Heath, Somerset is an area of Fen Carr and has never been a heath. In this case, the names 'Green' and 'Common' are important, together with Heath, which is interpretable as Rough grassland/genuine Heath in this case.

It must be stressed that place names are merely a complement to other sources, and not a means of detection in their own right.

TABLE VI.

Table showing distribution of Rubus fruticosus Agg. in Kingswood Area.

SITE NUMBER:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SPECIES:																	
Rubus lindleianus	+	+		+	+	+		+					+		+		+
R. cardiophyllus	+	+	+	+	+	+		+		+							
R. imbricatus	+	+		+	+		+				+			+			
R. polyanthemus		+	+	+		+			+							+	
R. rhombifolius	+		+				+	+			+	+					
R. leucostachys	+	+	+		+		+				+						
R. dasyphyllus	+	+	+	+	+	+		+		+							
R. mucronulatus		+				+		+	+	+							
R. raduloides			+			+		+	+								
R. discerptus	+			+		+											
R. affinis			+	+					+								
R. koehleri		+		+				+									
R. pyramidalis	+		+		+												
R. bakereanus			+				+										
R. halsteadensis				+		+											
R. villicaulis	+			+													
R. rotundatus								+									
R. oligocladus																+	
R. retrodentatus										+							
R. egregius							+										
R. X pyramidalis X rusticanus						+											
R. winteri	+																

SITES:- (1) Conham, (2) Stapleton, (3) Rodway Hill, (4) Siston Common, (5) Bury Hill, (6) Ivory Hill, (7) Frampton Cotterell Common, (8) Yate Common, (9) Clifton Down, (10) Frome Valley in Frenchay/Fishponds area, (11) Hanham, (12) Milbury Heath, (13) Leap Bridge, Downend, (14) Inglestone Common, (15) Troopers Hill, (16) Mount Hill, Kingswood, (17) Brandon Hill.

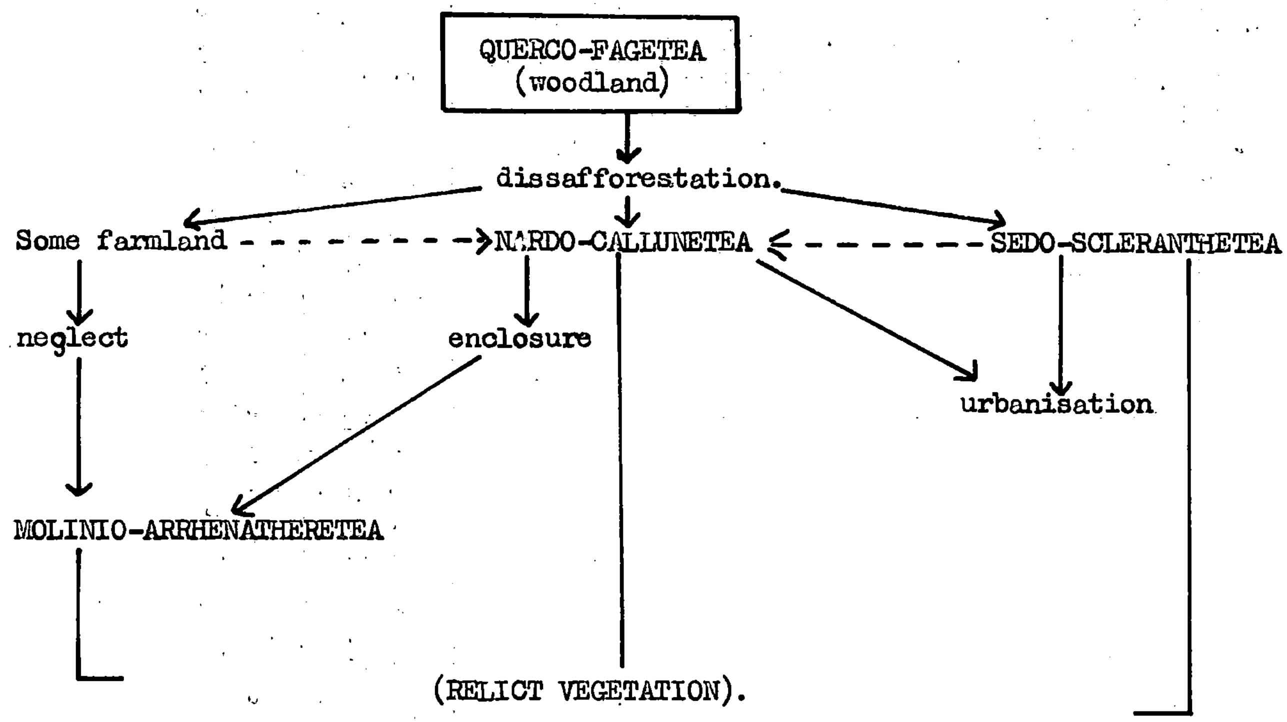

QUERCO-FAGETEA
(woodland)
dissafforestation.
Some farmland
NARDO-CALLUNETEA
SEDO-SCLERANTHETEA
neglect
enclosure
urbanisation
MOLINIO-ARRHENATHERETEA
(RELICT VEGETATION).

Fig. VI.ii.

The distribution of these is shown on Map 1. 'Heath' is notably commoner on the sandstone areas, 'Green' and 'Common' tend to occur more frequently on the low lying marls. These areas were probably used as cattle grazing for the villages and Hamlets, virtually since dissafforestation. Their distribution does give a clear reflection and confirmation with the other data, of the former extent of Heathlands in South Gloucestershire.

VI.5. Conclusion.

The sources and methods outlined above show how it is possible to bring together a large amount of information on the present and past, of an area. This information has enabled a picture of vegetational, and landscape change. The anthropogenic influences and effects are more easily seen, and the value and benefits of this in conservational studies cannot be neglected. From Section VI.4. of the text, a diagram of the vegetational change has been prepared. (Fig.2.)

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