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A PHYTOSOCIOLOGICAL SURVEY OF
BRITISH ARABLE-WEED AND RELATED COMMUNITIES

ALAN J. SILVERSIDE

Ph.D. Thesis

(Text Volume)

Supported by N.E.R.C. Research Studentship

GT4/69/NC/36

Supervised by Dr. D.J. Bellamy

Department of Botany, University of Durham

1977

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A Phytosociological Survey of British Arable - weed
and related Communities

A. J. Silverside

Abstract

Weed communities of British arable land have been extensively surveyed and classified using Zürich-Montpellier ("Braun-Blanquet") methods of analysis. After comparison of British results with continental literature it is concluded that most stands are referable to the class Stellarietea. A number of associations can be distinguished, classified as follows:

Order: Polygono - Chenopodietalia

Alliance: Fumario - Euphorbion

Five associations

Alliance: Spergulo - Oxalidion

Seven associations

Order: Eragrostietalia

Alliance: Panico - Setarion

One association

Order: Centauretalia cyani

Alliance: Arnosericidion

Two associations

Alliance: Aphanion

Two associations

Alliance: Caucalidion

Three associations

Other communities of undefined rank have also been distinguished. Three new associations are provisionally described within the Spergulo - Oxalidion.

Additionally, it has been found that some arable stands are referable to syntaxa of the classes Agropyretea or Plantaginetea. Such stands are related to the effects of soil deterioration and selective herbicides. Limited investigation of annual communities of other disturbed ruderal habitats has shown that they are usually referable to the order Sisymbrietalia of the Stellarietea.

Association between species has been investigated in some areas by chi-squared analysis. Plexus diagrams showing inter-specific association have been prepared for the Outer Hebrides, Dorset, the Isles of Scilly, the Brecklands, the Lower Greensand plus Bagshot Sands formations and arable bryophyte synusiae. Results from these are compared with those of the Zürich-Montpellier analysis.

Factors affecting arable communities are extensively reviewed. Special consideration has been given to the floristic and ecological nature of the field boundary.

All original work reported here is entirely my own
and has not been previously submitted for a
degree in the University of Durham or elsewhere.

A. J. Schwend

To my Parents

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In fairness to my supervisor I should make it clear that this work was written, rather hurriedly, away from Durham and he has not had the opportunity to advise on the final form of the manuscript or to point out any errors which may exist within it.

"That a soil may be distinguished by the Vegetables it naturally produces, is observed even by the Vulgar. There where the Corn-Marigold, which they call Golding, grows, they observe it to be, and that truly, a loose and Sandy Soil: And it is a sure Mark with them of a land that is fit for Rye ..."

John Morton, 1712 (Quoted from Coombe (1952))

"In considering the association of weeds with soil ... it is necessary to lay more stress on the particular communities in which the plants occur than on the connection of one particular species with one definite type of land."

Winifred Brenchley (1920 : 120)

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Overlays

Chapter One

Introduction

1.1 Aims and scope of the survey

The title of this thesis immediately leads to controversy, in that there are many definitions of "weed" to be found in the literature, and hence the concept of communities "related" to arable weed communities itself requires further explanation. A much quoted definition of a weed is "a plant out of place". This forms the basis of most published definitions, which are comprehensively reviewed by Harlan and de Wet (1965) and King (1966). However, workers approaching the study of weeds from an ecological rather than from an agronomic basis have used definitions of "weed" and "weediness" which take on a broader meaning than the direct relationship to agricultural practices. Thus Bunting (1960) declared that, "weeds are pioneers of secondary succession, of which the weedy arable field is a special case". Harlan and de Wet (op. cit.) take this discussion further, and provide a comprehensive ecologically-based concept of weeds and weediness.

At first sight, this is a typical example of scientists taking a word in general usage and giving it a more precise but somewhat altered meaning. However, an ecological concept of weediness is also understood and accepted by the general public. The annual colonizers of building sites and refuse tips cannot be said to be "out of place", their presence being totally irrelevant to the functions of these places, yet an ecologist would see similarities between these sites and arable habitats and the average layman would still regard the vegetation as being composed of "weeds". Baker (1965) crystallised



this idea in his definition, "a plant is a 'weed' if, in any specified geographical area, its populations grow entirely or predominantly in situations markedly disturbed by man (without, of course, being deliberately cultivated plants)". This, then, is the basis of the work reported here, an attempt to examine community relationships of the species of arable land, i.e. "agrestals", and of the species, often the same, of disturbed ground, i.e. "ruderals".

The inclusion of non-arable vegetation in this survey immediately presented further problems. It was felt that examination of arable land only, ignoring stands of the same species elsewhere, would result in distorted final conclusions. However, extension of the survey to "related" habitats has inevitably involved subjective decisions as to which sites are of interest and indeed to uneven coverage of such sites. In defence of these repeated subjective decisions it may be said that the resulting data set has proved, very largely, to be referable to one class of vegetation, as repeatedly established by other workers. As well as arable land, including such habitats as farm gateways and the like, an attempt has been made to cover other disturbed sites such as refuse-tips, dumped soil, building sites, disturbed roadsides, industrial wasteland and indeed wherever communities of annual plants have resulted from man's activities. The decision not to include communities of perennials was originally made in order to limit the scope of the work to a sensible level, but this decision has proved to be justified on syntaxonomic grounds. Natural pioneer communities, such as those of sand-dunes, river-shingles, rabbit-warrens, plus semi-natural communities of such habitats as quarry floors and gravelly tracks, have not been included.

Although the bulk of the data has been obtained from arable fields, this survey has been an ecological rather than an applied agronomic exercise. The arable field has been approached as an ecosystem,

and the "weeds" have been viewed as components of this system or systems. It should be understood that the exercise has not been the standard experimental approach of examining the effects of one or a few factors on community structure (e.g. comparison of a series of wheat and barley fields, each chosen at random) but an attempt to examine and describe the overall range of variation and relate it to published results from other parts of Europe. Only when the community structure is known can more detailed studies be usefully carried out, though it is hoped that the body of observations reported here will suggest hypotheses which can be investigated in the future by planned experiments.

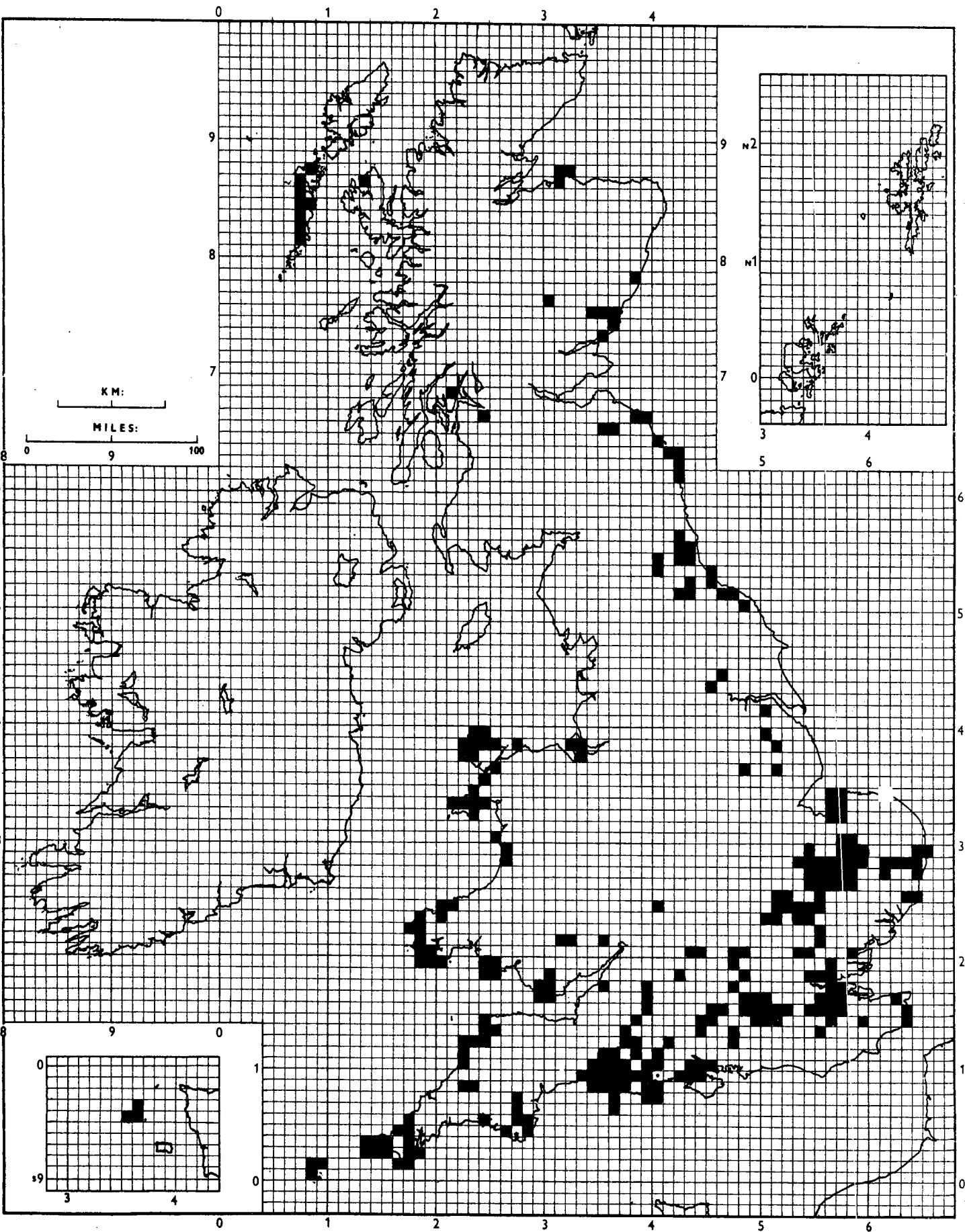
As far as possible, this has been a national survey. However, in the time available it clearly would not have been possible to visit all parts of the British Isles. The areas sampled are shown in Figure 1, though this does not show areas inspected without suitable sites being found. This figure must be interpreted with regard to the distribution of arable land (Figure 2). The most important omissions have been S.W. Scotland and perhaps the Shetlands; information from these areas would be valuable for a fuller understanding of the phytogeographical aspects. The rest of Scotland has been poorly covered as have been the English Midlands and the important arable areas of Lincolnshire and South Yorkshire, but it is unlikely that much new information would have been obtained from these regions.

1.2 The habitat

1.2.1 Agricultural land in Britain

1.2.1.1 The aim of the farmer is to create the optimum habitat for the crop plant, at least so far as is consistent with the need for the crop to be in harvestable condition, with all agricultural activities prior to harvest being directed to this end. The goal, then, is to

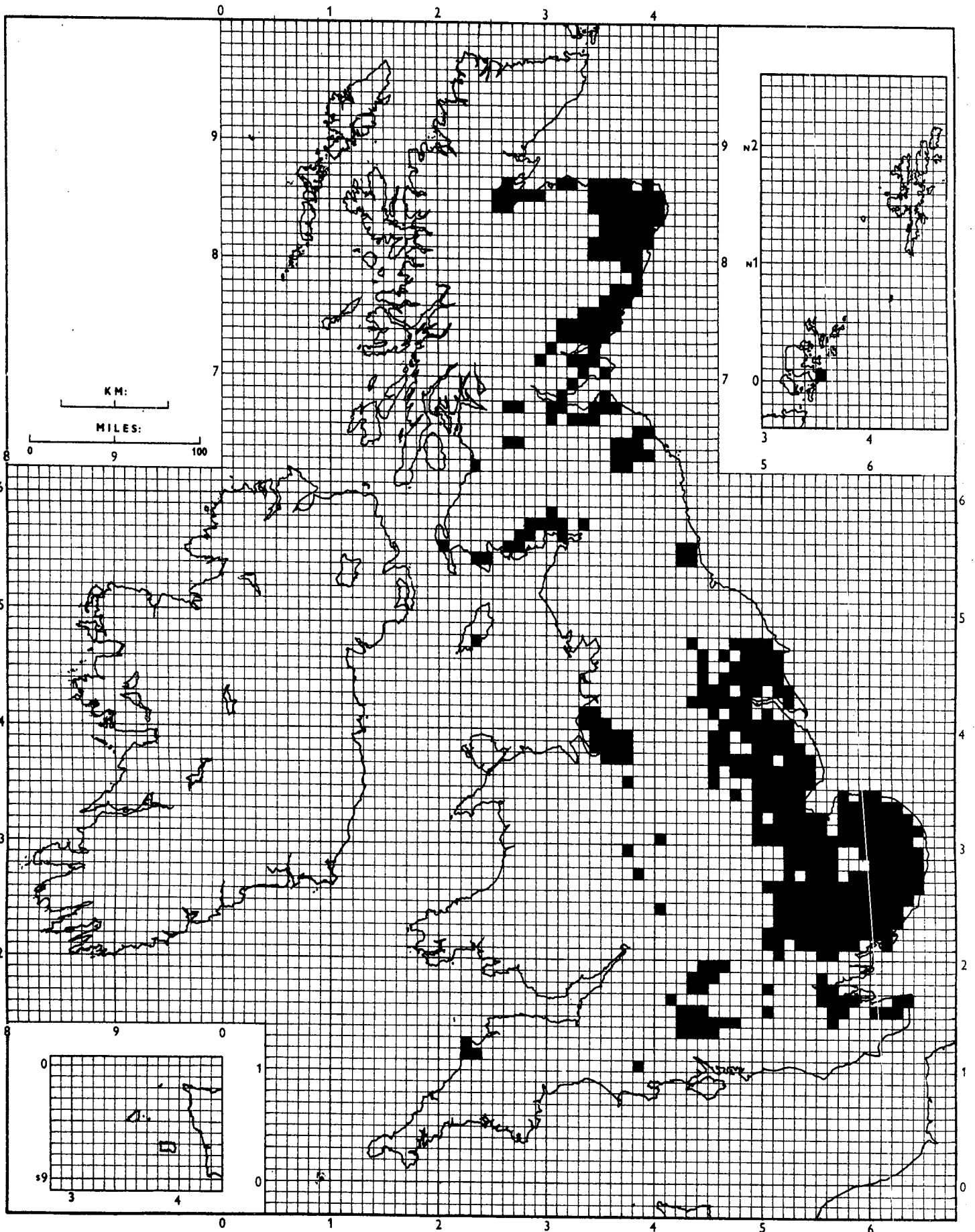
Fig.1 Areas sampled



BASED UPON BOTANICAL SOCIETY OF THE BRITISH ISLES DISTRIBUTION MAPS SCHEME

Fig. 2

The Distribution of Arable Land in Britain



BASED UPON BOTANICAL SOCIETY OF THE BRITISH ISLES DISTRIBUTION MAPS SCHEME

10 km squares with >50% arable land.

Land Utilisation Survey of Britain - Ordnance Survey 1944

recreate as nearly as possible the precise habitat niche of the crop plant. Since most of our crops evolved in other parts of the world, e.g. the cereals in the Middle East, this goal can never be completely achieved. Crop plants are grown under favourable, but not necessarily ideal conditions, although plant-breeding has considerably narrowed the gap between what is possible and what must be regarded as the ideal. However, Britain must still be considered as rather marginal for arable farming and the effects of competition from other species are bound to be serious.

The very act of cultivation gives an immediate advantage to the crop plant over most members of the indigenous flora, but there remain a number of species which tolerate or even require the conditions of cultivated land. The number of species which can exist under these conditions is very high, even in Britain, where an area of ploughed land left fallow can support a lush and diverse flora. However, the efforts of the farmer to create a precise habitat for his favoured species rule out a substantial number of these possible competitors.

As Harper (1960a) points out, weed competition is inevitable, since a monospecific stand of the crop plant will not fully exploit a habitat. Resources will always be available for the colonisation of the crop by other species, and these species will then compete with the crop for some of its requirements. Indeed as agricultural machinery demands that most crops be planted in rows, gaps between plants and between rows are immediately available for colonisation. Much of a farmer's energy is employed directly against competing species, by means of herbicides or mechanical weed removal, but the effects of his habitat manipulations must be just as important in determining the final communities that exist in his fields.

Perhaps the most well-known example is provided by Chrysanthemum segetum, a decreasing species in most parts of Britain. Unlike most

decreasing weeds, C. segetum is not especially susceptible to herbicides; the thick waxy cuticle on its deeply divided leaves provides a measure of protection from foliar sprays. However the application of lime to produce a more beneficial soil pH for the crop plant alters the habitat in such a way as to reduce the relative competitive ability of C. segetum, very often to the point where it cannot survive.

A full understanding, then of cultural methods is essential for the correct interpretation of weed community data and indeed for the study of arable ecosystems. Comprehensive studies of British arable habitats are largely non-existent: the review by Potts and Vickerman (1974), though sadly deficient from the botanical point of view, being perhaps a hopeful sign for the future. Plant ecologists have almost entirely ignored arable land and similar vegetation on waste sites, including Tansley (1939), who, in his classic account of British vegetation, somehow failed to notice that large tracts of land in Britain are covered by arable vegetation, with its own characteristic flora and fauna. Cultural operations render this vegetation "unnatural", though in fact in areas where farmers follow the same practices year after year, the weed flora reaches a remarkable stability, almost comparable with closed vegetation. It is where these rigid environmental factors are removed that concepts of definable communities become relatively meaningless (see Section 2.2.2.10).

A full review of agricultural methods would be out of place here, but a summary of relevant cultural operations follows. Agricultural soils are well reviewed by the Agricultural Advisory Council (1970), while some of the implications of changing agricultural techniques are reviewed in Section 4.5.

1.2.1.2 Tillage treatments

Most arable land undergoes two cultivations per year. Shallow cultivators break up the surface soil and destroy any annual weeds present, thus

providing a suitable seed bed for sowing or planting the crop. After harvest, crop residues and accompanying weeds are ploughed in, enriching the organic content of the soil. Use of deep ploughs at this time turns up long furrow-slices which can be weathered over winter, with water percolating to the subsoil and frost action breaking down clay soils to a more friable consistency. The timing of these operations has a significant effect on the weed flora, both quantitatively and qualitatively.

At one time the post-harvest ploughing followed the harvest relatively quickly, so that stubble weeds were ploughed in before many of them had time to fruit. However, stubble-burning and the use of herbicides on root crop residues limit the fruiting of weed species as well as cutting down the amount of material to be incorporated into the soil. Thus stubble-burning, though carried out primarily to reduce the amount of straw, also controls weeds in the same way as the ancient procedure of "Devonshiring". The delayed autumn ploughing then brings seeds to the surface which may germinate in quantity only to be killed by winter frosts. Frost resistant species, notably Stellaria media, Poa annua and Capsella bursa-pastoris, are at an obvious advantage under these conditions.

The above assumes that the land is left fallow over the winter, with a spring cultivation before the sowing or planting of the crop. In Britain today this is largely true, with very substantial acreages devoted to spring barley. However winter wheat and other winter crops are still extensively grown, and the difference in the time of the tillage treatments can be very significant. In Europe, there is a clear division of weed species into those which are winter hardy and those which are not. The nitrophilous species of root crops, e.g. Chenopodium album, Atriplex spp. and Polygonum spp., generally cannot survive the continental winters and thus do not occur as weeds

of winter cereals. For this reason, the syntaxonomy of European weed communities is based very substantially on winter crops. However, in Britain, most species have peaks of germination in both autumn and spring and many more can survive the milder oceanic winters. Thus the sharp distinction between winter and spring crops on the continent is less evident in Britain, but obligate winter annuals are now rare or absent from areas where spring cereals are exclusively grown.

Sometimes, summer fallowing is employed to control weed infestations. As few British weeds have their peak germination in the summer, fallowing at this time is not very effective against most annual species, though Papaver rhoeas may be an exception (Brenchley and Warrington, 1945). Its great value is in preventing photosynthesis in perennial species by destroying the above-ground parts of the plants and so depleting their underground food reserves. At the same time, the procedure is of value in controlling seedlings of Sonchus arvensis (Thurston, 1960). During fallow periods, harrowing breaks up the soil surface and encourages germination, subsequent harrowing then leaving the young plants exposed on the soil surface. Harrowing or hoeing between crop plants thus will eventually result in a decline in the weed population without affecting its composition (Koch, 1964) except that perennial species may be more effectively controlled. The effectiveness of this procedure depends to some extent on the soil type, the finely granulated surface layer of clay soils often producing a higher emergence of seedlings (Chepil, 1946b).

Regular tillage may become outmoded due to ever-increasing labour costs and the adverse effects of heavy agricultural machinery on soil structure. The availability of a wide range of herbicides and drilling machines capable of sowing seed without preparation of a seed-bed has caused many agriculturalists to question the need for cultivation.

Thus techniques of nil-cultivation, with weed control entirely by herbicides, and minimal cultivation, where rotovation to create a shallow tilth is also employed, are being investigated. Experiments on these lines are reported by Jones (1966) who found that these techniques favoured grasses, especially Agrostis stolonifera and Agropyron repens, rather than "broad-leaved weeds", compared with traditional cultivation procedures. Presumably minimal cultivation would also favour arable bryophytes, which are relatively resistant to herbicides and would benefit from lack of disturbance of the ground during autumn and winter. A study by Roberts (1963) suggests that general use of rotovation may favour Poa annua and Senecio vulgaris.

1.2.1.3 Rotation of crops

A former feature of arable farming was the regular rotation of crops in the fields of a farm such that crops followed a regular sequence in the same field. Successive years might see wheat, root crops, barley and grass leys or clover (this being the traditional "Norfolk" four-year rotation) or the introduction of a year of fallow or perhaps a few years of temporary pasture. The precise rotations varied widely, being dependant on the farming system, local custom, and, for tenant farmers prior to 1874, the terms of the lease (Shirlaw, 1966). Such rotations were designed primarily to maintain soil structure and fertility. A bonus for the farmer was that many weed species were discouraged, in that conditions would change each year and hence a species which might have been abundant in one season would be checked the following season. From the community point of view, rapid rotation prevents the full development of the expected species complement (see Section 2.2.2.9.2).

However, the advent of chemical fertilizers has hastened the breakdown of old rotation systems and modern intensive farming means that large areas are devoted to one crop for several successive years.

Coppock (1971), for example, reports an instance of 25 successive crops of barley. This stability results in the development of characteristic weed communities, though these may be much modified by herbicides. Soil-borne pests and diseases are also favoured by regular crops of the same plant and Potato-root Eelworm is giving trouble in the Fens, while the fungus Ophiobolus causing "Take-all" of wheat is a problem in wheat-growing areas (Shirlaw, loc. cit.).

1.2.1.4 Additives

1.2.1.4.1 Manures

Organic matter in the soil builds up and maintains a desirable crumb structure. This aggregation of the soil particles into crumbs gives suitable pore spaces for the retention of moisture, yet free movement of air, easy drainage of excess water and easy penetration by roots are allowed. A good crumb structure will withstand the effects of farm machinery and periods of increased and reduced rainfall. However, maintenance of soil structure for many soils demands at least three per cent of organic matter, whereas levels in many arable soils are as low as two per cent, or even less in loamy sands (Agricultural Advisory Council, 1970). In very sandy soils, where clay be more or less absent, organic matter is also of great importance as a base-exchange material retaining mineral nutrients. Adequate levels of organic matter are often not maintained merely by ploughing in crop residues.

Sources of organic manures are diverse and, not surprisingly, they vary much in character and constituents. The manure used depends very much on what is available locally; the major types are comprehensively reviewed by the Ministry of Agriculture, Fisheries and Food (1968).

In general, heavier dressings of organic manures are applied to light soils and to ground being prepared for root-crops.

Characteristically, such soils support nitrophilous species such

as Chenopodium album, Polygonum spp., Euphorbia spp. and Lamium spp. However, more information is available from long-term cereal crops at the experimental plots of Rothamsted and Woburn: Where manuring schemes have been constant for many years, farmyard manure has tended to favour Atriplex patula, Stellaria media, Polygonum aviculare, Chenopodium album, Tripleurospermum inodorum, Odontites verna and Veronica polita (Warrington, 1924; Brenchley and Warrington, 1930; Mann, 1939), though it is likely that the last of these was confused at the time with Veronica persica (Brenchley and Warrington, op. cit.). Warrington also noted that use of farmyard manure in spring barley discouraged Sonchus arvensis and Cirsium arvense and that use of rape cake on winter wheat appeared to promote a marked increase in Odontites verna.

Very locally, distillery waste and wool waste, or "shoddy", may be used as a top dressing. These wastes contain viable weed seeds, and shoddy fields, in particular, are famous for the large numbers of alien species that occur. Very few of these species present any serious agricultural problem and since most are natives of warmer climates, they do not normally persist for more than a single season.

1.2.1.4.2 Chemical fertilisers

With the abandonment of old rotation systems and the development of intensive growth of many crops, chemical fertilisers are becoming ever more important. Under intensive arable farming systems, organic manures are often not locally available and all nutrients must be supplied in chemical form. Again these are comprehensively reviewed by the Ministry of Agriculture, Fisheries and Food (1968).

The effects of chemical fertilisers on weed floras are difficult to assess in that it is necessary to take into account the extent to which the native soil supplies the mineral requirements of each individual species. Application of, e.g. sodium nitrate, may be beneficial

to a weed species on one soil and effectively toxic to it on another. Thus comparative studies of different weeds must be carried out on the same soil, and even then results must be interpreted with care.

In continuous winter wheat at Rothamsted, Warrington (1924) noted that such perennial weeds as Cirsium arvense, Tussilago farfara and Equisetum arvense were associated with nitrogen deficiency, or where ammonium salts were supplied but potash and phosphorus were withheld. By contrast, a weed flora of annual species, especially Alopecurus myosuroides, Papaver rhoeas, Veronica hederifolia, Scandix pecten-veneris and Stellaria media, was best developed under more complete mineral treatments. Ammonium salts appeared to be disadvantageous to Stellaria media, Aphanes arvensis, Vicia "sativa" and Lathyrus pratensis, but beneficial to Anagallis arvensis. Subsequent work on these fields has shown that Chaenorhinum minus, Aethusa cynapium and Euphorbia exigua can be grouped with Anagallis as being favoured by the use of ammonium sulphate (Brenchley and Warrington, 1930) while even when conditions are such that most species benefit from ammonium sulphate, Medicago lupulina still shows a marked preference for complete mineral fertilisers (Brenchley and Warrington, 1945).

At Rothamsted, applications of ammonium sulphate had no appreciable effect on soil pH and it is reasonable to assume that the observed differences in weed floras can be related directly to the fertilisers. However, on many soils, long-term use of ammonium sulphate results in a substantial degree of acidification. On the sandy soils of Woburn Mann (1939) records soils with a pH of 4.4, with fields dominated by Spergula arvensis, Polygonum aviculare and Poa annua. The latter two species also occurred extensively on other soils, but Spergula was almost restricted to these highly acid soils. Its absence from plots where lime had been used to counteract the acidifying action of ammonium sulphate showed that this known calcifuge was influenced

by soil pH rather than by direct action of the fertiliser. Of the perennial species, Holcus mollis and Rumex acetosella showed similar distributions.

In recent years, substantially greater amounts of inorganic nitrogen have been applied to arable land (Agricultural Advisory Council, 1970) and this may well be having an overall effect on the British arable weed flora. Species characteristic of nitrogen-rich woodland edge communities, notably Urtica dioica and Galium aparine, appear to be more frequent on arable land than in the past. Higher nitrogen levels may also be benefiting some arable bryophytes, e.g. Pottia truncata (Thomson and Silverside, unpublished data). On the other hand, chemical fertilisation of some very nutrient-poor sands may well be the cause of the virtual extinction of Arnoseris minima and some of its associated species.

1.2.1.4.3 Lime

The value of liming, and the various forms of lime in use are fully reviewed by the Ministry of Agriculture, Fisheries and Food (1969). Liming supplies the mineral calcium, counteracts acidification of the soil, hence preventing aluminium or manganese toxicity, and may have some effect in maintaining soil structure.

Weed species can naturally be divided into calcifuges, calcicoles and pH-indifferent species and it is hardly surprising that regular liming will affect weed floras. Top dressings of lime are intended to improve soil fertility and thus liming is beneficial to most weed species. Calcifuge species such as Chrysanthemum segetum, Spergula arvensis and Rumex acetosella would then be excluded by competition. In general, markedly calcicolous species such as Legousia hybrida or Kickxia spuria do not appear on non-calcareous soils, even when these are regularly limed, though where non-calcareous soils occur close to outcrops of chalk, and chalk has been transferred to these soils

for generations, calcicole weed floras may develop. Presumably under these conditions, long-term weathering of chalk fragments has produced the characteristic structure of fertile chalk soils.

1.2.1.4.4 Herbicides

It is hardly necessary to state that application of herbicides has an effect on weed species, and this subject is extensively reviewed in Section 4.5. However, there has been some suggestion that herbicides may be having long-term adverse effects on arable land. This possibility was considered by the Agricultural Advisory Council (1970) and they concluded that, "There is, however, no evidence at present that existing herbicides and pesticides, or those in prospect, have any deleterious effects on soil fertility or its structure."

1.2.1.5 Farming systems

It is very likely that the nature of the weed flora of an arable field is influenced by the importance of the field itself within the farm or farming combine. Though weed communities have apparently never been considered from this point of view, it would seem reasonable to suppose that more effort will be put into weed control where the crop is a potential source of direct revenue than where the crop will form winter feed for farm animals. Where arable crops are being grown for sale as commercial seed, this must be so, since weed seed contamination of these crops must not exceed rigidly defined legal limits.

Agricultural geographers classify farms into a number of farming systems, based on the relative importance of arable land, dairy farming and stock rearing and fattening. Shirlaw (1966) recognises eleven categories, of which nine are relevant to the arable habitat. Four of these may be grouped together, in that animal stock is the important source of revenue. Arable fields will be sown, but except when prices are particularly high, the crops will be harvested entirely for fodder.

Two-thirds or more of the land will be under permanent grass, while most of the rest will be under some form of arable rotation. A typical rotation could be three years arable and three years grass ley, with the arable sequence being cereal, roots, cereal. Since these farming systems are to be found mainly in upland areas, and in the north and west, the traditional cereal has been oats, but hardier strains of barley are now often replacing oats in one of the cereal breaks. Typical root crops are turnips, swedes and Kale, though potatoes are locally important, particularly in Scotland where seed potatoes can be a profitable enterprise. On dairy farms, it is quite normal for the arable phase of the rotation to occupy only a single year before the land is returned to grass. Restoration of grass leys begins during the previous cereal break, where the crop is undersown with Lolium and often clover.

Under these conditions, it is not surprising that rich weed floras do not develop. When a ley is ploughed, there may be no other arable land in the area and hence the only weeds that can appear will be those whose seeds are lying dormant in the soil. While some species, e.g. charlock, Sinapis arvensis, may appear in abundance, it will often be found that the major weeds are grasses, e.g. Agrostis spp., Poa trivialis which would be present in the previous temporary ley. Agricultural forms of native species, e.g. Lolium perenne, Phleum pratense, Trifolium pratense are also common. On the other hand, weed control may not be considered important, and so such fields may provide refugia for herbicide-sensitive species. The late summer may see the fields of Kale and other root crops being used directly to provide grazing, and Stellaria media thrives in these nitrogenous conditions.

Three more of Shirlaw's categories of farming-system are characterised by a greater importance of the arable land. On the more fertile soils and under the more favourable climatic conditions,

cash crops such as wheat, barley, potatoes and sugar-beet become profitable. Nevertheless, rotations may include grass for periods of up to ten years and this will have the same effects on the weed flora as described above.

Dominantly arable farms are restricted in the main to East Anglia and the vast areas of reclaimed fens stretching from the region around the Wash up through Nottinghamshire and Lincolnshire to the Holderness region of south Yorkshire. However, other important areas are the Plain of Lancastria and parts of east and south-west Scotland. Their distribution can largely be inferred from Figure 2. The silty soils of the Fenlands are particularly suitable for potatoes, sugar-beet, market garden crops and, locally, bulbs and cut flowers. On light soils, sugar-beet and especially barley are important crops, and on heavier soils, beans, oats and winter wheat are important. It is in these wheat growing areas that Allium vineale and winter annuals such as Avena ludoviciana and Alopecurus myosuroides can be serious weeds. Throughout the barley growing areas, Avena fatua is presenting the greatest problems.

Although particular soils are theoretically best suited to certain crops the pattern of farming is much influenced by the availability of ready markets. Thus large acreages of potatoes are grown near London. Under current economic conditions, barley is the most important single arable crop, the total acreage of barley in England and Wales having risen by 75 per cent in the period between 1960 and 1966, while wheat has also shown a corresponding increase (Ministry of Agriculture, Fisheries and Food et al., 1970). The very largest arable holdings account for a high proportion of the total barley, wheat, potatoes and sugar beet grown in Britain today.

Horticulture and market gardening forms the last of Shirlaw's categories, though it is difficult to make generalisations about

this diverse group of enterprises. These holdings are generally confined to light soils and are a feature of alluvial soils in river valleys near cities and large towns. As the crops are of high cash value, fertilisers can be used liberally and market gardening is extensive on the very nutrient-poor sandy soils of the Lower Greensand and Bagshot Sands. On the sandy soils of the south, Galinsoga parviflora is becoming an abundant weed, while some extremely rare weed species, e.g. Digitaria ischaemum, Spergula morisonii and Veronica triphyllos, in its only current extra-Breckland locality, persist at certain establishments.

1.2.2 The climate in relation to agriculture

From a phytogeographical viewpoint, Britain occupies a virtually unique position. Both northern and southern influences are represented in the flora, as well as the major influence of the Atlantic. Bearing in mind the unusually diverse geology of Britain, it is not surprising that a substantial number of different weed communities can be recognised here. The number of weed associations accepted for Britain in later chapters is higher than for most if not all other countries in northern and western Europe. This may, of course, be wishful thinking, with several parallel examples in the field of idiotaxonomy. However, the high number is perfectly logical in consideration of the diverse geology and climate.

South-east England and East Anglia are comparable to the major cereal-growing areas of the continent. The light, often calcareous soils, low rainfall, warm summers and cold winters are comparable to much of southern Europe. Thran and Broekhuizen (1965) classified Europe into agro-climatic provinces and sub-provinces and Thran's modification of this (in Broekhuizen, 1969) is summarised for Britain in Figure 3. Their "sub-province 45" is marked by, "always just sufficient precipitation" and a sufficiently long growing season,

averaging over 10°C for six months of the year. This same area is recognised in Shirlaw's (1966) classification, which is repeated in Figure 4. This region is thus suitable for many of the more thermophilic species of southern Europe and this is reflected in the weed associations.

It must be admitted, however, that many thermophilic weed species have decreased very substantially over the last two hundred years or so. Torilis arvensis, today a rare species of the extreme south of England once reached as far north as the limestone island of Lismore off the coast of west Scotland (Lightfoot, 1777). This record has been overlooked or ignored in recent years, but Lightfoot, undoubtedly a very competent botanist, was English and would have known the plant well. Similarly there are many records of Ranunculus arvensis as an established weed well north of its current range, while two grasses, Setaria viridis and Lolium temulentum, formerly established weeds, are now casuals rarely surviving on the British mainland for more than a single season. This climatic deterioration from Mediaeval times is accepted by meteorologists and described by Lamb (1970). So while somewhat thermophilic weed associations are accepted for Britain, it must also be admitted that they are (now) poorly developed here, even disregarding the effects of herbicides, and that such associations are at the limits of their ranges.

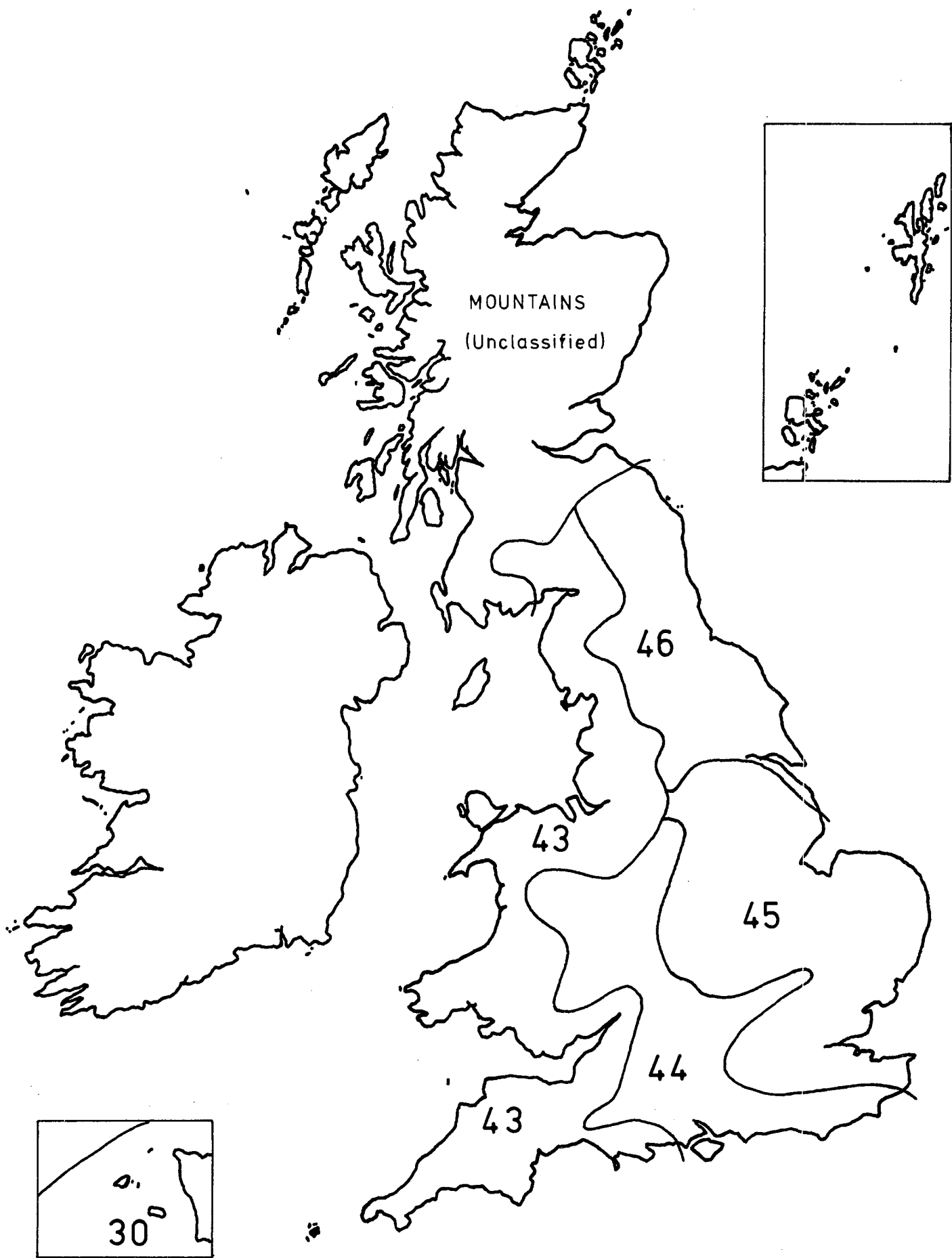
Although south-east England is here treated as one agro-climatic region, the inland part of East Anglia has a particularly marked "continental" climate, with colder winters and a lower rainfall than surrounding areas. Lamb (op. cit.) regards this region as being more comparable with Berlin than with the more adjacent parts of the European mainland. The implications of this are that the recent intensive work on East German weed communities is more relevant to Britain than might have been supposed.

The "sub-province 44" of Thran and Broekhuizen again corresponds with the section of south and central England segregated by Shirlaw. The length of the growth period corresponds with that of sub-province 45, but the winter is a little milder and the rainfall supplying "always just sufficient to abundant precipitation". On suitable soils arable farming is just as successful as in the south-east, and where not ravaged by herbicides, species such as Adonis annua still just survive. Arable farming is, however, of little importance on the heavier soils to the north of this division.

North-east England comprises sub-province 46, but since Thran and Broekhuizen describe Scotland as "mountains" and hence unclassifiable according to their system, the division stops at the Scottish border. Shirlaw, quite rightly from the evidence of the weed flora, extends the division up the east coast of Scotland. It is characterised by cooler summers, with an average temperature over 10°C for only four months of the year, and "always sufficient precipitation". Thermophilic species are absent from the weed flora and the communities correspond to those of Scandinavia and, to a lesser extent, the Baltic coast of Germany.

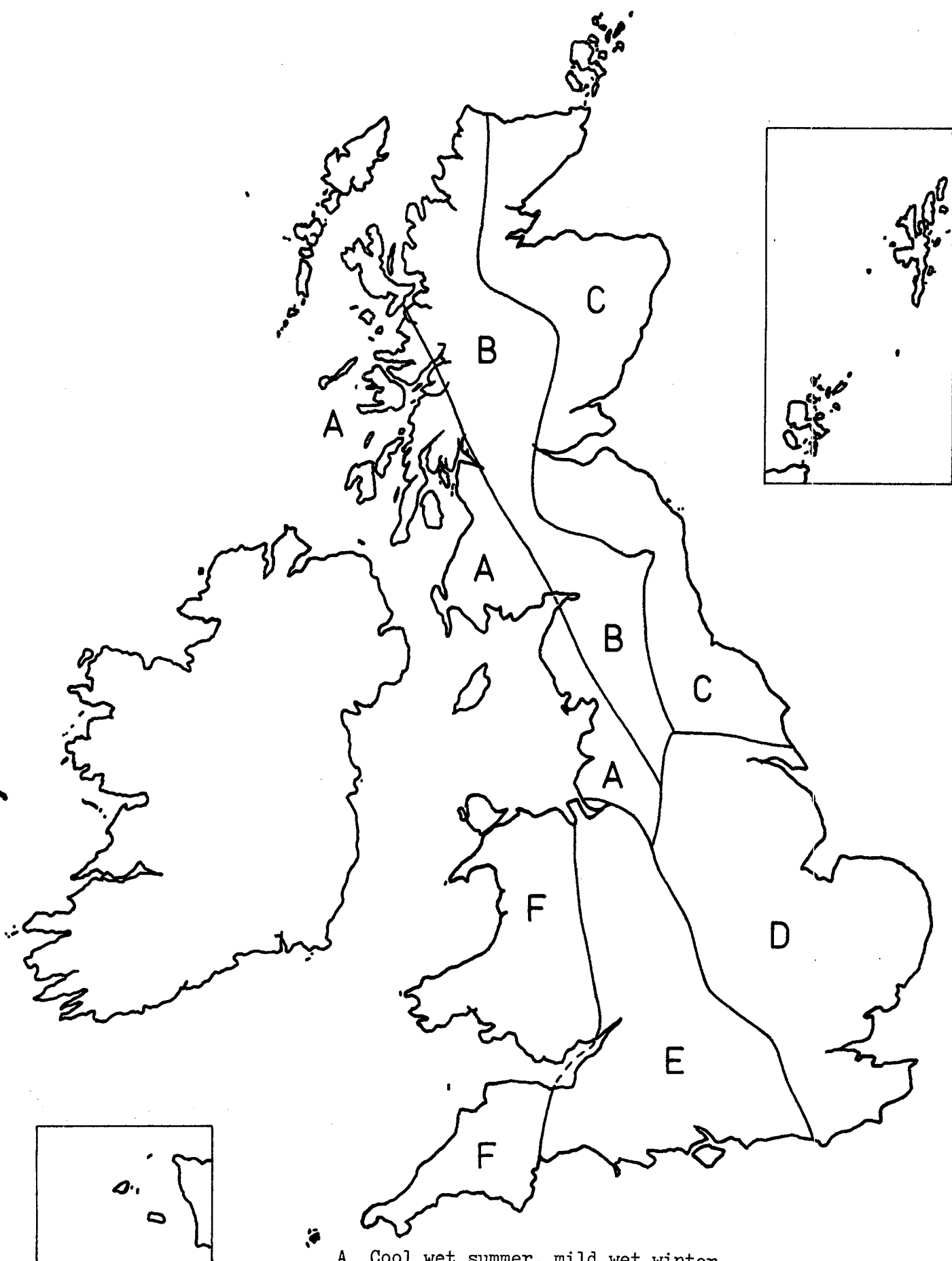
The "sub-province 43" consisting of South-west England, Wales and the Solway counties of Scotland is virtually unique in a European context. The oceanic climate tends to override edaphic factors here with mild winters, a long growing period and "always abundant precipitation". Precipitation during the growing season frequently exceeds 30 cm (Figure 5). Not only is the rainfall relatively high, but so are the figures for relative humidity. Thran and Broekhuizen present values for the average yearly relative humidity of the air, as measured at 2 p.m. Values for the north-west mainland of Europe are typically around 65 to 75 per cent, with similar measurements recorded from southern England and the Thames Valley. However, much

Fig. 3 Thran's Agroclimatic Sub-provinces



After Thran in Broekhuizen (1969). For description of sub-provinces, see text.

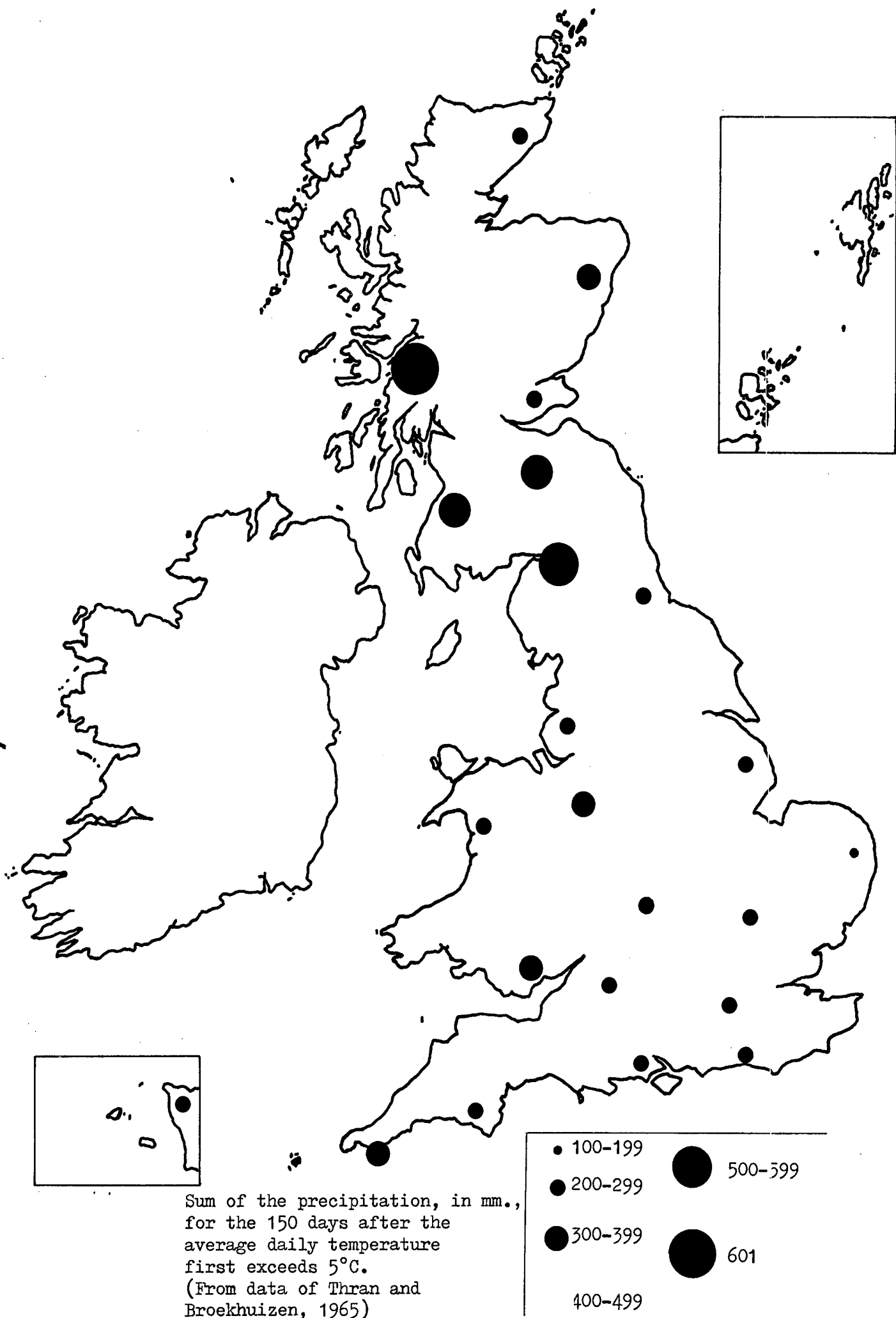
Fig. 4 Climatic Regions of Britain



- A Cool wet summer, mild wet winter
- B Cool wet summer, cold wet winter
- C Cold dry summer, cold dry winter
- D Hot dry summer, cold dry winter
- E Hot dry summer, mild dry winter
- F Hot wet summer, mild wet winter

After Shirlaw (1966)

Fig.5 Precipitation during the
Growing Season



of Britain, especially the west, has readings between 75 and 85 per cent. Values above 80 per cent in mainland Europe are recorded only from the coasts of Norway and Denmark.

It is not surprising that the west of Britain has a distinct weed flora, and species such as Stachys arvensis and Fumaria bastardii become locally common. Both of these species are of phytosociological significance.

It is questionable whether the tip of Cornwall and the Isles of Scilly really belong to sub-province 43; botanically they would seem better classified with the Channel Islands and northwestern France in "sub-province 30". The winters are wet but very mild and the well-drained sandy soils warm up quickly in the spring to ensure a long growing period. These conditions are favourable for the development of mediterranean-type thermophilic spring ephemeral communities in sheltered localities and the area is important as representing the transition between the true oceanic-mediterranean weed flora of Spain and the atlantic flora of Ireland, western Britain and the coast of the Netherlands.

New "Agricultural Land Classification" maps are being produced by the Ministry of Agriculture (Gilg, 1975). These will contain more detailed information on the agricultural climate and it will be interesting to see how they relate to the distributions of the weed communities recognised in the present work.

1.3 Weed communities as pioneer communities?

Bunting's (1960) definition of weeds as pioneer species of secondary successions has already been quoted. He continues at length on the soil nutrient changes associated with secondary successions, but the concept of an arable field as an early seral stage of a secondary succession deserves further consideration. The transient assemblage

of species on a disturbed roadside or mound of dumped soil can quite justifiably be regarded as a pioneer community. A collection of Polygonum spp., Fumaria spp., Sinapis arvensis etc. might very quickly be invaded by Agropyron repens and other perennial grasses and so secondary succession would quickly operate. But does this apply to arable land?

An investigator visiting the same arable field for several successive years might very well begin to doubt that he was observing a "pioneer community". Certainly there would be instability, particular species would be more abundant in some years and apparently absent in others. New species might become established in the field; others might become extinct. However, these processes occur in so-called climax communities just as in earlier stages of a succession. The only major change which the investigator would be likely to observe would be the sudden disappearance of the dominant and its replacement by another, i.e. changes in crop. But in a rotation, dominants would replace each other in a cyclic sequence. Cyclic succession is unusual, but not rare, several cases of cyclic succession in climax vegetation being documented by Watt (1947). So while an arable field contains species characteristic of the pioneer stages of secondary successions, and while observed over a single year it would show dramatic changes (but so does any other community), viewed at the height of the growth season it could quite reasonably be regarded as having reached a plagioclimax. Admittedly it would be an extraordinary plagioclimax, with cyclic succession of the dominants and probable accompanying minor changes in the ground-flora, but nevertheless the view is quite tenable.

Perhaps due to the rarity of the event, there is remarkably little information available on what happens when arable fields are abandoned and further succession really does take place. The overall pattern

of establishment of grassland, followed by scrub and finally forest is clear enough, but we have very little knowledge of the details. Bazzaz (1968) presented a fine account of succession on abandoned fields in the U.S.A. but little similar information is available of greater relevance to Britain. In that the present work is, or claims to be, the first systematic account of British weed communities, perhaps this is not surprising, but little guidance is available in the European literature. Hejny (1973) and Pysek (1977) have both considered succession in Czechoslovakian ruderal communities, but of other European phytosociologists, only Sissingh (1950) has made any real attempt to consider possible successions from arable weed communities. The present work will not add much, but possible succession will be discussed where it has been possible to examine fallow or abandoned fields.

1.4 Nomenclatural and taxonomic notes

1.4.1

An up-to-date nomenclatural list of British higher plants is, at present sadly lacking, and it is no longer possible to cite any one authority. In general, an attempt has been made to keep the names reasonably up-to-date, even though this has involved the use of some presently unfamiliar names, e.g. Bilderdykia convolvulus for Polygonum convolvulus. The names used here are, then, based very much on personal opinion, but are used in one or more of the following standard publications:- Dandy (1958, 1969), Clapham et al. (1962), Tutin et al. (1964, 1968). Names of wool aliens are based on Lousley (1961) and cereals on Bowden (1959).

Names of bryophytes, though also somewhat outdated, are based on Warburg (1963) and Paton (1965), except that nomenclature of the Bryum erythrocarpum complex follows Crundwell and Nyholm (1964). The few higher fungi are named after Dennis et al. (1960).

The above publications also represent the taxonomic opinions followed for identification purposes, except as detailed in Section 1.4.2.

Names of syntaxa used here are those considered correct, though important synonyms are given and it is indicated when names are used in senses differing from usage in standard reference works. The overall arrangement of syntaxa is again a reflection of personal opinion, but the scheme is based largely on Oberdorfer et al. (1967), Westhoff and den Held (1969) and Oberdorfer (1970). Spellings follow the rules of Rauschert (1963).

1.4.2 Taxonomic notes on critical groups

Infra-specific taxa have been abbreviated in the tables using an asterisk system. Explanation of these names, plus notes on particular taxa, follow.

Veronica hederifolia agg.

Veronica * hederifolia = Veronica hederifolia ssp. hederifolia

Veronica * lucorum = Veronica hederifolia ssp. lucorum (= V. sublobata)

Separation of these two taxa follows Benoit's (1971) modification of the description by Fischer (1967). Many of the records reported here predated Benoit's paper but there appears to be no disagreement of views over British material. Poor material has been confirmed by measurements of stomatal lengths. Both sspp. occur widely in Britain, ssp. lucorum on loams and clays, where it is predominantly a species of gardens and shady places, and ssp. hederifolia on sandy soils, where it may be frequent on arable land. A distinct form, currently assigned to ssp. hederifolia occurs on boulder clay in arable fields in two places in North Essex. This apparent ecotype does not correspond with ecotypes described by Saaristo (1971).

Polygonum arenastrum

This species is interpreted according to the treatment in Clapham et al. (1962). Records apparently include both P. aequale and P. calcatum.

Polygonum lapathifolium agg.

Polygonum * lapathifolium = Polygonum lapathifolium ssp. lapathifolium

Polygonum * nodosum = Polygonum lapathifolium var. nodosum Bab.
(= P. nodosum)

Polygonum * tomentosum = Polygonum lapathifolium ? ssp. tomentosum
Dans.

The Polygonum lapathifolium aggregate has given a lot of taxonomic problems. Timson (1963), in a study based mainly on herbarium material, concluded that P. nodosum could not be maintained as a separate species. However, since unusual specimens of common plants are more likely to be collected for the herbarium, this can hardly have been an unbiased survey. P. nodosum is normally easily distinguishable in the field, and recognition of a third taxon, here regarded as P. lapathifolium ssp. tomentosum does much to solve the remaining difficulties. The three taxa have been recorded separately, although it does seem best to regard them as infra-specific variants of one polymorphic species.

P. * lapathifolium is taken to comprise greenish-white flowered plants with more or less colourless glands.

P. * nodosum has brick-red, often slenderer inflorescences, golden-yellow glands and swollen nodes.

P. * tomentosum has dingy-red inflorescences, more or less colourless glands, leaves conspicuously tomentose beneath (but not above) and an upright, slender habit - which may be phenotypic. Some continental phytosociologists have undoubtedly applied this name to the forms of P. lapathifolium, with leaves silvery-hairy on both surfaces, which occur on drying mud. Britton (1933) certainly used the name in this

way. However, Hanf (n.d.) illustrates what appears to be the true plant and Moss's (1914) P. nodosum forma salicifolium appears to be this. (It is unfortunate that the caption of Hanf's photograph of typical P. lapathifolium has been interchanged with P. persicaria).

As it has turned out, P. * lapathifolium and P. * nodosum regularly occur together and there appears to be no phytosociological value in their separation, though the same could almost be said of P. persicaria which is undoubtedly distinct. P. * tomentosum is more often a cornfield weed and appears to be more common in the west.

White-flowered plants of P. persicaria have not been confused with this group.

Oxalis spp.

British data has been identified following Clapham et al. (1962) and Young (1958) and no particular problems arise. However, before Young's revision of the genus, there was considerable confusion and the European literature must be treated with care. Where continental data has been quoted in this work, "Oxalis violacea" has been treated with scepticism while "Oxalis stricta" has been treated as an aggregate of Oxalis europaea and O. dillenii. Both the latter species are widespread in Europe and phytosociologically distinct (Ciba-Geigy, Ltd., 1973).

Viola arvensis

This has been divided up in the past into a number of segregates. Specimens were collected during field-work but little of value appears to have come of this exercise. It is possible that upright forms, "segetalis-type", are particularly characteristic of the syntaxonomic order Centauretalia, while partially decumbent forms, "ruralis-type" occur primarily in the Polygono-Chenopodietalia, but this requires more investigation.

Scleranthus annuus

All records are of ssp. annuus

Solanum sarachoides agg.

During the fieldwork, it was felt that Solanum sarachoides appeared to consist of two separate taxa, a dark, toothed-leaved form on refuse tips and a paler green, more spreading, entire-leaved form in a number of arable fields on the Lower Greensand. A photograph in Merker (1959) appeared to show this entire-leaved plant, under the name of S. nitidibaccatum Bitter, which Dandy (1958) places under S. sarachoides. Saarisalo-Taubert (1967), whose spelling of "sarachoides" is followed here, also separates S. nitidibaccatum, with its description again applying to the British entire-leaved plant. The recent study by Haeupler (1974) further seems to confirm this.

Despite having presumably seen British material, Edmonds (1972), in a monographic study of the entire critical group, does not take this view. While admitting the distinctness of some "S. nitidibaccatum", in the context of observed variation in the entire South American aggregate she regards them as forms of one variable species. Accordingly, all plants have been called S. sarachoides in this present work.

However, this matter has recently been investigated independently in Britain by Leslie (1976 and pers. comm.). He also finds the two forms quite distinct, and while it is not unusual for different populations of an introduced species to differ markedly from one another, his work strongly suggests that S. nitidibaccatum deserves specific rank. All arable records in the current work belong to this taxon. The single ruderal record is regarded as true S. sarachoides it is worthy of note that this is the same colony which interested Leslie in the problem.

Rumex acetosella

No attempt has been made to segregate R. angiocarpus, which does not seem to be worthy of specific recognition in any case.

Vicia sativa agg.

Vicia * sativa = Vicia sativa ssp. sativa

Vicia * angustifolia = Vicia sativa ssp. angustifolia var. angustifolia

Vicia * segetalis = Vicia sativa ssp. angustifolia var. segetalis Koch

True Vicia sativa ssp. sativa is a very robust plant with very large, rounded leaflets and pairs of flowers usually exceeding 2.5 cm in length. It is no more than a rare agricultural relic, rarely persisting for any length of time. The large plant normally called "V. sativa" by British botanists is here regarded as V. * segetalis.

Aethusa cynapium

Aethusa cynapium - records normally refer to ssp. cynapium, including var. domestica Wallr.

Aethusa * agrestis = Aethusa cynapium ssp. agrestis

Dwarf plants of Aethusa cynapium are of frequent occurrence on arable land. While their stature usually has a genetic basis (see Section 4.4), their taxonomy is not clear. It has been tempting to equate them with var. agrestis Wallr. as described by Weimarck (1945) and given sub-specific rank by Tutin et al. (1968). However, except in stature, most British plants do not match the descriptions of this taxon. Consequently, only a few plants have been assigned to this sub-species. Taller plants from ruderal habitats readily fit Weimarck's concept of var. domestica which is here regarded as ssp. cynapium.

Bromus * hordaceus = Bromus hordaceus L. ssp. hordaceus (= B. mollis)

Montia * chondrosperma = Montia fontana ssp. chondrosperma

Tripleurospermum

Tripleurospermum inodorum and T. maritimum are here regarded as separate species. Hence mention of "T. maritimum" invariably refers to the coastal species, and not to the aggregate including T. inodorum.

Erodium

Erodium * cicutarium = Erodium cicutarium ssp. cicutarium

Erodium * dunense = Erodium cicutarium ssp. dunense

Odontites

Odontites * verna = Odontites verna ssp. verna

Odontites * serotina = Odontites verna ssp. serotina

Identification of these taxa follows Perring and Sell (1968).

Observation of these two taxa in S. England, within the range of both ssp., suggests that ssp. verna tends to replace ssp. serotina in cornfields.

Lolium

Lolium * perenne = Lolium perenne ssp. perenne

Lolium * multiflorum = Lolium perenne ssp. multiflorum

Records of L. * perenne include both the native plant and agricultural relics, which have usually been recorded as such. Agricultural strains of ssp. perenne frequently include some multiflorum ancestry, though the obvious hybrid (L. x hybridum) has been recorded separately.

Asparagus * officinalis = Asparagus officinalis ssp. officinalis

Plantago major agg.

During the period of fieldwork, it was noted that a distinct form of P. major occurred in damp fields. Such plants were small, with toothed leaves which were hairy below and often tinged violet. However, since they appeared to grade into P. major, a very variable species, and since modern British floras gave no plausible alternative, they

were not recorded separately. It now seems highly likely that some of these plants were P. intermedia Gilib., a taxon widely accepted by European phytosociologists and of which a description in English is given by Lousley (1958).

While given wider acceptance on the continent, it must not be assumed that the taxon, if it be a good species, is always interpreted correctly. Some phytosociological tables include P. intermedia with a suspiciously high frequency, and indeed some workers record P. intermedia and not P. major. In view of this probable confusion, the taxa are combined in this work when continental data are quoted.

Bryum erythrocarpum agg.

As noted in Section 1.4.1, treatment of this complex follows Crundwell and Nyholm (1964). Unfortunately, the rhizoidal gemmae, on which identification is largely based, are often only sparsely produced during the summer months. This has meant that many gatherings have lacked gemmae. Such specimens which have distinctly bordered leaves and leaf cells at least 16 μ wide have been accepted as Bryum rubens, which is, in any case, much the most common species. Specimens with narrower leaf-cells, and small fragments of material in general have been left as "B. erythrocarpum agg.". In practice, serious difficulties have not arisen. The other typically arable species with non-violet rhizoids, i.e. B. sauteri, B. micro-erythrocarpum and B. klinggraeffii, all appear to produce abundant gemmae, even in the summer.

Bryum bicolor agg.

Paton (1969) reports on some of the taxa being delimited in this complex by H. L. K. Whitehouse. Two taxa that Paton describes in Cornwall are both of wider distribution in arable land.

"Taxon A" consists of plants with a distinct shine and with axillary bulbils with distinct leafy points.

"Taxon B" consists of more robust plants with long excurrent points to the leaves and large leafy bulbils. Arable B. bicolor seems more often to be this, though it can take on a somewhat shiny appearance and grade into Taxon A.

Bryum argenteum

Bryum * argenteum = Bryum argenteum var. argenteum

Bryum * lanatum = Bryum argenteum var. lanatum

Only material clearly distinct from var. argenteum has been accepted as var. lanatum; much arable material is intermediate. Var. argenteum is the typical taxon of wasteground; var. lanatum is the usual taxon of sandy arable fields.

Dicranella

A very common, though inconspicuous, species of arable fields is Dicranella staphylina Whitehouse (Whitehouse, 1969). That so common and distinct a moss could be overlooked for so long is an indication of how poorly arable mosses are known. Most British records of D. varia from non-calcareous soil refer to D. staphylina, as must much of the European phytosociological data. Some plants encountered in south-west England bore a superficial resemblance to D. schreberana but have been identified as D. staphylina on the characters of the rhizoidal gemmae.

Pleuridium

The two species are separated according to current usage. It is unfortunate that the names have been used in opposite senses in the past, and this has been borne in mind when using early literature.

Pottia

Pottia davalliana has been recorded only when sporophytes have been present. The name has been retained according to current concepts,

though Chamberlain (1969) has shown that the application of the name is doubtful and that the species should be regarded as a subspecies of P. starkeana in any case. As interpreted here, it seems to be a strict calcicole. The notes on the group by Paton (1969) make it clear that other sspp. are likely to be found on arable land and so non-fruiting material has been recorded as "P. starkeana agg."

P. intermedia is apt to be over-recorded (see Paton, op. cit.) but after discussion with Dr. Chamberlain, the identifications given here are still considered correct. The resulting phytosociological data accord well with continental results.

Phascum * maximum = Phascum cuspidatum var. maximum

Eurhynchium praelongum agg.

There is every possible gradation on arable land between typical E. praelongum and E. praelongum var. distans ined. as described by Nyholm (1965). It seems to be purely a matter of opinion whether var. distans is assigned to E. praelongum or E. swartzii, or whether E. swartzii itself is specifically separable. Although often quoted as an arable moss, E. swartzii (i.e. E. praelongum var. rigidum Boul. of Nyholm, op. cit.) is here regarded as primarily a moss of calcareous grassland, very unusual on arable land and not encountered during the present survey. The concept of E. praelongum, as interpreted here, thus includes E. swartzii, pro parte, of some workers.

1.5 Explanations of abbreviations

Abbreviations used in the thesis are listed below. Standard nomenclatural abbreviations not given here will be found in Stearn (1973).

1.5.1 Abbreviations used in phytosociological tables

Char. Sp.	-	Character species (including infra-specific taxa)
Diff. Sp.	-	Differential species

Diag. Sp. Gp. - Diagnostic species - group

Pref. Sp. - Preferential species (i.e. optimal in syntaxon)

Area:- L - large, i.e. areas exceeding 50m²

Percentage Cover:- n - negligible, i.e. approx. 1% or less

Slope:- measurements are in degrees

Exposition:- standard points of the compass

Month:- usual sequential numbering

Soil:-	l - loam	ch - chalk
	c - clay	g - gravel
	s - sand	p - peat
	si - silt	v - very

Capital letter in soil abbreviation indicates main component,

i.e. vsL = very sandy loam

Sc = sand with some clay

sC = sandy clay

Crop:-

2B	-	2-rowed barley, <u>Hordeum vulgare</u> L., Group <u>distichon</u>
6B	-	6-rowed barley, <u>Hordeum vulgare</u> L., Group <u>vulgare</u>
Bb	-	Broad beans, <u>Vicia faba</u>
Br	-	Beetroot, <u>Beta vulgaris</u> , ssp. <u>vulgaris</u>
Bs	-	Sugar-beet, <u>Beta vulgaris</u> ssp. <u>vulgaris</u>
Bu	-	Bulbs (various)
Cb	-	Cabbage, <u>Brassica oleracea</u>
Ce	-	Celery, <u>Apium graveolens</u>
Clh	-	Clover, <u>Trifolium hybridum</u>
Clp	-	Clover, <u>T. pratense</u>
Clr	-	Clover, <u>T. repens</u>
Ct	-	Carrots, <u>Daucus carota</u> ssp. <u>sativus</u>
Cu	-	Cauliflower, <u>Brassica oleracea</u>
D	-	Cock's-foot, <u>Dactylis glomerata</u>
Fa	-	fallow

Fb	-	French beans, <u>Phaseolus vulgaris</u>
Fl	-	Flowers (various)
H	-	Hops, <u>Humulus lupulus</u>
K	-	Kale, <u>Brassica oleracea</u>
Le	-	Lettuce, <u>Lactuca sativa</u>
Loh	-	Rye-grass, <u>Lolium x hybridum</u>
Lom	-	Rye-grass, <u>L. * multiflorum</u>
Lop	-	Rye-grass, <u>L. * perenne</u>
Lu	-	Lucerne, <u>Medicago sativa</u>
Ma	-	Marrows, <u>Cicurbita pepo</u>
Mu	-	Mustard, <u>Sinapis alba</u>
Mz	-	Maize, <u>Zea mais</u>
Oa	-	Oats, <u>Avena sativa</u>
Ob	-	Black Oats, <u>Avena strigosa</u>
On	-	Onions, <u>Allium cepa</u>
Pe	-	Peas, <u>Pisum sativum</u>
Po	-	Potatoes, <u>Solanum tuberosum</u>
Rb	-	Runner beans, <u>Phaseolus multiflorus</u>
Ry	-	Rye, <u>Secale cereale</u>
Sh	-	Shrubs (various)
St	-	Strawberries, <u>Fragaria x ananassa</u>
Sw	-	Swedes, <u>Brassica napus</u>
To	-	Tobacco, <u>Nicotiana tabacum</u>
Tm	-	Tomatoes, <u>Lycopersicum esculentum</u>
Tu	-	Turnips, <u>Brassica rapa</u> ssp. <u>rapa</u>
W	-	Wheat, <u>Triticum x aestivum</u>

1.5.2 Abbreviations used generally in text

Abbreviations of quantitative measurements and other very common abbreviations follow normal usage.

Sp.	-	Species (singular)
Spp.	-	Species (plural)
Ssp.	-	Subspecies (singular)
Sspp.	-	Subspecies (plural)
Agg.	-	aggregate
Z-M	-	Zürich-Montpellier (school of phytosociology)
S.D.	-	Standard deviation
n.d.	-	No date (i.e. undated publications)
Tab.	-	Table. Arabic numerals refer to tables in body of text, Roman numerals to phytosociological tables in folio volume.
Fig.	-	Figure
P	-	Probability
log.	-	logarithm, logarithmic
Ass.	-	association
Subass.-		subassociation
All.	-	alliance
Ord.	-	order
Cl.	-	class
Comm.	-	community
Subcomm.-		subcommunity
Aufn.	-	aufnahme, aufnahmen
I.P.A.	-	Index of Potential Association (see Sect. 2.3.3.)

Chapter Two

Methodology I (Theoretical)

2.1 Possible approaches to the classification of weed communities

2.1.1 The choices

2.1.1.1 At the outset of the project, it was intended to use the Zürich-Montpellier system of phytosociology. To some extent, the project is not just an investigation of the community structure shown by different weed phytocoenoses, but also a test of the Z-M system as a suitable way to classify these phytocoenoses. However, it is always a mistake to use any method without considering the alternatives, for only by doing so can the relative strengths and shortcomings of the chosen method be assessed. The following is not intended to be a full review of other methods (for which, see Whittaker, 1962; Greig-Smith, 1964; Lambert and Dale, 1964; Pears, 1968; Shimwell, 1971c; etc.) but a brief summary of the options available.

It should be noted that the use of the term "plant community" and its equivalents can be used in both concrete and abstract senses. For the concrete unit of vegetation, the term "stand" is used here, or where the inter-relationships of the species are also implied, the term "phytocoenose". The terms "plant community" and "nodum" are here used in the abstract sense (see Section 2.2.2.7).

This immediately leads to the first major question to be considered which is whether the abstract "plant community" actually exists. This has long been a controversial issue, and one which has perhaps already occupied more than sufficient valuable journal space. Some would say that the abstract community does not exist. This is the essence of the "individualistic" view of vegetation, where each stand

is regarded as being unique (Gleason, 1926, 1939). Thus Gleason (1926) writes:-

"We all readily grant that there are areas of vegetation, having a measurable extent, in each of which there is a high degree of structural uniformity throughout, so that any two small portions of one of them look reasonably alike.... More careful examination of one of these areas, especially when conducted by some statistical method, will show that the uniformity is only a matter of degree, and that two sample quadrats with precisely the same structure can scarcely be discovered."

On the other hand, Tansley (1920) writes:-

"But if we admit, as everyone who has worked at the subject does admit, that vegetation forms natural units which have an individuality of their own, and that these units owe their existence to the interaction of individual plants of different species with their environment, then it becomes clear that a mere study of the distribution of species cannot form the basis of the science of vegetation,"

and further,

"The view that a given plant population, which we recognise as a unit of vegetation, is simply a chance collection of individual plants belonging to species that happen to be present on a given area or that can arrive and establish

themselves there with the means of migration and ecesis at their disposal, cannot be maintained. The same species are constantly present in the same kind of place and show the same groupings, so that the plain man has actually been impressed by these aggregates as entities and has given many of them common names."

Tansley regarded the plant community as sharing sufficient integrated structure to be regarded as a "quasi-organism". However, he readily accepted that this "organismal" view of vegetation was acceptable only up to a point and he was scathing in his condemnation of ecologists such as Clements and Phillips who likened plant communities to real organisms (Tansley, 1935).

Clements (e.g., 1936) regarded climax vegetation, at least, as being organic entities, capable of growth, maturation, reproduction and death. Within one area, one complex organism was struggling to develop, and while it would show variation, such variation would simply be its response to its habitat, presumably an equivalent of phenotypic variation. Phillips (1935) took this organismal concept to its ultimate conclusion, endowing plant communities with the philosophical concept of holism.

No-one would take such an extreme view today, one presumes, but this controversy is far from buried. As Yarranton (1967a) points out, the fundamental choice between individualistic and organismic views influences the choice of methodology for investigating community structure. Ordination techniques attempt to place each sample unit (i.e. OTU of numerical taxonomists) into a one- to multidimensional positioning, thus indicating overall relationships and implicitly assuming that no two sample units will come to occupy quite identical

positions. The use of classificatory techniques, on the other hand, assumes the existence of categories into which the sample units can be placed. The Z-M system used here quite definitely assumes the existence of Tansley's "quasi-organisms", and one suspects that some of its practitioners hold views not too far divorced from those of Clements and Phillips.

2.1.1.2.1 Ordination methods are designed to analyse a conceptual vegetational continuum. In fact, as Lambert and Dale (1964) point out, there are two concepts here. Just as it is possible to visualise both the real and the abstract community, so is it possible to visualise one real community grading into another, and one abstract community grading into another. General approaches to analysing these continua are reviewed by Austin and Orloci (1966), McIntosh (1967) and Whittaker (1973).

These include simple ordination techniques involving ordering by relatively simple mathematical indices, e.g. Bray and Curtis (1957), Anderson (1963) and Gittins (1965). While useful for relatively undisturbed closed vegetation, it is difficult to imagine such techniques being at all useful for weedy vegetation.

Of far greater potential for the study of weed vegetation is the technique of principal components analysis and similar methods (Goodall, 1954; Orloci, 1966; Austin and Orloci, 1966; Yarranton, 1967b; van der Maarel, 1969). This is an efficient method for multidimensional ordination of sample units, which may be stands or species, though the ecological significance of the selected axes of variation may often be far from clear. In fact a regular drawback of this approach is that it may turn out that the stands have simply been ordered according to increasing abundance of one major species. This difficulty has, however, been solved by Bates (1975). The great potential of principal components analysis is that the sample units

will usually be at least partly clustered. Clusters of stands according to floristic similarity may thus be regarded as belonging to one community, or at least as providing reference points, "noda", within a matrix of variation.

Whittaker (1967) proposes the ordination of sites by habitat data rather than floristic data, the approach being "gradient analysis". Past work on British weed vegetation (see Chapter 5) could be said to be on this basis. On present knowledge, the method seems to have little to offer here.

2.1.1.2.2 Amongst classificatory methods, association analysis (Goodall, 1953; Williams and Lambert, 1959, 1961; Ivimey-Cook and Proctor, 1966b) is much the best known. It is a divisive, monothetic method usable either for species or for sites. Its simplicity and ease of comprehension are, however, accompanied by a grave disadvantage. Division of sets of quadrats into two depending on the presence or absence of one particular species inevitably will break down in the case of weed data, where weed species will often be absent from stands in which they could easily occur but for chance. Noy-Meir et al. (1970) point out that the opposite is also true, presence of one tiny plant of the species in question is enough to place the quadrat in the "plus" group, with consequent heterogeneity of this group. Lambert and Williams (1962) describe the potentially useful "nodal analysis" which classifies both species and sites at the same time, but this suffers from the same drawbacks.

Information analysis (Williams et al., 1966; Lambert and Williams, 1966), an agglomerative polythetic approach, could be potentially useful, but would have been prohibitive in terms of computer time.

The classificatory methods described so far have been "objective" numerical methods. Traditional continental methods have been much more subjective. Foremost amongst these have been the Zürich-

Montpellier system (e.g. Braun-Blanquet, 1964; Westhoff and van der Maarel, 1973) and the Scandinavian tradition (Trass and Malmer, 1973; see also general review of these systems by Shimwell, 1971c).

The Zürich-Montpellier system is based on total floristics and is described in detail in Section 2.2. By contrast, the Scandinavian tradition, with which might be grouped Gimingham's (1961) "network of variation", is based on the dominant species of the stands. As it considers the dominants of each layer, it has been much criticised (e.g. by Ashby, 1935) for resulting in large numbers of ill-defined associations. It is now largely out-moded, but in any case, dominance has little meaning in weedy vegetation. A very recent development has been the development of "indicator species analysis" (Hill et al., 1975; Horrill et al., 1975). This is a numerical, divisive, polythetic method which may prove useful as an objective support to Z-M methodology in the future, but which was developed too late to be of use in the present case.

A similar system, combining aspects of both the Z-M and Scandinavian traditions, is the method of "successive approximation" (Poore, 1956, 1962). Like the Z-M system, it uses a tabular procedure, whereby quadrats are aggregated into "noda", reference groups of more or less similar stands of vegetation. British patriotism aside, it seems to have little to offer compared with the more sophisticated, and hence informative, Zürich-Montpellier system, but it has produced the classic work on Scottish mountain vegetation of McVean and Ratcliffe (1962).

2.1.2 Suitability of the Zürich-Montpellier system

A suitable approach to the study of weed vegetation must be a flexible one. It was assumed at the outset that weed communities exist, or at least that there is a reasonable possibility of their existing, but the stability of closed communities could not be expected. The

constituents of an arable weed phytocoenose include not only species which might be predicted from their biology and mode of reproduction, but also a wide variety of "accidentals", plants of other habitats which have germinated from stray seeds and are persisting, at least for the time being. The total number of species recorded during the present survey is high, certainly more than 500, and many of these are not normally considered arable weeds. They include, for example, such unlikely species as Astragalus danicus and Dactylorhiza praetermissa.

On the other hand, an arable field resulting from the ploughing of permanent grassland may very well be deficient in some or many of the weed species which could be expected to occur but for the absence of a local source of seed. It follows, then, that a methodology must be chosen which is not unduly influenced by the presence or absence of any one particular species. Indeed, the amount of any particular species must also not be allowed to become too important.

In practice, there is very little choice over the methodology. It was intended that the survey be a national one, with results that could be compared with data from the continent. The resulting data matrix consists of 873 quadrats and, as mentioned above, over 500 species. Such a sampling programme requires rapid fieldwork and efficient sorting of the resultant data. A review of several methods by Moore et al. (1970) makes it clear that Z-M methodology here scores heavily over other methods in terms of efficiency. Another assessment by Frenkel and Harrison (1974) again favours the Z-M system, in combination with information analysis, but in the present case, information analysis as a general technique has already been ruled out. Frenkel and Harrison make the point that an advantage of the Z-M system is in the clarity of its results, again essential for the present purpose.

Nevertheless, Z-M methodology is not perfect. The subjective sorting of data is a weakness, rendering the method liable to human error. A functioning computer programme partly solves this (see Section 2.2.2.11) but a supporting objective numerical approach would seem desirable. Moore and O'Sullivan (1970) found that a cluster analysis technique, though generally inferior to a Z-M classification, did identify a mis-classified site. In the present work, certain areas have also been investigated using a chi-squared analysis, as described in Section 2.3.

In selecting the Zürich-Montpellier methodology one must accept its limitations. Webb (1954) makes very cogent criticisms of the system, both in its nomenclature and in its hierarchical classification. Nevertheless, it works over the greater part of Europe, and later results suggest that it works reasonably well, even on "difficult" vegetation, in Britain. It is hoped that principal components analysis, or the related principle co-ordinates analysis, can be applied to part of the data in the future. This would provide interesting comparative results.

2.2

The Zürich - Montpellier System2.2.1 Introduction

"Plant societies are of absorbing interest, and phytosociology will one day engage the sedulous attention of our best botanical intellects; but the Zürich-Montpellier line went astray when it hitched its wagons to that grand old puffer we call formal taxonomy."

(Meikle, 1971)

"It is a great pity that controversy over the Braun-Blanquet system ever became a quasi-ecological issue. Whatever one may think of some aspects of the theory and practice of Zürich-Montpellier phytosociology, the fact remains that it has been responsible for a vigorous and coherent descriptive ecology over much of central and western Europe, and it has produced a rich literature full of value to the British ecologist if he is prepared to take the trouble to understand it."

(Proctor, 1967)

These two quotes represent the divergence of opinion amongst British ecologists. To the mathematically based, it is an "unscientific" and unacceptable approach. Indeed, there is much justification in their criticisms; the inherent simplicity of the method can easily lead to totally unjustified conclusions which would

not stand up to statistical analysis. Regrettably, much European literature is open to this criticism, even, sadly, some papers published by those who should know better. Acceptance outside its countries of origin has long been held up by the absence of full accounts of the methodology (Küchler, 1967), but as shown by the existence of Proctor's quote given above, there is a growing trend towards cautious acceptance of the results of the system. It may well be that an impetus has been given to this by the attractive presentation and obvious value of the classic work on Dutch plant communities by Westhoff and den Held (1969).

It is not intended that a full description of the Z-M system should follow. There are now a number of general accounts in the English language (Becking, 1957; Shimwell, 1971c; Westhoff and van der Maarel, 1973) while practical accounts of the manipulation of tables are given by Benninghof (1966), Küchler (1967 - but other parts of this account are not trustworthy), Shimwell (op. cit.) and Mueller-Dombois and Ellenberg (1974).

The essence of the Z-M (or "Braun-Blanquet") approach is admirably summed up by Westhoff and van der Marrel (op. cit.) in three major points:-

- "i) Plant communities are conceived as types of vegetation, recognised by their floristic composition. The full species composition of communities better express their relationships to one another and environment than any other characteristic.
- ii) Amongst the species that make up the floristic composition of a community, some are more sensitive expressions of a given relationship than others. For practical classification

(and indication of environment) the approach seeks to use those species whose ecological relationships make them most effective indicators; these are diagnostic species (character species, differential-species, and constant companions).

iii) Diagnostic species are used to organise communities into a hierarchical classification of which the association is the basic unit. The vast information with which phytosociologists must deal must, of necessity, be thus organised; and the hierarchy is not merely necessary but invaluable for the understanding and communication of community relationships that it makes possible."

The emphasis, then, is on the full species complement. This is in contrast to the system traditionally used in Britain and America. The common method of describing and naming communities has been to add the suffix -etum to the stem of the generic name of the dominant, hence "Callunetum" to describe heather moors. This has a long history; Daubenmire (1968) and others credit J. F. Schouw with the original initiation of the system, as long ago as 1822, though the originator may well have been von Humboldt in 1805 (Westhoff and van der Maarel, op. cit.). Tansley (1939) used this terminology in his classic work on British vegetation, so it is hardly surprising that it has become thoroughly established.

However, examination of Callunetum at different sites quickly reveals that this community description covers many different communities. Calluna vulgaris may dominate vast areas of Sphagnum bog, yet it can also be seen forming a patchy scrub with calcicoles directly

Fig. 6 Fieldwork form

Serial No. 515	Date 26 May 1971	Grid Reference SV 880 084
Locality Middle Town, St. Agnes, Is. of Scilly		
Area of Quadrat 4 m ²	Area of Stand Large	% Cover 90
Year of Colonisation 1		No. of Species 28
Habitat Interior of hedged bulb-farm, sheltered from the wind.	Soil Sandy loam	Slope —
Geology Blown sand over Granite	Exposition —	
Altitude < 25'		
Farming Methods Strip of bullock field left fallow and used (rarely) as a track.	Chemical Treatment - Herbicides - other - NONE	

Crop: —

Vascular Plants (% Cover 85)

<i>Fumaria capreolata</i>	22
<i>F. boraei</i>	22
<i>Vicia hirsuta</i>	22
<i>Gladiolus byzantinus</i>	21
<i>Cerastium glomeratum</i>	12
<i>Aphanes microcarpa</i>	12
<i>Oxalis pes-caprae</i>	12
<i>Anagallis arvensis</i>	12
<i>Juncus bufonius</i>	22
<i>Galium aparine</i>	+2
<i>Poa annua</i>	12
<i>Arabidopsis thaliana</i>	11
<i>Anisantha sterilis</i>	+2
<i>Medicago arabica</i>	+2

<i>Sagina procumbens</i>	+
<i>Agrostis stolonifera</i>	13
<i>Vicia angustifolia</i>	+
<i>Erodium moschatum</i>	+2
<i>Ranunculus bulbosus</i>	+2
Potato (reltic)	12
<i>Fumaria bastardii</i>	+2
<i>Sereno vulgaris</i>	+
<i>Trifolium dubium</i>	+2
<i>Ranunculus parviflorus</i>	(+)

Bryophytes etc. (% Cover 5)

<i>Ceratodon purpureus</i>	12
<i>Riccia sorocarpa</i>	+
<i>Wetisia rubilans</i>	+2
<i>Bryum bicolor</i>	+2

on limestone pavement, as near Ingleborough. Tansley himself was aware of, and avoided as far as possible, these dangers of oversimplification, but the nomenclature has become entrenched.

So while the addition of -etum to generic stems is used also in the Zürich-Montpellier system, this does not imply classification based only on the dominant. In open weed communities, with chance playing a much greater role than in more homogeneous closed communities, it is particularly important to realise that dominance by a single species does not, of itself, identify or delimit a weed association, a point emphasised by Morariu (1967).

2.2.2 Summary of method

2.2.2.1 The sample unit of the system is the aufnahme or releve. Selection of the site and precise details of the recording technique, as used here, are covered in Section 3.1. A typical aufnahme from the present study is shown in Fig. 6.

2.2.2.2 Cover and abundance of species in each aufnahme were assessed by use of the Braun-Blanquet cover-abundance scale (Braun-Blanquet, 1932, 1964). This is basically a five-point scale devised for the rapid estimate of cover. A quantitative measure for each species is thus obtained, with divisions of the scale being broad enough to sustain hopes of reliability from a subjective estimate. Although it is a widely used scale, there are various modifications of it, and symbols are not always used in the same way by different workers. The scale as used here in the phytosociological tables is given in Tab. 1.

Barkman et al. (1964) have proposed modifications of the scale, whereby values +, 1 and 2 are sub-divided into three, e.g.:-

2m very abundant (more than 100 individuals in the minimal area), cover below 5%

2a 5-12.5% cover, irrespective of number of individuals

Table 1 The Braun-Blanquet cover-abundance scale

<u>Symbol</u>	<u>Meaning</u>
5	75-100% cover of total plot area, irrespective of number of individuals
4	50-75% cover of total plot area, irrespective of number of individuals
3	25-50% cover of total plot area, irrespective of number of individuals
2	5-25% cover of total plot area, irrespective of number of individuals
(or)	less than 5% cover of total plot area, but very abundant
1	abundant and with very low cover, or less abundant but with higher cover, in any case less than 5% cover of total plot area
+	occasional and less than 5% cover of total plot area
r	one, or at most a few, small individuals (not visually forming any appreciable part of the community)
1st	a seedling of a normally large plant or tree (from the German "ein Stück", a fragment)
(+)	used to denote presence of the species immediately outside the sample area in the same stand of vegetation

2b 12.5% - 25% cover, irrespective of number of individuals
This modification for value 2 is recommended by Westhoff and van der Maarel (op. cit.) but the present author can see no advantage attached to a new nine-point scale as compared to the already widely used ten-point Domin scale.

2.2.2.3 Sociability

The second figure allotted to each occurrence of each species in the phytosociological tables is a measure of the aggregation of the individual plants, or individual stems, within the quadrat. The figures refer to the Braun-Blanquet sociability scale (Braun-Blanquet, 1932):-

- 1 scattered single plants
- 2 grouped or tufted
- 3 in troops, small patches or cushions
- 4 in small colonies, in extensive patches, or forming carpets
- 5 forming more or less pure populations or unbroken carpets (at least, when viewed at one layer in the stand)

This again is a subjective estimate, but this is all that is needed to give a brief picture of the behaviour of each species in the aufnahme. In terms of subsequent classification, sociability can be used to describe a distinct facies of a community, and it can also be related to the question of pattern (see Section 4.2).

It is not a measure of vitality. It is frequently the case that a species in a non-optimal habitat channels energy into vegetative growth forming a clumped habit and few flowers, though of course annual species of arable land typically do the reverse. Species performance within the quadrat can be described further with the use of appropriate fertility and vitality symbols (Braun-Blanquet,

op. cit.) but these require careful examination of a quadrat over a period of several visits before any reliability can be attached to the results. Such scales have not been used in this primary survey, though it would be interesting to have more information on selected species, e.g. Thalictrum minus in the association Chenopodio - Violetum.

2.2.2.4 Sorting the data

Once the data were complete, it was necessary to sort them into manageable groups for tabular analysis. Here the subjectivity could very well be criticised. During the actual fieldwork phytosociological literature was left largely unread, so that unconscious selection of "typical" stands would not bias the results. However, it was clearly impossible to deal with all the aufnahmen in one giant table and so some form of prior arbitrary sorting was unavoidable. By this time, much of the phytosociological literature had been consulted, so the first step was to classify the data-set into provisional sub-groups. Some of these sub-groups were thought to show similarity to syntaxa described from Europe, others apparently did not. The size of these sub-groups varied, in some cases they consisted of less than ten aufnahmen thought to show similarities, in other cases the sub-groups contained more than one hundred aufnahmen. However, these large sub-groups were not further subdivided at this stage.

For each set of data, a "raw table" was prepared. This and subsequent tabular manipulations are described by Shimwell (1971c), though the methodology differed from his account in various minor details. The "raw table" shown by Shimwell (op. cit.: 189), for example, appears to be partly sorted. He shows the separation of phanerogams and cryptogams and also shows future community recognition by addition of a series of dashes to complete tabular blocks. In the present case, the raw tables were genuine raw tables showing no presupposition of community structure, and there was no separation

of phanerogams from cryptogams. Not only would this prior separation have added a further lengthy stage to the analysis, but also there was no logical need or justification for this. These criticisms aside, Shimwell's description adequately summarises the procedure adopted.

So an initial two-dimensional table of aufnahmen and species was drawn up. This was annotated suggesting possible similarities between aufnahmen, and possible similar distributions shown by different species. Based on this information, the table was rewritten with the species and aufnahmen re-ordered, comparing the supposed similarities. Groups of species would be investigated separately from the rest in "partial tables". Transfer of information to successive tables normally involved the use of "transfer strips" as described by Shinwell. As errors could very easily be made at this stage, checks were rigorously made that there were the correct number of entries in the rows and columns. This was a safeguard which was adopted through to the production of the tables in their final form, as presented here. An alternative sometimes adopted was to cut tables up and physically re-order rows and columns. However, this was of limited practicality; layers of adhesive paper rapidly built up on the backs of tables, inhibiting further cutting and, more seriously, once tables were cut in both dimensions, squares of paper were apt to come adrift.

This was a long, time-consuming stage. As fully differentiated tables took form, anomalous entries could be identified and transferred to other data-sets. Some tables proved to be heterogeneous and their contained aufnahmen were dispersed elsewhere. Other tables were combined, often only to be split up again. At this stage, then, all aufnahmen were again being considered at once, and errors introduced by the early arbitrary sorting were eliminated. Eventually a series of tables existed which it was believed corresponded to definite communities. Some of these tables, it is true, contained apparently

anomalous aufnahmen, usually with a "tail" of unusual species indicating heterogeneity (see Section 2.2.2.10). Shimwell advocates discarding such aufnahmen, but it was felt that this shedding of inconvenient data could not be justified.

For several communities, synoptic tables were prepared. These provided summaries based on presence or constancy classes as widely used by European phytosociologists. Presence or constancy is summarised on another five-point scale:-

- V Occurring in more than 80% of the quadrats
- IV Present in 61-80% of the quadrats
- III Present in 41-60% of the quadrats
- II Present in 21-40% of the quadrats
- I Present in up to 20% of the quadrats
- s Single occurrence only, used here only in
tables of more than 10 aufnahmen

Strictly, many of the synoptic tables presented here summarise "presence degree" (German: "Stetigkeit") since quadrat size has not been absolutely uniform. Where all quadrats have been of equal size, such tables show "constancy" (German: "Konstanz").

2.2.2.5 Identification or characterisation of the syntaxonomic units

Once the community has been abstracted, the next stage is to compare the synoptic table with the literature and with tables of similar vegetation types from other areas. This comparison will normally result in the identification of the table, or units within it, with a described syntaxonomic unit, both in terms of total floristic similarity and particularly by the presence of "character - taxa" - taxa of narrow ecological amplitude which are thus restricted to particular vegetation types.

The use of particular species to characterise syntaxonomic units is a standard part of the Z-M methodology. Traditionally, a "character -

species" (German: "Charakterart", "Kennart"; Dutch: "kensoort") is one which is confined to one particular syntaxon. It is thus diagnostic for that unit. With detailed knowledge of the communities of one area within the higher syntaxa, it is further possible to use other species of wider ecological amplitude which occur outside the higher syntaxon but which are confined to only one community, or a few specialised communities, within it. Thus it is possible to use these species to differentiate between related communities within one higher syntaxonomic unit. Such a species is a "differential species" (German: "Differentialart", "Trennart"; Dutch: "differentiërend soort").

Frequently a plant taxon used in this way is of a rank below that of species, e.g. a subspecies or variety (or, ideally, ecotype) and strictly, the preferred term should be character- or differential-taxon. Thus Westhoff and den Held (1969) use the term "kentaxon" throughout. More rarely, an entire genus can be used in this way, for example the use of any species of the genus Spartina by Beeftink (1968) to characterise the saltmarsh alliance Spartinion.

Those species which are neither character- nor differential-species for any level of syntaxonomic unit within the community under discussion are collected together as "companion-species" (German: "Begleiter"; Dutch: "begeleiders").

The foregoing describes the ideal situation. Unfortunately with the exception of extremely localised endemics, few species are considerate enough to confine themselves strictly to particular communities. In the past, fidelity was an important concept in Z-M methodology, and Braun-Blanquet devised another scale to represent the fidelity of any species for any recognised syntaxon. Thus a fidelity degree of five described a taxon completely or almost completely confined to one community, while a value of one on the same scale

would fit a species which was more or less "accidental" in the community and typically occurring outside it, e.g. the case of a grassland perennial seeding itself into an arable field, many examples of which will be found in the present work.

It is not intended that the concept of fidelity should be fully discussed here (see, e.g. Westhoff and van der Maarel, 1973) but the continued use of the concept by critics of the system necessitates further consideration of the subject. Firstly it is a purely local concept and no practitioner of the system would pretend otherwise. Many species show substantial differences in ecological requirements in different parts of their range and correspondingly occur in widely different plant communities. Schoenus nigricans is an example well known to British ecologists, the plant requiring rheotrophic conditions in Central Europe and parts of Great Britain and yet also occurring in ombrotrophic blanket-bog vegetation in the Outer Hebrides and Western Ireland. The arable weed Anthemis arvensis is undoubtedly more calcicolous in Britain than throughout most of Europe. In many cases, differing ecological behaviour of a species across its range has been shown to be through ecotypic differentiation.

Thus any determination of fidelity must refer to one area only. This is implicit in the use of the term "local character-species" for a species which is of diagnostic value in one part of its range but occurs in a wider range of syntaxa elsewhere. Within that area it may be possible to use the fidelity of a species to a particular community, but of course the species concerned may already have been used in the initial characterisation of the community. Here we have the apparent circular argument recognised by critics of the system, e.g. Poore (1955a, 1956). However, this use of character species to identify vegetation in the field has been much misunderstood, as succinctly expressed by Moore (1962):-

"In present practice, associations are not distinguished in the field at all, but only when editing the tables of releves. The first step involves describing uniform tracts of vegetation, not representative stands of a presumed association. Only when sufficient releves have been accumulated and analysed can one discern the associations. Of course, in observing continental phytosociologists at work in their own homeland whose vegetation they know, one may be misled as to their methodology. They will now have reached the second stage.... of checking the reality of units already distinguished. They will not necessarily make this clear to a visiting enquirer."

In any case, despite the assertions of Poore (1955a, b, 1956) and Becking (1957), fidelity is now a largely outmoded concept. To quote Moore (op. cit.) again, critics who use it to attack the Z-M methodology "flay a horse long since dead".

When one deals with arable weed vegetation, the system of character- and differential-species comes close to breaking down altogether. In open communities, the control exerted by other species of the community, so important in closed communities, may be unimportant or entirely lacking. Hence species even of very narrow ecological amplitude can frequently germinate and grow in fairly open stands of weed vegetation, even if they would not normally be able to compete with their surrounding species under the prevailing conditions. This in simple niche theory terms is the essence of Hutchinsonian hypothetical and realised niches, where the open vegetation allows

the realised niche to be much wider than it would be if the surrounding species exerted the control that they would in denser stands. Thus presence or absence of any species is of very little value in the description and identification of a weed community.

The result is that in the present work, the concept of individual character- and differential-species has generally been abandoned. In their place has been adopted the "diagnostic species group", on the grounds that the occurrence of several "important" species in one stand is of considerably more classificatory value than the presence of one particular character species. This idea is not new, Beeftink (1968) states, "The view that the character-species.... is a special case of the differential-species.... leads to the development of the concept of 'differential-species-combination' (Trennartengefüge). By means of this new concept in which the character species are included, the characterisation of syntaxa is better founded."

Westhoff and den Held (1969) similarly use the term "kencombinatie" wherever it is more useful to do so, while Kropac and Hejny (1975) use the term "diagnostically significant species".

Finally, in this section it is necessary to emphasise again that whatever the technical term attributed to a species, the actual amount of it present in the stand of vegetation is of little or no relevance to its classificatory value. It is possible that a character species may also be a dominant, in simple communities this is very often the case, but it makes no difference if the species typically occurs in very small quantity. This is in marked contrast to British, American and Scandinavian traditions.

2.2.2.6 The association table and its hierarchical classification
If the vegetation is found to be identifiable with a described syntaxonomic unit, the final step is the drawing up of a full association table. This is again a point where critics of the system

may be under a misapprehension. Continental work which is most likely to come to the attention of the non-phytosociological British ecologist is often not drawn up as a strict association table. Thus misunderstandings can arise. For example the table given by Kershaw (1964, 1973), taken from Poore (1955b) is not an association table in the Z-M sense, and is not claimed as such by Poore.

A full association table represents the syntaxonomic unit and its full classification. The basic unit of the Z-M system is the "association" per se. These are then grouped into a hierarchy of successively higher units:- the "alliance", the "order" and the "class". All these are named by the addition of the appropriate latinised ending (Tab. 2). These basic units can be modified by recognising intermediary categories when it is convenient to do so, e.g. suballiances, suborders. These have the same latinised endings as the major units on which they are based. As well as the association, all these have character-species, thus a species restricted to a group of closely related associations becomes a character-species for the alliance that contains them. In an area where only one of the associations occurs, the species will also be a local character-species for that association.

Although the class is the highest formal nomenclatural unit, the informal grouping of classes is often done. The most commonly used category is the "formation", but other terms used include "division" (Westhoff and van der Maarel, 1973), "vegetation-type" (Hadac, 1967), "formation-group" (Passarge and Hofmann, 1968) and "class-group" (Tüxen, 1970a). Thus the class of arable-weed vegetation, the Stellarietea, is grouped with other similar classes of vegetation e.g. of natural wet mud (Bidentetea) and maritime strand-line vegetation (Cakiletea) into one formation (e.g. by Westhoff and van den Held, 1969).

In this way, associations and their successively higher units

* But see page 88 for recent proposals.

Table 2 Nomenclature of Zürich-Montpellier Ranks

<u>English</u>	<u>Dutch</u>	<u>German</u>	<u>Ending</u>	<u>Example</u>
Class	Klasse	Klasse	-etea	Stellarietea mediae
Order	Orde	Ordnung	-etalia	Centauretalia cyani
Alliance	Verbond	Verband	-ion	Caucalidion lappulae
Association	Associatie	Assoziation	-etum	Linarietum spuriae
Sub-association	Subassociatie	Subassoziation	-etosum	Linarietum spuriae sherardietosum

For ranks below association, see also Table 3

are assembled together according to their floristic similarities. It would be very strange if the resulting units did not have some ecological meaning, but ecological knowledge is not used at this stage. (Some exceptions to this are discussed by Westhoff (1967)). Ecological meaningfulness is essentially a test of each unit once it is proposed. Above the class level, however, units such as formations may be determined as much by physiognomy as by floristic similarity.

Thus the field data are now expressed in a full association table, with the quadrats and species arranged to display the basis of the classification. Species of similar diagnostic value are grouped together, with the remaining species, the "companion species" listed in a convenient manner towards the foot of the table. Association tables normally include simple habitat data, e.g. altitude or soil type.

2.2.2.7 Units below the association

So far it has been assumed that the lowest rank of syntaxon present in the association table has been found to be a recognised association. However, in larger sets of data it will normally be the case that lower units are also recognisable in the data set. Again, a number of categories are available in the Z-M system (Tab. 3) although their usage varies considerably from worker to worker.

Of these, the two important categories are the subassociation and the variant. The relative status of the two terms has been subject to individual interpretation. Tüxen (1937) regards the variant as subordinate to the subassociation, whereas others, e.g. Meijer Drees (1951), Schubert and Mahn (1968), regard the two as being of equal status but rather different meaning. Z-M tables, in principle, attempt to classify on a linear basis, as in a one-dimensional ordination, and it is particularly in infra-association analysis that this simple approach gives problems. Thus the subassociation can be regarded

as representing an ecological gradient in one direction, e.g. water status or a similar edaphic factor, whereas the variant can recognise variation on a geographical basis, e.g. a second dimension based on climate.

There seems to be no reason why either edaphic factors or geographical factors should be regarded as being subordinate to the other and thus the present author cannot accept the recommendation of Westhoff and van der Maarel (1973) that the variant should continue to be subordinated to the subassociation. In the present work, both are regarded as being of equal status. In restricted areas, of course, the problem is less likely to arise; while an association may be represented by two or more subassociations in one locality, the presence of more than one variant, as here defined, would be unusual.

A valuable feature of the subassociation concept is that it can be used to express transitions of the association towards related associations (e.g. Duvigneaud, 1946).

Furthermore, subassociations can be used to represent parallel variation in a range of associations, e.g. damp ground forms of various arable associations containing Gnaphalium uliginosum, Juncus bufonius, Ranunculus repens and similar species of damp mud. Because of their similar ecological requirements, these species form a sociological species group (see Section 2.2.2.12) which cuts across the floristic classification of the higher syntaxa. In practice it is more convenient to ignore this group until infra-association structure is considered, which is allowed by the flexibility of the system. This is where the Z-M system scores over the monothetic inflexibility of Association Analysis. Despite the linear arrangement of the aufnahmen, a fully structured association table can represent multi-dimensional variation in two dimensions, a fact which does not appear to have been appreciated by Webb (1954).

It should be noted that in all cases, named subassociations depart from the typical form of the association by the presence of sets of differential species. The central "nucleus" of the association lacks these species and becomes the typical subassociation or "subassociation typicum". The typical subassociation does not have differential species of its own; if it had, there would be a case for the splitting of the association.

The "vicariant" is a more problematical concept. Meijer Drees (1953) regards vicariants as being of equivalent status to subassociations and variants, but existing "when the differences in floristic composition between two (or more) subdivisions of an association are due to purely geographic influences", i.e. where the differences are not due to either edaphic or climatological factors. This is a highly dubious definition in practice since "purely geographic influences" are extremely difficult to recognise, if indeed they exist, a point made by Barkman (1953b) in his critique of Meijer Drees's proposals. It seems better to abandon the vicariant as a syntaxonomic unit, and make use of the more loosely defined "Rasse" to express minor geographical variation.

As an adjective, the word "vicariant" is of considerably more use, when it can be used to describe very closely related units which differ largely in their geographical range, e.g. the two vicariant associations Oxalido - Chenopodietum polyspermi subatlanticum Siss. (1942) R.Tx. 1950 of western Europe and Oxalido - Chenopodietum polyspermi medioeuropaeum R.Tx. 1950 of central Europe, which may well be no more than variants of one association. Such vicariant associations have been termed "Gebietsassoziationen" by Oberdorfer (1963).

Unlike other association subdivisions, the "facies" is not characterised by differential species but by dominance of a species normally present in smaller amounts. This, then, is the Z-M equivalent

of the "sociation" of the Scandinavian phytosociologists. A facies may be regarded as a deviation phenomenon, often as a result of human interference (Westhoff and van der Maarel, op. cit.). In such heterogeneous vegetation as that of arable fields, it is doubtful if the term, facies, has any real meaning.

All this pre-supposes that the data for the association are of sufficient quantity for valid subdivision into defined units. In the present work, this is not the case for most of the associations recognised. Infra-associational units are often discernible, but except where they can be certainly matched with the described units of other workers, it is unsafe to accord to them any defined rank, or even to state categorically that they exist. It would be very easy to give names to apparent units which were no more than artefacts of the method. Except, then, where it has been possible to be more dogmatic, infra-associational units have simply been recognised as "noda".

The word "nodum" is taken here to refer to an abstract community of unassigned syntaxonomic rank. Thus it is used in the same sense as Poore (1955a) and McVean and Ratcliffe (1962) rather than in the more rigid sense of Lambert and Williams (1962) in their Nodal Analysis technique. A better term might be "phytocoenon" (van der Maarel, 1965, - as "Phytozönon") or even "synecium" as proposed by Huguet del Villar in 1929 (Meijer Drees, 1951), but nodum is convenient and established in the British literature.

2.2.2.8 Nomenclature of the formal syntaxonomic units

The general method of naming syntaxa will already be apparent from previous sections. A syntaxonomic name is based on either one or two species, which are either character-taxa, or at least typical of the syntaxon. The name is latinised, with the appropriate endings as given in Table 2. The author and the date of publication are

appended to the end of the name. Occasionally, and only where necessary ecological or geographical information is included in the name, e.g. the vicariant associations quoted in the preceding section, or the Thero - Airion R.Tx. ex Oberdorfer 1957. However, as far as possible, such modifications to the basic binomial name are to be avoided (Meijer Drees, 1953).

Subassociations are based on one taxon name only, which is also latinised with the author's name and date of publication appended, e.g. Linarietum spuriae Krus. et Vl. 1939 subass. sherardietosum Siss. 1946. Other syntaxonomic units below the rank of association are also based normally on one name only, but this is not usually given a formalised ending, e.g. Spergulo - Chrysanthemetum segeti (Br. Bl. et De Leeuw, 1936) R.Tx. 1937 variant of Anagallis arvensis. Note also the absence of the name of the author of the variant; names at this level tend to be informal in view of their local applicability. Thus in the example given, the variant, as given by Sissingh (1950), is unrecognisable outside the Netherlands.

All this sounds relatively simple, but like formal taxonomy, the apparently simple system quickly becomes extremely complicated, requiring detailed codes of nomenclature. Even the two examples given above show deviations from the foregoing account. The Spergulo - Chrysanthemetum was formally described by R. Tüxen in 1937, but his description was based on an aufnahmen published by Braun-Blanquet and De Leeuw in 1936, hence the form of the author-citation.

The case of the Thero - Airion is rather more complex. The name was published, but invalidly, by Tüxen in 1951, and was then validated by Oberdorfer in 1957 (Moravec, 1968). However, because of the general laxity in applying such rules as exist, we still see "Thero - Airion Tx. 1951", e.g. in Westhoff and den Held (1969).

This, in fact, can be one of the main criticisms of Z-M

methodology, in practice if not in theory. Nomenclatural rules do now exist, but many phytosociologists are reluctant to apply them, particularly if this should involve an apparent criticism of a few leading exponents of the system.

The first coherent set of rules was published by Dahl and Hadac (1941), a set of ten rules based on the code of botanical nomenclature. Their paper, however, was generally overlooked, and it was not until the International Botanical Congress at Stockholm in 1950 that a further impetus was given to consideration of this important subject. Barkman (1953a) presented proposals similar to those of Dahl and Hadac and an independent contribution soon followed from Meijer Drees (1951, 1953), with further comments by Barkman (1953b). The rules of Meijer Drees provoked much controversy (see Vegetatio, Vol. 4) but they served to produce a working hypothesis and, more importantly perhaps, to point out the unscientific and haphazard way in which new names were formed and new communities "described". At long last rules were put forward to deal with such basic problems as priority of names, type communities, minimum requirements for a valid syntaxon description and procedure for altering the rank or status of described syntaxa.

Nevertheless, perhaps because of the very cogent criticism of Barkman (1953b) and others, these recommendations do not appear to have had any immediate impact. A further contribution, concerned primarily with the Latin grammar involved in name-forming, was made by Bach et al. (1962). This gained much greater acceptance but unfortunately included the rule that changes in taxonomic opinion regarding the name of a taxon used in a syntaxonomic name would result in changes in the syntaxon name too. Linaria spuria, used in the association Linarietum spuriae Krus. et Vl. 1939, is now placed in a separate genus, Kickxia, thus the association would (and has) become

the "Kickxietum spuriae Krus. et Vl. 1939". Although this is no longer recommended (see, e.g. Moravec, 1968) application of this rule has led to a substantial number of superfluous names and further nomenclatural confusion. In common with Meijer Drees, Bach et al. also propose the use of the ending -osum for infra-associational syntaxa other than the subassociation. This again does not seem desirable to the present author but in any case, few phytosociologists have followed the proposal.

Production of important syntaxonomic reviews (e.g. Lohmeyer et al., 1962; Oberdorfer et al., 1967) and work towards the Prodromus of European Plant-communities have forced a greater awareness of the necessity for a comprehensive set of rules and to this end Moravec (1968) proposed a set of 26 articles at the symposium of the Internationale Vereinigung für Vegetationskunde at Stolzenan in 1964. Neuhäusl (1968) in an excellent paper gave detailed instructions for the determination of valid syntaxonomic names, especially following syntaxonomic rearrangements. Finally, Moravec (1969) put forward a further eight articles regularising the rules concerning nomenclatural types.*

Thus at last, there is no excuse for nomenclatural laxity. Neuhäusl (op. cit.) was still able to write, in 1967 (usual publication delay) regarding this laxity.

"Reasons for not respecting the existing proposals are many. Besides the objective reasons subjective factors also accede here, such as conservatism of the authors, respecting prominent authorities, underestimation of the need for the stabilisation of names, having regard to lability and frequent changes in the system itself."

*See page 88 for an addendum to this account.

It is to be hoped that this is no longer true, certainly in the present work, any deviations in formal Z-M nomenclature are errors on the part of the author. The new associations have been named according to the grammatical rules presented by Rauschert (1963), a source which has been freely used to resolve other orthographical tangles.

2.2.2.9 Nomenclature of weed communities - some special cases

2.2.2.9.1 The previous section has covered in detail the serious nomenclatural confusion which has prevailed in the Z-M system. It will be readily apparent that deviations from the standard methodology must be thoroughly justified. In the special case of arable weed communities there are indeed cases when the system requires some modification.

One of the most serious problems encountered by any worker on open vegetation-types is the much more nebulous concept of the association, or indeed any abstract syntaxonomic unit. Even if the association can be accepted as a totally real concept in closed vegetation-types, in weedy vegetation it is much more the ideal which may be approached but rarely attained. Consequently, the description of any new syntaxonomic unit must be subject to considerable caution. Even with fairly large sets of data, many workers have quite properly regarded their new syntaxa as provisional.

The standard method of labelling units which are provisional is to add the abbreviation "(prov.)" following the syntaxon name. This, it should be added, is a normal part of the Z-M system and is not particularly restricted to weedy vegetation. The alternative method of depicting somewhat provisional associations, though used for all types of vegetation, is, however, more generally used for weedy vegetation. This is simply the non-latinisation of the association name, e.g. "Alchemilla_arvensis - Matricaria_chamomilla - Ass. Tx. 1937". Workers at a later date, who find the unit is worth

maintaining, can then latinise the name without any need to declare the unit as no longer "provisional". Thus the example above, though somewhat modified from Tüxen's original concept, is still maintained and should not be written in latinised form. Thus Tüxen (1950), in his monograph on "weedy" communities, listed 125 syntaxa at the association level. Of these, 83 were given in non-latinised form (though admittedly, it is not clear whether the non-latinised names in this case mean "provisional" quite in the sense described above).

In practice, however, this non-latinised form is clumsy in use, persists in the literature long after the syntaxon has become thoroughly established, and is very frequently used when no degree of provisionality is intended. It seems better to abandon names of such form unless the syntaxon is not assigned to a particular rank. Until a possible new association is definitely worth describing, it would be better to use the form, "Stachys arvensis - community", where no formal rank is given.

2.2.2.9.2 A greater difficulty associated with community description of arable field vegetation is that the stand may very easily lack important species, i.e. those normally of diagnostic value, and be essentially a fragmentary community. Thus Brun-Hool (1963, 1966), in an extensive survey of Swiss arable fields, found that 19% of stands lacked characteristic species of any known communities, and were too poor in species to justify the establishment of new communities. At heights over 950 m. the percentage of fragmentary communities was over 50% and above 1200 m. it rose to over 80%. He further established that the number of fragmentary stands was increasing and that character-species of alliance and order rank have shown a decrease throughout the century in comparison with class character-species.

He divided these fragmentary communities into two major categories

differing more in history than in present structure:-

a) "Rumpfgesellschaften", communities which appeared to be incompletely developed, or arrested in their development. This incomplete development was due either to increasing altitude, hence the results above, or to rapid rotation of crops whereby the habitat itself would change each year preventing the full development of any community.

b) "Restgesellschaften", residual communities depleted of species by modern farming methods, notably by herbicides.

It should be noted that altitude does not always have a deleterious effect on arable weed stands; Häfliger and Brun-Hool (1971) recognise a "montane level" (a minor infra-associational category) characterised by Campanula rapunculoides, Euphorbia platyphyllos, Lapsana communis, Medicago lupulina and Reseda lutea. However, Brun-Hool (1963) does not regard these species as being of any diagnostic value within the classes Chenopodietea or Secalinetea and thus these additional species would not effect the status of a montane stand as a Rumpfgesellschaft.

In Britain, such fragmentary communities are common. In upland areas, where arable fields are rare, isolated and frequently rotated with short-term pasture, Rumpfgesellschaften are the norm. In the low-lying, cereal-growing parts of the country, modern agricultural methods have ensured that almost every arable stand is to some extent a Restgesellschaft.

Thus one is faced with the problem of classifying arable stands which cannot be assigned to particular associations. Brun-Hool's scheme of nomenclature provides a simple and convenient answer.

In essence it is very simple. Stands which cannot be assigned to any particular association are identified, if possible, to the alliance, or failing that, to the order or class. Stands assigned

to a higher syntaxonomic unit are then examined and it frequently happens that subgroups can be discerned based on the high constancy of one or more species. Such groupings can be abstracted out and named by prefixing the name of the constant species to that of the higher vegetation unit. Thus within the alliance Chenopodion (equivalent to the order Polygono_-Chenopodietalia in the present work) Brun-Hool recognised two such fragmentary communities, the Sonchus asper - Chenopodion - Gesellschaft and the Setaria viridis - Chenopodion Gesellschaft.

Such abstractions may not be applicable to very large scale surveys but within one country, the communities described may be just as real and just as useful as the more rigidly defined associations. In the present work similar units have been described where it has seemed useful so to do.

A recent extension of the Brun-Hool system has been advanced by Kopecky and Hejny (1974). Working on anthropic marginal communities they introduced a new nomenclature based on the Z-M terminology, recognising three categories of community: "basal communities", "deviate communities" and "cenologically (sic) saturated communities". Basal communities are composed of species with relatively broad ecological and coenological ranges and lack species with a narrow ^{or unique habitats}. Deviate communities differ from basal distribution in rare communities by the dominance of a species of much narrower ecological and coenological amplitude. Kopecky and Hejny define a cenologically saturated community as "a phytocenosis consisting of character- and differential-species of the relevant superior syntaxonomic units, of accompanying species and of one or several species with narrow ecological amplitude, which are, within the given territory, exclusively or mainly confined to this community." This definition virtually corresponds to that of the association in traditional Z-M terminology.

The bulk of the classification in the present work was completed before the author was aware of Kopecky and Hejny's paper. Nevertheless, the classification corresponds well with their system. Tables presenting stands classified to the level of class, order or alliance without further refinement correspond, at least in part, to the class-, order- or alliance-basal communities of their terminology. Brun-Hool communities compare directly with their deviate communities and, of course, the correspondence of associations with their system has already been covered.

2.2.2.9.3 A problem glossed over so far is that of the syntaxonomic status of the crop plant. When one is dealing with a stand of vegetation it is clearly unsatisfactory to ignore the dominant species. Yet the crop plant has been introduced to the habitat artificially and is usually ecologically "fit" enough to survive only because of the overwhelming influence of man as a biotic controlling factor. The influence of the crop plant on the rest of the community cannot be denied (see, e.g., Potts and Vickerman (1974) for a comprehensive review).

In western Europe, the crop has usually been regarded as forming part of the habitat in which the weed community develops (e.g. Friederichs, 1966). Consequently the nature of the crop is normally indicated at the top of the association table, along with other habitat data.

Many East Europeans, however, have adopted the alternative viewpoint, regarding the crop, quite properly, as part of the phytocoenose. But if the crop plant is accepted as part of the stand of vegetation, can it be allowed to take part in the syntaxonomy of the stand? If so, to what extent? Ujvarosi (1954, quoted from Kropac et al., 1971) provided a useful solution. In normal Z-M methodology, a syntaxon dominated by one species may, as previously explained, be

named a "facies". Therefore Ujvarosi introduced the term "cultifacies". Thus the Linarietum spuriae hordeicolum would be the barley cultifacies of the association, while the Linarietum spuriae avenicolum and the Linarietum spuriae trititicolum would be the oats and wheat cultifacies of the same association. Bodrogkőzy (1955) adopted a similar terminology in his work on the weeds of Hungarian vineyards using the term "Konsoziation", e.g. Digitario - Portulacetum Konsoziation Vitis vinifera.

In some cases, however, the crop plant has been allowed a far more important syntaxonomic status. Clover and lucerne fields are difficult to classify since the crops tend to form nearly pure stands and any extracted weed community is usually fragmentary. Accordingly, within the order Centauretalia cyani, East European phytosociologists recognise an alliance named after these crops, the Trifolio - Medicaginion sativae Balazs 1944 em. Soo 1961, containing the association Plantagini - Medicaginetum Soo et Timar 1957 (see, e.g. Timar, 1957; Soo, 1961). Soo (op. cit.) further recognises an alliance of rice-fields, Oryzion sativae W. Koch 1954, again named after the crop. Miyawaki (e.g., 1965) has in turn elevated Japanese rice-fields to class status, the Oryzetea sativae Miyawaki 1960.

It is difficult to tell to what extent these alliances are accepted by West European phytosociologists, but there does appear to be general agreement on the Lolio remoti - Linion R.Tx. 1950 of flax fields, based on flax, Linum usitatissimum, and a typical seed impurity and weed of flax fields, Lolium remotum. Tüxen (1950) names L. usitatissimum as one of the character species of the alliance. The crop now figures in a higher syntaxon, in fact, as J. and R. Tüxen have created a new order for the alliance, the Lolio - Linetalia J. et R. Tx. 1961 apud. Lohm. et al. 1962.

In general, however, it is more convenient to adopt the standard

approach of recording the crop virtually as a habitat factor.

Differences between stands caused by the crops do not seem to be as important as other biotic and abiotic factors, certainly this is the case in Britain, and to base syntaxa on the crop plants could well obscure other floristic relationships. Where the nature of the crop needs to be emphasised, the approach of Ujvarosi is perhaps the best.

2.2.2.10 The concept of homogeneity

Implicit in this, and all other work comparing the species complements of different defined areas is the idea that each site is characterised by one set of ecological characteristics, and hence by one species-group. In other words, the sites are "homogeneous". The converse of this is, of course, that heterogeneous sites must be avoided. Here lies much of the controversy involved with different phytosociological methods. One has the choice between truly random selection of sites, with the likelihood of including sites which detract from the ecological meaning of the data-set, or the subjective rejection of unsuitable sites, with the consequent invalidity of subsequent statistical treatment. In practice most approaches attempt a compromise between these two choices.

However, heterogeneity itself is not a simple concept. In fact it is possible to reject sites on at least three precepts, all falling under the heading "heterogeneity".

i) Site heterogeneity

This is the reverse of the concepts of homogeneity termed "intensive homogeneity" by Barkman (1958) and "analytical homogeneity" by Westhoff and van der Maarel (1973). It is usually the most obvious form of heterogeneity in the field. If different ecological parameters characterise different parts of a single sampling area, then the area is clearly heterogeneous. In the present study, this type of

heterogeneity is most likely to occur on wasteground, where the proportions of builders' sand, concrete rubble and similar materials in the soil may vary markedly within very small areas. An aufnahme from such a site will provide, at best, only an "average" of the wasteground conditions, though it will still, of course, be clearly distinguishable from aufnahmen from other habitats. In practice, an ecologist can never be certain that his site is truly homogeneous, since he cannot prove that the concentrations of the various soil minerals, micrometeorological conditions and other invisible parameters are truly uniform. In the present case, it is known that soil microtopography is of great importance at the seedling stage (Harper et al., 1965; Pemadasa, 1976) and hence the distributions of weed species can never be completely random. At best the ecologist can use his experience to judge from the topography and vegetation whether his site is sufficiently uniform to be of scientific value. Dahl and Hadac (1949) do provide a mathematical methodology to determine the homogeneity of a stand of vegetation, but this would be very time consuming and totally impractical in the present context.

A clear case of site heterogeneity occurs when a vegetational boundary crosses a proposed sampling site. A limes convergens (see Section 4.1) situation should be instantly obvious and for most purposes can be rejected. However, a limes divergens situation poses a much greater theoretical problem. Limes divergens situations, containing their own characteristic species, can cover relatively large areas (Bellamy et al., 1969), and no phytosociological survey can afford to ignore such situations when they occur. Fortunately this has not been a serious problem in the present work.

The foregoing discussion assumes, of course, that the vegetational boundary demarks two unrelated plant communities. Much more controversial is the case where the boundary lies between two

phases of the same cyclic system, as in the cases described by Watt (1947) and Kershaw (1973). This is essentially the same problem as that posed by a simple, coarse-grained pattern (see Section 4.2) and is best treated in much the same way. Detailed sampling with a very small quadrat size reveals the very real differences between the phases of the cycle, while sampling with a much larger quadrat size, though including a heterogeneous vegetational mosaic, is still of value for purposes of comparison with neighbouring communities which do not form part of the system. Again, since the present study is concerned with very open vegetation, it is not appreciably subject to these problems.

ii) Colonisation heterogeneity

If the vegetation is cleared from an area of relatively mature soil, the resulting habitat is ecologically highly unusual in one special way. This is that the seeds of a very sizeable proportion of all higher plant species are potentially able to germinate and grow. This is, quite simply, the principle on which garden flower-beds are based. In the absence of competition, species otherwise restricted to specialised habitats are able to grow to maturity, with perhaps only climate as a major environmental factor. Only when there has been sufficient recolonisation of the ground for competition to become effective are the finer details of the autecology of a species relevant.

It follows that when an area of ground is cleared, the plants that recolonise the ground are initially representative only of the available seed, not of the environmental features of the locality itself. While it is true that most of the colonising species will be annuals, which, by their short life cycles and prolific production of small seeds, are well adapted for their role, a miscellaneous collection of other species are also likely to appear, until they are eliminated by competition. Furthermore, a greater variety of

annual "weeds" are likely to occur than would be the case in an arable crop, again until competition becomes effective. It is not surprising, therefore, that the classification of stands of vegetation on disturbed ground is often difficult or impossible; the stands being referable only to the order or class (see also Section 6.13 and Tabs. LVIII, LXI). It is this mixture of species of differing ecological requirements that is here termed "colonisation heterogeneity".

A special case of colonisation heterogeneity is the fallow field. The relaxation of the selection for a certain group of species following the removal of a crop means that other species may appear. Consequently fallow fields tend to be species rich (see, e.g., Tab. 4) and, while usually still referable to a particular association, often contain atypical species. In association tables, such aufnahmen automatically show up as cases of theoretical heterogeneity.

It should be noted that colonisation heterogeneity as here defined is not normally applicable to the initial stages of primary succession. The pioneer vegetation of sand-dunes and other natural open situations consists of specialised groups of species which are able to grow successfully on the unstable and immature soils of such habitats. River shingles are perhaps an exception to this, Though most shingle systems support fairly characteristic species assemblages, atypical and often surprising species are of frequent occurrence.

iii) Theoretical heterogeneity

The two preceding types of heterogeneity refer to individual stands of vegetation. However, it will readily be appreciated that if data from different homogeneous stands are amalgamated in one table, that table will not necessarily be homogeneous too. This homogeneity of abstract vegetational units has been termed "synthetic homogeneity" (Westhoff and van der Maarel, 1973), "extensive homogeneity" (Barkman, 1958) and "homogeneity" (Tüxen, 1970c; Moravec, 1971). In that

the concept extends to cases where an aufnahmen is excluded from a phytosociological table on the grounds that it is atypical, the terms "theoretical homogeneity" and "theoretical heterogeneity" are preferred here. As stated in similar terms by Dahl and Hadac (1949), a syntaxon is homogeneous when the stands from which it has been built up, if placed together, would form a homogeneous plant community according to the criteria by which a single stand is judged.

Moravec (op. cit.) recognises three distinct causes of heterogeneity in phytosociological tables. Firstly there is the diffuse variability caused by a number of species of low constancy being regularly distributed in a set of aufnahmen. Secondly, there is the heterogeneity caused by the presence of aufnahmen containing an abnormally high number of such species of low constancy. Finally, even where all species in the table occur with relatively high constancy, there may still be variability of the total species totals of different aufnahmen. Phytosociological tables in the present work clearly show these three influences.

Measurement of heterogeneity in tables has been a much debated topic, with a number of formulae proposed to detect individual atypical aufnahmen or to measure the degree of heterogeneity of the entire data-set (e.g. Hofmann and Passarge, 1964; Ceska, 1966; Moravec, op. cit.; Westhoff and van der Maarel, op. cit.; Goodall, 1973). Methods for detecting heterogeneity have often been based on the "Law of Distribution of Frequencies" proposed by Raunkiaer (1918, reprinted in English, 1934). This law relates to the proportions of different species in the five frequency classes 1 - 20%, 21 - 40%, 41 - 60%, 61 - 80% and 81 - 100%. For one "formation", Raunkiaer stated that there was a progressive decrease in the numbers of species falling into each successively higher frequency class, though not always between the third and fourth class, except for an increase

in the fifth class of species with over 80% frequency or constancy. This rise in the fifth class has very often been regarded as the sign of a homogeneous data-set. Moravec (op. cit.) considers that in a fully homogeneous table, all species occur with 100% frequency, but more generally it has been considered sufficient for the fifth class to contain more species than the third and fourth classes (e.g. Cain and De Oliveira Castro, 1959). On this basis, the phytosociological tables presented here are all highly heterogeneous, often lacking any species with a frequency of over 80%. However, Raunkiaer, himself, stated that his law did not apply to open vegetation. In any case, Greig-Smith (1964) has shown that the basis of such thinking is unsound, and writes of the fifth frequency class, "It has played a notorious part in some attempts at definition of plant associations."

The presence of aufnahmen with a high number of species of low constancy presents practical and ethical problems. Moore (1962) writes, "A long 'tail' of isolated occurrences at the foot of the table may.... be the sign of a badly chosen stand", while Böttcher (1968) demonstrates that large tables may contain a number of particularly species-rich or species-poor aufnahmen. Tüxen (1970b) recommends a preliminary procedure excluding such aufnahmen. However, to do this seems to come dangerously close to falsifying results and to exclude such aufnahmen might well be to lose valuable information on infra-associational syntaxa. Thus atypical aufnahmen have been retained in the phytosociological tables presented here, but have been separated to one side when this has been appropriate or convenient. In such cases, the aufnahmen have not been used in the production of constancy tables.

2.2.2.11 The use of computers

The relatively recent introduction of sophisticated computers has resulted in the development of a large number of phytosociological

techniques (Moore, 1972). It is clearly desirable that the table manipulations of the Z-M system be carried out by computer, in that an efficient computer programme could remove the charge of subjectivity from this aspect of the methodology. Furthermore, such a programme would hopefully produce the most accurate or satisfactory possible result and eliminate errors of transcription. Programmes which carry out at least part of the Z-M tabular methodology have accordingly been developed (e.g. Benninghof and Southworth, 1964; Ceska and Roemer, 1971; Moore, op. cit.).

However, despite the development of so-called standard computer languages, a major problem in this field is that different dialects exist for each make of computer. At the time of this research, attempts to adapt programmes to the University of Durham computer were meeting with mixed success, and so all tabular manipulations were carried out manually. This is not regretted, since this has given a deeper knowledge of the species combinations, including those tried but discarded. It is unfortunate that there are limits to the storage space in any computer, since the computerised investigation of very large sets of data could give very valuable results. The alliance Aphanion is a good example; the syntaxonomy of this is in need of overall revision, but this would involve reanalysis of tens of thousands of published and unpublished aufnahmen, an impossible task.

2.2.2.12 "Ecological-sociological species groups"

As previously stated, association tables contain species grouped together for their classificatory significance and the residual species grouped together as "companion species". These companion species are a heterogeneous collection, including widespread species occurring in a number of classes, species characteristic of another class but occasionally occurring in the vegetation in question, and species of relatively narrow ecological amplitude but not distributed in

a manner corresponding with the overall classification adopted. These, then, are all species with an ecology that just does not happen to fit in with the imposed syntaxonomy of the communities. Considered more generally, it is possible to observe similarities in the ecological distributions of these species and hence to recognise groups of species which appear to have some meaning but which cut across the defined boundaries of the abstract communities. If this similarity in distribution can be seen within the confines of one association, then the group of species can be classified together as diagnostic of an infra-associational syntaxon. If, however, the species are so common or so rare in the association that their similarity in distribution is not obvious, then they are relegated to the companion species.

Some East German workers, notably Schubert and Mahn (1968), have adopted a logical alternative to this long list of unclassified companion species. Based on the work of Hilbig et al. (1962) they have listed all companion species in their tables according to their more general "ecological-sociological species groups". Similarly, Scamoni and Passarge (1959) recognised the existence of sociological species groups in the ground floras of forest communities and Scamoni et al. (1965) trace the distribution of such groups in different forest associations. Doing (1969) advocates the use of sociological species groups in situations where full Z-M methodology proves too inflexible.

Such sociological species groups have not been used in the work reported here, except that infra-associational noda based on more or less the same species will be repeatedly seen in different associations. It is probable that analysis of the data by a cluster analysis technique, or by the inverse association analysis of Williams and Lambert (1961), would have produced such groups, but for this to be valid, non-weed vegetation would also have had to be included. However, the concept

of sociological-species-groups is very relevant to discussion of other European approaches to the study of arable weed vegetation (see Section 5.1.2).

2.2.3 Discussion of the Zürich-Montpellier system

Preceding sections have shown that the Z-M system promises to be a suitable approach to the study of British weed floras. This decision is made despite long-standing prejudice against the system in Britain. There is little doubt that the greater diversity of British habitats and the pervading influence of the Atlantic Ocean are a contrast to the large, uniform stands of vegetation on the continent and have thus hindered the acceptance of the methodology here. Added to this, influential British ecologists, notably Tansley (1922), while expressing interest in much of the methodology, strongly opposed the nomenclatural aspects of the developing Z-M school.

Thus while the system was being refined on the continent, and extensive information and knowledge was built up, knowledge of British communities was largely limited to the wealth of descriptive information from specially selected sites in Tansley (1939). Further critical accounts of the Z-M methodology followed from Webb (1954) and Poore (1956) and while the system was defended by Moore (1962), the literature was about to be swamped by a flood of numerical methods as computers became more accessible.

It may just be that this abundance of literature on numerical methods has, paradoxically, resulted in the increase of interest in the Z-M system in Britain. Increasing numbers of papers refining numerical methods to levels of high mathematical sophistication without adding to ecological literature, may have swung the tide towards a system which still very obviously was concerned with real vegetation. There is much catching up to do, but published accounts now exist of calcareous grassland (Shimwell, 1971a, b), sea-cliffs (Malloch,

1971) and a general account of the island of Skye (Birks, 1973). Limited accounts of the Irish vegetation were published by Braun-Blanquet and Tuxen (1952) and subsequent work has included an account of the grasslands (Molinietalia) by O'Sullivan (1968).

However, the increased acceptance of the system, not only in Britain, but also in other parts of Europe, is exposing what may be the most serious flaw of all. Much of Braun-Blanquet's early work was carried out in Switzerland, while Tuxen has worked mainly in N.W. Germany. Oberdorfer's work has dealt mainly with S. Germany and Passarge has more recently covered the North German Plains. Westhoff, Sissingh and others have brought the Netherlands to the same level of knowledge. France was served by the classic work of Allorge early this century and recent work has been done by Gehu. In recent years, East Germany has been very well covered by Schubert and others at the Karl-Marx Universität. The point of all this is that phytosociological knowledge has developed about a number of centres. When significant differences were found by comparison between association tables from different areas, new associations were described for each area. If the associations were clearly closely related, they were regarded as vicariant, the "Gebietsassoziationen" of Oberdorfer (1968).

For many vegetation types, this state of affairs has not proved too serious, but arable land is almost continuous across Europe. For disjunct vegetation such as heathland, it is permissible to compare the Breckland heaths, say, with the North German Lüneburger Heide or the Hungarian Steppes. But when one deals with arable land, barring a few interruptions such as the English Channel or the Alps, one is dealing with an almost continuous series of stands. Our communities naturally differ from those of Germany or Hungary but continued work on the areas between the classic centres is breaking down the illusion

of concrete differences. One has not yet reached the continuum stage, but it is clear that particularly for arable communities, the described "associations" will have to become a series of reference points.

It is here, perhaps, that the most valid criticisms of the Z-M school, or any similar system, can be made. The Z-M school has set out to provide a rapid-survey methodology and a series of names to which any piece of vegetation can be matched. If one has to describe a weed community on a chalk soil somewhere in mid-continental Europe as "50% Cauca~~l~~ido - Scandicetum, 30% Galio - Adonidetum, 15% Adonido - Iberidetum amarae, 5% Linarietum" one is losing most of the benefits of what is meant to be an easy and simple system.

This is not entirely a flight of fancy. Ellenberg (1954, quoted from Kùchler, 1967) attempted to integrate plant communities near Ulm in southern Germany into Tùxen's system for northern Germany. He found that more than three-quarters of all the communities came to lie between two or three subassociations and associations, and even between alliances and orders. Yet within the area around Ulm, the communities could be readily determined and mapped.

Luckily, Britain is on the edge of the complex. One can accept a certain amount of geographical variation in British weed communities as, for example, compared with those of the Netherlands, without having to worry about equally similar communities with different names on the other side of us. The one exception to this could be our western stands of the Spergulo - Chrysanthemetum segeti which are intermediate between the Dutch stands of the same association and the Fumarietum bastardii in Ireland. In this case, however, it is the status of the Fumarietum bastardii which comes under doubt.

Sections 2.2.2.6 and 2.2.2.8 - Addenda

Since these sections were written, the author has been able to see a new code of phytosociological nomenclature which is to be regarded as the "official" code of the International Society for Vegetation Science (Barkman et al., 1976). It is questionable whether a statutory code ought or can be introduced by one society without the backing of an International Botanical Congress but nevertheless its appearance must be welcomed.

The code bears strong resemblance to codes of idiotaxonomy, including the use of the type for nomenclatural stability. Important features are Article 11, providing new endings for suballiances, suborders and subclasses, Article 34, rejecting geographical and ecological epithets where these stand as if they were the specific epithets of name-giving idiotaxa, and Articles 43-45 governing changes in syntaxonomic names where the idiotaxonomic names have been shown to be based on homonyms or incorrect identifications.

Recommendation 13A suggests that the phrase "subassociation typicum" be avoided in the future, with all subassociational names being based on idiotaxa. This, however, seems to go against the concept of a typical state of an association, with no differential species of its own, plus various divergent states of this association each categorised by differential species. As to use any species other than a differential species to name a subassociation would be absurd, the nomenclature presented here has not been altered in the light of this recommendation.

2.3 Measurement of Association between Species

2.3.1 As well as the standard application of Zürich-Montpellier methods, some groups of data were subjected to chi-squared analysis as described by Agnew (1961).

Quadrats were the same as those used for Z-M analysis, except that any quadrats not conforming to the standard size of $4m^2$ were rejected. As a standard size of quadrat was adopted, this automatically meant that species adjacent to the quadrat, recorded with the symbol "(+)" in the phytosociological tables, were also rejected in this case. It could be objected that the selection of sites was not random in a statistical sense (see Section 3.1) but as explained by Ivimey-Cook and Proctor (1966b) this does not rule out the use of a statistically based method when the object is to examine data in relation to the results of another phytosociological method. In any case, the results are presented here as hypotheses and the tests for significance should merely be regarded as guidelines. Even if the statistical tests were strictly valid, they would only provide a test of the reasonableness of the same hypotheses. As will be explained shortly, it is difficult to be at all certain about levels of significance anyhow.

As explained by Agnew, each data set was subjected to chi-squared analysis by means of 2×2 contingency tables, with the application of Yates' Correction (Yates, 1934). As this method becomes inaccurate in the case of species occurring with low frequency, species occurring five times or less in a data set were omitted. Occasionally, species of apparently special significance but occurring only four times were still included, but all such results were interpreted with care and such species were not included in general calculations based on each data set.

The chi-squared results were incorporated in matrix diagrams and plexus diagrams were drawn showing positive associations. Three levels of significance were used: $P = .05$, $P = .01$, $P = .001$.

Plexus diagrams are widely used in vegetation studies (McIntosh, 1973) in that they provide an attractive summary of the calculated relationships. A problem is that they are usually little more than that; the clusters or "species constellations" are usually incomplete and difficult to quantify. A simple solution is the measure of cohesiveness ("connectedness", "internal continuity") provided by Wirth et al. (1966). They proposed that the cohesiveness can be expressed by the ratio:-

$$\frac{\text{Total number of existing connections} - \text{necessary connections}}{\text{Total possible connections} - \text{necessary connections}}$$

The number of "necessary connections" is the minimum number that could connect the units of the cluster, i.e. one less than the number of units. Hence if the units are connected linearly, the cohesiveness is zero. This index of cohesiveness is of less use than it might be due to the difficulty of defining the cluster. To chose a nucleus with a high cohesion may often be less satisfactory than to include other connected units with the consequent lowering of the index of cohesiveness.

The omission of negative associations from a plexus diagram is a regrettable defect. Negative associations have been used here in the arrangement of diagrams but they are not clearly shown. McIntosh (1957) did incorporate dotted lines to represent negative association in a plexus diagram, but even though his was a simple diagram, and negative association was important to his discussion, the result was not very satisfactory. It may be that a modification incorporating arrows to show repulsion could have produced a clearer result, but in the more complex diagrams presented here, this would not have

been feasible.

It is sometimes advocated (e.g. Shimwell, 1971c) that the distance apart of two species in an association diagram should be proportional to the reciprocal of the relevant chi-squared value. As Shimwell's example is mathematically inaccurate anyway, perhaps no problem arose, but a moment's consideration of the need to incorporate chi-squared values of, say, 0.081 and 27.0 on the same diagram would show that this suggestion is nonsensical. These values, typical of the results reported here, would require distances of a ratio of $1 = 333.3$. Use of a logarithmic scale would solve this but this still ignores the fact that a multidimensional situation is being represented in two dimensions, with inevitable distortion. In the diagrams given here, species showing strong association are placed close together, but clarity of presentation has been regarded as more important than the imposition of any scale. In any case, it is not valid to use chi-squared with Yates' Correction as a coefficient of association (Williams and Lambert, 1959).

As the situation is a multidimensional one, it could make sense to produce three-dimensional models. However, this was tried by Looman (1963), who photographed the model from three angles and published diagrammatic representations of the results. The small size of his published diagrams may not have been helpful, but from the small amount of additional insight that seems to have been gained, it is unlikely that this would be worthwhile for more species-rich situations.

The general two-dimensional approach has been generally successful in vegetation studies, examples using chi-squared including Bates (1975), Dale (1966) and Welch (1960). Welch's work is notable for an exceptionally clear cluster at the $P = 0.001$ level, though application of the index of cohesion shows that its connectedness

is only .687. At the level of significance this is nonetheless remarkable, and shows very clearly the result of a data set containing two dissimilar vegetation types. It must be borne in mind that the method is an analysis of a data set, not the original vegetation, and must be interpreted accordingly.

A previous successful application of this method to arable weed data, in Poland, is that of Borowiec et al. (1972). Studies using other coefficients of association include work on lowland grasslands by De Vries (1952) and on alpine grasslands by Hegg (1965); the various coefficients that can be used are reviewed by Goodall (1973).

2.3.2 It has been assumed so far that the usual form of the chi-squared statistic, incorporating Yates' Correction, is an accurate measure of the probability of association. However, Yates (1934) points out that at the tails of a chi-squared distribution there is still a very slight tendency towards over-estimation of probability. This would only be effective at probabilities less than $P = .001$ so it is unlikely to have effected the results of the analysis. As the effect is to reduce the apparent level of significance, no spurious associations will have resulted.

Another effect of Yates' Correction requires further comment however. The correction, of course, is the subtraction of 0.5 from the value of each deviation from an expected value, and as such counteracts the tendency of the chi-squared distribution to give misleadingly high levels of significance when dealing with low figures. When, however, a chi-squared value is very close to zero, with the deviations less than 0.25, Yates' correction has the anomalous result of increasing the deviations, and hence chi-squared, and changing a positive association to a negative association and vica versa. As this can only occur where the significance is virtually zero, the effect is in no way relevant to the plexus diagrams. It does,

however, explain the negative values shown on graphs of positive association cited in the next section.

In view of the slight inaccuracy of chi-squared, even with Yates' correction, more accurate versions have been proposed for vegetational analysis. Gilbert and Wells (1966) provide such an improvement, but it is hardly likely that use of this would have provided any tangible benefit in relation to the far greater complexity of their procedure. However, Pielou (1969a, b) makes more fundamental criticisms. It is normally assumed that the marginal totals of a 2 x 2 contingency table are fixed, as shown by Yates (op. cit.). However, this assumption applies to the data-set only, and not to the vegetation from which the data have been drawn. If, for example, a set number of quadrats are taken from an area of vegetation, the frequency of a particular species will be constant in that data-set and so the marginal totals will indeed be fixed. However, if the vegetation is repeatedly re-sampled, the frequency of the species in question will not be constant from data-set to data-set and consequently the marginal totals of 2 x 2 contingency tables are themselves variables with respect to the original vegetation.

Pielou, accordingly, proposes a modified form of chi-squared to correct this inaccuracy. Nevertheless, the error is of little consequence in normal use and becomes important only when chi-squared values are summed, as in association analysis. It is more likely to under-estimate than to over-estimate significance levels.

However, the point Pielou raises here is of greater importance than a consideration of minor inaccuracies in the chi-squared value. Results from the analysis of a data-set are often unthinkingly applied to the original vegetation without any consideration of the structure of the data collected. In the results presented here, some arable weed species tend not to occur in the same quadrats. That is not

to say that they are totally mutually exclusive, some quadrats might contain both species, of a generally disassociated pair, but the tendency towards negative association may well be significant. However, if the sampling included not only arable land, but also associated pastures, the results would be very different, the previously negatively associated species would be part of a large cluster of highly, positively associated arable species. This effect has already been noted in the data of Welch (1960). The decision of whether or not to include pasture would, of course, have had to be made regardless of whether sampling was "random". The example quoted here may be an extreme one, but it may very well operate at more subtle levels. It follows that the analysis must be strictly concerned with the data-set, and only the subsequent interpretation applied, with caution, to the original vegetation. In the present context, Pielou's correction is thus irrelevant and possibly misleading.

Yet another version of chi-squared is given by Nagy (1963). 0.5 is added to the cells concerned with joint presence and joint absence and subtracted from the cells concerned with presence of one species. This would give spuriously high significance levels and, since results were indeed related to probability, is presumably erroneous.

2.3.3 So far, in discussing levels of significance, it has been assumed that it is enough to look up the value of chi-squared in statistical tables and accept what is written there. Unfortunately there is the standard snag what when a large series of tests are carried out, phrases such as "one chance in twenty" begin to lose their meaning. If, for example, 80 species are compared for the existence of associations, this involves 3160 comparisons. At the $P = .05$ level of significance, this logically means that even if the species

are all distributed at random, 158 species-pairs would be expected to show association. 79 of these would be expected to be positive, and 79 negative. At the $P = .01$ level, 32 significant associations might be expected, while at $P = .001$ the figure would be 3. This argument is put forward by Agnew (1961), except that he realises that when a species is rare in a data-set, it will not be able to show negative association with many species, and hence the expected number of significant negative associations will be less than might be expected.

This effect can be seen in the case of data from the Isles of Scilly. The data-set described in Section 7.6 comprises 91 species and hence 4095 different pairs of species. At $P = .05$, if all species are distributed at random, 205 significant associations would be expected. The actual results give 204 significant associations, of which 166 are positive (as compared with an expected figure of 102) and 38 negative (expected number again 102). Thus it is quite clear that there is much structure in the data, but a much lower number of negative results as predicted by Agnew. At $P = .01$, the results are similar. The total of significant associations is 78 (expected: 41) of which 69 are positive (expected: 20) and 9 are negative (expected: 20). At $P = .001$, the total of significant associations is 22 (expected: 4) of which all 22 are positive (expected: 2).

Data from the Hebrides (Section 7.2) however provides a marked contrast. 35 species are involved, giving 595 species-pairs. At $P = .05$, the total of significant associations is 20 (expected: 29) of which 14 are positive (expected: 15) and 6 negative (expected: 15). Even allowing for the rounding up effect on these "expected" figures, these results are surprising. On the assumption of a totally random distribution, the "expected" figures are the minimum that could be

predicted. At higher significance levels the actual figures from the Hebrides do exceed the expected figures, but it still seems likely that there could be a flaw in the reasoning here.

Williams and Lambert (1959) do point out one invalid assumption. If the species are not distributed at random, then it is likely that the significant associations are not independent. This being the reason for applying the analysis in the first place, it is thus impossible to predict the number of associations to be expected by chance.

However, the major unwarranted assumption is that each species occurs in precisely half the number of quadrats. When a species occurs in either less or in more quadrats, its ability to show significant association with other species is correspondingly reduced. Thus not only is a rare species less likely to show significant associations, as Agnew pointed out, but also a common species is less able to show significant associations, a fact which was realised by Goodall (1953) but which has been generally overlooked. To sum up, the apparently obvious statement that at $P = .05$, one in twenty results will be significant just by chance is not true, unless the species are not only distributed at random but also occur with a frequency of precisely 50%. With typical frequency distributions, the expected number will be less, but not readily predicted.

This state of affairs has been investigated by analysing sets of theoretical data. Fig. 7 shows the extent to which two species occurring 20 times in 40 quadrats, i.e. a frequency of 50 per cent are able to form positive and negative associations. Significant results are possible over an appreciable range of degrees of joint occurrence. By contrast, Fig. 8 shows the extent to which two species occurring only five times in the same data set could form associations. Negative association cannot reach significance level and it requires three joint occurrences to constitute a significant positive association.

Fig. 9 shows a very typical situation. In a set of 40 quadrats, a number of species would be expected to occur around ten times. As the figure clearly shows, no species occurring more than 20 times could be significantly positively associated with the first species at $P = .001$. A species occurring 25 or more times would not be able to reach the significance level at $P = .01$, while a species occurring more than 28 times out of 40 quadrats could not be significantly positively associated with the first species even at the $P = .05$ level, howsoever it was distributed. Fig. 9 also shows the extent to which rare species could show significant positive associations, but such species would, of course, usually be omitted from the analysis.

It follows that when a data-set is analysed, its potentiality to form associations should be investigated. This could no doubt be done by calculating the average deviation from 50 per cent frequency in the data. However, this measure would not relate linearly to the chi-squared values, as can be deduced from Figs. 9 and 10. A measure based directly on chi-squared values appears to offer advantages. The chi-squared value for a species compared with itself represents the highest chi-squared value it can form (Fig. 10). Accordingly, an Index of Potential Association (I.P.A.) is proposed.

$$\text{I.P.A.} = \frac{\text{Sum of maximum } X^2 \text{ for each species}}{\text{No. of species} \times \text{No. of quadrats}}$$

Where uncorrected chi-squared is used, the I.P.A. takes a value of unity when every species occurs with 50 per cent frequency and would be zero if all species were present in all quadrats (or absent from all quadrats, though this is of no more than theoretical interest). Use of Yates' Correction affects these figures; for a group of 20 quadrats it can be shown that the highest possible value of the I.P.A. equals 0.8100, whereas for 200 quadrats the I.P.A. could reach 0.9801. It is possible to eliminate the effects of Yates' Correction (see

Fig. 7 2×2 Contingency Tables with Yate's Correction
 Effect of species abundance on positive and negative correlations: a) 20 occurrences per species in 40 quadrats.

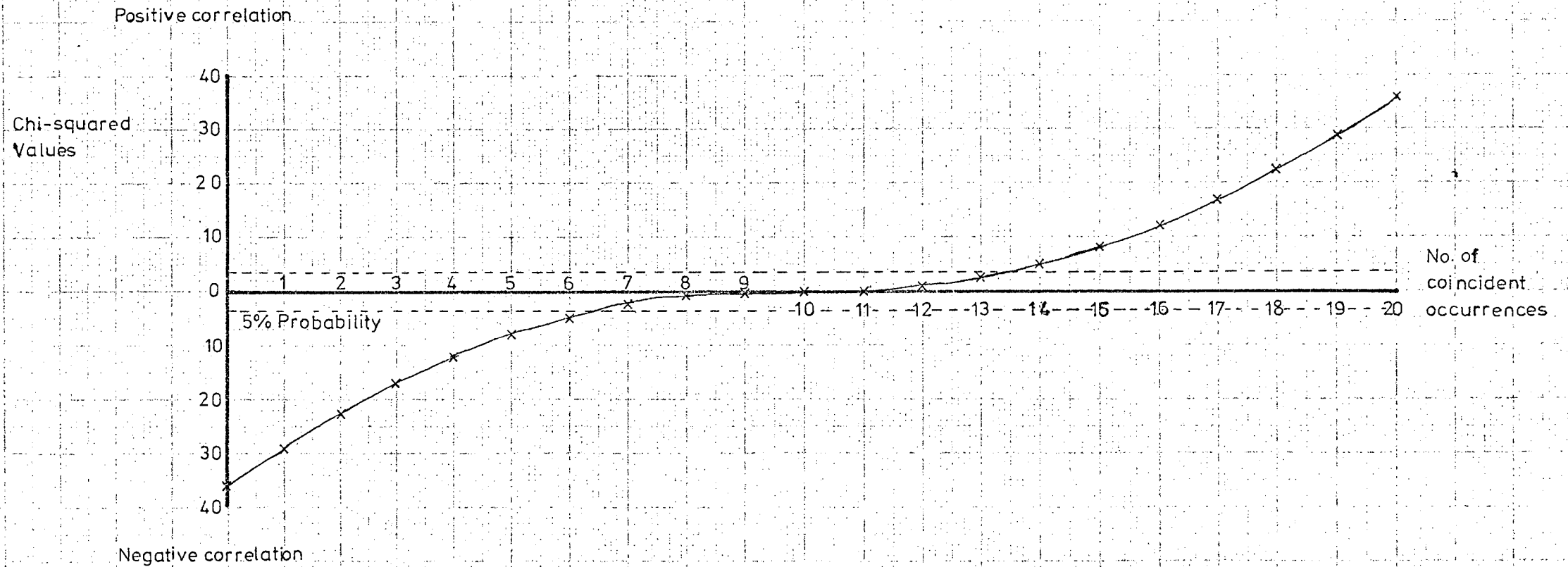


Fig. 8

2×2 Contingency Tables with Yates' Correction

Effect of species abundance on positive and negative correlations:
b) 5 occurrences per species in 40 quadrats.

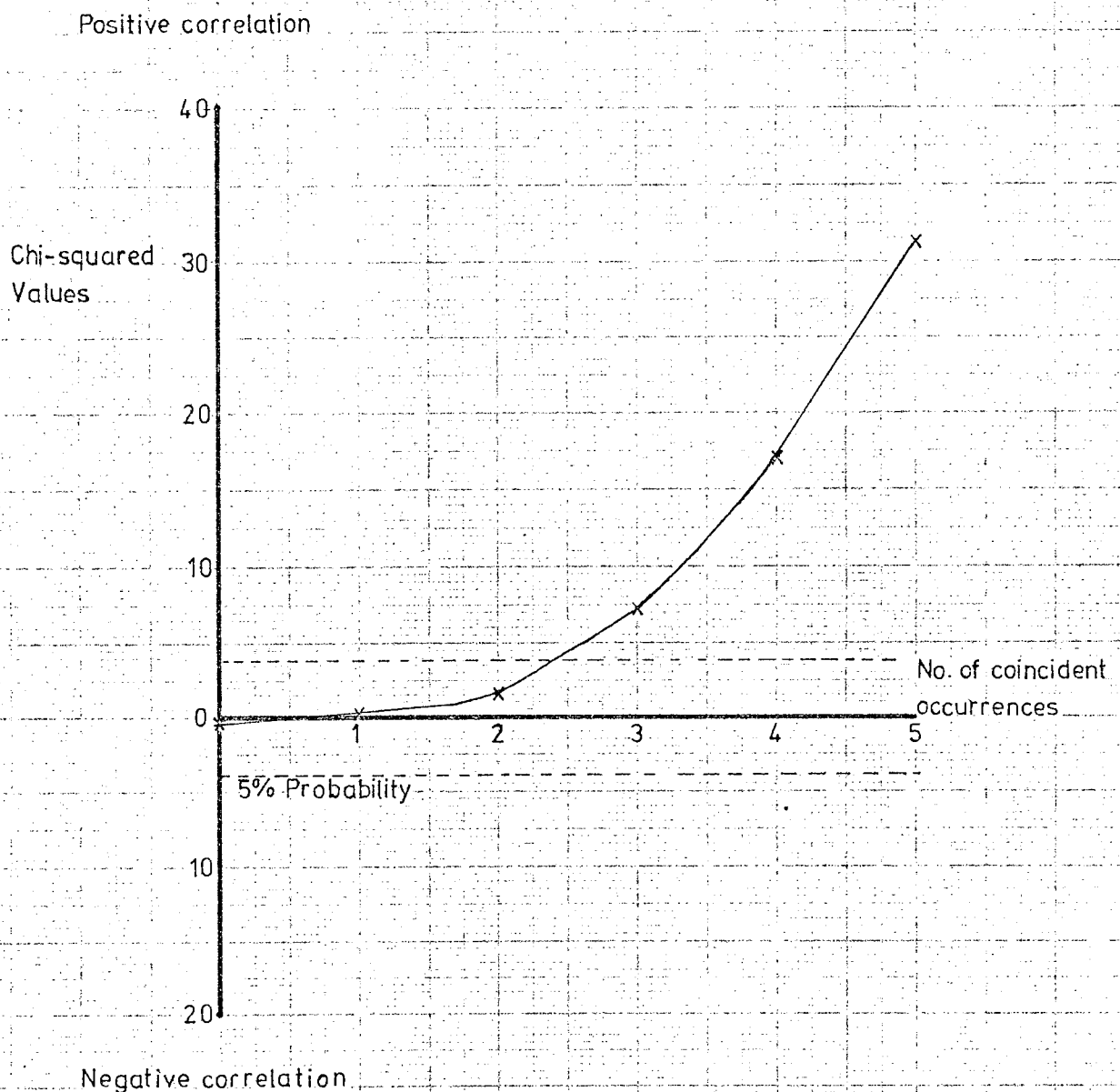


Fig. 9 2x2 Contingency Tables with Yates' Correction

Effect of frequency in a species showing complete positive association with a species occurring 10 times in 40 quadrats.

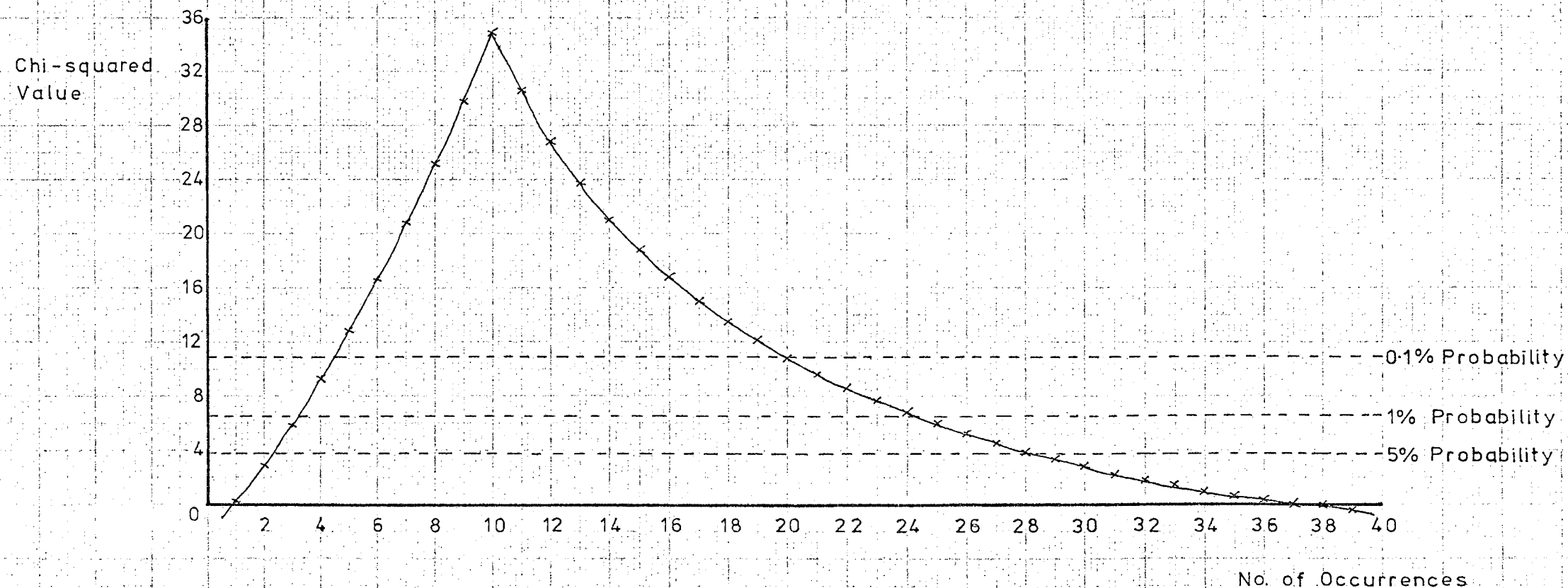
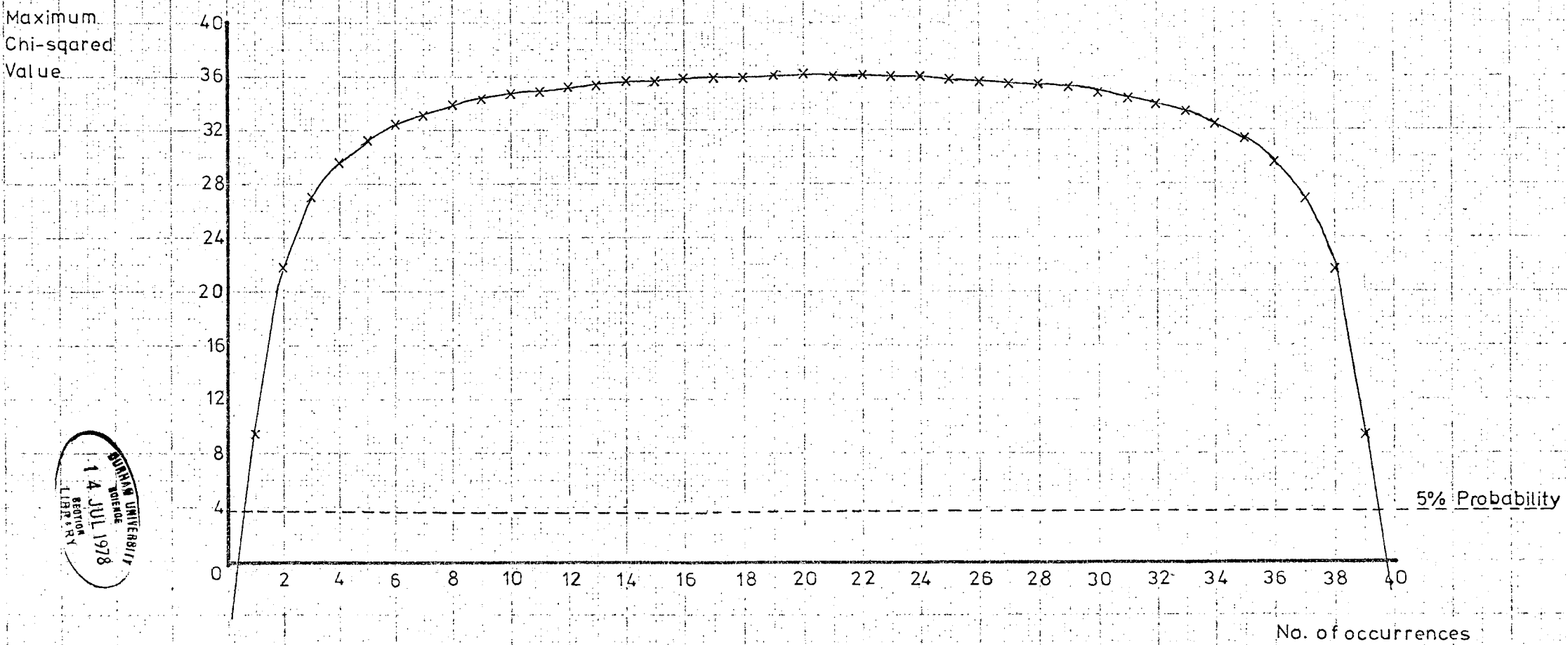


Fig. 10 2x2 Contingency Tables with Yates' Correction
Effect of no. of occurrences/species on maximum possible Chi-squared Values (for 40 Quadrats).



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Section 7.1) but since Yates' Correction is a very important factor in determining the amount of potential association, it is recommended that the I.P.A. normally be expressed in uncorrected form.

This decidedly unsophisticated (but understandable!) measure can only acquire an empirical meaning. Accordingly it is quoted for each data-set analysed, but more experience of other sets of data is needed before the significance (in the non-statistical sense) of values of the I.P.A. can be assessed.

2.3.4 An important influence not yet considered is quadrat size. The fact that quadrat size is of crucial relevance to the interpretation of the results has been realised by most workers (e.g. Greig-Smith, 1957; Kershaw, 1961). Byer (1970) investigated this by the use of nested quadrats. By using a series of successively smaller quadrats positioned at the centres of larger quadrats, he analysed data from the same random points. As quadrat size was reduced, the values of most of the product-moment correlation coefficients, based on quantitative data, became less positive or more negative. In most cases these changes were relatively small. If the quadrat size is reduced to the size of the individual plant, competitive exclusion becomes complete and, naturally, only negative associations would be obtained.

Byer's analysis accords well with arable weed data, where the scale of pattern is assumed to be relatively fine. Greig-Smith (op. cit.) and Pielou (1969a) describe the effects of coarser patterns and under these circumstances the changes to be expected with changes in quadrat size are more complex. In the arable vegetation analysed here, the quadrat size of 4m^2 is substantially larger than the largest observed clump size. It is likely, however, that this sampling size will have missed fine details of structure in the vegetation, e.g. Sagina procumbens associated with bryophytes in damp hollows.

Nevertheless, since some fields contain damp hollows and others do not, the association between these species is still observable in the data. Thus while the contention of Yarranton (1966) that the only truly valid samples would be point samples is undoubtedly correct, the use of the sampling size that has been accepted for the main phytosociological exercise (see Section 3.2) appears to be equally acceptable here.

The analysis, of course, gives no information as to the reasons for observed associations. Direct species interactions such as parasitism, allelopathy and epiphytism must be borne in mind, as well as the results of common microhabitat requirements.

Chapter Three

Methodology II (Practical aspects)

3.1 Sampling Procedures

The selected methods of analysis have already been described. It remains to describe the field sampling system that was chosen to provide data suitable for this analysis.

The Zürich-Montpellier system does not require that sites are selected at random, which is fortunate since a truly random selection of arable sites would have been impossible. In this primary survey, as wide a coverage of the country as possible was attempted, as described in Chapter 1. Within each area, fields were selected in advance if they were known sites for rarities. This selection of rarity-sites is at first sight contrary to normal phytosociological procedures. However, it is these rarities which are often of most use in relating British communities to those of the continent and being rarities they hardly biased the overall picture. Ecologically unusual communities are better represented in the total aufnahmen than would have been the case with a totally random survey, but this was largely the point of such selection. Most of the rarer arable weeds can no longer be found by chance; of the real rarities included here, only one site for Adonis annua was found in a new modern locality.

Where no sites had been chosen in advance, the main criterion on which sites were chosen was ease of parking. What result this has had on the results is difficult to predict; it is an undeniable fact that areas with narrow country lanes were sampled less readily than those where broad road-verges were common.

Location of the actual quadrats was also a matter of deliberate decision. Treatment of areas near field gateways took one of two

forms. Normally the field edge was followed away from the gateway until species such as Matricaria matricarioides and Plantago major, characteristic of trampling, no longer occurred, and only the "typical" weed flora of the field remained (though in some cases this would contain these species). An aufnahme would then be taken, usually at a point where the weed flora was well developed to avoid gaining only fragmentary descriptions of the community. It must be noted that the "typical weed flora" was not a preconceived idea, each field was regarded in isolation and so far as possible the site of the quadrat reflected this flora. A site a short way ahead, i.e. with the weed species still hidden by the crop, would be arbitrarily selected, but if it proved to be ^{ab}normal, either heterogeneous or with only seedlings present, it would be rejected.

Alternatively, or additionally, an aufnahme would be taken close to the gateway to obtain a representative description of the gateway-influenced community, which analysis might later show to be a distinct syntaxon. If suitable, the track entering the field, outside the ploughed area, might be similarly treated.

A typical aufnahme is shown in Fig. 6. 4m^2 was adopted as the normal sampling size, for reasons discussed in Section 3.2. Any species close to the quadrat and apparently in the same stand of homogeneous vegetation would also be included, with the symbol "(+)". For obvious practical reasons, quadrats were usually located at the edge of the field when sampling standing crops. This, in any case, is necessary since the weed flora is usually fully developed only at the edge of the field. There are several reasons for this, reduced levels of herbicide treatment and increased light availability being major factors. In most cornfields, only a few grasses survive more than very few metres from the field edge. This matter is discussed more fully in Section 4.1. Restriction of quadrats to the field

edge meant that it was often more convenient to use a rectangular area of 4 x 1 m. Such rectangular quadrats, though not often used, were recommended for many purposes by Clapham (1932).

The danger of field-edge quadrats is that one runs the risk of heterogeneity due to the proximity of the field boundary. In general, the edge of the standing crop rather than the edge of the ploughed area was taken as the field boundary. Obvious outgrowths from the surrounding community, often stoloniferous or liana-type species such as Agrostis stolonifera, Galium aparine, Convolvulus arvensis, Calystegia spp. were avoided. The same species were, of course, sampled in the normal manner if genuinely rooted and established in the arable field itself. Young plants of perennial species are also common along field edges. Although dependent upon fresh introduction of seed from the bounding community each year, these perennials were included without special treatment.

It should be noted that a few species are probably restricted to the actual boundary of the arable field and the surrounding community, including Ajuga chamaepitys and Filago pyramidata. These were sampled with the necessary comments.

Higher plants and the larger bryophytes were identified on the spot. Small bryophytes were provisionally identified, and so given cover-abundance and sociability scores, but collected for microscopic confirmation. Such microscopic examination is necessary not only to check field identifications, but also enables very sparse and inconspicuous species such as Ditrichum spp., Pleuridium spp. to be recognised in the gatherings. Higher fungi were also recorded when present, though this involved special problems. Arable agarics are not well known; species include typical grassland spp. such as Coprinus plicatilis, plus presumably specialised arable species on decaying straw. This latter group of unfamiliar species are largely

unrepresented in the data since it was rarely possible to get them to a laboratory in good condition, and even then they defied identification. One Agaricus species was certainly distinct from all known British species of the genus and it seems likely that arable fields hold a number of additions to the British agaric flora. Generally, fungi are too rare in arable fields to be of syntaxonomic value, though there is no doubt that they are of considerable potential in other vegetation types (e.g. Hofler, 1937; Pirk, 1953).

Although the field recording form has a space for fertiliser and herbicide treatments, this information was not often collected. The action of any particular herbicide is dependent on many factors, primarily time of application, dosage, soil composition and the weather. In a survey such as this, it is clear that, even if every field had been treated with the same herbicide, significant information on its effects on species composition in the different crops and weed communities would have been difficult to obtain. But the survey includes the results of the application of many different herbicides, individually or in combination. Consequently, while herbicide treatment has been noted where known, no particular effort has been made to obtain this information.

When soils were collected, the top inch of the soil was first scraped aside, in case a residual surface layer of concentrated fertiliser was present. Soil was then collected from the top few inches below this. This is the rooting zone for the majority of annual arable weeds, though not, of course, for most crops. Soils were stored in polythene bags and dried at the first opportunity. In view of the pH changes which rapidly occur in stored damp soils, no attempts at pH measurement were made. Methods of subsequent analysis for exchangeable calcium and potassium are given in Appendix II.

3.2 Minimal Area?

As previously noted, quadrat size has a very substantial influence on the observed association between species and, on the assumption that a uniform size is desirable (though not essential for Z-M analysis), the size of the sampling unit must be chosen with some care. This involves the often quoted concept of "minimal area", the smallest quadrat size which effectively and efficiently samples a community. However, opinions have differed as to how this should be defined; the meanings encompassed by "minimal area" are reviewed by Goodall (1962), Hopkins (1957) and Westhoff and van der Maarel (1973).

Early interest in the relation between species-number and area, often zoological, was not concerned with communities but with the expectation of numbers of species from different regions of different size, and the effects of this on frequency distributions (c.f. Jaccard, 1912; Dony, 1963; Williams, 1964). However, Arrhenius (1921) analysed a number of stands of different vegetation types, counting the numbers of species present with successive increases of sampling area. He derived a simple formula, incorporating a constant characteristic of each type of vegetation. He made the mistake of confining his observations to very small areas and extension of his formula to substantial areas suggested impossibly high species totals (Gleason, 1922). Nevertheless, Arrhenius had made the important observation that the precise species-area relationship was a characteristic of the community.

"Community" here can be taken in both the concrete and abstract senses, for, as Westhoff and van der Maarel (op. cit.) point out, it is possible to distinguish between the "analytical minimal area", for the phytocoenose, from the "synthetic minimal area" for the phytocoenon. Although minimal areas are usually considered in relation to phytocoena, they are usually determined analytically from single

stands.

A number of different definitions are to be found in the literature. Westhoff (1951) defined the "minimal space" as the "minimal surface which as a rule has to be occupied by a sample of a plant community, if the normal specific assemblage will be able to develop". Cain and de O. Castro (1959) rather similarly stated that, "Minimal area is the smallest area that provides sufficient space or combination of habitat conditions for a particular stand of a community type to develop its essential combination of species or its characteristic composition and structure.". These two definitions are typical of the phytosociologically based definitions, requiring a knowledge of the species to be expected and embodying the idea of the syntaxon being properly developed. Archibald (1949) took an unusual view for defining the analytical sampling unit of a stand, suggesting that the "50% area" be used, i.e. the area which, on average, would contain half of the number of species in the community. This, of course, would require a knowledge of the total species number in the stand. Goodall (1961) adopted a different approach by defining an analytical minimal area as, "The smallest sample area for which, in all species, the variations between replicate samples is independent of the distance between them.".

The Scandinavian approach to minimal area was that of a progressive increase in quadrat size until a substantial number of species would be "constant", occurring with more than 90 per cent frequency (c.f. Du Rietz, 1930). Pearsall (1924) points out the invalidity of attempting to determine a minimal area in this way.

Practitioners of the Zürich-Montpellier school (e.g. Braun-Blanquet, 1932; Tüxen, 1970c) have relied on the shape of the species-area curve. A typical curve shows a rapid rise in species number with area, but as the sampling area becomes larger, the curve tends to

flatten off. There is normally a readily observable point of inflection and the area corresponding to this point is the minimal area. If, after the curve has flattened, it begins to rise again, this is a sign that the sampling has extended into another community. Stands less than this minimal area in extent are fragmentary and should not be incorporated in phytosociological data.

Unfortunately, as Cain (1938) pointed out, the location of the point of inflection depends on the scales of the axes used in plotting the curve. Cain suggested that the use of a fixed percentage increase in species number per fixed increase in area could accurately define a minimal area. His suggestion that this should be equal to the maximum number of species found divided by the total area sampled was, however, criticised by Ashby (1948), who pointed out that this assumes a knowledge of the shape of the extrapolated species-area curve, and that there is no justification for such an assumption.

Particularly disturbing evidence is shown by Cain and de O. Castro (op. cit.) who provide a set of three curves from a geometric series of nested quadrats, the subplots ranging from 0.0025 sq.m. to 2048 sq.m. This data (from the work of Evans and Cain) is unusual in that it covers a far greater range of area than most such surveys. In their first curve, covering the samples up to 0.32 sq.m., a "minimal area", defined by the point of inflection, is apparent at around 0.16 sq.m. In the second curve, to a smaller scale and covering the samples up to 32 sq.m., a "minimal area" is again apparent, but at 16 sq.m. Finally, the third curve, which contains all the data, gives yet another "minimal area", at 128 sq.m. This alarming discrepancy cannot even be explained by the use of different x-axis : y-axis ratios; all three curves are plotted to the same ratio, differing only in scale. Even at the largest sampling size, the upper asymptote has still not been reached; all the indications are that the curve

is parabolic. It is clear that these differing "minimal areas" are nothing more than artefacts and are totally meaningless. It follows, therefore, that unless a curve clearly flattens off, it is of no value in determining a minimal area.

It is clear then, that whether species-area curves really flatten off or not is of fundamental importance. Published curves take three main forms, which are fully reviewed by Frey (1928).

Firstly there is the "Arrhenius-type" based on the proposition of Arrhenius (1921, 1923) that there is a linear relationship between the log. species number and the log. area. Preston (1962) also presents data of this form.

Secondly there is the "Gleason" or "Romell-type" presenting a linear relationship between the species number and the log. area. Gleason (1922) presents a plot on this basis approximately to a straight line and Williams (1944, 1964) also presents similar data. Hopkins (1955) plotted data which he claimed to show this relationship but, as Preston (op. cit.) points out, his curves tend to be somewhat concave with a steadily increasing slope, and log. - log. plots might be more appropriate.

The third form of curve is the "Kylin-type" reaching "saturation" and hence taking a sigmoid shape with an upper asymptote. It follows that even logarithmic plots must show a flattening off. Vestal (1949), Archibald (1949) and Tüxen (1970c) present curves apparently of this type. However, the reality of these curves is questionable and will be discussed below. Vestal uses his curves to distinguish three grades of sampling site, the "smallest representative area", the "minimum area" and the "fair sized stand".

Analysis of four weed stands

At the outset of this phytosociological survey, it was quickly found that 4 m^2 was a convenient sampling size. However, despite

the theoretical objections, it was decided that weed vegetation should be investigated by species-area curves, in the hope of establishing the best quadrat size. Accordingly, four stands of weed vegetation were analysed by nested quadrats of increasing size:-

- i) Bonallack Barton, Cornwall; grid ref. SW 790263; 19th May, 1971. Unplanted part of bulbfield on sandy clay-loam. Referable to the Stachys - arvensis Comm. but species-rich due to fallow conditions.
- ii) Basingstoke, Hampshire; grid ref. SU 633526; 6th July, 1971. Wasteground left after roadworks, soil a chalky-clay subsoil. An unclassifiable Stellarietea species-assemblage.
- iii) Portway Heave, Eriswell, Suffolk; grid ref. TL 741771; 9th September, 1971. Edge of beetfield in the Brecklands, soil a chalky sand, crop very poor and sparse due to grazing by rabbits. Referable to the Papaveretum argemonae but species-rich.
- iv) Machair Robach, North Uist; grid ref. NF 865756; 18th September, 1971. Interior of stubble ryefield on typical Hebridean machair, soil a loamy sand. Referable to the Chenopodio - Violetum curtisii, but regarded as heterogeneous in floristic terms and transitional to the Galio - Koelerion.

The raw data from these areas are given in Tables 4 to 7. The species-area curves are shown in Figures 11 to 14, the species-log. area relationships in Figures 15 to 18 and the log. species - log. area relationships in Fig. 19.

The species-area curves all follow a similar shape, showing the expected rapid rise before beginning to flatten off. While few extra species were added in the largest areas sampled, none of the curves becomes horizontal.

When the species number is compared with the area plotted on a log. scale, the results are less clear. The data from Bonallack Barton and Machair Robach come close to a linear relation, but, just

Table 4 Minimal Area 1 : Bonallack Barton, Cornwall

[illegible]

Table 5 Minimal Area 2 : Basingstoke, Hants

[illegible]

Table 6 Minimal Area 3 : Eriswell, Suffolk

[illegible]

Table 7 Minimal Area 4 : Machair Robach, North Uist

[illegible]

Fig. 11

Minimal Area 1: Species - area curve

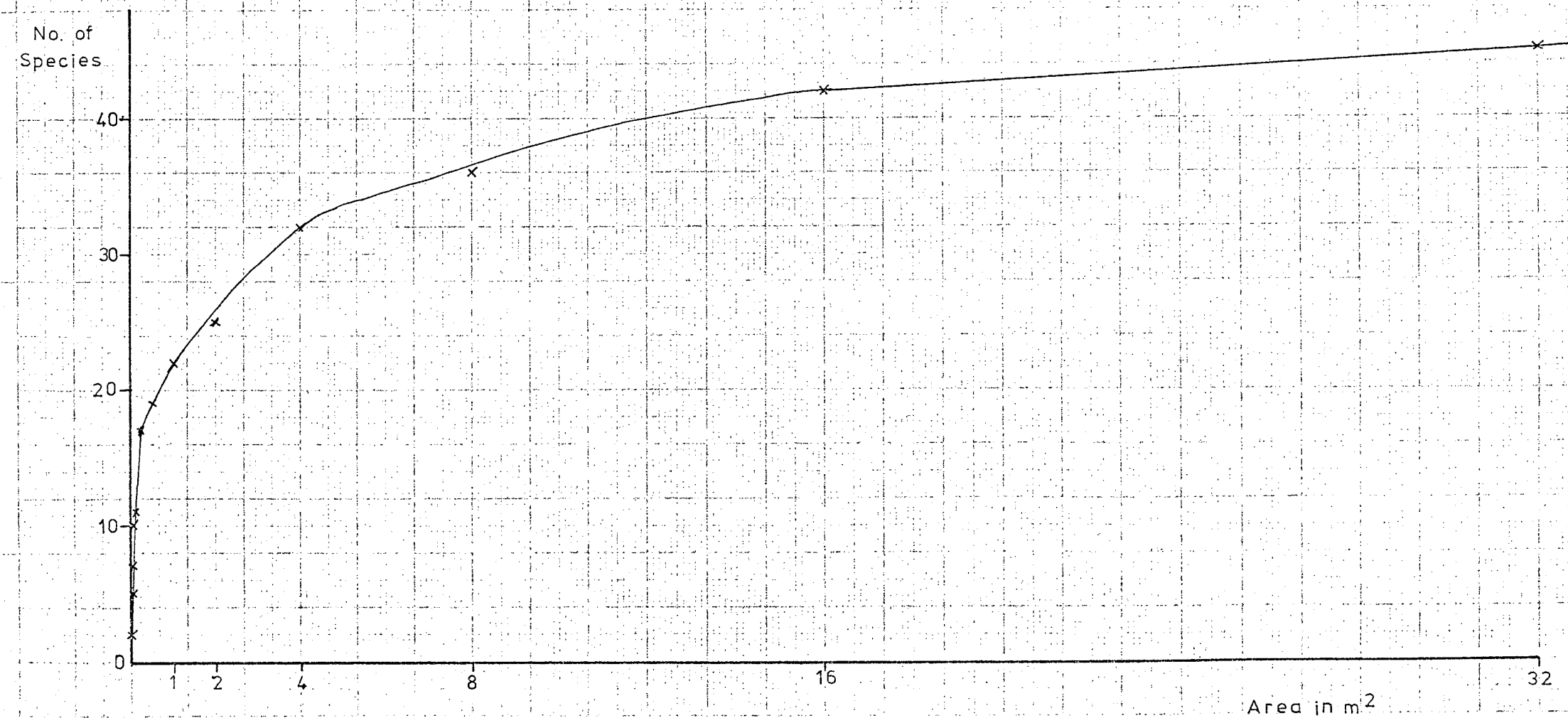


Fig.12

Minimal Area 2: Species - area curve

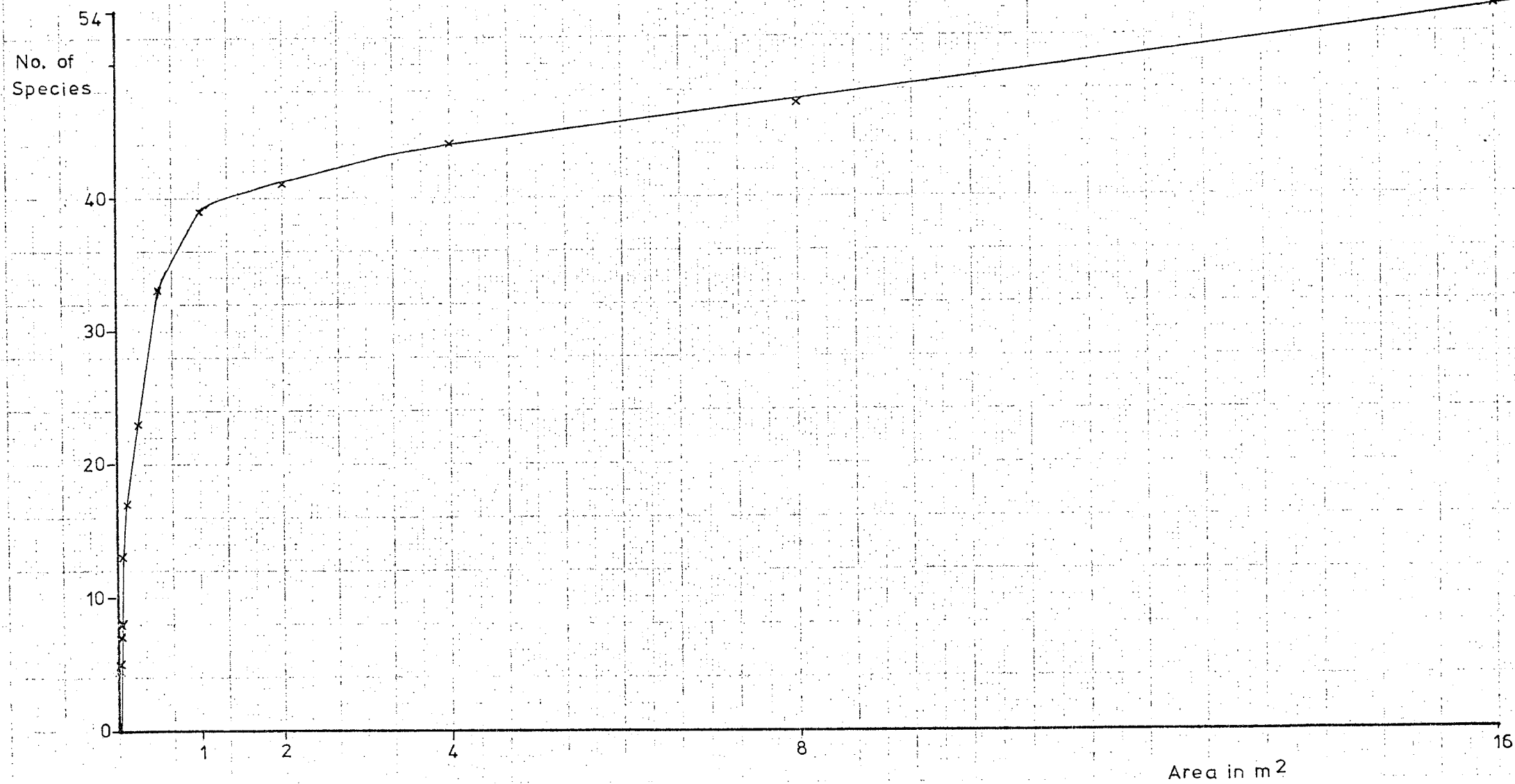
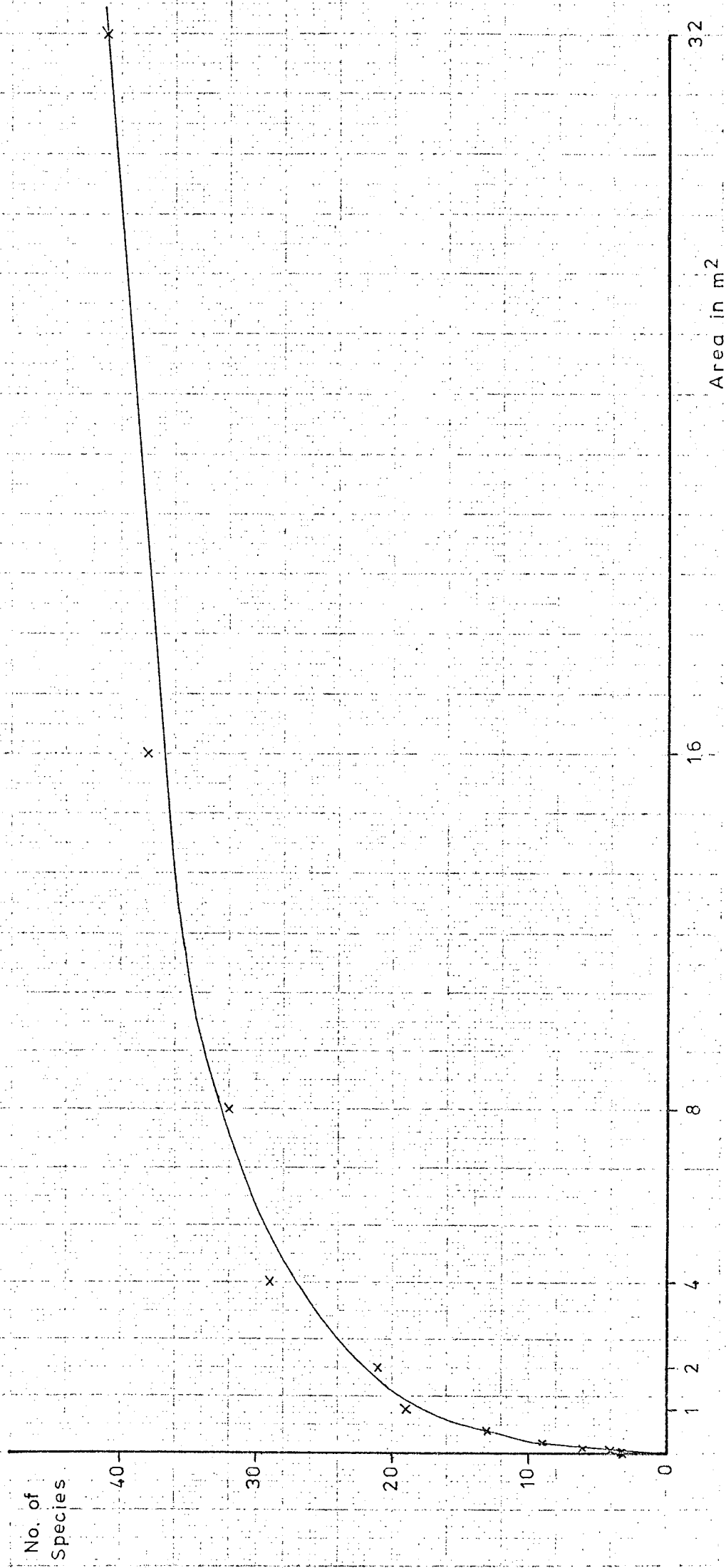


Fig.13

Minimal Area 3: Species-area curve



Minimal Area 4: Species-area curve

Fig.14

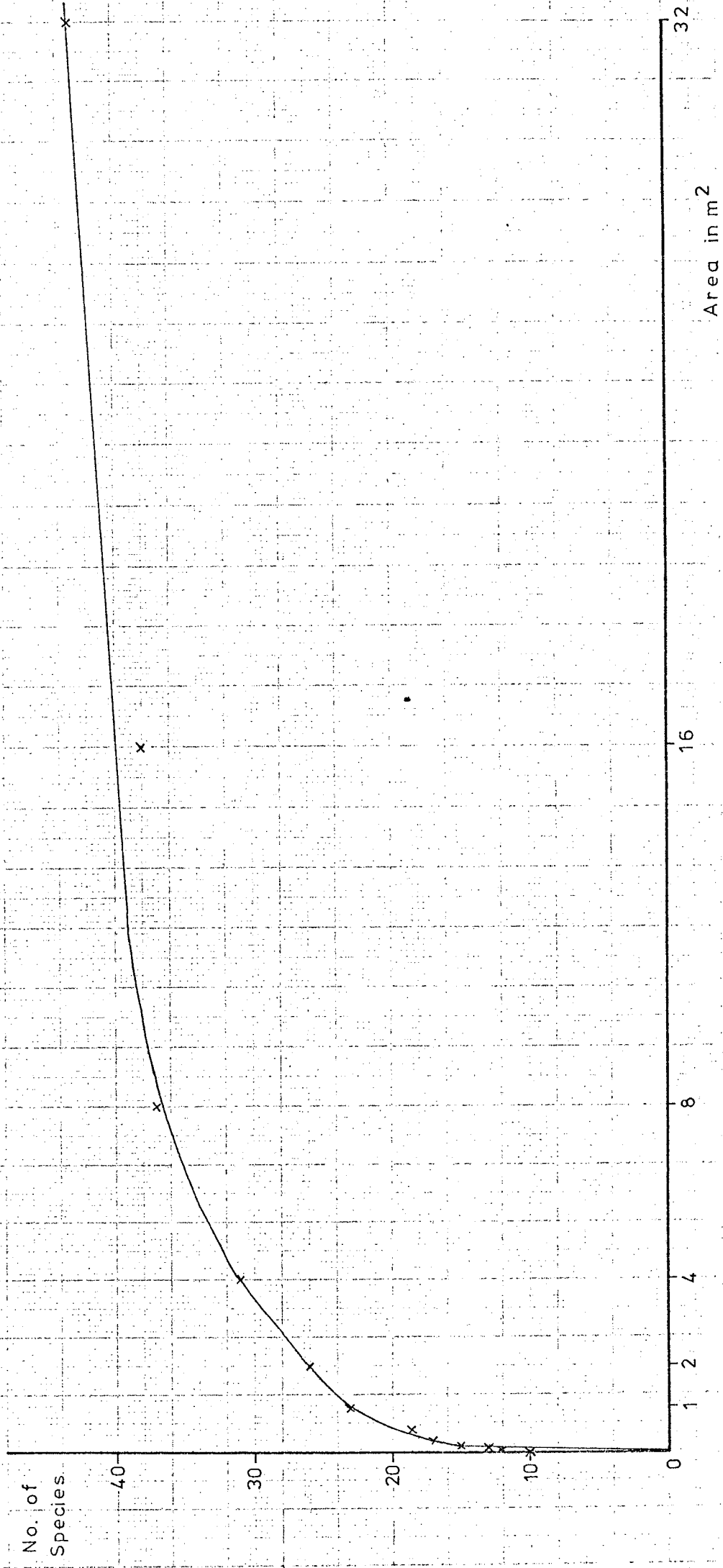


Fig. 15 Minimal Area 1: Species - log-area relation

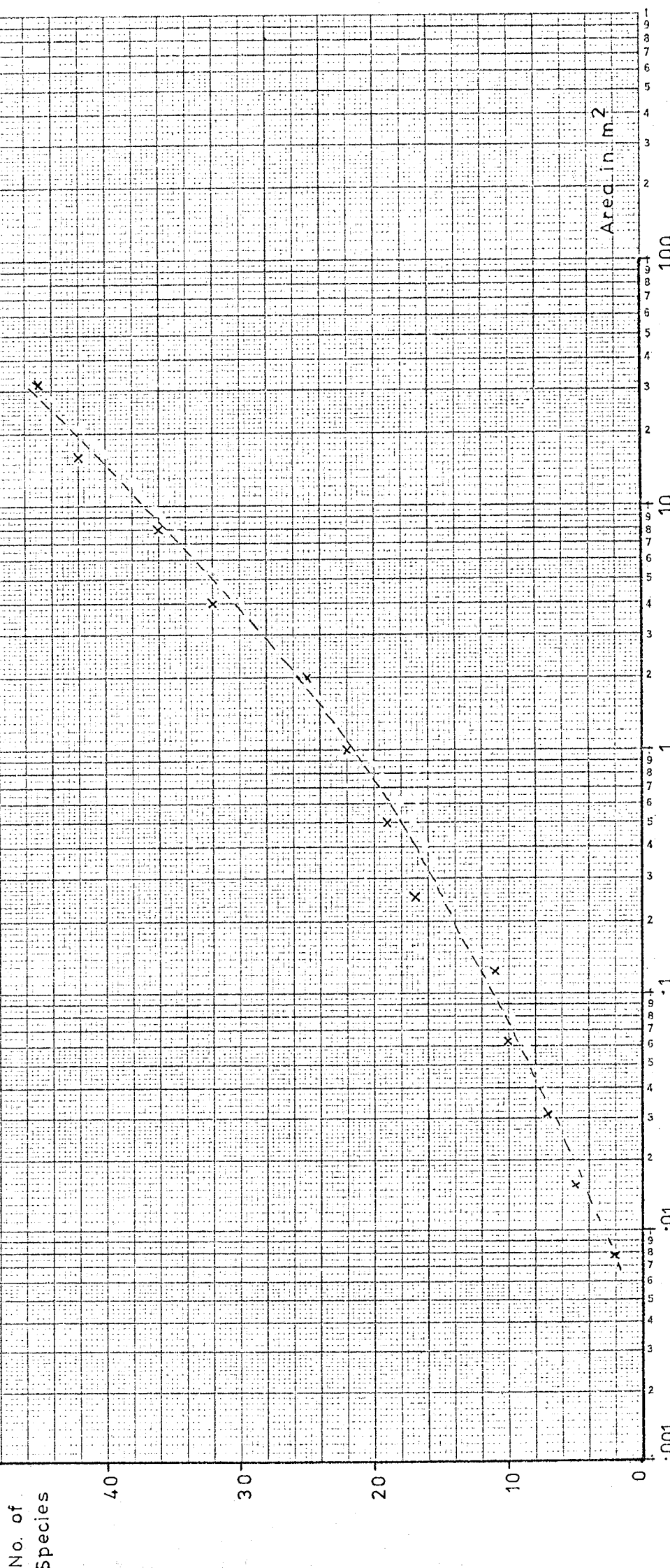


Fig.16 Minimal Area 2: Species - log-area relation

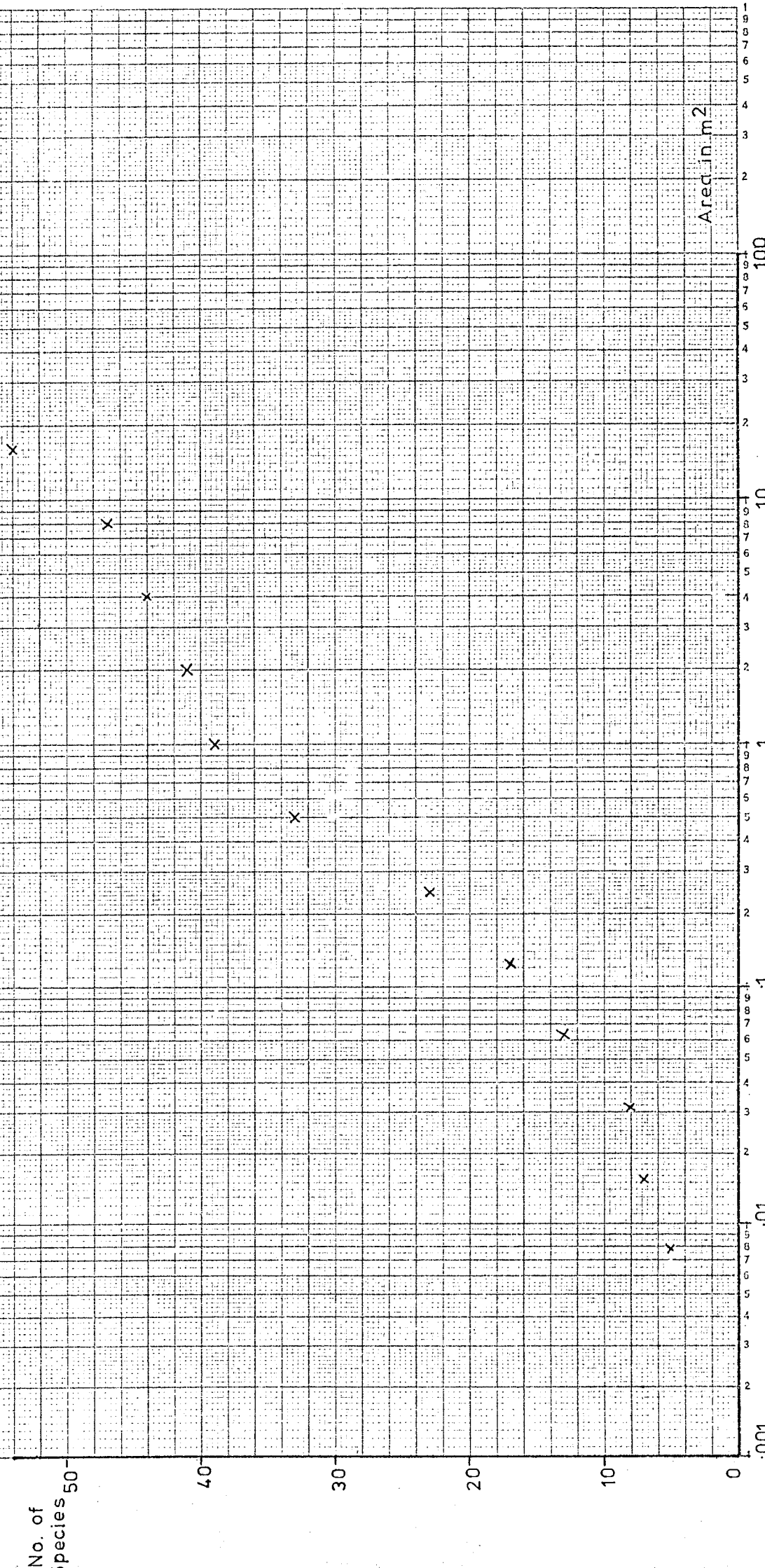


Fig. 17 Minimal Area 3: Species - log-area relation

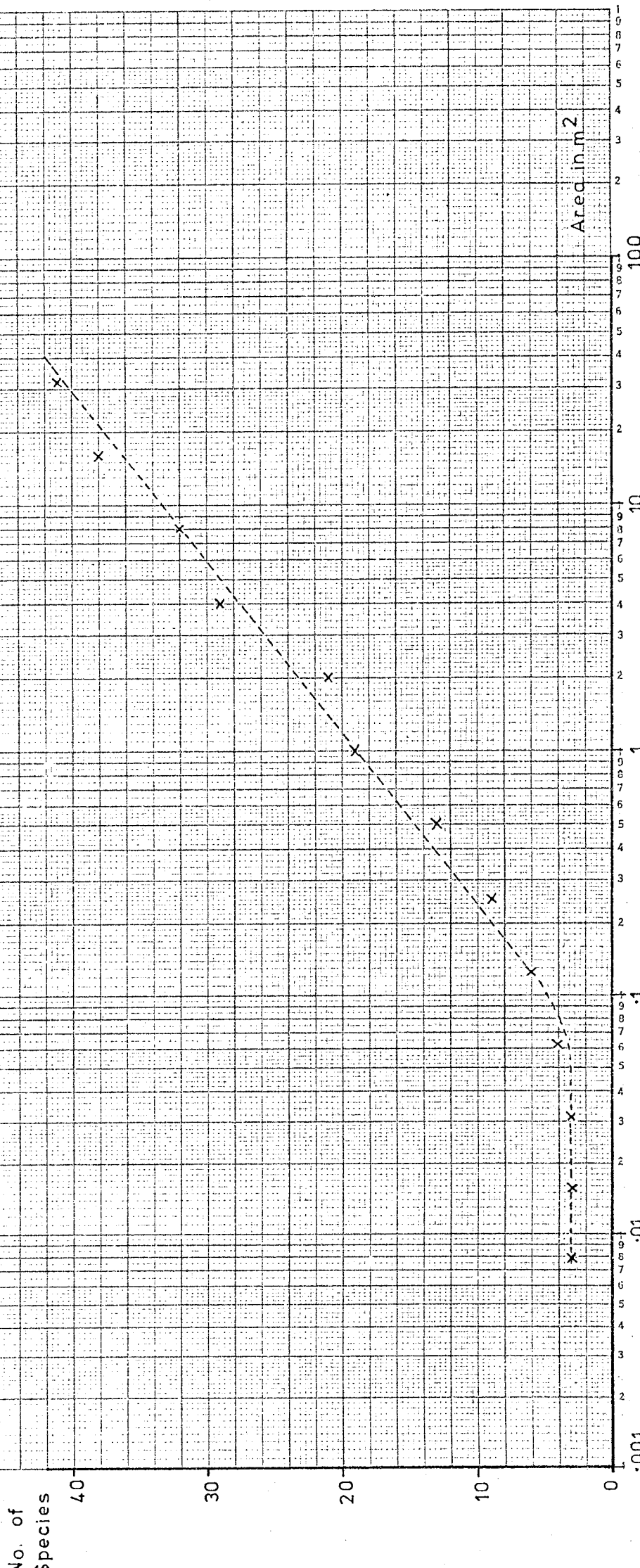


Fig.18 Minimal Area 4: Species - log-area relation

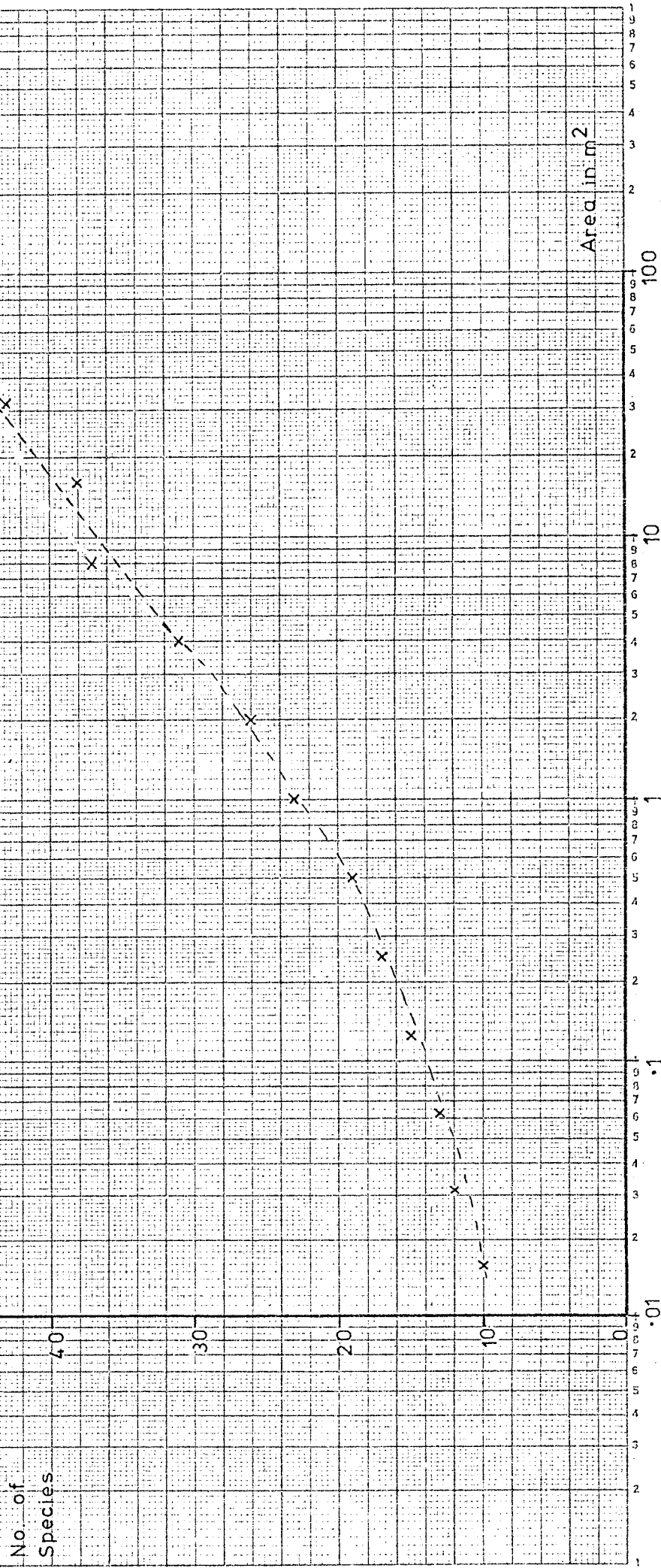
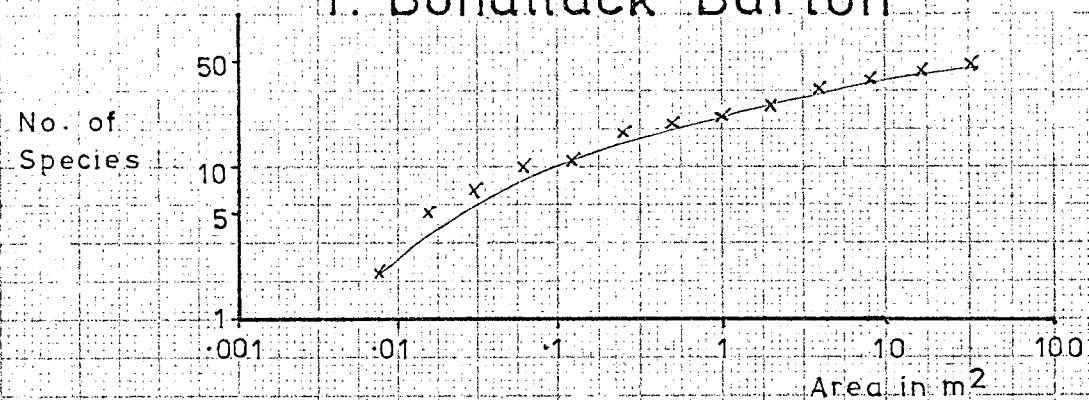
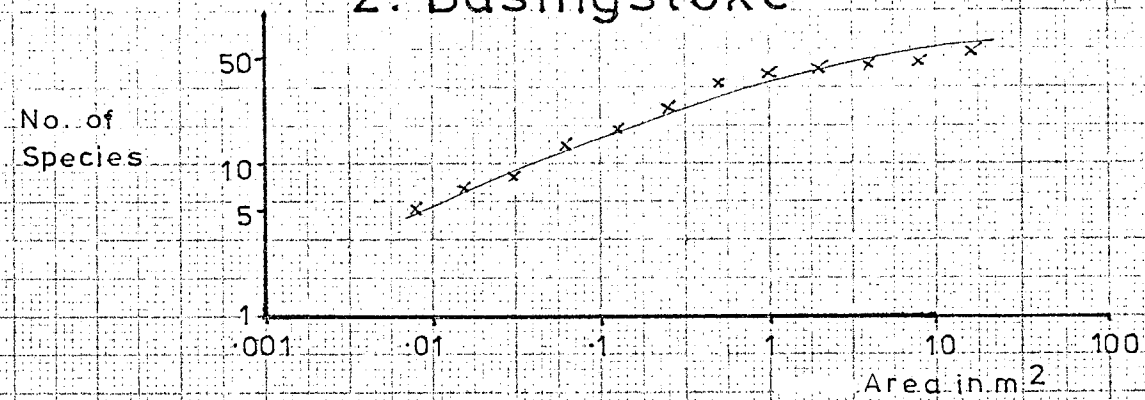


Fig. 19 Minimal Areas 1-4: Log-species - log-area relationships

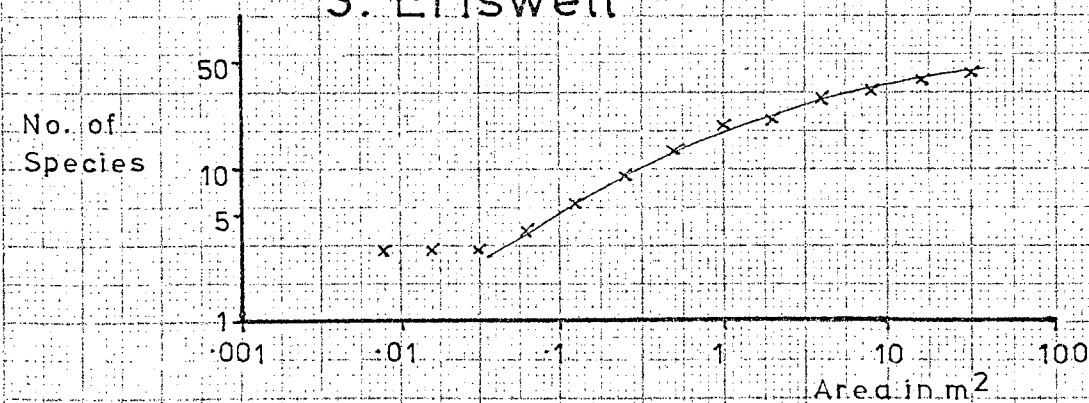
1: Bonallack Barton



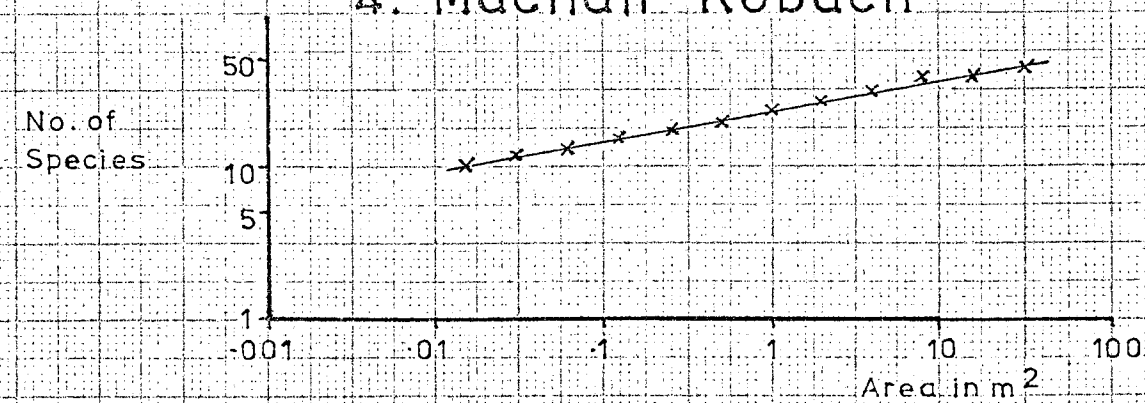
2: Basingstoke



3: Eriswell



4: Machair Robach



as Preston observed in Hopkins' curves, the relation is somewhat concave. The graph of the Basingstoke site is similar, but more irregular, suggesting site heterogeneity. Nevertheless, the plotted points suggest concavity. By contrast, the Eriswell site is strongly suggestive of a linear relationship. At very small areas this relationship breaks down, but this is typical of most published results and in this case can be readily explained as the result of having only a single count for each quadrat size.

Comparison of the four sites in Fig. 19 shows that the Bonallack Barton, Basingstoke and Eriswell sites all approximate to straight lines when both species and area are plotted on a logarithmic basis. However, these straight lines are not perfect; in all three cases there is a slight convexity and a suggestion that the curves might flatten off at larger quadrat sizes. Nevertheless, there is no evidence that a maximum species number is being reached. The Machair Robach site does not show this convexity and shows good agreement with the Arrhenius logarithmic relation.

Data from these four sites thus provide no useful guidance towards the determination of a minimal area. Data from further increases in area could have been highly informative, but on the evidence available, both the Arrhenius logarithmic relation and the Gleason/Romell log. - linear relation could apply to weed vegetation and investigation of more sites seems desirable before any firm conclusions could be drawn. There is no evidence here for the Kylin saturation relationship, but maybe areas of sufficient size were not included.

The question remains as to whether an upper asymptote is ever reached. It could be objected that any vegetation type has a maximum number of species which can occur in it, and given a sufficient area of uniform vegetation, this limit must be reached. However, all types

of vegetation contain species of low frequency. Such rare species probably compete with each other only infrequently and given a uniform community of immense area it is possible to visualise the evolution of many such species, perhaps exploiting the same niche in different regions. There is, then, no reason to assume that a species - area curve must become horizontal, as has often been suggested (e.g. Arrhenius, 1923; Gleason, 1922; Kilburn, 1966). On the other hand it is certainly plausible (cf. Preston, 1962).

Re-examination of published curves is inconclusive. Vestal's (1949) curves are sigmoid, but not conspicuously so. Tuxen (1970c) does provide curves reaching an upper limit, for very uniform, species-poor communities, but many of his fitted horizontal lines do not seem justified from the amount of data presented. His curve, for a weed association, the Veronico - Lamietum does not reach a horizontal region. Archibald's (1949) curves appear at first sight to be excellent examples, but these are based not only on her counts from different areas but also in the total number of species occurring at the sites. As Hopkins (1955) points out, this extrapolation from her largest quadrat size to the size of the stand is unjustifiable, for it would be very difficult to find all the species present by a general inspection of an entire stand, and only a very few extra species would negate her assumed sigmoid portions of her curves. Only one of her sites, a Limonium-dominated saltmarsh, suggests a sigmoid species - area relation from her own data, and Hopkins (op. cit.) failed to obtain similar results at the same site.

So there seems to be little justification in trying to determine a minimal area from the arable sites examined. Indeed they may very well be parabolic curves of the type described by Cain and de O. Castro (op. cit.). Bond, reported by Williams (1964), found no evidence of a minimal area from the analysis of larger areas of a Ceylonese

weed community. By ignoring species of less than 20 per cent frequency (determined by 6 x 6 inch quadrats), Singh and Das (1939) did establish an upper asymptote for an Indian arable community, but this was at the surprisingly small area of 800 - 3200 sq.cm. As concluded by Hopkins (1957), it is unlikely that minimal areas can be established for a community, Goodall's (1961) method establishing independence of inter-sample variance and inter-sample distance seems most promising. Mueller-Dombois and Ellenberg (1974) quote a "minimal area" of 25 - 100 m² for agricultural weed communities, but it is often difficult to find homogeneous areas of this size in arable fields. By recording species outside the sampling size of 4m² used here, an area equivalent to 25m² or more was often cursorily examined. The very few extra species, and not merely conspicuous species, added to most aufnahmen suggests that the sampling size used was well chosen.

Chapter Four

Factors affecting arable weed communities

This chapter reviews some of the factors which must be taken into account in the interpretation of arable weed community data.

4.1 Field boundaries and the edge situation

4.1.1 The edge of an arable field is a complex situation. Within the length of a metre there may be natural grassland forming a bank bounding the field, the vertical edge of this bank, often colonised by bryophytes, a strip of ploughed but unplanted ground, and then the crop itself. Even the vegetation in the crop is often far from uniform, the first 1 - 4m are often characterised by vigorous weed growth, but then the weeds become sparse or composed of few species only.

Some species appear to be characteristic of this boundary situation. Ajuga chamaepitys is often quoted as a rare weed of chalky cornfields, but only rarely does it occur within the crop, and then perhaps only when rabbits have reduced the competitiveness of the corn. Its typical habitat appears to be the bare, crumbling chalk bank between the permanent grass and the arable field itself, often at the top of a steep slope below a wood. Other species are less exacting in their requirements, and consequently a lot more common, but still show a marked tendency to occur just between the bank and the crop. Papaver hybridum and Papaver argemone are two such examples; very often they have been present at sites for aufnahmen but have been ignored as part of the heterogeneous vegetation outside the boundary of the crop itself. Papaver rhoeas also shows this effect, yet sometimes

it can be the dominant weed throughout an entire field.

At the centre of the field, the situation may be very different. For obvious reasons it has rarely been possible to examine the centres of arable fields until after harvest, when there may be rapid germination and growth of weed species after the removal of the competition from the crop. However, Tab. 8 shows a situation which appears to be typical. In the centre of the barley field, exposed by a new cart-track through the standing crop just prior to harvest, the aufnahme contains just four grasses. The situation here is no doubt intensified by herbicide application, but this is one of the factors that contributes to the sharp difference between the edge and the interior of the average crop.

Any account of arable weed communities must include a full consideration of this situation. Subjectively, the species of the edge situation do not give way to a different community at the field centre. Most species appear to grow more vigorously near the edge and then become weaker and less frequent further into the crop. However, this generally seems to be an effect of competition with the crop; if any factor weakens the crop, e.g. rabbit grazing, poor drainage, then the same species may occur throughout the ^{field. There do not appear to be any species characteristic of the} centres of fields that do not occur in the marginal zones.

Nevertheless, questions still must be asked, and require objective answers. Is the difference between the centre and the edge qualitative as well as quantitative? How distinct indeed is this marginal zone? The problem was approached by taking transects into fields at two sites and measuring the qualitative change (presence - absence) from one contiguous quadrat to the next.

4.1.2 Sampling was by recording the species in a line of 0.625m^2 contiguous quadrats, extending from the surrounding community through the field edge into the interior of the crop. The resulting data-

Table 8 Weed Flora within a Barley Crop

Restricted weed flora at the centre of a barley-field

Aufnahme	133		
No. of Species	4	Exposition	-
Area of Quadrat in m ²	4	Altitude in ft.	150
Area of Stand	L	Month	7
% Cover	60	Soil	cL
Slope	-	Crop	2B

Poa trivialis	2.2
P. annua	1.1
Lolium * perenne	+ .2
Avena fatua	+

sets were analysed using several different similarity or dissimilarity measures:-

i) Czekanowski's Index of Similarity

$$S = \frac{2c}{a + b}$$

Where a = no. of spp. in first quadrat of pair
 b = no. of spp. in second quadrat of pair
 c = no. of spp. common to both quadrats

This well known similarity measure, also commonly attributed to Sorensen, was used to compare successive quadrat pairs, i.e. first with second, second with third, etc. The other indices discussed below were also applied in this manner. Czekanowski's Index was also used to compare the quadrats at the two ends of the transects.

ii) van der Maarel's Information Index
 (van der Maarel and Leertouwer, 1967)

$$I = a + b - 2c$$

Notation as above; a measure of dissimilarity.

iii) Fresco's Similarity Measure
 (Fresco, 1972)

$$G_{RG} = \frac{c}{a + b - c}$$

Notation as above.

iv) Fresco's Information Statistic
 (Fresco, op. cit.)

This differs from the preceding measures in that it involves three quadrats at a time, considering the dissimilarity of a quadrat from its neighbouring quadrats on both sides.

For a quadrat Q, preceded by quadrat P and succeeded by quadrat R,

$$G_G(Q) = \sum_{i=1}^{Sq} \frac{b_i}{Sq}$$

Where Sq = no. of species in quadrat Q

b_i = 0 or 1 - see below

If the "ith" species occurs in all three quadrats, P, Q, and R, then it does not contribute to any distinction and $b_i = 0$. If it occurs in any one or two of the quadrats, but not all three, then $b_i = 1$. Fresco's Information Statistic is thus based on the number of species which distinguish between the quadrats, expressed as a proportion of the species total in the central quadrat so that it is not unduly influenced by the species-richness of the vegetation.

v) van der Maarel's "H Statistic"

Information on this unpublished(?) statistic is taken from Bridgewater (1970 and pers. comm.). Unfortunately, Bridgewater's written account shows inconsistencies and so it may be that the following account deviates from van der Maarel's original concept.

The general formula is,

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

Where p = performance, e.g. frequency, biomass.

g_i = the "ith" species

$p(g_i, a)$ = performance of the "ith" species in quadrat "a"

$p(g_i, b)$ = performance of the "ith" species in quadrat "b"

p Max = maximum performance, e.g. maximum possible frequency in a + maximum possible frequency in b.

G = total no. of species

The "half" in the formula makes no effective difference, of course, in the way that the formula is used here.

The formula is adopted in the present case using frequency. Quadrats are taken four at a time and the four are grouped into two pairs, i.e. two contiguous quadrats of 0.125m^2 , each divided into two cells. Each species can have a frequency of 0, 1 or 2 in each double quadrat. So each species is taken in turn, and the positive difference between its frequency in the first double quadrat and its frequency in the second double quadrat is divided by its maximum possible frequency for the two double quadrats (i.e., 4). Hence "H" is calculated from the sum of these values. Thus a species occurring in the first two of the four original transect quadrats and not in the second two, or vica versa, will make the greatest contribution to "H". A species occurring with equal frequency in the first two and in the second two will make no effective contribution.

As used here, the H Statistic was calculated for quadrats 1 to 4 of the transect, then 2 to 5, and so on, moving the division between the double quadrats by 25cm at each step.

vi) "Modified H"

It will be readily apparent that "H" as described above is strongly influenced by the species-richness of the vegetation. Indeed, it is so influenced by this that it does not convey much more information than would a measure of the changes in no. of species from quadrat to quadrat. Some kind of correction factor thus seemed desirable. Dividing by the total number of species in the set of four quadrats could have accomplished this, but a further modification seemed worth investigating.

It can be easily shown that a species can be distributed in the four quadrats in 16 different ways, including the case where it is

absent from all four. The probabilities of obtaining each of these distributions would depend on the frequency distribution of species in the vegetation at that point. However as a basis for further discussion it could be taken that all sixteen possibilities are equally likely. If this were so, then the expected value of H in vegetation containing sixteen species would be 1.5, i.e. the average contribution to the H value by each species would be,

$$\frac{1.5}{16} = 0.09375$$

i.e. expected value of H = 0.09375 n,

where n = no. of species in the vegetation at that point
(for convenience, approximated to the number
of species recorded from the four quadrats)

$$\text{Thus "Modified H"} = \frac{H}{n \times 0.09375} \times 100$$

where H is the calculated value as in v) above.

Modified H is expressed as a percentage of the predicted value.

As the assumptions above are speculative, the "predicted" value is in no way "expected" in any statistical sense, but it provides a potentially useful basis for comparison.

4.1.3 Transect 1 : Portway Heave

Transect 1 was made into a beetfield at Portway Heave, Eriswell, Suffolk; grid ref. TL 741771; 9th September, 1971; soil a chalky sand with flints; crop poor and sparse, severely rabbit grazed, missed altogether by the transect.

The original data are shown in Tab. 9. The transect was begun in the somewhat disturbed grassland at the field edge, in the partial shade of pines. Quadrats 1 - 3 were sited on this boundary grassland,

quadrats 4 - 20 in the arable field. However the edge of the grassland was broken and indistinct and scattered clumps of similar vegetation occurred also in the crop, explaining the presence of such species as Phleum bertolonii as an arable weed.

Results of the analysis are given in Tabs. 10 - 12 and Figs. 20 - 27. Taking the third quadrat to be grassland and the fourth to be arable vegetation (though no attempt was made to align the quadrat boundaries with the field boundary, even if the latter had been clear) the transition between the two shows clear troughs in the similarity plots (Figs. 20, 22) and peaks in the dissimilarity plots (Figs. 21, 23, 24, 25). However, it is clear from the figures that pairs of quadrats within the arable field may be just as dissimilar as this visually obvious discontinuity. Species richness declines away from the margin of the field (Fig. 24) and measures influenced by species number show the field/boundary discontinuity more clearly.

A full comparison of all quadrats by Czekanowski's Similarity Index was also carried out on this data. The results are shown in Fig. 26. An interesting feature of the results is that although quadrats 1, 2 and 3 are clearly different from the rest, the low similarities of these with quadrats 5 - 8 are followed by rather higher similarities with the succeeding quadrats. Significantly, quadrat 9 is that which contains Phleum bertolonii. It appears that the index has picked up the visual heterogeneity at this point. As Fig. 26 is not notable for its clarity, similarities to the end quadrats are also shown in Fig. 27. The expected trends of a steady decline in similarity to the ends of the transect are clearly visible, as is again the area from quadrats 9 - 14 which shows some similarity to the grassland field boundary.

Table 9 Transect 1 : Portway Heave

No. of Quadrat	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of Species	8	11	13	11	8	10	8	11	10	9	12	8	7	8	7	6	4	5	4	5
<i>Plantago lanceolata</i>	+		+	+																
<i>Agrostis tenuis</i>	+	+	+	+	+	+				+	+	+	+							
<i>Festuca rubra</i>	+	+	+																	
<i>Galium verum</i>	+	+	+																	
<i>Convolvulus arvensis</i>	+	+	+																	
<i>Capsella bursa-pastoris</i>	+	+	+	+			+	+	+			+	+							
<i>Stellaria graminea</i>	+	+																		
<i>Achillea millefolium</i>	+	+	+																	
<i>Echium vulgare</i>		+	+	+	+	+	+	+	+	+	+		+	+	+					
<i>Koeleria cristata</i>		+																		
<i>Arenaria serpyllifolia</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
<i>Brachythecium rutabulum</i>	+																			
<i>Dactylis glomerata</i>			+	+					+	+	+									
<i>Myosotis arvensis</i>			+								+	+								
<i>Medicago lupulina</i>			+	+						+				+					+	
<i>Sedum acre</i>			+																	+
<i>Silene alba</i>				+				+				+	+							
<i>Anthemis arvensis</i>				+	+	+	+	+				+	+	+	+	+	+	+	+	+
<i>Reseda lutea</i>				+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
<i>Valerianella dentata</i>				+	+	+														
<i>Acinos arvensis</i>					+	+														
<i>Erodium cicutarium</i>					+	+			+				+	+		+				
<i>Apera spica-venti</i>						+														
<i>Silene vulgaris</i>						+	+	+												
<i>Viola arvensis</i>							+	+	+					+	+					
<i>Veronica arvensis</i>							+					+	+				+	+		

Table 9 (Cont.)[illegible]

Table 10 Transect 1 : Portway Heave

Calculated changes in Czekanowski's Index of Similarity,
van der Maarel's Information Index and Fresco's Similarity
Measure.

<u>Quadrat Pair</u>	<u>Czekanowski</u>	<u>van der Maarel</u>	<u>Fresco</u>
1-2	0.737	5	0.583
2-3	0.667	8	0.500
3-4	0.583	10	0.412
4-5	0.632	7	0.462
5-6	0.889	2	0.800
6-7	0.556	8	0.385
7-8	0.736	5	0.583
8-9	0.667	7	0.500
9-10	0.526	9	0.357
10-11	0.572	9	0.400
11-12	0.700	6	0.538
12-13	0.667	5	0.500
13-14	0.533	7	0.364
14-15	0.800	3	0.667
15-16	0.769	3	0.625
16-17	0.600	4	0.429
17-18	0.889	1	0.800
18-19	0.667	3	0.500
19-20	0.667	3	0.500

Table 11 Transect 1 : Portway Heave

Calculated changes in Fresco's Information Statistic

<u>Quadrat</u>	<u>Information Statistic</u>	<u>Quadrat</u>	<u>Information Statistic</u>
2	0.455	11	0.750
3	0.692	12	0.500
4	0.727	13	0.714
5	0.250	14	0.625
6	0.600	15	0.429
7	0.375	16	0.500
8	0.545	17	0.250
9	0.600	18	0.600
10	0.556	19	0.250

Table 12 Transect 1 : Portway Heave

Calculated changes in van der Maarel's H-statistic
and its modification

<u>Quadrat Group</u>	<u>H</u>	<u>Modified H</u>
1-4	2.625	140.0
2-5	2.875	139.4
3-6	3.000	152.4
4-7	1.375	86.3
5-8	2.375	149.0
6-9	2.125	119.3
7-10	2.250	126.3
8-11	2.500	127.0
9-12	2.625	140.0
10-13	1.750	109.8
11-14	2.375	140.7
12-15	2.000	152.4
13-16	1.000	97.0
14-17	1.125	120.0
15-18	1.000	118.5
16-19	0.625	83.3
17-20	1.000	133.3

Fig. 20

Transect 1: Portway Heave. Comparison of successive quadrat pairs by Czekanowski's Similarity Index.

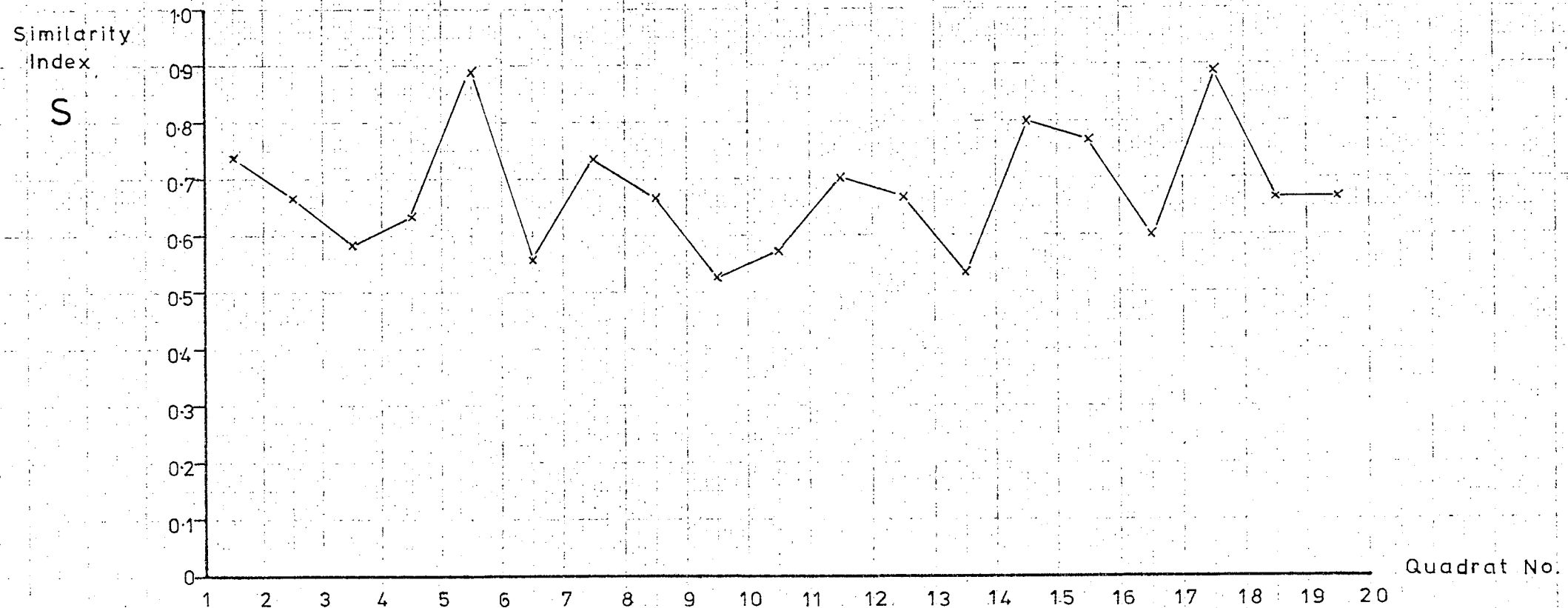


Fig. 21

Transect 1: Portway Heave. Comparison of successive quadrat pairs by Van der Maarel's Information Index, I .

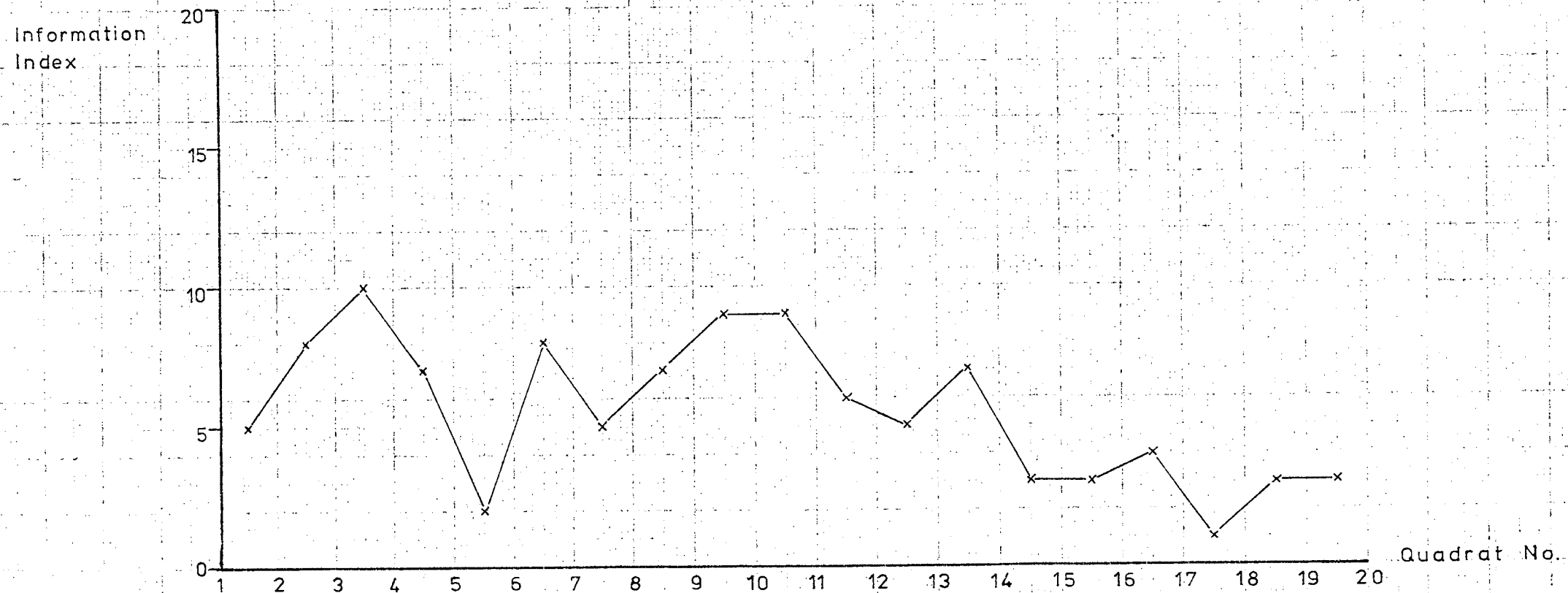


Fig. 22

Transect 1: Portway Heave. Comparison of successive quadrat pairs by Fresco's Similarity Measure, G_{RQ} .



Fig. 23

Transect 1: Portway Heave. Fresco's Information Statistic for successive quadrats.

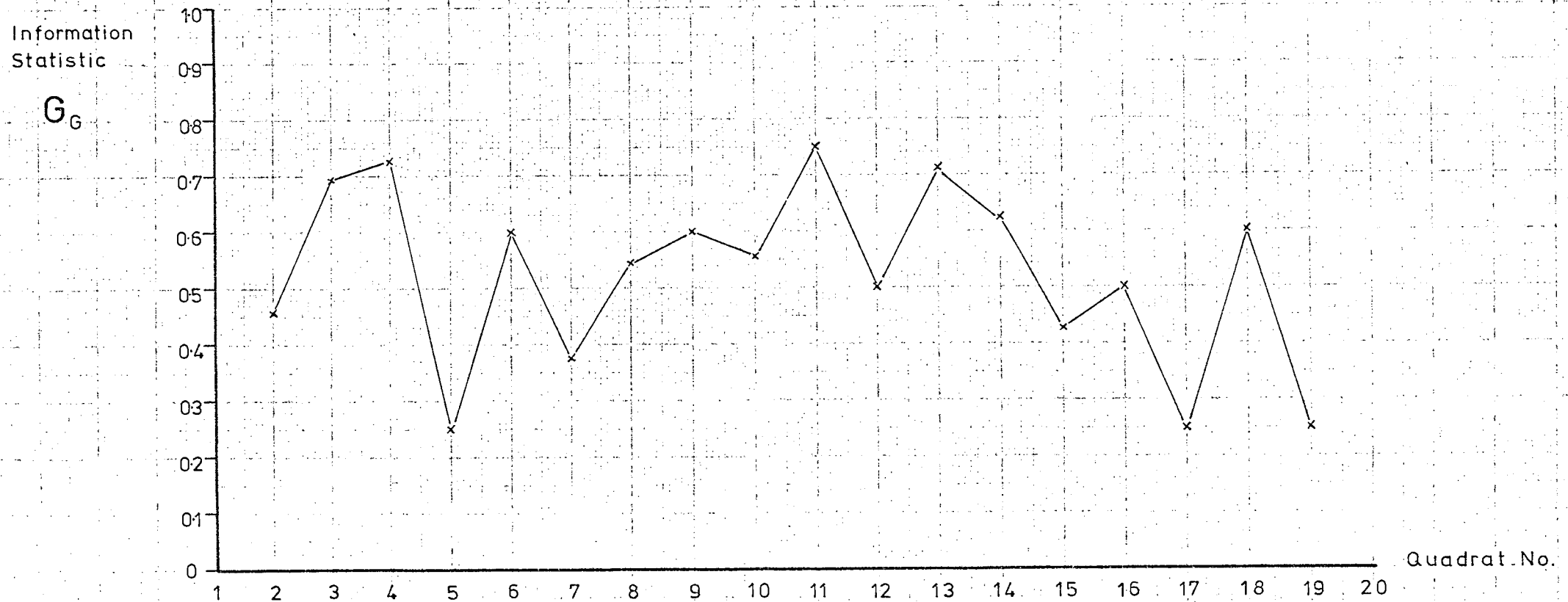


Fig. 24

Transect 1: Portway Heave

Analysis by Van der Maarel's "H Statistic".

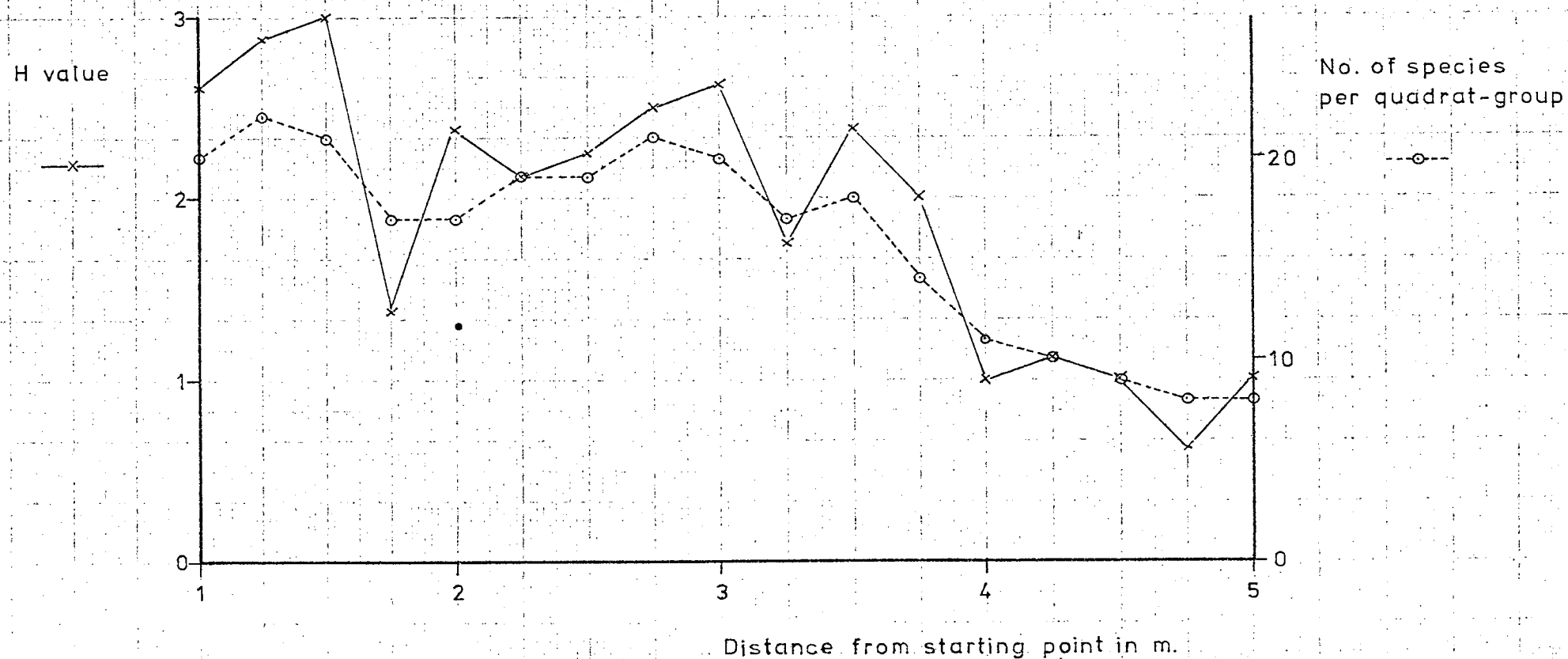


Fig. 25

Transect 1: Portway Heave
Analysis by "Modified H Statistic".

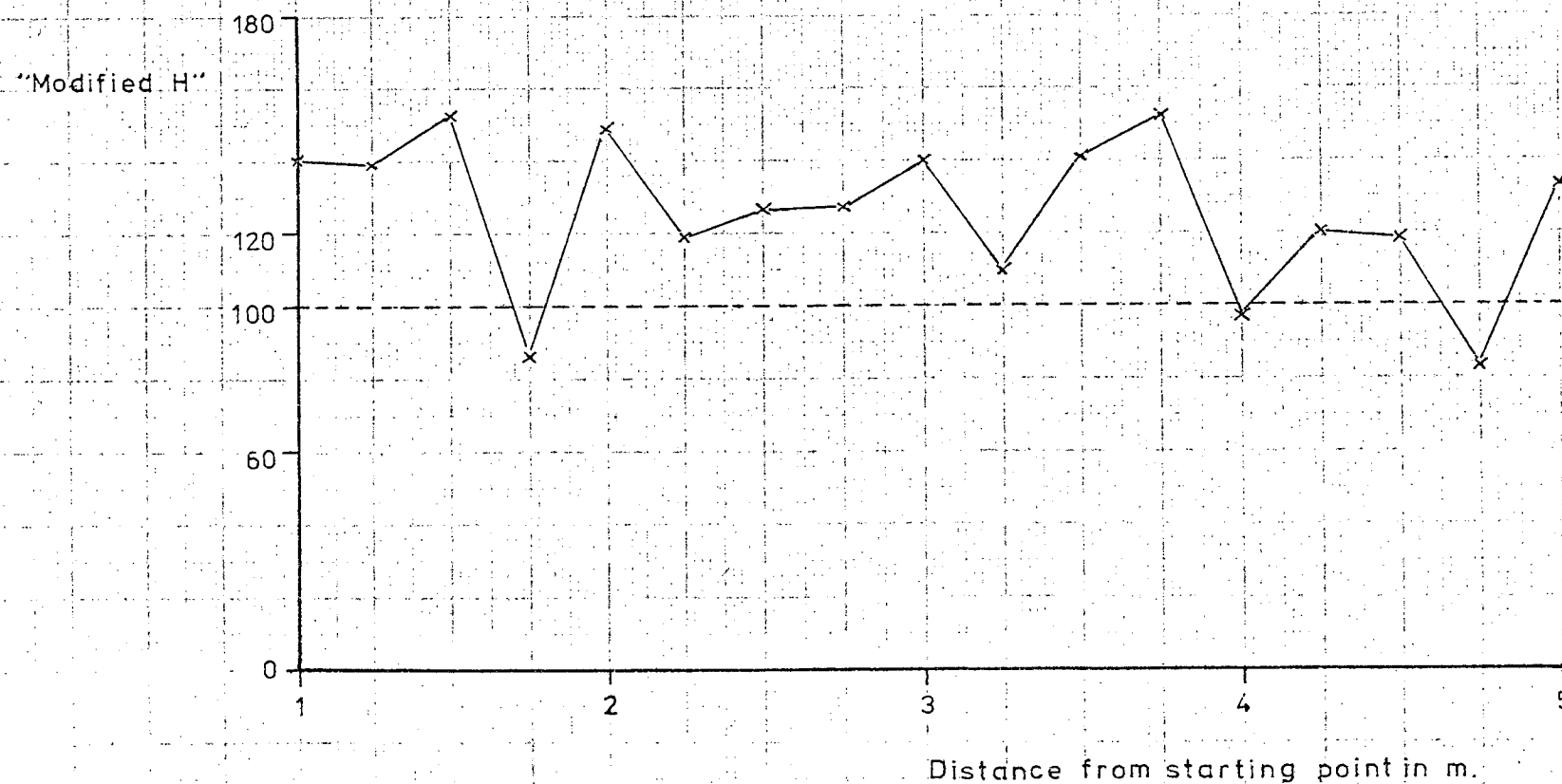


Fig. 26

Transect 1: Portway Heave
Comparison of quadrats by
Czekanowski's Similarity Index

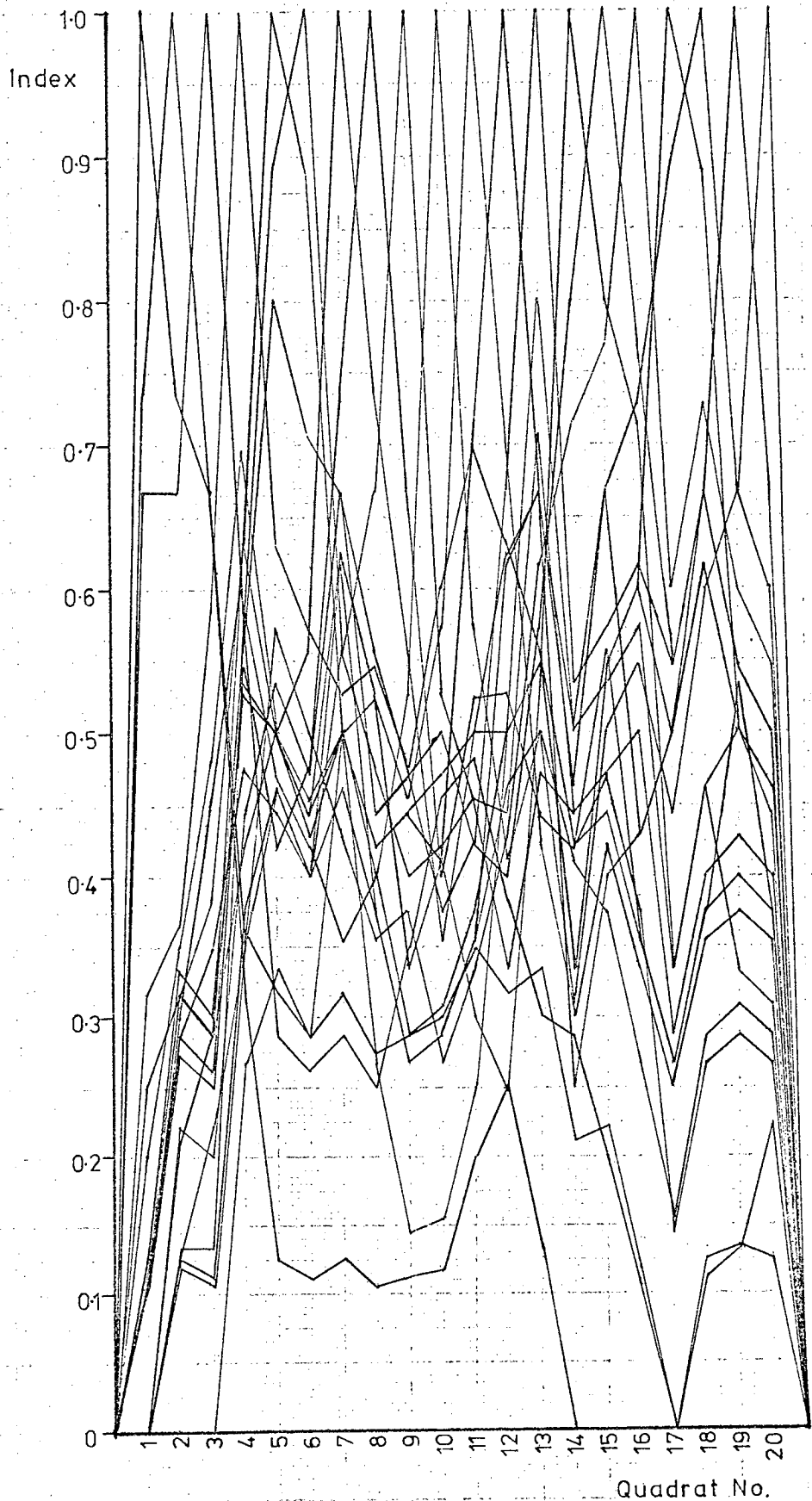


Fig.27

Transect 1: Portway Heave
Comparison of end quadrats by
Czekanowski's Similarity Index

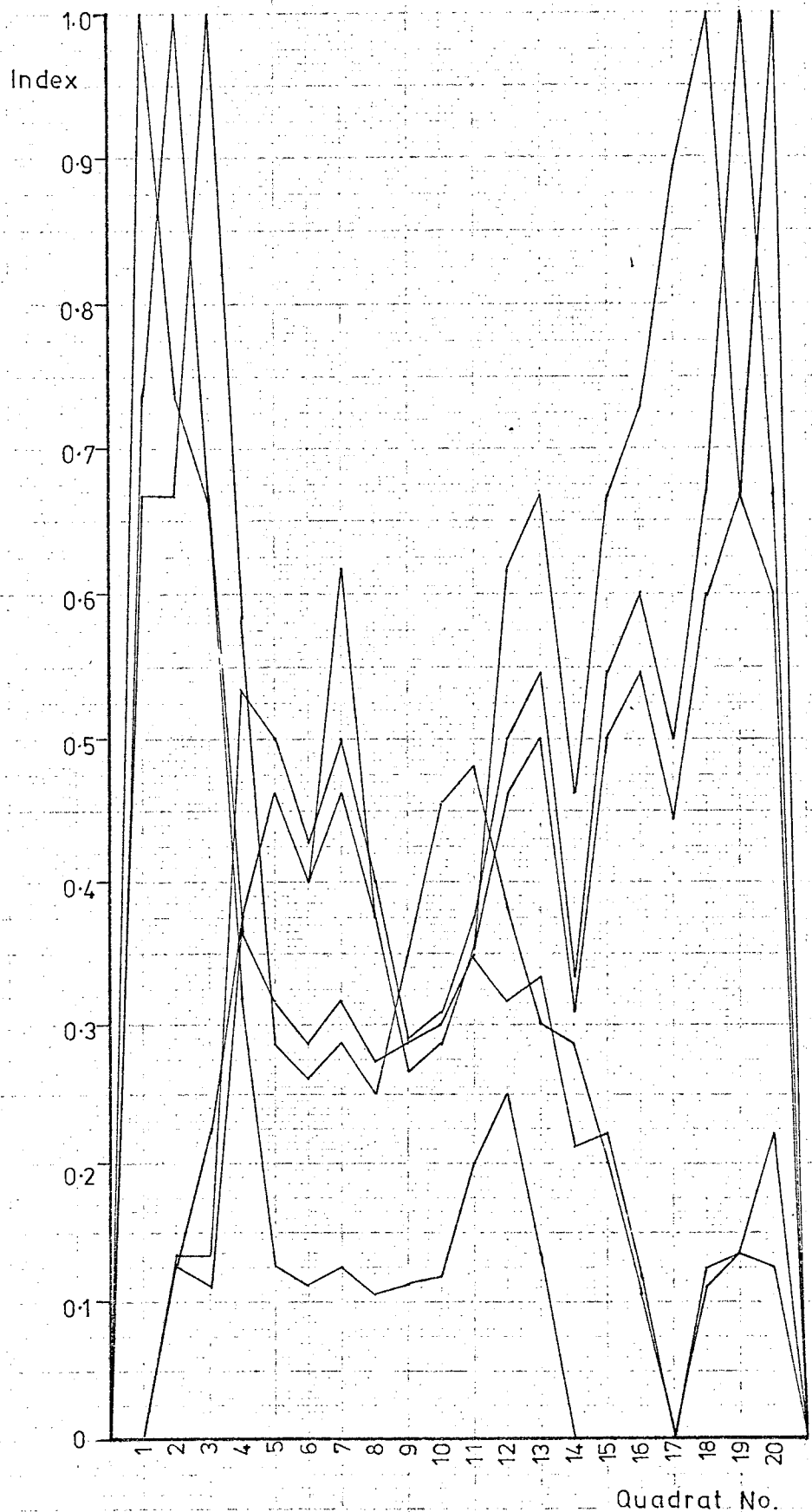


Table 13 Transect 2 : Machair Robach

Quadrat No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of Species	15	15	21	16	9	8	9	8	11	8	9	10	10	11	14	8	8	11	10	14
<i>Cynosurus cristatus</i>	+	+	+																	
<i>Galium verum</i>	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
<i>Rhinanthus stenophyllus</i>	+	+	+																	
<i>Trifolium pratense</i>	+	+	+	+		+	+			+										+
<i>Plantago lanceolata</i>	+	+	+	+	+	+		+		+	+	+		+	+				+	+
<i>Ranunculus repens</i>	+	+	+		+	+							+	+	+		+			+
<i>Helictotrichon pubescens</i>	+		+																	+
<i>Trifolium repens</i>	+	+	+	+			+	+	+									+	+	
<i>Odontites verna</i> ssp. <i>verna</i>	+																			
<i>Poa trivialis</i>	+	+	+	+																
<i>Euphrasia</i> sp.	+																			
<i>Holcus lanatus</i>	+	+	+	+	+				+	+								+	+	+
<i>Festuca rubra</i>	+	+	+	+		+			+	+			+	+					+	+
<i>Carex flacca</i>	+	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+	+	+
<i>Koeleria gracilis</i>	+	+	+	+			+	+			+	+			+		+	+	+	+
<i>Achillea millefolium</i>		+									+	+			+	+	+		+	
<i>Crepis capillaris</i>		+											+							
<i>Senecio jacobaea</i>		+	+	+	+															
<i>Paneolina foenesecii</i>			+																	
<i>Lotus corniculatus</i>			+					+	+	+	+									+
<i>Coeloglossum viride</i>			+																	
<i>Rhytidiadelphus squarrosus</i>			+	+																
<i>Pseudoscleropodium purum</i>			+	+																+
<i>Brachythecium albicans</i>			+	+																+
<i>Lophocolea bidentata</i>			+	+																
<i>Secale cereale</i>				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Avena strigosa</i>				+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+
<i>Mnium punctatum</i>				+																
<i>Hypericum humifusum</i>					+							+								

Table 13 (Cont.)[illegible]

Table 14 Transect 2 : Machair Robach

Calculated changes in Czekanowski's Index of Similarity,
van der Maarel's Information Index and Fresco's Similarity
Measure.

<u>Quadrat Pair</u>	<u>Czekanowski</u>	<u>van der Maarel</u>	<u>Fresco</u>
1-2	0.800	6	0.667
2-3	0.722	10	0.565
3-4	0.703	11	0.542
4-5	0.480	13	0.316
5-6	0.706	5	0.545
6-7	0.588	7	0.417
7-8	0.706	5	0.545
8-9	0.632	7	0.462
9-10	0.632	7	0.462
10-11	0.588	7	0.417
11-12	0.842	3	0.727
12-13	0.700	6	0.538
13-14	0.762	5	0.615
14-15	0.800	5	0.667
15-16	0.545	10	0.375
16-17	0.625	6	0.455
17-18	0.526	9	0.357
18-19	0.667	7	0.500
19-20	0.583	10	0.412

Table 15 Transect 2 : Machair Robach

Calculated changes in Fresco's Information Statistic

<u>Quadrat</u>	<u>Information Statistic</u>	<u>Quadrat</u>	<u>Information Statistic</u>
2	0.200	11	0.556
3	0.571	12	0.400
4	0.750	13	0.400
5	0.556	14	0.364
6	0.500	15	0.643
7	0.667	16	0.375
8	0.375	17	0.500
9	0.727	18	0.545
10	0.500	19	0.500

Table 16Transect 2 : Machair Robach

Calculated changes in van der Maarel's H-statistic and its modification.

<u>Quadrat Group</u>	<u>H</u>	<u>Modified H</u>
1-4	2.875	109.5
2-5	2.875	113.6
3-6	3.750	160.0
4-7	2.000	101.6
5-8	2.000	133.3
6-9	1.500	100.0
7-10	1.750	124.4
8-11	1.250	88.9
9-12	2.250	141.2
10-13	1.875	117.6
11-14	1.625	108.3
12-15	1.375	86.3
13-16	1.375	81.5
14-17	1.875	117.6
15-18	1.375	77.2
16-19	1.875	111.1
17-20	1.875	95.2

Fig. 28

Transect 2: Machair Robach. Comparison of successive quadrat pairs by Czekanowski's Similarity Index.

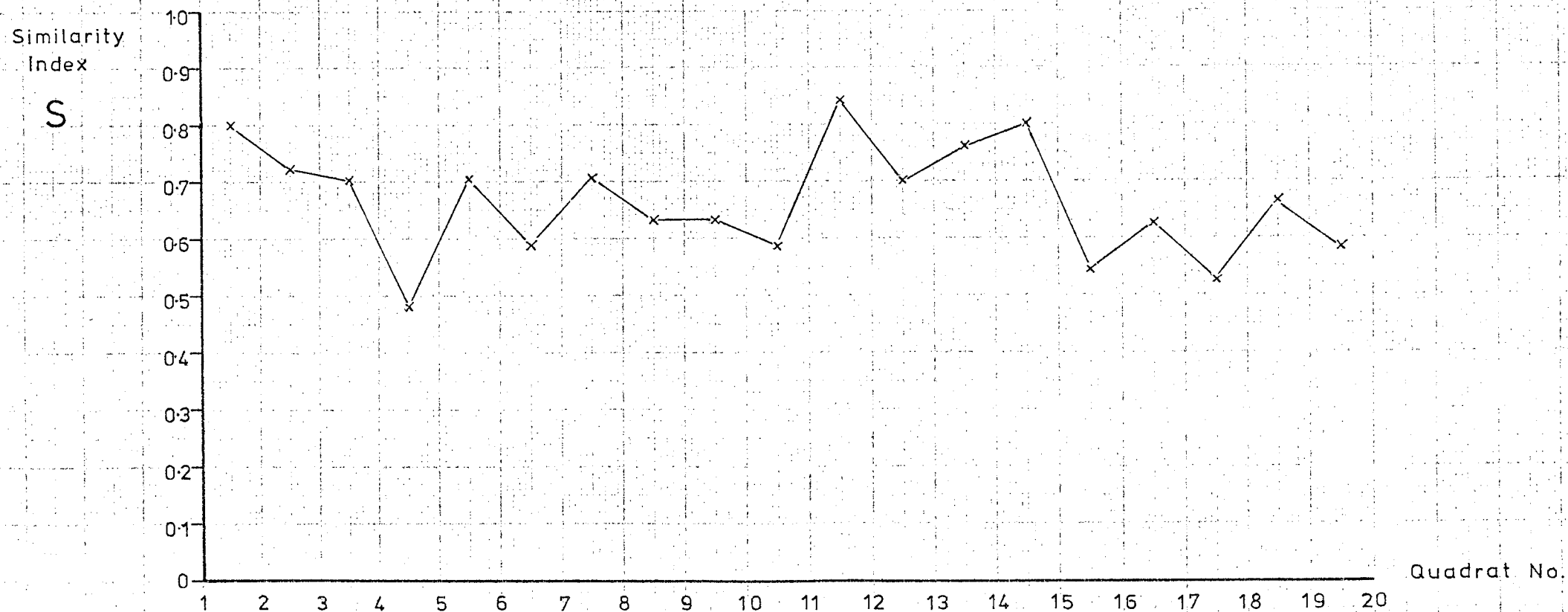


Fig. 29

Transect 2: Machair Robach. Comparison of successive quadrat pairs by Van der Maarel's Information Index, I.

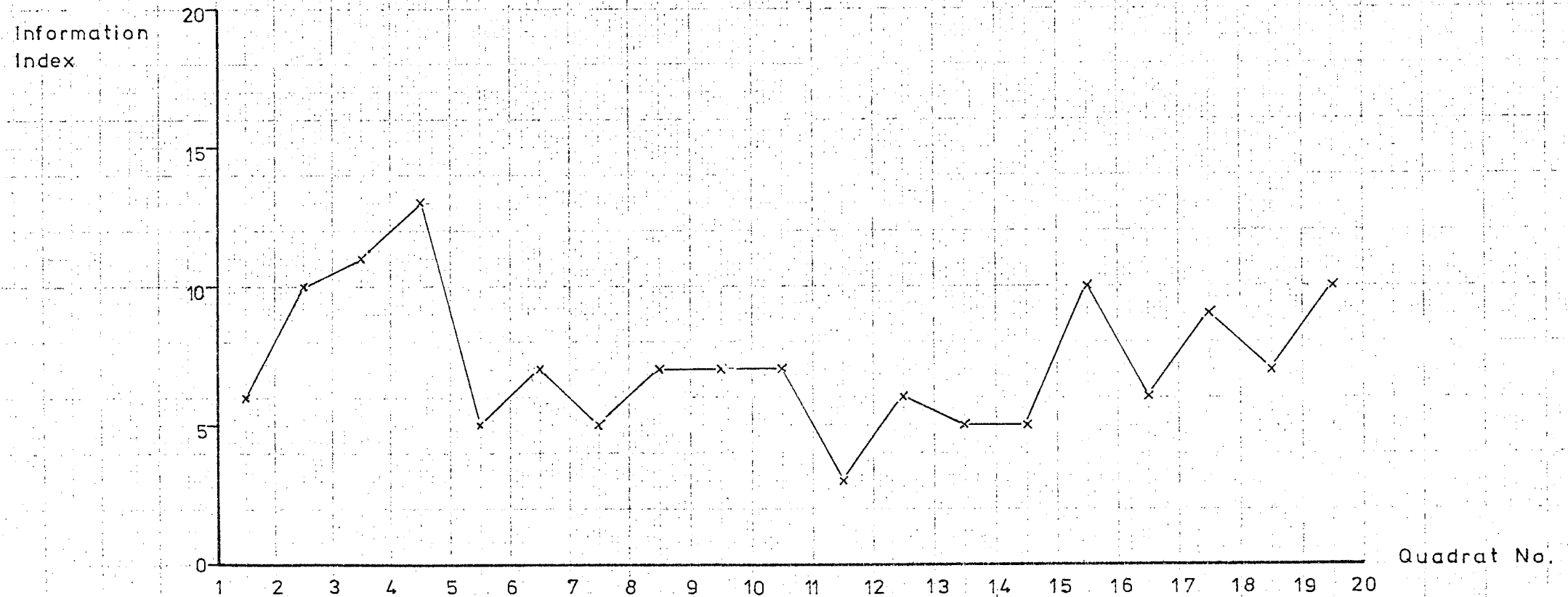


Fig. 30

Transect 2: Machair Robach. Comparison of successive quadrat pairs by Fresco's Similarity Measure, G_{RQ} .

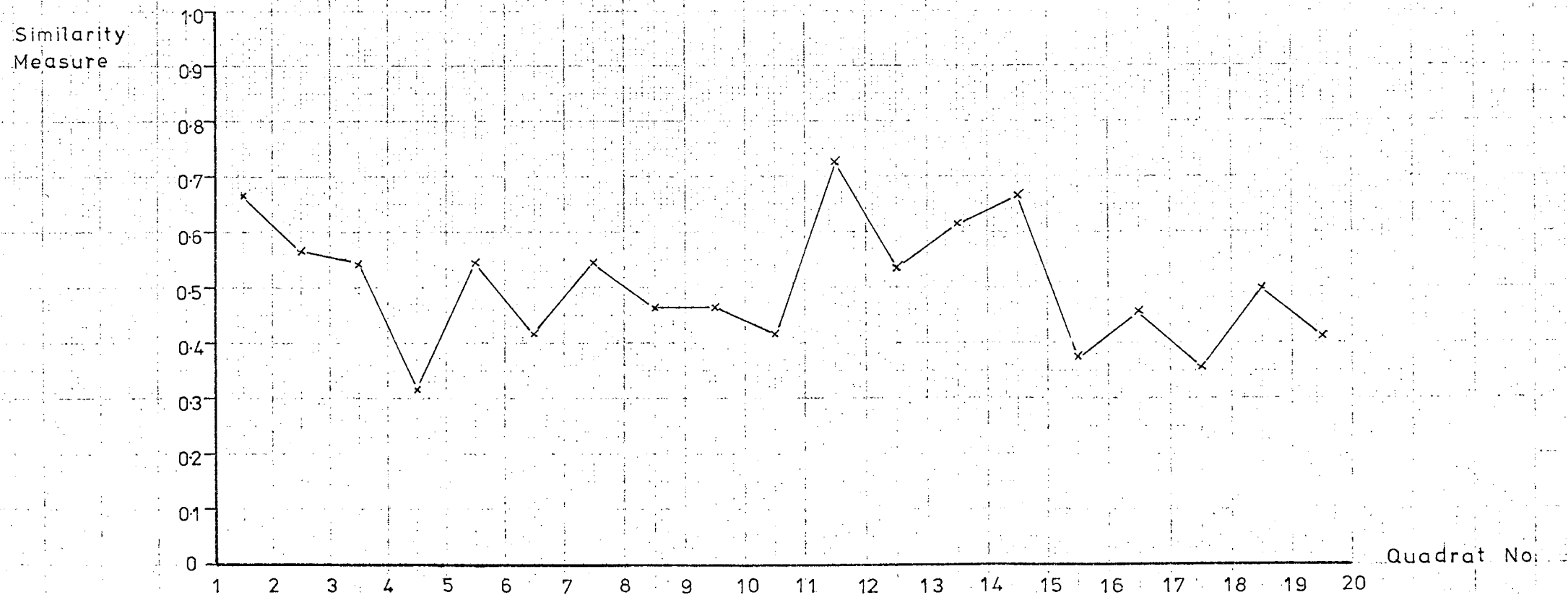


Fig. 31

Transect 2: Machair Robach, Fresco's Information Statistic
for successive quadrats.

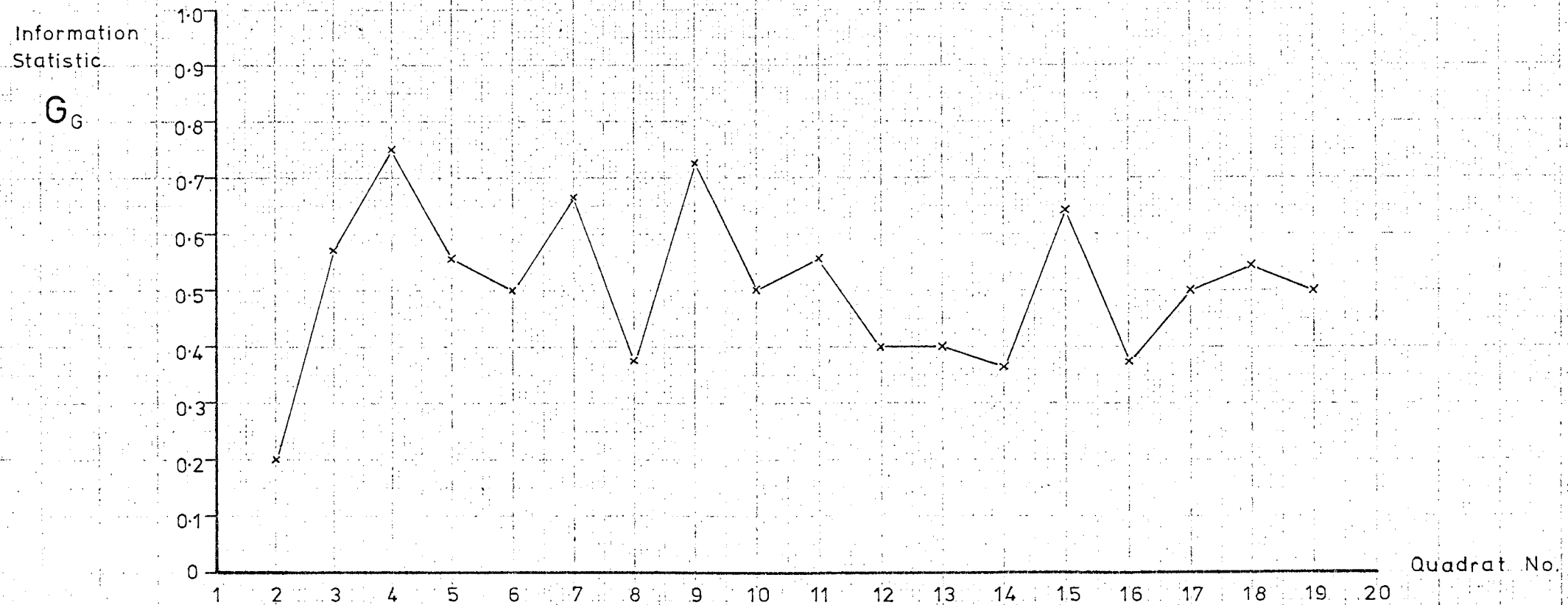


Fig. 32

Transect 2: Machair Robach

Analysis by Van der Maarel's "H Statistic".

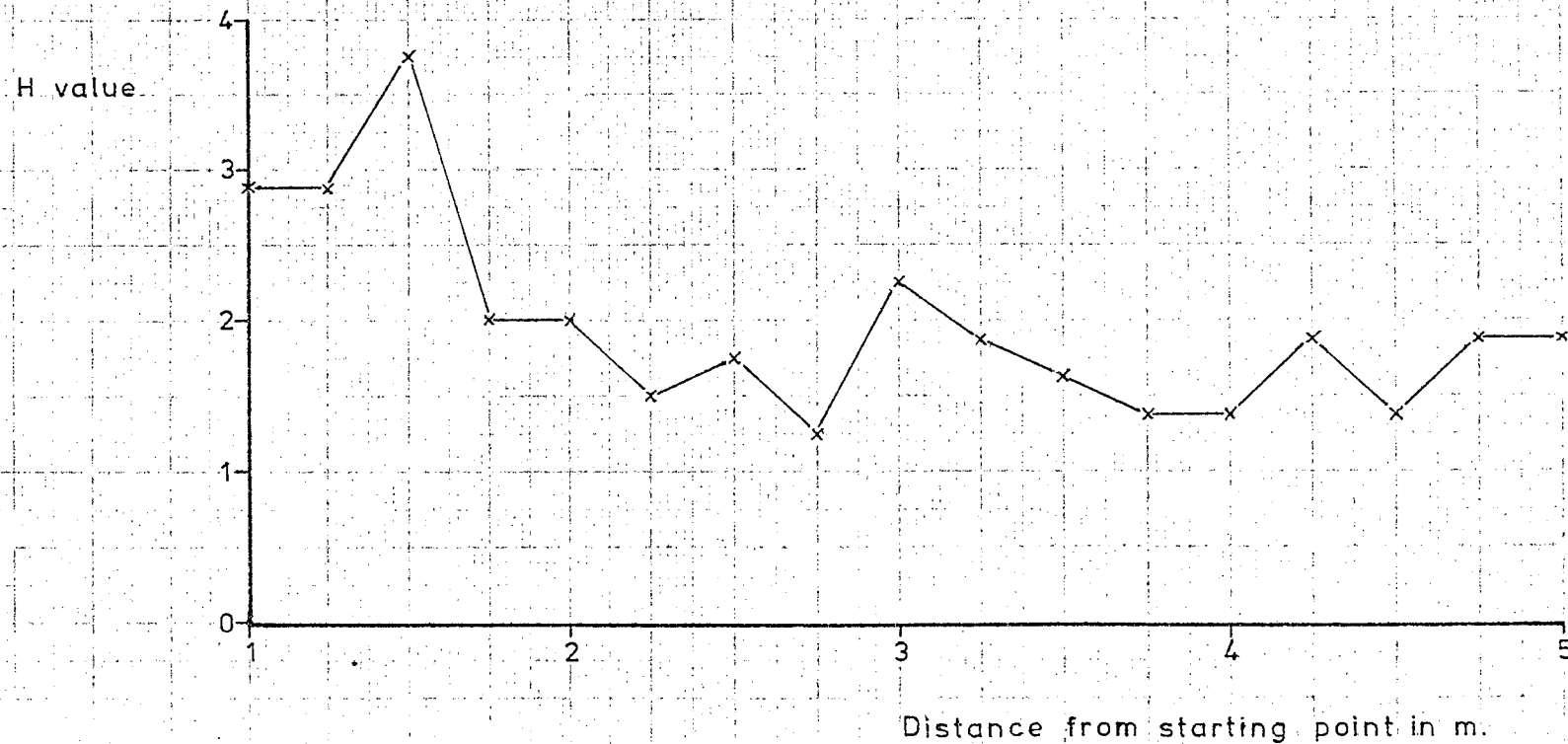


Fig. 33

Transect 2: Machair Robach
Analysis by "Modified H Statistic".

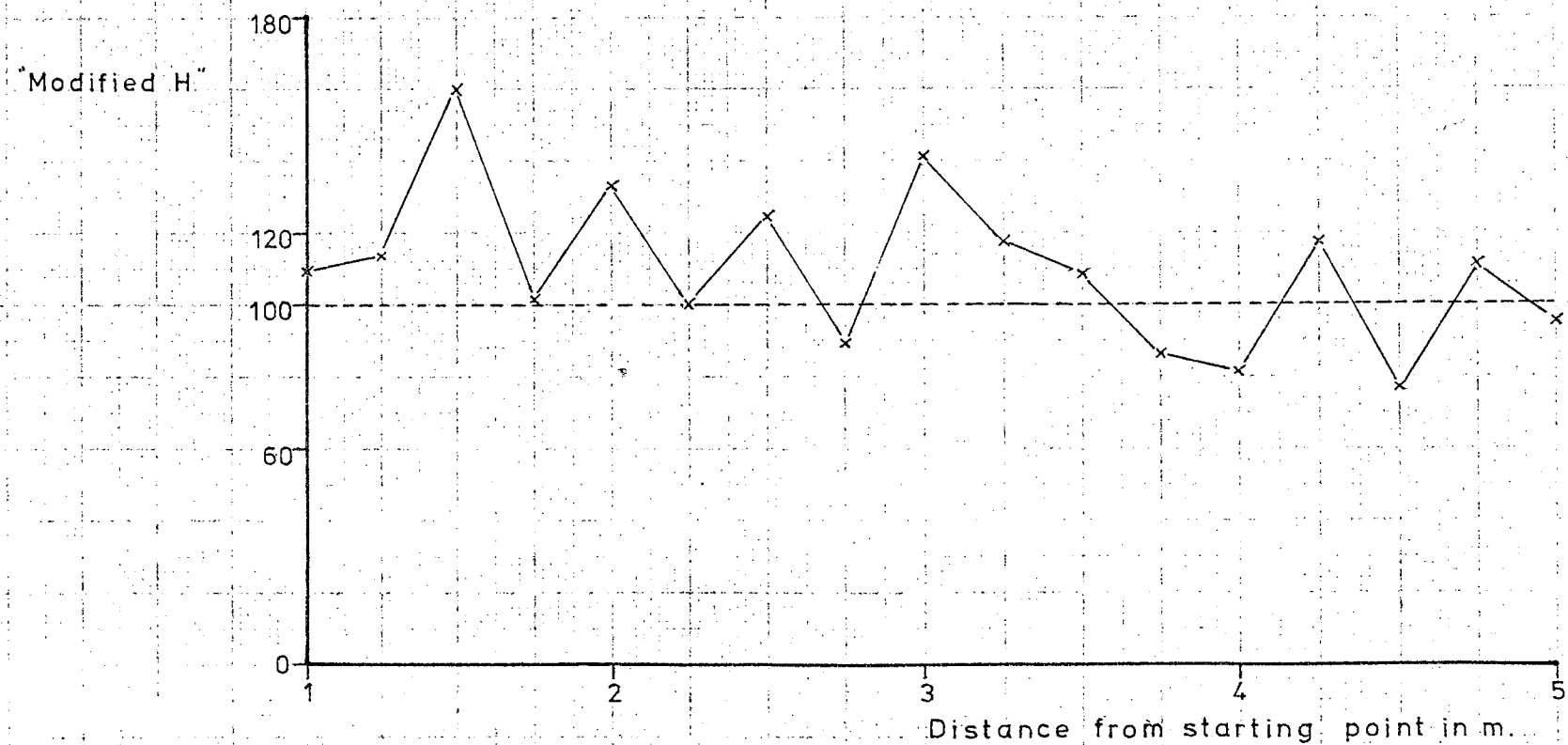
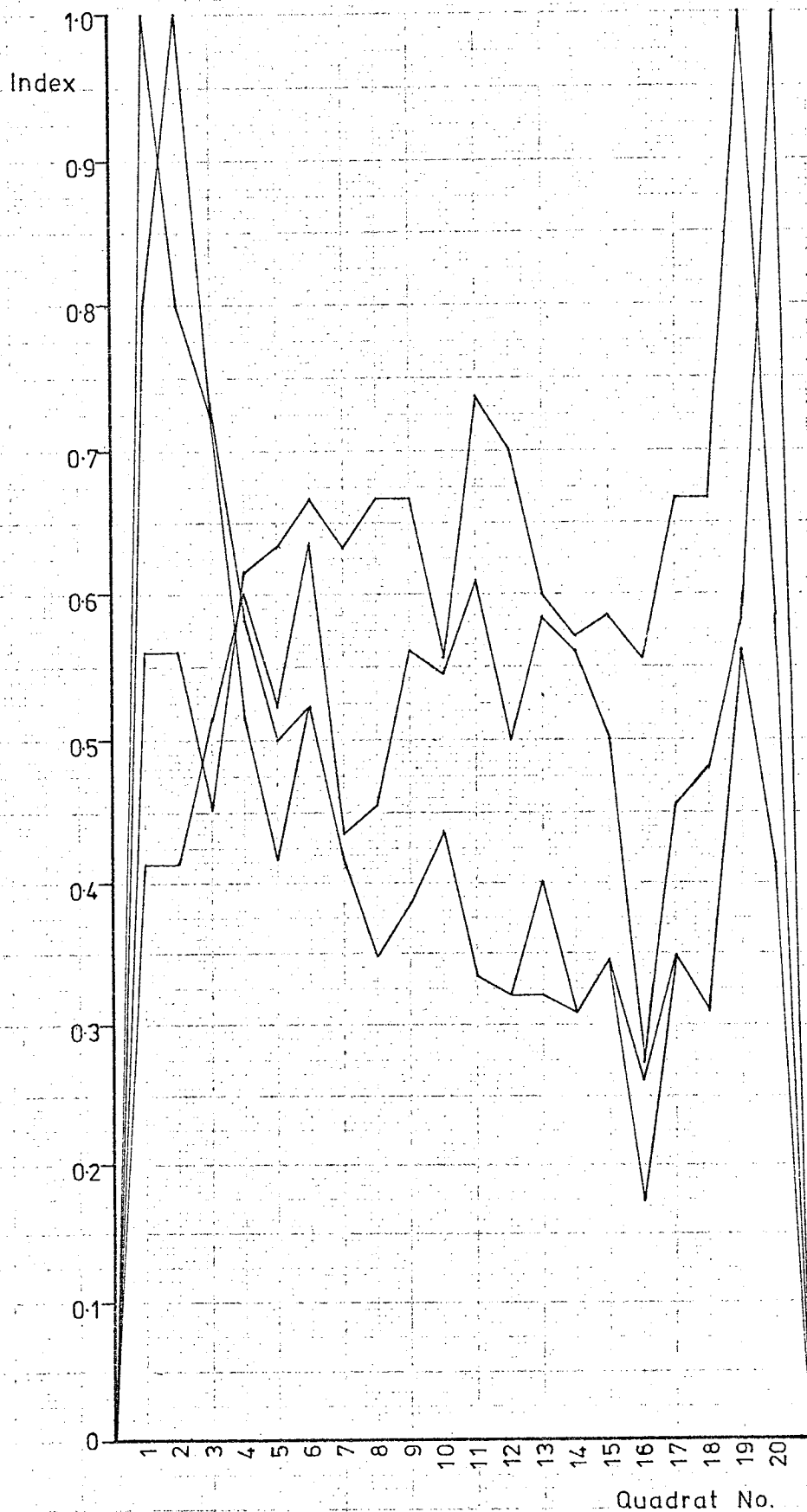


Fig. 34

Transect 2: Machair Robach

Comparison of end quadrats by
Czekanowski's Similarity Index



4.1.4 Transect 2 : Machair Robach

Transect 2 was made from undisturbed species-rich grassland into a ryefield at Machair Robach, North Uist; grid ref. NF 865756; 18th September, 1971; soil typical machair loamy sand; crop present as post-harvest stubble with Avena strigosa persisting as an agricultural relic.

The original data is shown in Tab. 13. The first three quadrats were sited on relic natural machair grassland, dominated by Festuca rubra, Koeleria gracilis, Carex flacca, etc. with a diverse flora containing such species as Coeloglossum viride. The rest of the quadrats were sited in the arable field, as picked out in Tab. 13 by the distribution of rye (Secale cereale). Quadrats 2 and 3 show a group of bryophytes, Rhytidiadelphus squarrosus, Pseudoscleropodium purum, Brachythecium albicans, Mnium punctatum and Lophocolea bidentata, characteristic of the very edge of the grassland. As is typical of these machair fields, several of the grassland species occur also as arable weeds and hence occur throughout much of the transect. Quadrats 19 and 20 contained tufts of grass comparable with the field boundary, and these tufts provided a habitat for two of the aforementioned mosses.

Results of the analysis are given in Tabs. 14 - 16 and Figs. 28 - 34. The field/boundary discontinuity is clearly visible in each plot, but as in the case of the Portway Heave transect, measures which are influenced by the number of species involved show this change most clearly. The field contains fewer species, but there are clearly substantial differences from quadrat to quadrat. The general pattern appears to be considerable change between successive quadrats near the margin of the field, a fairly uniform area in the neighbourhood of quadrats 11 - 15 and then an increase in dissimilarity

towards the end of the transect (see, especially, Fig. 29) where heterogeneity had been observed visually. Fig. 34 shows the greater similarity of quadrats 19 and 20 to the field boundary compared with the vegetation in between.

4.1.5 It is unfortunate that time did not permit the planned analysis of a third site. A cornfield with a very pronounced marginal zone would have provided useful data for comparison. However, both sites show an interesting degree of heterogeneity. Van der Maarel's H-statistic, and to a lesser extent, his Information Index, show the transition from surrounding community to arable field very well, and while it might be argued that this is primarily due to changes in species-richness of quadrats, diversity is an important characteristic of any vegetation type. There is, further, a suggestion that there is a decrease in heterogeneity, independent of species number, away from the edge of a field, shown most clearly by the "Modified H" measure in Fig. 33.

Boundary situations have been analysed by van Leeuwen (e.g. 1966), who distinguished two types of boundary, the "limes divergens", a broad zone of transition between two communities, marked by stability and species-richness, and the "limes convergens", a sharp boundary marked by instability and low species diversity. The edge of an arable field is a clear, though complex example of a limes convergens situation. However, it is arguable whether the boundary situation is wider than the abrupt transition between crop and bounding community. Grass banks above arable fields must undergo some disturbance, even if this is only chemical or hydrological. Not infrequently, the vegetation of such banks includes species of orchid, noted by van Leeuwen as characteristic plants of limes divergens situations. In the same way, despite the instability of the vegetation, it could be possible to regard the marginal zone of an arable field as showing

limes divergens characteristics, with a diffuse transition to the field centre.

Meijer Drees (1951) adopts the same viewpoint. He uses the word "ecocline" in a regrettable non-genetic context to refer to transitional vegetation boundaries and states, "Probably the most complicated examples of ecoclines are found on arable lands. Here the number of disturbing factors is very great: ploughing, manuring, weeding, sometimes even burning and irrigating have all their special results; acting together they make it rarely possible for one factor to dominate or even to show distinctly its specific influence on the composition of the vegetation. The vegetation is inclined to develop into different directions at the same time, but the tendencies are not realised."

Large scale boundary situations are recognised in other habitats. Weaver and Clements (1938) cite the existence of broad, indefinite ecotones on the American prairie borders and Bellamy et al. (1969) suggest that the arctic-alpine vegetation in Upper Teesdale represents a boundary complex.

In discussing the results presented here it must be borne in mind that just as in so many ecological exercises, the effects of pattern must not be forgotten. The results are derived from just one quadrat size, which was deliberately chosen to be small enough to detect small scale variation in species content. If, as is very likely, the marginal zone of a field is merely the result of more vigorous growth of several species, use of a larger quadrat size may well have resulted in the disappearance of the observed heterogeneity within the fields. This may represent another approach to the concept of minimal area, on similar lines to that of Goodall discussed in Section 3.2.

4.1.6 So far, the question of why a marginal zone should exist has not been fully discussed. Apart from the possible presence of boundary species requiring areas of low productivity, of which the already quoted case of Ajuga chamaepitys may well be an example, the marginal zone probably arises from the combined influence of three major factors.

Firstly there is the effect of uneven herbicide application. It is quite reasonable to suppose that field edges might receive lower quantities of herbicide than the rest of the field and so herbicide sensitive species would tend to be restricted to the field margins, while grass species occur further into the crop. Strong evidence for this effect is provided by the examination of cornfields immediately after harvest. Very often, in an otherwise almost weed-free field, strips of dense weed vegetation will be found. Examination of the stubble usually gives no indication of the crop having been thinner at such points, so the obvious explanation is that these are strips which have been missed during spraying. Such strips often occur many metres from the field margin but contain identical species.

Secondly, one genuine difference in species composition between the margin of a field and its centre is the result of introductions from the surrounding community. Perennials such as Reseda lutea, Silene vulgaris, Heracleum sphondylium and Artemisia vulgaris regularly germinate in arable field and while they rarely reach maturity, young plants are common in, and characteristic of, the marginal zone.

Where the field is bounded by a hedge, this effect may be intensified as slowing of the wind and air turbulence in the lee of hedges results in the deposition of windborne seeds (Pollard et al., 1974). In fact Pollard et al. review a number of effects hedges have on field margins and it is very likely that hedges exert a direct effect on the marginal weed flora, plus an indirect effect via the effects

of the hedge on the crop. Very close to the hedge there is direct shading and competition by root growth for water and nutrients. Crop yields have been shown to be depressed within a distance of twice the height of the hedge, and this may well benefit the weed flora. Turbulence close to dense hedges may also cause lodging of cereals. Farther from the hedge, up to about twelve times the hedge height, the shelter effects cause increased crop yields. These effects include slightly higher daytime temperatures, a reduction in evaporation and hence slightly higher humidities and soil temperatures. In wet years, however, this shelter may delay crop ripening and depress yields. The implications of this for the weed flora require further investigation, but it is interesting to note that a number of invertebrates are more frequent towards the edges of fields close to hedges.

Allusion has already been made to competition from the crop, and this constitutes the third major factor. Crop - weed interactions are more fully discussed in Section 4.4, but the greater availability of light towards the margin of cornfields and other dense crops is undoubtedly of very great significance. Several species typical of field margins are known to require light for germination, including Trifolium repens, Matricaria matricarioides and Urtica dioica. (Bates, 1935; Greig-Smith, 1948). Sonchus oleraceus and S. asper are strongly light-requiring beyond the seedling stage (Lewin, 1948). However the simple distinction between light and dark has been challenged by recent work reproducing more accurately the lighting conditions under leaf canopies. Thus Popay and Roberts (1970) have shown that Senecio vulgaris can germinate in total darkness, but germination is inhibited by far-red light. Inhibition of germination by far-red light has also been demonstrated in Chenopodium album, Rumex obtusifolius, Arenaria serpyllifolia, Veronica arvensis and

Cerastium fontanum (Taylorson and Borthwick, 1969; King, 1975), while the growth of Veronica persica has been shown to be inhibited specifically by far-red light, as compared with a related woodland species (Fitter and Ashmore, 1974). However, not all arable species are so affected; Popay and Roberts (op. cit.) failed to demonstrate any effect of far-red light on Capsella bursa-pastoris.

It is clear that any species that can grow in a dense crop well away from the edge must be shade tolerant. The most successful species are those which can project above the crop, e.g. Avena fatua, Agropyron repens, Poa trivialis, Sonchus arvensis, Cirsium arvense, and more locally, Avena ludoviciana and Apera spica-venti. In root crops, Chenopodium album can be added to this list. Although the annuals in this list can probably germinate and keep pace with the crop to avoid substantial shading, the perennials must be shade-tolerant in order to make new growth. Williams (1970) has demonstrated shade tolerance in Agropyron repens.

4.2

Pattern in arable vegetation

The scale of any pattern in arable vegetation has already been mentioned in connection with discussions on suitable sampling areas. Any syntaxonomic account of any vegetation type must consider the possible effects of pattern, and arable vegetation is no exception to this.

No analysis of pattern has been attempted in the course of the survey but it would seem highly unlikely that any large scale regular pattern exists. In that the habit is ploughed up each year, any structure in the vegetation is reduced to a minimum. From a visual inspection, the most obvious pattern is shown by the crop plants. Most crops exhibit a regular (underdispersed) distribution, though in many cases it could be said that the crop plants are clumped (overdispersed) and that the clumps are regularly distributed.

The best example of this is a typical potato field with a pronounced ridge and furrow system. The potato plants are confined to the ridges and thus show a regular pattern of clumps. While the crop is young, manual weed control keeps the furrows clear, though to avoid disturbance of the potato plants, the ridges are often left substantially unweeded. Weed species then show the same distribution as the potatoes. Later, as the crop smothers its competing weeds and weed control is discontinued, it may well be that late-germinating species are distributed mainly along the furrows.

The ridge and furrow system of potato and bulb-fields is the largest scale of obvious pattern that has been encountered and the sampling size of $4m^2$ is large enough to include both ridges and furrows. In other crops the pattern is much finer and usually has no readily observable effect on weed distributions. There has been no observed tendency, for example, for any species of weed to follow or avoid

the line of the drill in cereals. This does not mean that no such distribution exists, but no distribution is observable without statistical analysis. The sampling size is large enough to avoid the effects of quadrat size discussed by Goodall (1961) and Byer (1970).

There appears to be very little published work on pattern in arable communities. Visually, most weed species appear to be distributed at random. Naturally species spreading vegetatively are not distributed at random, though only a few species, e.g. Agrostis gigantea, A. stolonifera, Sonchus arvensis, form large dense patches in spite of cultivations. Indian work shows that species of high density are not randomly distributed (Singh and Chalam, 1937), while most other species show some degree of aggregation when analysed by relative variance, even when this non-randomness is too slight to be detected using the Poisson series (Singh and Das, 1938, 1939).

It is a problem with all phytosociological work that communities present a different appearance at different times of year. This may be merely physiognomic, with individual species becoming more conspicuous at certain seasons as they flower, or it may be due to changes in quantity of the different species through the year, or it may even be due to qualitative differences. This often means that for a full aufnahme of any site, it ought to be visited more than once.

In woodland, for example, there may be an early spring profusion of snowdrops, followed by later growth of Mercurialis perennis and Ranunculus ficaria, the typical "spring flora", followed by the growth of nettles and various grasses in the early summer. An ecologist surveying the site in the summer, when the vegetation reaches maximum development, might very well feel very satisfied at finding the last remains of Ranunculus ficaria. He would have no inkling that he was missing the snowdrops altogether, a plant with very nearly 100 per cent cover in his woodland site.

In the open vegetation of an arable field, composed of species with short life-cycles, it follows that the same situation could arise. In fact it almost certainly does. One of the common arable mosses, Pottia truncata, has a very short life-span, occurs as isolated individuals, and germinates and grows mainly in the winter months. Except where there are damp patches in the fields, or when there has been prolonged wet weather, this moss is probably missed during summer recording, even when other immature bryophytes are recognised.

As the syntaxonomy of arable vegetation is based on the higher plants, missing a few mosses probably does not influence results

to any great extent. However, a number of higher plant "spring ephemerals" are known to occur in arable fields and there must presumably be a danger of missing them during summer recording. Certainly this appears to be the case in Eastern Europe, for example Wiedenroth (1960) describes a spring aspect of a community with Erophila verna, Myosotis stricta, Holosteum umbellatum and Arabidopsis thaliana, while Timar (1954) describes spring and summer aspects differing substantially in species content for some Hungarian communities. In a special study of the seasonal succession of species on an area of arable land, Ubrizsy (1955) cites Veronica hederifolia, V. triphyllos, V. arvensis and Holosteum umbellatum as the most striking of the spring species which have disappeared by the end of June. In the same fields, Ubrizsy notes the summer appearance of species such as Ajuga chamaepitys, Misopates orontium and Kickxia spuria. Further west, Häfliger and Brun-Hool (1971) provide an outstanding series of photographs showing the dramatic changes in the course of a month on a plot in winter wheat in Switzerland.

The seasonality of weed floras is recognised by continental workers who have used the Z-M system. Realising that an autumn-sown crop may contain winter annuals which would be largely absent from a spring-sown crop, they have based the syntaxonomy of weed communities on winter crops. On this basis, West European arable weed communities are split into the orders Centauretalia and Polygono-Chenopodietalia, often recognised as separate classes (see Sect. 6.3). Theoretically the Centauretalia is characterised by winter annuals and is the order of winter cereals. Polygono-Chenopodietalia species germinate mainly in the spring and early summer and thus cannot colonise established winter cereals but can grow in root crops and spring cereals. Some appear to be particularly well adapted for late growth in mature spring cereals; Aspinall and Milthorpe (1959) have shown

that the major growth period of Polygonum lapathifolium corresponds with the decline in leaf area and root growth in barley as the crop ripens. Polygono - Chenopodietalia spp. are often dominant in stubble.

With this dependence of the weed flora on the crop, there may not be just seasonal variation but an alternation of weed communities with arable rotations. Thus Sychowa (1959) describes the alternation of the association Papaveretum argemonis in rye or oats with Echinochloo - Setarietum in potatoes. It could be argued that this is an extreme form of aspect with alternating phases of one weed community. Barkman (1973) criticises Oberdorfer's (1954a) account of Balkan weed communities from the same viewpoint, regarding the associations as synusiae. However, as already discussed (Sect. 1.3), weed communities seem remarkably stable in Britain, and much more independent of the crop.

Thus the foregoing discusses the position in Europe, but it would be incorrect to assume that British weed communities show the same phenomena to the same extent. Stapledon (1910) kept careful observations on a plot of winter wheat in the Cotswolds and while there was a conspicuous growth of Veronica hederifolia s.l. early in the year, this was still relatively abundant when the community reached its full development in June and disappeared only as the crop smothered most weeds in July. Newman and Newman (1918) made very detailed observations on a number of fields on boulder clay in East Anglia and again they recorded no spring ephemeral species, though Sinapis arvensis, Silene alba and Ranunculus arvensis declined rather more rapidly than other species before harvest.

If any part of Britain was to be marked by spring ephemerals in its fields, it would be the Brecklands of East Anglia. Fully described in Section 7.3, the area is famous for its spring ephemeral flora. However, even in the Brecklands, the predominant crop of

spring barley is largely free of these species. Areas where the Arabidopsidion ephemeral community is developed are dry and largely bare in the summer months, while in April and May, most arable fields contain only seedlings of the summer weeds. Only Arabidopsis thaliana and the rare Veronica praecox seem to be part of an unrecognised spring aspect of summer communities. Other species typical of the Arabidopsidion which occur in summer crops, e.g. Veronica arvensis, V. triphyllus, persist in these crops long after the ephemeral communities have died down.

It would seem, therefore, that the aufnahmen presented here are reasonably complete. A few species, e.g. Arabidopsis thaliana, Cardamine hirsuta, Veronica hederifolia ssp. lucorum and, in the south west of England and Wales, Ranunculus parviflorus, may have died down completely and been missed but the effect of this will have been small. Such omissions will not have altered the status of the Arabidopsidion, Cardaminetum hirsutae, Veronica sublobata - Comm. or the Medicagini - Ranunculetum parviflori.

Nevertheless, it should be borne in mind that different species characteristically germinate at different times. General reviews are provided by Brenchley and Warington (1930; 1933); Chepil (1946a) and Salisbury (1961). Most species show two peaks of germination, one in autumn and a more substantial peak in the spring. Typically autumn germinating species include Aphanes arvensis, Avena ludoviciana and Legousia hybrida, while the ability of Allium vineale to germinate from bulbils in the autumn and continue to grow right through the winter makes it a serious weed of winter wheat in some areas (Lazenby, 1960). Polygonum spp. germinate in the spring, while Kickxia spp. may not germinate until the early summer. However, in Britain, the maritime influence on the climate extends the periods over which weed species may germinate (Naylor, 1972a) and populations may contain

substantial age ranges. Moreover, species whose dormancy is broken by such factors as soil microbial activity or leaching of a soluble germination inhibitor may germinate sporadically at any time (Harper, 1957a).

In view of the unpredictability of arable conditions, germination in many weed species is particularly complex. Dormancy is often under genetic control and species may show genetic polymorphism, producing two or more types of seed which germinate under different conditions. Common examples include Chenopodium album (Williams and Harper, 1965), Rumex crispus and R. obtusifolius (Cavers and Harper, 1966), Avena fatua and Atriplex hastata (Chepil, op. cit.). Regular application of post-emergence herbicides on a chosen date each season may also result in evolution of later-germinating strains (Harper, 1956).

This overall uncertainty of germination of different weed species has an important implication for the study of arable weed communities. While the effects of aspect as such in Britain have been virtually discounted above, it is difficult to be so complacent about the seeds in the soil which have not germinated at all. It could be quite justifiably claimed that an aufnahme is no more than a list of species which have germinated in the previous months, and as such is a result of the weather over that period as much as of edaphic factors. The only defence to this is that weed communities based on aufnahmen collected in one season do really seem to exist.

No discussion of aspect in weed communities should entirely neglect mid-winter vegetation. No data is presented here, but winter root crops are often choked with weeds. Lawson (1972) describes a winter community dominated by Poa annua which is replaced in the early spring by dominance of Stellaria media. These two species plus Capsella bursa-pastoris, Lamium purpureum, Senecio vulgaris

and Veronica persica are very typical of winter weed vegetation on a variety of soils, and are known to be able to continue growth by maintenance of high sugar levels in the cell sap, thus providing frost resistance. However, Woodruffe-Peacock (1912) ascribed the particular success of Poa annua and Senecio vulgaris in mid-winter to their ability to grow under very poor light conditions. In view of the high light requirement of many arable weed species, this aspect should not be overlooked.

4.4 Association and interaction of weeds with crops

4.4.1 As discussed in previous sections, the crop plays an important part in determining the composition of the accompanying weed flora. In the atlantic fringe of Europe this effect is apparently less than in continental Europe, and will often not alter the syntaxonomic name given to the community, but nevertheless it is undoubtedly true that the nature of the crop will have beneficial or adverse effects on the occurrence or abundance of individual weed species.

Crop - weed interactions may be a direct interaction between the crop species and the weed species, or more often the preparation of the ground for a particular crop will affect the weed flora so causing indirect interactions.

Direct positive association arises in case of parasitism. There have been relatively few higher plant parasites of arable crops in Britain, Odontites verna, Melampyrum arvense and Rhinanthus serotina on cereals, Orobanche ramosa on hemp and tobacco, O. minor on clover and Cuscuta spp. on clover and flax. Odontites verna is still a frequent, though unimportant weed of cereal crops, but the other species are now extinct or surviving only in non-arable habitats. Nevertheless, Cuscuta spp. were locally abundant in the past and R. serotina was sometimes dominant in barley (Anon., 1923; Brenchley, 1913b).

Less obvious but probably of much greater importance are allelopathic interactions. Crops producing toxins, e.g. onions, could result in negative associations with particular weed species, while where the weed produces the toxin it could depress the yield of particular crops, so resulting in positive association between weed and crop. Thus Camelina spp. are well known associates of flax and Grummer and Beyer (1960) have shown that Camelina produces water-

soluble phenolic compounds from the leaves which considerably reduce crop yields. Decaying rhizomes of Agropyron repens inhibit the growth of rape seedlings (Welbank, 1960) and of lettuce (B. Boag - unpublished data) and this may well be one reason for the success of this weed species. Martin and Rademacher (1960) put forward evidence to suggest that Polygonum persicaria has an allelopathic effect on potatoes and flax. They also showed that the poor growth of Sinapis arvensis and Papaver rhoeas in oats and of S. arvensis and Tripleurospermum inodorum in rye was almost certainly a result of root exudates from these crops.

It is possible that even seeds may inhibit the germination of other species. Evenari (1949) cites some possible examples, including a marked suppression of germination and seedling development in Agrostemma githago when treated with beet-seed extract. A. githago is a species which has perhaps never been fully established in Britain; though formerly sometimes abundant when introduced with foreign rye-seed, its lack of seed dormancy and inability to grow in the root crop phase of arable rotations has meant that it has always been of uncertain occurrence. The failure of other mediterranean weeds lacking dormancy to establish themselves in Britain may partly be due to the same effect, though Harper (1957a) treats this evidence with caution. Rice (1974) reviews further possible cases and it would seem likely that this will prove a widespread phenomenon.

4.4.2 In theory it should be possible to list the weed species positively or negatively associated with each crop. However, a survey of the literature shows that there is little agreement between areas, between workers or even between different data sets of the same worker. Most observations have been incidental to other work, unsupported by statistical treatment and very often concerned with

presence or absence on whole fields rather than abundance.

Species said to be associated generally with cereals, as distinct from root crops or seed crops, have been said to include Anthemis cotula, Sinapis alba, S. arvensis, Centaurea nigra, C. cyanus, Poa annua, P. trivialis, Legousia hybrida, Lamium amplexicaule, Lapsana communis, Potentilla reptans, Ranunculus arvensis, R. repens, Anagallis arvensis, Papaver rhoeas, Plantago major, Bilderdykia convolvulus, Veronica agrestis, V. arvensis, Scandix pecten-veneris, Scleranthus annuus, Polygonum aviculare, P. persicaria, P. amphibium, Cirsium arvense, Apera spica-venti, Viola arvensis, Vicia hirsuta, Conyza canadensis, Rumex acetosella, Trifolium arvense, T. repens, Achillea millefolium, Sonchus arvensis, Tussilago farfara, Stellaria media, Spergula arvensis, Raphanus raphanistrum, Tripleurospermum inodorum, Bromus arvensis, Agrostemma githago, Myosotis arvensis, Stachys palustris, Juncus bufonius, Medicago lupulina, Silene noctiflora and Euphorbia helioscopia (Brenchley, 1911, 1912, 1920; Borowiec, Grinn and Kutyna, 1972).

Any weed species associated primarily with root or seed crops could automatically be regarded as being negatively associated with cereals, but Brenchley (1920) specifically cites Geranium molle and Plantago lanceolata as occurring substantially less often in cereals.

As described in Section 4.3, weed species can be classified according to their germination behaviour and so many of these species could, perhaps, be more precisely correlated with winter or spring cereals. However, relatively few species have been classified thus; those said to be generally characteristic of winter cereals include Avena ludoviciana, Delphinium amiguum and Lithospermum arvense (Thurston, 1954; Hanf, n.d.) and those cited for spring cereals are Raphanus raphanistrum, Sinapis arvensis, Spergula arvensis and Bilderdykia convolvulus (Hanf., op. cit.).

Species associated with wheat include Agrostis stolonifera, Odontites verna, Cerastium fontanum, Myosotis arvensis, Poa annua, Ranunculus arvensis, Veronica arvensis, V. hederifolia (agg.), Alopecurus myosuroides, Arenaria serpyllifolia (agg.), Galium aparine and Avena fatua (Brenchley, 1920; Brenchley and Warrington, 1930; Pavlychenko and Harrington, 1934). More specifically cited for winter wheat are Aphanes arvensis (agg.), Juncus bufonius, Legousia hybrida, Papaver spp., Tripleurospermum inodorum, Vicia hirsuta, Viola arvensis, and Allium vineale (Brenchley and Warrington, 1933; Lazenby, 1960), though it is likely that the majority of species associated with wheat are really associated with winter wheat as compared with spring barley. Brenchley (1920) quotes Chenopodium album and Spergula arvensis as relatively less frequent in wheat.

Apart from the difference in drilling time of the average crop, barley differs from wheat in being a more efficient competitor. It makes earlier, denser growth than spring wheat (Cussans, 1968) and has much superior root development (Pavlychenko and Harrington, 1935). Farmers often regard it as a smother crop, eventually killing the weeds which germinated during the preceding cultivation. It follows that not all species that grow in other cereals can show the same degree of association with barley. Species recorded as being associated with barley include Chenopodium album, Euphorbia helioscopia, Silene vulgaris, Veronica polita, Capsella bursa-pastoris, Spergula arvensis, Lamium amplexicaule and Thlaspi arvense (Brenchley, 1920; Brenchley and Warrington, 1930; Pavlychenko and Harrington, 1934). While virtually all barley in Britain is spring barley, weeds cited particularly for spring barley include Gnaphalium uliginosum, Polygonum aviculare, Bilderdykia convolvulus, Senecio vulgaris, Stellaria media and Veronica persica (Brenchley and Warrington, 1933). Additionally, Broad (1952) gives Raphanus raphanistrum, Polygonum

persicaria and Convolvulus arvensis as being particularly characteristic impurities in commercial barley-seed, though it must be remembered that impurities in crop-seed will not be all those weeds in the original crop, but merely those that are sufficiently similar in seed or fruit size to the crop to survive cleaning operations.

Species said to be generally less frequent in barley include Veronica arvensis, Aphanes arvensis (agg.), Agropyron repens, Tripleurospermum inodorum, Sherardia arvensis, Sinapis arvensis and Chenopodium album (Brenchley, 1920; Pavlychenko and Harrington, 1934); it is interesting to note that different workers have reached opposite opinions regarding Chenopodium album.

Oats have relatively few named associates, Spergula arvensis, Rumex acetosella, Avena fatua and, at least in Canada, Amaranthus retroflexus (Brenchley, 1920; Pavlychenko and Harrington, 1934). As characteristic seed impurities, Broad (op. cit.) also lists Polygonum persicaria, Vicia hirsuta and Galeopsis tetrahit. Brenchley (1920) lists Geranium molle and Veronica arvensis as less frequent in oats. Although phytosociological literature has not been included in this review, it is worth noting that Pignatti (1957) considers the weed stands of oatfields to be more difficult to classify than those of wheat and rye. The syntaxonomy of weed communities is based primarily on those of wheat, barley and the major root-crops, so perhaps it is not surprising that oatfield phytocoenoses do not fit in to this classification so readily.

Rye is rarely grown in Britain and has generally not figured in agricultural surveys, though Agrostemma githago is an often quoted case of a species characteristic of rye throughout Europe. In addition to the expected A. githago, Broad (op. cit.) gives a number of common impurities in rye-seed, of which Vicia hirsuta, V. angustifolia, Agropyron repens and Tripleurospermum inodorum are most noteworthy

in comparison with other cereals.

Z-M phytosociological tradition regards all character and differential species of the order Polygono - Chenopodietalia as being generally characteristic of root-crops, though this is not so evident in the agronomic literature. Weeds regarded as being favoured by root-crops include Plantago major, P. media, Fumaria officinalis, Chenopodium album, Achillea millefolium, Polygonum * nodosum, P. minus (according to Polish work, hardly a typical arable weed in Britain), P. amphibium, Equisetum arvense, Cirsium arvense, Capsella bursa-pastoris, Taraxacum officinale, Stachys palustris, Ranunculus repens, Galinsoga parviflora, Sinapis arvensis, Viola arvensis, Raphanus raphanistrum, Thlaspi arvense, Scleranthus annuus, Echinochloa crus-galli and Agropyron repens (Roberts, 1958; Borowiec, Grinn and Kutyna, 1972). Those species which grow poorly in root-crops include Anagallis arvensis, Odontites verna, Sinapis alba, Cerastium fontanum, C. glomeratum, Euphorbia exigua, Papaver rhoeas, Silene alba, Plantago major, Ranunculus repens, Tussilago farfara, Viola "tricolor" (probably V. arvensis), Tripleurospermum inodorum, Scandix pecten-veneris, Bilderdykia convolvulus, Rumex crispus, Trifolium pratense, T. arvensis and Veronica arvensis (Brenchley, 1920; Roberts, 1958, 1962). Contradictions between different workers will again be readily apparent.

Most of the major root and other vegetable crops appear to support similar weed floras. However, Brenchley (1920) regards Alopecurus myosuroides and Ranunculus arvensis as particularly characteristic of peas and beans, while she gave Centaurea nigra, Euphorbia helioscopia, Potentilla anserina, Knautia arvensis, Silene vulgaris, Taraxacum officinale and Fumaria officinalis as being rare in these two crops.

The final major group of crops to be considered are those classified

as seed-crops, primarily legumes such as clover and lucerne, though first year grass leys may also be included in the term. Well grown fields of lucerne or clover are often almost weed-free, the fragmentary communities within the crop not being suitable for phytosociological analysis separately from the crop species. Consequently, few such fields have been investigated in the present survey. However, since clover species are often undersown into cereals and since such fields have been included in the survey, it is relevant to consider those species said to be associated with seed crops. They comprise Arenaria serpyllifolia (agg.), Cerastium fontanum, Geranium columbinum, G. molle, G. dissectum, G. pusillum, Sherardia arvensis, Anthemis arvensis, Daucus carota, Silene alba, Plantago lanceolata, Viola "tricolor", Carduus nutans, Cirsium vulgare, Filago vulgaris and Reseda lutea (Brenchley, 1912, 1920). Additionally, Broad's (1952) data shows the following weed species to be particularly characteristic impurities of commercial legume seed: Prunella vulgaris, Plantago major, Holcus lanatus, Rumex acetosella, R. crispus, Alopecurus myosuroides, Ranunculus repens, Melilotus spp., Anthemis cotula, Silene dichotoma, Picris echioides, Setaria viridis, Vicia hirsuta and Poterium muricatum. Such seed is, of course, of foreign origin and modern seed is much cleaner and only very rarely contains the exotic species included here.

As would be expected, other weed species are rare or absent in fields of legumes, including Agropyron repens, Agrostis spp., Atriplex patula, Chenopodium album, Equisetum arvense, Galium aparine, Lamium purpureum, Mentha arvensis, Poa annua, Polygonum aviculare, P. persicaria, Bilderdykia convolvulus, Sinapis arvensis, Spergula arvensis, Stellaria media, Veronica hederifolia (agg.) and V. perisca (Brenchley, 1920; Fogg, 1950).

Interestingly, it would appear that some species are characteristic of both seed crops and wheat, in comparison with other crops.

Brenchley (1920) cites Aphanes arvensis (agg.), Arenaria serpyllifolia (agg.), Cerastium fontanum, Myosotis arvensis and Veronica arvensis.

Plant nurseries often contain interesting assemblages of weed species. It is even less possible to generalise regarding typical weed species of nurseries than it is for normal arable crops, though a few species, e.g. Spergula arvensis, Urtica urens and Galinsoga parviflora, now seem fairly standard in the nurseries on sandy soils in south and east England. Cox (1973) lists the following weeds as problems at Notcutts shrubbery nurseries in Suffolk, on land regularly treated with simazine: Urtica urens, Sinapis arvensis, Sonchus arvensis, Polygonum spp., Sherardia arvensis, Galium aparine, Veronica spp., Cirsium arvense, Equisetum arvense, Rorippa sylvestris, Carex spp., Agropyron repens, Convolvulus arvensis, Tussilago farfara and Heracleum sphondylium.

Ideally, there should remain a set of species which are of more or less equal frequency and abundance in all crops, these being, perhaps, the class character-species of the Stellarietea plus the more ubiquitous companion species. Brenchley (1920) lists several of these "indifferent" species: Sinapis arvensis, Capsella bursa-pastoris, Cirsium arvense, Convolvulus arvensis, Linaria vulgaris, Rumex acetosella, R. crispus, Senecio vulgaris, Sonchus arvensis and Veronica agrestis. However, most of these species have been cited in one or other connection above, and Brenchley herself pointed out that they varied in abundance according to the crop, her figures referring to frequencies in lists from entire fields.

4.4.3 It is evident, then, that association between most weeds and most crops is of a very flexible nature. In a few cases, it is possible to cite with reasonable accuracy the weeds associated

with particular crops, these being cases where a set of fields in the same locality and on the same soil-type have each carried a particular crop for several successive years. Differences between their weed floras can then be related to the crops, though even then, the factors which determine the differences in the weed floras are likely to be tillage, fertilizer and herbicide effects as much as any intrinsic characteristics of the crop species themselves. However, opportunities for comparisons of this sort are largely confined to experimental stations such as Rothamsted and Woburn, from which Brenchley drew many of her conclusions. More general surveys immediately encounter the problem that crops themselves are not distributed at random.

These problems are clearly shown by data extracted from the present survey and presented in Tables 17 to 21. Analyses of association between weed species in specified areas were enlarged to incorporate crops and other factors amenable to chi-squared analysis. Thus data is available on crop - weed associations in Dorset (Tab. 17), where a diverse geology is present in a relatively small area, in the Lower Greensand and Bagshot Sands areas of southern England (Tab. 18), with relatively little edaphic variation but more geographically diverse, and the Brecklands (Tab. 19), which are both edaphically and geographically restricted. Table 20, presenting results from the Outer Hebrides, is based on too little data to produce much useful information, but does contain two unusual crops. Table 21 is an excellent example of how not to apply statistics, but throws an interesting light on the preferences of some bryophyte species.

Table 17 contains, for example, lists of associated species with wheat and barley, and compares with published results quoted in Section 4.4.2. However, it is clear that the differences between

the wheat and barley floras are primarily edaphic. In Dorset, wheat is grown mainly on the heavy clay soils of the Kimmeridge Clay and similar formations whereas barley is grown on the lighter sandy or chalky soils. The associated species are those typical of such soils. In Table 18, wheat is shown to be associated with various grass species; here the explanation is likely to be the effects of selective herbicides, ploughing of grassland for wheat growing in marginal arable areas, or a combination of these two factors.

The association of bryophyte species with wheat, as shown in Tables 17 and 21, is interesting. Again this is most likely to be due to the practice of sowing wheat on heavy ground, the poor drainage suiting bryophytes such as Phascum cuspidatum, Bryum rubens and Pottia spp. However, as winter cereals would provide a longer period for growth and a more sheltered and stable environment during the winter itself, it might be expected that winter wheat would contain a richer bryophyte flora than spring barley during the summer months. Very often barley seems to contain nothing more than small quantities of Bryum rubens, which presumably can develop rapidly in the early summer from its rhizoidal gemmae. Table 21 shows another effect of the edaphic preferences of the crop plant. Wheat is particularly suited for growth on immature chalk soils and thus the group of calcicolous species, Bryum klinggraeffii, Dicranella varia, Phascum floerkeanum and Pottia starkeana agg. (i.e. P. davalliana) are shown as associated with wheat.

It is noteworthy that Table 18 does not show this association of bryophytes with wheat. On the rather uniform, base-poor soils, wheat and barley are grown under much more similar conditions, and it is barley which appears to be more suited to bryophytes.

The necessity for very careful interpretation of all data on crop - weed associations is shown most clearly by the case of Funaria

Table 17 Association of weed species with particular crops: 1

Dorset

(Total No. of Quadrats = 114; Total No. of Species in Analysis = 87)

Crop	No. of Quadrats (Crop)	Type of Association	Weed Species	Significance Level (χ^2 with Yates' Correction)
Wheat	39	Positive	Poa trivialis	***
			Phascum cuspidatum	***
			Agrostis stolonifera	**
			Lolium * multiflorum	**
			Prunella vulgaris	**
			Bryum rubens	**
			Pottia intermedia	**
			Arrhenatherum elatius	*
			Dactylis glomerata	*
			Geranium dissectum	*
			Holcus lanatus	*
			Barbula unguiculata	*
			Bryum erythrocarpum agg.	*
		Negative	Capsella bursa-pastoris	*

N.B. In this and succeeding tables, significance levels are represented by asterisks according to the convention that *** represents $P \leq 0.001$, ** represents $P \leq 0.01$ and * represents $P \leq 0.05$.

Table 17 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Oats	6	Positive	NONE	
		Negative	NONE	
2-rowed barley	54	Positive	Atriplex patula	*
			Euphorbia exigua	*
			Sonchus arvensis	*
		Negative	Agrostis stolonifera	*
			Juncus bufonius	*
			Lolium * multiflorum	*
			Phascum cuspidatum	**
Cereals (general)	101	Positive	Poa trivialis	**
			Bryum erythrocarpum agg.	*
		Negative	Atriplex hastata	*
			Solanum nigrum	*
			Spergula arvensis	**
			Capsella bursa-pastoris	***
			Chenopodium album	***
			Polygonum * lapathifolium	***
			Senecio vulgaris	***

Table 17 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Root Crops (general)	9	Positive	Senecio vulgaris	***
			Capsella bursa-pastoris	**
			Chenopodium album	**
			Sinapis arvensis	**
			Atriplex hastata	*
			Sonchus asper	*
		Negative	Agrostis stolonifera	*
			Poa trivialis	*

Table 18 Association of weed species with particular crops: 2

Lower Greensand + Bagshot Sands

(Total No. of Quadrats = 96; Total No. of Species in Analysis = 94)

Arable fields on these two formations in southern England. Soils mostly base-poor and sandy. This analysis includes occurrences of weed species outside but adjacent to the 4m² quadrats.

Crop	No. of Quadrats (Crop)	Type of Association	Weed Species	Significance Level (X ² with Yates' Correction)
Wheat	13	Positive	Avena fatua	***
			Lolium * multiflorum	***
			Phleum pratense	***
			Poa trivialis	***
			Agropyron repens	**
			Chrysanthemum segetum	**
			Cirsium arvense	**
			Lolium * perenne	**
			Ranunculus repens	**
			Dactylis glomerata	*
			Tripleurospermum inodorum	*
		Negative	Senecio vulgaris	***
Barley (all 2-rowed)	26	Positive	Bryum rubens	**
			Dicranella staphylina	**

Table 18 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Barley (Cont.)		Positive	Artemisia vulgaris	*
			Polygonum aviculare	*
			Barbula convoluta	*
			Bryum micro-erythrocarpum	*
			Phascum cuspidatum	*
		Negative	Chenopodium album	*
			Lamium amplexicaule	*
			Rumex acetosella	**
			Senecio vulgaris	**
			Solanum nigrum	**
			Urtica urens	**
			Capsella bursa-pastoris	***
Shrubs (Nurseries)	7	Positive	Holcus mollis	**
			Ornithopus perpusillus	**
			Papaver dubium	**
			Rumex acetosella	**
			Erodium * cicutarium	*
		Negative	NONE	
Cabbages	6	Positive	Capsella bursa-pastoris	*
			Senecio vulgaris	*
			Urtica urens	*

Table 18 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Cabbages (Cont.)		Negative	NONE	
Cereals (general)	42	Positive	Agropyron repens	***
			Bryum rubens	***
			Dicranella staphylina	***
			Anagallis arvensis	**
			Chrysanthemum segetum	**
			Poa trivialis	**
			Polygonum aviculare	**
			Tripleurospermum inodorum	**
			Agrostis stolonifera	*
			Avena fatua	*
			Dactylis glomerata	*
			Phleum pratense	*
			Phasium cuspidatum	*
			Pleuridium subulatum	*
			Pottia intermedia	*
			Riccia sorocarpa	*
		Negative	Chenopodium album	*
			Ornithopus perpusillus	*
			Lamium amplexicaule	**
			Capsella bursa-pastoris	***
			Rumex acetosella	***
			Senecio vulgaris	***
			Urtica urens	***

Table 18 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Root Crops	27	Positive	Senecio vulgaris	***
			Urtica urens	***
			Capsella bursa-pastoris	**
			Galinsoga parviflora	**
			Chenopodium album	*
			Sinapis arvensis	*
			Solanum nigrum	*
		Negative	Chrysanthemum segetum	*
			Lolium * perenne	*
			Lycopsis arvensis	*
			Poa trivialis	*
Fallow	13	Positive	Rumex acetosella	***
			Equisetum arvense	**
			Anisantha sterilis	*
			Raphanus raphanistrum	*
			Rumex crispus	*
			Spergula arvensis	*
			Vicia * angustifolia	*
		Negative	Bryum rubens	*

Table 19 Association of weed species with particular crops: 3

The Brecklands

(Total No. of Quadrats = 48; Total No. of Species in Analysis = 60)

Crop	No. of Quadrats (Crop)	Type of Association	Weed Species	Significance Level (χ^2 with <u>Yates' Correction</u>)
2-rowed Barley	17	Positive	Anthemis arvensis	**
			Linaria vulgaris	**
			Lycopsis arvensis	**
			Bilderdykia convolvulus	*
			Dactylis glomerata	*
			Papaver rhoeas	*
			Polygonum aviculare	*
			Silene noctiflora	*
			Viola arvensis	*
Carrots	5	Negative	NONE	
		Positive	Senecio vulgaris	*
		Negative	NONE	
Beet	7	Positive	Solanum nigrum	**
			Spergula arvensis	*
		Negative	NONE	

Table 19 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Lucerne	5	Positive	Achillea millefolium	**
			Linaria vulgaris	*
			Reseda lutea	*
			Silene alba	*
		Negative	NONE	
Cereals (general)	19	Positive	Anthemis arvensis	*
			Linaria vulgaris	*
			Lycopsis arvensis	*
			Papaver rhoeas	*
		Negative	NONE	
Root Crops (general)	15	Positive	Solanum nigrum	*
		Negative	NONE	
Fallow	13	Positive	Cerastium semidecandrum	***
			Myosotis ramosissima	**
			Saxifraga tridactylites	**
			Rumex tenuifolius	*
			Sedum acre	*
			Veronica arvensis	*
		Negative	Polygonum aviculare	**

Table 20 Association of weed species with particular crops: 4

The Outer Hebrides

(Total No. of Quadrats = 24; Total No. of Species in Analysis = 37)

A small amount of rather uniform data from N. and S. Uist and Benbecula. Mainly from cultivated machair, where black oats (*Avena strigosa*) are a crop in some fields and a weed in others. The two cereals, rye and black oats, are often grown together.

Crop	No. of Quadrats (Crop)	Type of Association	Weed Species	Significance Level (χ^2 with Yates' Correction)
Rye	11	Positive	<i>Agrostis tenuis</i>	*
			<i>Avena strigosa</i>	*
			<i>Erodium * cicutarium</i>	*
		Negative	<i>Chrysanthemum segetum</i>	*
Black Oats	5	Positive	NONE	
		Negative	NONE	
Potatoes	5	Positive	NONE	
		Negative	NONE	
Cereals (general)	15	Positive	NONE	
		Negative	NONE	
Root Crops (general)	7	Positive	NONE	
		Negative	<i>Cerastium fontanum</i>	*

Table 21 Association of weed species with particular crops: 5

Arable Bryophytes

(Total No. of Quadrats = 184; Total No. of Species in Analysis = 26)

The data of Tab. LXXXI, consisting of extracted bryophyte lists from all arable aufnahmen containing at least two species. Thus comparisons made here concern only those fields already containing bryophytes and apparent negative associations with some crops could well be positive if all fields had been included. Species rarely occurring in barley in comparison with wheat are probably strongly associated with barley in comparison with root crops. The results presented below are a by-product of the community analysis of arable bryophytes and must be interpreted with caution.

Crop	No. of Quadrats (Crop)	Type of Association	Weed Species	Significance Level (χ^2 with Yates' Correction)
Wheat	36	Positive	Barbula unguiculata	***
			Bryum klinggraeffii	**
			Dicranella schreberana	**
			D. varia	**
			Phascum cuspidatum	**
			Pottia intermedia	**
			Phascum floerkeanum	*
			Pottia starkeana agg.	*
		Negative	NONE	

Table 21 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
2-rowed Barley	62	Positive	NONE	
		Negative	Brachythecium rutabulum	*
			Dicranella schreberana	*
			Weissia rutilans	*
			Ceratodon purpureus	**
Oats	11	Positive	Brachythecium rutabulum	*
			Eurhynchium praelongum	*
			Pleuridium subulatum	*
Black Oats	5	Negative	NONE	
		Positive	Funaria fascicularis	***
			Brachythecium rutabulum	*
Bulbs	30	Positive	NONE	
			Bryum bicolor	*
			Ditrichum cylindricum	*
			Riccia sorocarpa	*
			Weissia rutilans	*
		Negative	Bryum klinggraeffii	*
			Barbula unguiculata	**

Table 21 (Cont.)

<u>Crop</u>	<u>No. of Quadrats</u>	<u>Type of Association</u>	<u>Weed Species</u>	<u>Significance Level</u>
Shrubs (Nurseries)	7	Positive	Ceratodon purpureus	***
		Negative	NONE	
Rye-grass (Under-crop)	5	Positive	NONE	
		Negative	NONE	
Fallow	20	Positive	Bryum argenteum v. lanatum	**
			Ceratodon purpureus	*
			Riccia sorocarpa	*
		Negative	NONE	

fascicularis in black oats (Tab. 21). F. fascicularis is a generally rare arable species which, in the author's experience, is pronouncedly western in its distribution. Thus in the Hebrides its distribution coincides with the area in which black oats are still grown as a crop. The highly significant association between the two is, then, almost certainly explicable purely on geographical grounds. However, all three Hebridean records given here are from fields of black oats, the moss not having been encountered in fields of pure rye, so it would be wrong to reject this result without further information.

Overall, the results given here correspond, at least in part, to the results of other workers. However, it is clear that careful observations using statistically acceptable recording programmes are needed before precise conclusions can be drawn. It does seem that some individual species show fairly predictable distributions with regard to different crops but consideration of communities rather than species appears to be more generally useful. Tables 17 to 19 show well the more typical species of the order Polygono_-_-Chenopodietalia, i.e. Senecio vulgaris, Chenopodium album, Solanum nigrum, Urtica urens, Capsella bursa-pastoris, Polygonum * lapathifolium, Atriplex hastata, Lamium amplexicaule and Galinsoga parviflora, as being generally associated with root crops.

4.4.4 The obvious approach to elucidating crop - weed interactions is to grow crops and their weeds together under experimental conditions. Many such studies have been carried out, but it is always difficult to extrapolate experimental results under artificial conditions to natural field situations. Thus Welbank (1963) grew a number of common weed species and was able to list the most efficient competitors with Kale and with wheat, but the results from one set of pot cultures are unlikely to remain constant on different soils

and in different microclimates. Nevertheless, by an understanding of the nature of crop - weed competition it is possible to visualise some of the weed species which could occur in a particular crop under particular conditions.

Although arable fields give the appearance of open vegetation, competition is often for rooting space (Pavlychenko and Harrington, 1934, 1935), with the species attaining the greatest total root length being likely to be the most efficient in taking up water and nutrients. For example, Pavlychenko and Harrington (1935) found that, on one soil at least, two-rowed barley has up to ten times the total root length of Avena fatua, which in turn has four times the root length of wheat. A. fatua was found to seriously affect wheat yields, but had relatively little effect on barley. Aspinall (1960) found that the well-developed root system of barley retarded the growth of Polygonum lapathifolium until the crop was sufficiently well grown to eliminate P. lapathifolium by shading. Addition of nutrients benefited P. lapathifolium in barley. However, Mann and Barnes (1950) noted that even on acidic Lower Greensand soils, Stellaria media competed very effectively with barley, being virtually unaffected in sparsely planted barley, while the crop yield could be reduced to only ten per cent of its growth in the absence of S. media.

A nutrient much quoted in competition studies is nitrogen. Mann and Barnes (1945) found that on Lower Greensand soils, barley obtained 75 per cent of the available nitrogen when in competition with substantial amounts of Spergula arvensis and Tripleurospermum inodorum, while Blackman and Templeman (1938) found that Sinapis arvensis and Chrysanthemum segetum competed successfully with barley for nitrogen. Fogg (1950) noted that addition of nitrogenous fertilizer was sometimes a cheaper alternative to eradicating Sinapis

arvensis. On the other hand, Welbank (1963) found that added nitrogen increased the effect on crop yields when Sinapis arvensis was grown in competition with Kale, and Chenopodium album with wheat. Naylor (1972b) found that winter wheat suppressed Alopecurus myosuroides more effectively at higher nitrogen levels, suggesting that in this case, A. myosuroides is more efficient at taking up nitrogen than is the crop when nitrogen is limiting. Significantly, perhaps, another grass, Holcus mollis, seems to be one of the few weeds which is superior to barley in ability to utilize nitrogen (Mann and Barnes, 1947).

Just as weed species normally reduce crop yields, so do crops normally adversely affect weed growth. Anagallis arvensis is an exception, when grown with Kale or wheat it was found not to interact with the crops due to its superficial root-growth (Welbank, op. cit.).

Competition for nitrogen thus ties in with the syntaxonomy of weed communities. Cereals are efficient in their use of available nitrogen and do not require large amounts of added nitrogenous fertiliser. Thus the weed species that occur in cereals are those with low nitrogen requirements, comprising the order Centauretalia. Root crops, requiring added nitrogen, are apparently less able to compete with many nitrophilous weeds and thus contain the typically nitrophilous species of the Polygono - Chenopodietalia.

The other major requirement for which there is competition is light. Watson and French (1971) adequately demonstrated that the rows of a wheat crop are sufficiently close to depress yields of individual plants, at least partly by competition for light, and Bunting (1960) points out that with modern farming methods, spring cereals are very effective cleaning crops. The high light requirements of many arable weeds are discussed in Section 4.1.6, but the implications of this in terms of association of weeds and

crops may be far-reaching. Thus Greig-Smith (1948) points out that the very high light requirement of Urtica urens causes it to be particularly associated with crops such as onions which cast little shade.

Competition for light between weed and crop is, of course, minimised if the weed and crop reach their maximum leaf-area indices at different times of year. Agropyron repens reaches its maximum growth rate after the period of maximum crop growth when grown in rape, beans, barley or wheat (Cussans, 1968) and if it is not eliminated by shade from the crop, will compete successfully late in the season as light availability increases again. Aspinall and Milthorpe (1959) showed that the late-germinating Polygonum lapathifolium survives in cereals owing to its main growth period coinciding with the decline in leaf-area index of the crop as the crop commences flowering. When crop and weed have coincident growth periods, the species which establishes itself first will usually dominate. Mann and Barnes (1947) found that when barley is thickly planted and begins growth before associated Holcus mollis, it will smother and eliminate the weed without loss of yield. However, if the crop is thinly planted, and H. mollis is already established in the ground from the previous year, it is the crop which is completely eliminated.

It must not be thought, however, that a crop and its associated weeds are a simple collection of individual competitions between the crop and each weed species. Haizel and Harper (1973) grew barley, white mustard and Avena fatua in pots sown with one, two or all three species. They found evidence for synergistic effects; for example, the yield of mustard was reduced much more by a mixture of barley and wild oats than would have been predicted from their separate effects.

Nor must all crop - weed interactions be deleterious to both

crop and weed; the crop plays an important part in determining the availability of microsites for germination and may increase the number (Harper, 1960b). However, the effects of other species, perhaps competing for the same microsites, would then have to be taken into account. Ultimately it is the entire community which has to be considered, perhaps on the basis of the Z-M method based communities described here.

4.4.5 The foregoing discussion has treated the weed species as a single entity, constant in its interactions with a crop species under specified conditions. However, most are annual species with high reproductive performances, just the attributes required for evolutionary adaptation to different farming methods. Genetic adaptation is well known in weed species, many cases being cited by Harper (1965) and Baker (1974). Even some general characteristics of particular weed species may be a result of relatively recent evolution; Salisbury (1974) has shown that the propagules of cornfield weeds of 18 genera exhibit greater masses than closely related, non-arable species and it is reasonable to suppose that a large seed or fruit size has been advantageous ever since man has collected the grain of cereal crops for re-sowing.

Any ecological or phytosociological work on weed species must, therefore, take account of the possible existence of ecotypic variation. Many species are primarily self-fertilizing, e.g. Capsella bursa-pastoris, Senecio vulgaris, and morphologically and ecologically distinct pure-breeding lines may be readily recognised. Two much quoted examples of arable ecotypes are the dwarf strains of Torilis arvensis and Aethusa cynapium which flower and fruit below the level of a scythe, or more relevantly now, a combine harvester (e.g., Harper, 1957b). Baker (1974) describes an upright, annual ecotype of Picris echioides which occurs in cornfields;

he regards the ancestral type as being the decumbent perennial form of undisturbed maritime grasslands. Physiological ecotypes have been recognised in Polygonum persicaria and P. lapathifolium (Hammerton, 1965; Hammerton and Stone, 1966). However, as Harper (1957a) points out, evolution in weed populations will not be so rapid as might be expected, due to the residue of non-adapted dormant seed in the soil, which may well be slowing down the acquirement of herbicide resistance.

In view of the uncertainty of arable habitats, seed polymorphisms may be of even greater relevance to the explanation of weed distributions. Williams and Harper (1965) describe the complex situation in Chenopodium album which produces four different types of seed differing in response to nitrate and other factors. Here could be the source, at least in part, of the anomalous behaviour of this species suggested by the results described in Section 4.4.2. Harper (1965) reviews a number of other examples.

4.5 Changing agricultural methods and their effects on weed floras

4.5.1 The general effects of agricultural methods on weed floras have already been briefly reviewed in Section 1.2.1. The purpose of the present section is to amplify this information from a historical viewpoint, ending with the dramatic changes resulting from the introduction of selective herbicides.

The history of British weed vegetation effectively pre-dates organised agriculture in Britain, with weeds such as Centaurea cyanus, Galeopsis tetrahit, Sonchus arvensis, Polygonum aviculare, Linaria vulgaris and probable Chenopodium album having a history going back to Late Glacial times (Godwin, 1960). Bunting (1960) has analysed the early records of British weed species and as a generalisation it can be said that the typically N. European species such as those cited above entered Britain with the retreat of the glaciers, while the thermophilic, typically Mediterranean species probably came with Neolithic man and his primitive cereals, or variously after this time. Many of the thermophilic species, e.g. Adonis annua, Arnoseris minima have a doubtful history in Britain, and are often regarded as relatively recent introductions. Except where remains of the species are found at archeological sites, such arguments are speculative and unresolved, but as noted in Section 1.2.2, the climate was substantially warmer in the past and there is no reason why they should not have been more common at the time, with as good a claim to native status as any other weed species. Adonis annua was certainly abundant enough in the past to be sold in bunches at Covent Garden Market on a regular basis (Salisbury, 1961).

Apart from the possible effects of climatic deteriorations, changing agricultural methods have had pronounced effects on the weed flora (see, e.g., Salisbury, op. cit.; Hammerton, 1968b). It is

common, today, to ascribe these changes to the introduction of herbicides, but the decline of many species began long before. Salisbury (1924) describes the decline in several species, e.g. Anagallis foemina, Legousia hybrida and Galeopsis angustifolia (as "G. ladanum"), that was already taking place at that time. Ironically, however, he wrote of Agrostemma githago, "It is possible that Lychnis githago should be added to the list of diminishing weeds, but the evidence is not conclusive.". Salisbury was writing of Hertfordshire; he would not find Agrostemma there today, nor would he find Bupleurum rotundifolium which was still fairly common then (Pugsley, 1941) and the then ubiquitous Scandix pecten-veneris would now be a very good find.

Long (1910) reviewed the weed-control methods in use around the turn of the century. Inorganic herbicides, notably copper sulphate, were already in use and proving effective against some species, notably Sinapis arvensis. More significantly, the importance of sowing crop-seed free of weed seeds was being emphasised, and this undoubtedly marked the beginning of the decline of some species. The role of foreign crop-seed in introducing alien species is reviewed more extensively in Section 4.6, but it seems likely that a number of species which were once at least locally common owed their status to repeated re-introduction. The case of Agrostemma githago has already been discussed; other formerly frequent species now reduced to the status of rare aliens include Cuscuta spp., Centaurea solstitialis, Stachys annua, Camelina sativa and Galium tricornutum.

On the other hand, species which, at least in this author's opinion, have a reasonable claim to native status, have also declined. The long list includes Briza minor, Valerianella rimosa, Torilis arvensis, Adonis annua, Galeopsis speciosa, Filago lutescens, Scandix pecten-veneris, Digitaria ischaemum and Centaurea cyanus, all of which

had distributions definable in ecological terms. Galeopsis segetum and Arnoseria minima have more than once been reported as extinct, while Bupleurum rotundifolium and Caucalis platycarpos appear quite definitely so. Melampyrum arvense, Gastidium ventricosum and Bunium bulbocastanum are verging on extinction as arable weeds, but survive in non-arable situations. Undoubtedly herbicides have caused or hastened the decline of many of these species, but this cannot be the whole answer. Most of the species quoted are thermophilic species, belonging especially to the alliance Caucalidion, with distributions based on southern Europe. It may well be that the previously mentioned climatic deterioration has reduced the reproductive ability and vitality of these species until they can no longer survive herbicides and modern vigorous crops. However, Galeopsis speciosa and Viola tricolor seem to have undergone a dramatic decrease in England very recently, though both species are still at least very locally frequent in Scotland.

Strid (1971) may provide the answer for many cases. He chronicles the rapid diminution of the cornfield subspecies of Nigella arvensis throughout Europe, from a widespread distribution to the brink of extinction, which has taken place in the last few decades. Apart from the effects of seed-cleansing and herbicides, he blames improved, early varieties of cereals. As N. arvensis flowers in the late summer, and often does not produce ripe seeds until September, it runs great risks of being cut before maturity. Thurston (1969), however, considers that the introduction of combine harvesters means a later harvest, with greater opportunities for ripening of weed seeds.

While the overall trend of many species towards apparent extinction is clear, several have shown marked fluctuations. Warrington (1924) records that Torilis arvensis showed substantial fluctuations at Rothamsted between 1867 and 1921, so this is not just a modern phenomenon. Bannister (1948) records the re-appearance of Ranunculus

arvensis and other species when pastures were ploughed during the Second World War, plus the appearance of other species which must have been crop-seed impurities. Adonis annua, another species which varies greatly in abundance from year to year (Salisbury, 1961), was one of several rare species which reappeared when earth was churned up during the building of the M4 motorway in Wiltshire (Horton et al., 1972; see also Tab. LI, aufn. 559). Despite the opinions of Horton et al., there appeared no reason to doubt that these occurrences were from long-dormant seeds. In fact it is very difficult to be sure of the extinction of many weed species; while dormant seed remains in the soil their reappearance is always possible.

While the disappearance of several weed species is highly relevant to the phytosociology of weed communities, since they are often the character or differential-species of these communities, the introduction and increase of other species is also of great importance. The appearance and spread of Veronica persica and Matricaria matricarioides have been well documented (e.g. Salisbury, 1961) and both species have achieved ecologically meaningful distributions and are of syntaxonomic value. Species of Amsinckia from N. America are now well established on sandy soils (e.g., Dony, 1953; Trist, 1956; Petch and Swann, 1968) and are still extending their ranges. They could well come to categorise the association Papaveretum argemonis in Britain.

Over the last two decades, a change in farming practice which may have great significance for the weed flora is the burning of stubble. The straw left behind by a combine harvester is uneconomic to bale and transport to stock-farming areas if these are at any distance, but it is too bulky to plough in. Chopping it up before ploughing would be an expensive operation and hence it is usually burnt off, despite the loss of organic matter this entails. Fruiting

weeds and their seeds on the surface of the soil would thus be destroyed. Late fruiting weed species must obviously be at a disadvantage. Furthermore, bryophyte species, which seem to be largely herbicide resistant, are also likely to be affected by stubble burning, though this does not seem to have been investigated.

4.5.2 The effects of herbicides

4.5.2.1 The possibilities of controlling weeds within crops by chemical means began in 1896 when G. Bonnet, in France, showed that a solution of copper sulphate would kill Sinapis arvensis in cereal crops, without killing the cereal. Dilute sulphuric acid, already in use in stronger solutions for burning off all vegetation, was later found to be useful for the same purpose, as was iron sulphate. Long (1910) lists some of the species which could be controlled. In 1932, an organic chemical, dinitro-ortho-cresol ("DN" or "DNOC"), was also used to destroy weeds in cereals. In 1942, Zimmerman and Hitchcock published their work on substituted phenoxy acids, including 2,4-dichlorophenoxyacetic acid ("2,4-D"). Until then, weedkillers all acted as caustic chemicals, causing immediate foliar damage, but 2,4-D was the first of the "auxin-type" herbicides which achieved high degrees of specificity by being tailored to the physiology of particular weed species.

A number of herbicides are in wide use today (see, e.g., Fryer and Makepeace, 1970; Ashton and Crafts, 1973). In a survey of herbicides in use on cereals in East Anglia, Elliot et al. (1968) reported that MCPA was used in just under half of the cases, while mecaprop, 2,4-D, dicamba, barban and dichlorprop were the other main herbicides used on the 104 fields of the survey. Also used were 2,3,6-TBA, ioxynil and triallate, while in 11 fields, no herbicide was used. The most frequent weeds, as recognised by farmers, were Sinapis arvensis, Stellaria media, Polygonum aviculare and "mayweed".

With the exception of S. arvensis, these are species generally regarded as herbicide resistant. Other generally herbicide resistant species include Polygonum lapathifolium, P. persicaria, Bilderdykia convolvulus, Veronica spp., Galeopsis spp., Tripleurospermum inodorum, Myosotis arvensis and various grasses (Evans, 1966; Thurston, 1969; Fryer and Chancellor, 1970).

As would be expected from the range of herbicides available, each herbicide has its own individual properties and controls different species. It would be impossible to list all the species controlled by each of the major herbicides; information on this is given by Fryer and Makepeace (op. cit.) and other standard texts. However, it must be remembered that the precise action of a herbicide depends on environmental factors (Hammerton, 1968a) and the time of application and so accurate predictions are difficult. Furthermore, herbicides are often applied in combination.

From the community viewpoint, this means that some species are removed from the stand or much reduced in abundance. The corollary of this is that some species are left behind, thus the dominance of different species in different fields is very often a function of the herbicide applied. Investigation of this aspect was quite impossible within the confines of the present survey, but a review of the published literature allows some conclusions to be drawn for different herbicides:-

i) Phenoxyacetic acids (including 2,4-D, 2,4,5-T, MCPA)

An important and widely used group of herbicides, with MCPA favouring Stellaria media, Agropyron repens, Apera spica-venti, Avena fatua, Tripleurospermum inodorum, Galium aparine, Polygonum spp., Chrysanthemum segetum, Galeopsis spp., Spergula arvensis, Viola arvensis, Lapsana communis and Lamium spp. (R. G. Hughes, 1966; Evans, 1966; Mukula and K8ylijarvi, 1965; Mukula et al., 1969;

Fryer and Chancellor, 1970), though presumably not all under the same conditions.

ii) Phenoxybutyric acids (including 2,4-DB, MCPB)

Herbicides of this group do not affect legumes, which makes them invaluable for use on cereals undersown with clover. However, Stellaria media, a major problem in undersown cereals (Evans, op. cit.), is relatively resistant to them. Fryer and Chancellor have shown that Galeopsis tetrahit and Tripleurospermum inodorum are relatively resistant to 2,4-DB, with the latter also resistant to MCPB (King, 1966).

iii) Phenoxypropionic acids (including mecaprop, dichlorprop and fenoprop).

Mukula and K8ylijarvi (op. cit.) noted that mecaprop gives reasonable control of Stellaria media, Viola arvensis and Galium vaillantii, but in one instance destruction of more susceptible competitors led to an increase of Lamium spp. They found, however, that mecaprop caused a weakening of the straw, and hence increased lodging of the crop, and furthermore tended to delay crop ripening which could benefit late-seeding weed species.

iv) Triazines (including atrazine, simazine)

Herbicides of this group are soil acting, active against germinating seeds and seedlings. Thus deep-rooted and perennial species tend to be favoured. Ubrizsy (1968) found that Convolvulus arvensis, Equisetum arvense and Cardaria draba were among the species favoured by the use of atrazine. H. M. Hughes (1966) examined the effects of simazine in various fruit crops and found that it controlled most weeds without the necessity for a spring cultivation. However, Polygonum aviculare was resistant and formed mats at a time when other species were unable to germinate in the hard crust of herbicide-

Table 22

Effect of Simazine on a Bulbfield Phytocoenose

<u>Aufn.</u>		441		
No. of Species		13	Slope	-
Area of Quadrat in m ²		4	Exposition	-
Area of Stand		L	Altitude om ft	150
% Cover - Total		90	Month	5
% Cover - Tracheophytes		30	Soil	scL
% Cover - Bryophytes		80	Crop	Bu
<u>Tracheophytes</u>		<u>Bryophytes</u>		
Rumex obtusifolius	2.2	Dicranella staphylina		4.4
R. crispus	1.2	D. schreberana		+ .2
Anagallis arvensis	+	Bryum rubens		1.2
Stellaria media	(+)	Barbula convoluta		1.2
		Pottia truncata		1.2
		Brachythecium velutinum		1.2
		B. rutabulum		+ .2
		Weissia rutilans		+ .2
		Pleuridium subulatum		(+)

vi) Dinitrophenols (e.g. DNOC, dinoseb)

Koch (1964) recorded an increase in Alopecurus myosuroides in spring cereals following the use of DNOC.

vii) Benzoic acids (including 2,3,6-TBA, dicamba)

A mixture of 2,3,6-TBA and MCPA gives better control than MCPA alone, notably of Fumaria officinalis, Tripleurospermum inodorum, Stellaria media and Viola arvensis (Mukula and K8ylijarvi, op. cit.).

However, they found that in only slightly weedy fields, wheat yields were decreased by this herbicide combination due to toxicity to the wheat. It is likely, therefore, that the lowering of the competitive ability of the crop would benefit surviving weeds.

viii) Bipyridyl herbicides (paraquat, diquat)

These herbicides are commonly used where it is desired to clear vegetation or keep areas clear without a build-up of toxic residues in the soil. Thus they are commonly used in shrubberies, major gardens, orchards and similar places. Characteristically, bryophyte carpets develop. Thus Robinson (op. cit.) found that paraquat produced the same bryophyte development as he observed when using simazine. Table 23 shows a community developed on a damp gravel path under the influence of regular applications of "Gramoxone". The community is a digressive form of the Cardaminetum hirsutae, perhaps representing a transition to the bryophyte-rich Sagino -- Bryetum argentei Diem., Siss. et Westh. 1940. Marchantia polymorpha, and probably another thallose hepatic, Lunularia cruciata, appear to be typical of paraquat-treated ground.

ix) Nitriles (including ioxynil, bromoxynil)

These "broad-spectrum" herbicides allow more complete control of dicotyledonous weed species, including Stellaria media, Tripleurospermum inodorum and Polygonum spp.

Table 23

Cardaminetum hirsutae - Digressive Form

Aufnahme	873	No. of Species	7
Area of Quadrat	1m ²	Area of Stand	20m ²
% Cover - Total	95	% Cover - Tracheophytes	5
% Cover - Bryophytes	95	Slope	-
Exposition	-	Altitude in ft	150
Month	5	Soil	G

Char. Sp. of Association

Cardamine hirsuta +

Char. & Diff. Spp. of Alliance

Veronica peregrina 1.2 Epilobium montanum +

Char. Sp. of Class

Senecio vulgaris +

Bryophytes

Marchantia polymorpha 5.5 Barbula convoluta 2.3
Brachythecium rutabulum 1.2

It is readily apparent that use of most selective herbicides favours grass species rather than dicotyledonous weeds. It is hardly surprising, therefore, that numerous workers have reported serious increases in some grass species and consequent changes in character of weed floras (e.g., Bachthaler, 1967; Pfeiffer, 1968; Fryer and Chancellor, 1971). The most problematical species appear to be Avena fatua, A. ludoviciana, Alopecurus myosuroides, Agrostis gigantea, A. stolonifera, Poa trivialis, P. annua, Agropyron repens, Holcus mollis and Apera spica-venti, though others, e.g. Phleum pratense, may also give trouble. It must not be imagined, however, that this is solely a modern problem, Holcus mollis was one of the most serious weeds on the light sandy soils of Bedfordshire as long ago as 1808 (Mann and Barnes, 1947). Typical of some fields today, however, is the "Unclassified Grass Community" (Tab. LXXVII), where a quadrat in a wheat-field contained eight grass species as weeds and no dicotyledonous species. This particular example is also influenced by the hayfield history of the site, but the action of a selective herbicide of some description is clear. Further development of grass-dominated weed communities is to be expected where sprays and direct drilling replace traditional pre-sowing ploughing in the recent trends towards minimal cultivation (Evans, 1966).

4.5.2.2 As discussed in Section 4.4.5, the "species" should not be taken as one genetic unit. As might be expected, evolution of herbicide tolerance is now known to be taking place in several species. Ryan (1970) reports the development of simazine resistant Senecio vulgaris and Ellis and Kay (1975a) the existence of MCPA resistant populations of Tripleurospermum inodorum. These resistant populations are consistent with previous spraying history. Other species showing similar trends include Agropyron repens, Cirsium arvense, Polygonum lapathifolium, Daucus carota and Cardaria draba (Hammerton, 1967;

Baker, 1974; Way and Chancellor, 1976). Harper (1956) predicted phenological changes in response to pre-emergence herbicides, with germination times becoming earlier or later, and Naylor and Jana (1976) have provided evidence for selection for dormancy in Avena fatua in response to regular following and recent herbicide applications. However, as Harper (1956; 1957a) points out, dormancy will retard evolution of herbicide resistance by providing a reservoir of non-resistant individuals.

Ellis and Kay (1975b) have demonstrated increases in resistance of susceptible populations experimentally. Starting with seed of Tripleurospermum inodorum from markedly non-resistant populations, they sprayed groups of 100 seedlings, grew on the progeny of cross-fertilisations of the five most vigorous survivors and sprayed these. In each case they found increased resistance, though nowhere near so high as existing resistant populations. An increase in resistance to ioxynil, to which the species is normally very sensitive, was most marked, but these single generation selection experiments also showed increasing resistance to MCPA and to simazine.

4.5.2.3 So far it has been assumed that the effect of herbicides on stands of a syntaxon has been to remove some species from the stand and promote the increased growth of other species already present. Thus the effect would normally be at the facies level of Z-M nomenclature, though where the removed species are those diagnostic for the syntaxon, classification becomes difficult (Tüxen, 1962; Brun-Hool, 1966). Long term experiments were carried out by Ubrizsy (1968) who found that 2,4-D and MCPA had substantial effects on the association Consolido - Stachyetum annuae Ubrizsy 1954, particularly at the aspect level, without changing its identity. However, he found that regular applications of atrazine converted stands of the Amarantho - Chenopodietum (?Timar, 1957; non Soo, 1953) to an "Echinochloa -

Amarantheum" or to a "Convolvulo - Portulacetum", and wasteground stands of Polygonetum avicularis Gams 1927 to "Lolietum" (presumably Lolio - Plantaginetum (Link. 1921) Beger 1930). Amarantho - Chenopodietum on wasteground also gave way to Agropyretum repentis (i.e. Convolvulo - Agropyretum repentis Felf. 1943). Unfortunately, Ubrizsy's individual syntaxonomic opinions and failure to quote authors for his syntaxa makes interpretation of his work difficult. The authorities given here represent the present author's interpretation of these names according to Soo (1961), though Ubrizsy's nomenclature remains unchanged. Soo (loc. cit.) refers Ubrizsy's Consolido - Stachyetum annuae, a later homonym, to the association Caucali lappulae - Setarietum Soo 1961 of the Caucalidion.

Despite the syntaxonomic confusion, it is clear that Ubrizsy found substantial changes after herbicide applications, and it is significant that he found conversion to the Convolvulo - Agropyretum. The present survey has been very much a description of British arable communities at one point in time, and long-term observations have, therefore, not been possible. However, it seems highly likely that the promotion of grass species as described in Sect. 4.5.2.1 has resulted in the existence of the stands here assigned to the Convolvulo - Agropyretum and to the Agrostietalia.

Our native flora is constantly being invaded by alien species from a variety of sources (Lousely, 1953; Salisbury, 1961; Harper, 1965). The routes by which they arrive are various, in packaging, especially near docks, as bird-seed, in imported wool or timber, as horticultural introductions, in ballast, as contaminants in foodstuffs and, most relevantly to the present discussion, as contaminants in crop-seed.

In the past, less stringent seeds regulations allowed quite substantial amounts of weed seeds to be present in commercial crop-seed. Dodder, in particular, was a problem (Anon., 1923), but improved cleaning methods and strict regulations have eliminated it as anything but a rare contaminant (Wellington, 1960). Unusual contaminants were, in fact, very useful for identifying the country of origin of seed samples (Johnson and Hensman, 1910; Stapledon, 1916b), though merchants were not above adding seed of Camelina sativa to poor quality Belgian flax-seed to suggest that it was the much superior "Riga Child" flax-seed of original Russian origin (Johnson and Hensman, op. cit.).

Poor quality seed imported during the Second World War contained a number of unusual impurities, with Echinochloa crus-galli and Centaurea solstitialis being well known aliens of carrot-fields, but improved cleaning methods have now eliminated virtually all of these exotic species. Broad (1952) listed the impurities then encountered in cereals, legumes and grasses. Legumes and grasses still contained high numbers of a variety of weed seeds, but cereals were usually almost clean. Of wheat, barley and oats, only Galium aparine, Bilderdykia convolvulus, Avena fatua and Rumex crispus occurred in more than five per cent of the samples of any of the three crops, while those reaching one per cent in any of these cereals

comprised only:- Polygonum aviculare, P. persicaria, Atriplex patula, Alopecurus myosuroides, Agropyron repens, Sinapis arvensis, Raphanus raphanistrum, Chenopodium album, Convolvulus arvensis, Vicia hirsuta, Galeopsis tetrahit and Ranunculus repens.

Wellington (1960) commented that seed-cleansing techniques were sufficiently advanced to remove all but Avena fatua from cereals, other contaminants being due to inadequate cleaning. He listed those species with a frequency of occurrence of more than one percent in any crop, an occurrence here being defined as at least one seed in four ounces. His list is identical to that of Broad, except that Galeopsis tetrahit and Ranunculus repens are omitted. He regarded vegetable seed as virtually free of weeds owing to their being produced by more intensive methods, though he cited Sinapis arvensis and Brassica nigra as being impossible to separate from seed of cultivated Brassicas during cleaning.

A survey of samples submitted for testing between 1961 and 1968 (Tonkin, 1968a; 1968b) suggests that the position has changed little. Tonkin found, on average, more impurities in barley than in oats or wheat, which contrasts with the findings of Broad and Wellington that oats contained most weed-seed. The major impurities are still Galium aparine, Polygonum aviculare, P. persicaria and Bilderdykia convolvulus, though he reported Bromus *hordaceus in oats.

It is apparent, therefore, that an arable crop today contains few, if any, weed species that were introduced with the crop. Of the species listed by Broad and subsequent workers, only Convolvulus arvensis is of any appreciable diagnostic value for an arable weed syntaxon, for the Convolvulo_-Agropyretum. However, it has occurred too often as a companion species in Stellarietea communities for there to be any danger that its introduction with crop-seed could have caused a misclassification of any aufnahme. It is, of course, arguable as

to whether an introduction of this sort should be involved in syntaxonomic classifications or not. As the introduction would still have had to germinate and grow, and as the Z-M system is ideally based on total floristics and not on prior ecological (in the widest sense here) knowledge, such introductions should presumably carry equal weight with the already established species. In the case of native species, this problem has not become important.

Introduced species from outside Britain pose much more substantial difficulties. At the association level, two problematic cases have arisen. The acceptance of the association Setario - Veronicetum politae for Britain rests entirely on the occurrence on Erucastrum gallicum as an established alien at a market garden. Here the resulting stands compare with data of the Setario - Veronicetum from southern Germany and there seems that there is little choice but to accept it, though the concept of an introduced plant community is a doubtful one, the more so since the other species present are natives. Fortunately, the site compares with southern Germany on climatological grounds and a reasonable alternative viewpoint is that E. gallicum has merely occupied a site from which it was absent by an accident of distribution.

More dubious is the acceptance of aufn. 708 (Tab.XXXV) as belonging to the association Echinochloo - Setarietum, the decision here being based on Digitaria sanguinalis and Amaranthus retroflexus, which were undoubtedly introduced with the crop. However, without those two species, the stand would have been very difficult to classify and could still have been regarded as an impoverished stand of the same association. Had other species been present which suggested a different hypothesis, then D. sanguinalis and A. retroflexus would not have been given the same importance.

Two other cases where aliens have been met in arable fields have been the bulbfields of the Isles of Scilly and fields manured with

shoddy.

In the Isles of Scilly, the alien species have become thoroughly established to compose a thermophilic element to the flora. This means that the existing associations of native species have been very substantially modified, but it has been found more convenient to recognise thermophilic variants within the existing classification rather than to erect new associations cutting across previous lines of demarcation.

As mentioned in Section 1.2.1.4.1, use of the wool waste known as "shoddy" introduces seed of exotic species from many parts of the world. The total number of wool aliens recorded from Britain is very high (see, e.g., Hayward and Druce, 1919; Lousley, 1961), but very few, most usually Medicago spp., are at all persistent. Where they have been encountered on arable land they have been treated as diagnostic of minor noda only (Tabs. XXIX, XXXIV and XXXVI).

Chapter Five

A review of previous work in Britain and Europe

5.1 The phytosociology of arable communities has received little attention from English-speaking ecologists and agronomists. King (1966), it is true, includes a chapter on phytosociology in his standard text, but it presents little information and shows little understanding of the Z-M classification. Where communities have been considered at all, the approach has almost invariably been to group weed species according to crop or soil requirements.

Bravender (1845) was perhaps the pioneer of the study of arable communities in Britain, listing the characteristic weeds of barren and fertile soils. He also related these weeds to geology, though his lack of geological knowledge led him into errors when dealing with mixed soils.

Buckman (1855) followed with a very comprehensive review of arable weed species, showing the occurrence of each on sandy, clay, calcareous and loamy soils. However, he did not classify the species into groups of any description and so could not be held to have been considering the existence of arable communities in any abstract sense.

Brenchley (1911, 1912, 1913a) provided the beginnings of a fairly comprehensive survey of British weeds, visiting one area at a time and noting soils, geology, crops and their related weed species. Her surveying was on an entire field basis, listing all the species in each field surveyed. However, she undoubtedly had difficulties with identification, admitting (1912) to problems with Anthemis, Ranunculus and others, and the species totals of her surveys seem rather low. Nevertheless, her accumulated data represent a valuable body of information, and was brought together in her classic work

(1920), which still remains the standard work on British weed vegetation.

Contemporary with Brenchley was Stapledon, whose main work (1916a) consists of a careful comparison of the weed flora of Central Wales with that of the Cotswolds. Again he dealt with groups of species rather than communities, but the influence of associations such as the Spergulo - Chrysanthemetum can readily be seen in his data.

A disadvantage of considering individual species is that discrepancies inevitably arise between different areas. Thus Brenchley (1912) found that Odontites verna, which she had previously classified as a calcifuge in Bedfordshire, was almost restricted to the chalk when she surveyed Wiltshire. Stapledon (op. cit.) commented that many of his species on the Cotswolds oolitic limestone were regarded as calcifuges by Brenchley.

Since this period, little further work has been carried out except in the applied field of weed control. Some local "floras" contain scattered data, which provide additional clues to the composition of weed floras before the advent of modern herbicides and clean seed. Information has tended to be either on the Brenchley pattern whereby weed species are classified according to their local soil requirements (e.g., Bowen, 1968) or else one or more plant lists are given from single fields (e.g., Clapham, 1969). In view of the lack of details on how such lists were taken, many being heterogeneous, such data have not been as helpful as would have been expected in interpreting the present survey.

Virtually no application of Z-M methodology to British arable vegetation has been tried before the present work. Braun-Blanquet and Tüxen (1952) reported on the International Phytogeographical Excursion to Ireland, describing the Fumarietum bastardii and providing

information on ruderal and Plantaginetea communities relevant to Great Britain, and Birks (1973) included two arable aufnahmen, one unidentifiable, in his phytosociological survey of the Isle of Skye.

5.2 A large proportion of European work on arable communities is, of course, based on Z-M methodology and will not be reviewed in this chapter. However, application of extensions of the "Brenchley-type" approach have produced interesting results.

Listings of typical weed species of different soils are a feature of European agronomic literature as much as of the British literature. The classic European account is undoubtedly that of Buchli (1936), who brought together the data of many other workers. The discrepancies mentioned in the preceding section become particularly noticeable in Buchli's review. The answer, as Brenchley (1920) concluded, is to consider combinations of species.

Eberhardt (1954) did this. He grouped species of similar soil requirements into distinct communities which, at least at the local level, were equatable with Z-M communities recognised by a different approach. The ecological-sociological species-groups of Hilbig et al. (1962), discussed in Section 2.2.2.12 can be regarded as a refinement of this procedure.

An interesting recent approach is that of Kuzniewski (1975), who classified Polish arable communities under "field utilisation complexes". The land was graded as one of:- very good wheat; good wheat; moderate wheat; very good rye; good rye; moderate rye; rye-lupins; good corn fodder; poor corn fodder; mountain wheat; mountain corn; mountain oat-potato complex. This tied in well with the assignation of stands to different weed communities. Thus stands of the "moderate rye" and "rye-lupins" complexes

corresponded to the Teesdalia - Arnoseridetum whereas the typical Ausbildung of the Euphorbia - Melandrietum G. Müll 1963 was represented by the "very good wheat" complex.

Perhaps the most important development of the ecological approach to arable vegetation is that of Ellenberg (1948, 1950), reviewed in English by Coombe (1952). Each species can be said to have a definable indicator value for a number of ecological parameters, including pH, soil moisture, soil nitrogen status, temperature ranges and soil particle size. Taking each parameter in turn, Ellenberg gave each species a numerical value according to its indicator value, including categories for species indifferent to any factor. As previously explained, use of individual species quickly leads to anomalies, but with Ellenberg's method, the mean indicator value for all the species of the stand can be calculated to obtain a very sensitive composite indication of the operation of the factor concerned. Using Ellenberg's calculations and data, many European workers have adopted this approach. However, its use does not appear to have spread to Britain. Undoubtedly Ellenberg's figures would have to be modified for Britain, with many species showing different distributions here compared with Germany and this would require a lot of detailed autecological work. However, it is envisaged that one of the most valuable applications of the present survey could be to provide a basis for such an exercise.

Chapter SixSyntaxonomic account of British weed communities6.1 Foreword to classes Bidentetea, Stellarietea, Agropyretea and Plantaginetea

The vegetation included in this account has two important features, the stands are anthropic and they contain mainly annual species plus biennials and perennials adapted to high-risk habitats. Though the syntaxa involved are not here included in one class, it must nevertheless be true that the classes must show similarities in ecology and floristics. This has been recognised in the past by placing virtually all of these communities into one class, the Rudereto - Secalinetea Br. Bl. 1936. (The original name of the class, as published by Braun-Blanquet (1936) was the Rudereto - Secalinetales, but such early orthographic variants, now considered illegitimate, will normally be corrected to modern usage without comment in this account, unless the matter becomes relevant.) The actual boundaries of the Rudereto - Secalinetea have been interpreted differently by many authors. Braun-Blanquet (op. cit.) based his class on all the communities here referred to the Stellarietea, i.e. Centauretalia, Polygono - Chenopodietalia, Sisymbrietalia and Onopordetalia, etc., but also included the association Bidentetum tripartiti Koch 1926 which is now the basic concept of the Bidentetea. Tüxen (1937) incorporated into the class the alliances Arction lappae Tx. 1937 and Atropion Br.Bl. 1930, which, though modified from Tüxen's concepts, are now placed in the Artemisietea vulgaris Lohm., Prsg. et Tx. 1950. Tüxen's (1937) classification also incorporated the Lolium perenne - Matricaria suaveolens - Ass. (Beger, 1930) Tx. 1937 and the Atriplex

litorale - Ass. Christiansen apud Tx. 1937, which would now be placed in the classes Plantaginetea maioris and Cakiletea maritimae Tx. et Prsg. 1950, respectively.

Sissingh (1950) reduced the growing chaos to order, providing an extensive review of the situation at that time, and re-defining the class as the Rudereto - Secalinetea Br. Bl. 1936 em Siss. 1950. Within the revised class he included the orders Secalinetalia Br. Bl. (1931) 1936, Chenopodietalia Br. Bl. 1936 em. Siss. 1949, Bidentetalia Br. Bl. et Tx. 1943, Cakiletalia maritimae Tx. (mscr.), Nanocyperetalia Klika 1935, Potentillo - Polygonetalia avicularis Tx. 1947, Onopordetalia Br. Bl. et Tx. 1943 and the Atropetalia Vlieger 1937. The Potentillo - Polygonetalia includes associations regarded in the present account as belonging to the Plantaginetea.

However Tüxen (1950) reviewed this entire group of syntaxa and divided the Rudereto - Secalinetea into six classes, the Cakiletea maritimae, Bidentetea tripartitae, Stellarietea mediae, Plantaginetea maioris, Artemisietea vulgaris and the Epilobietea angustifolii Tx. et Prsg. 1950. Except that the Stellarietea is usually sub-divided (see Sect. 6.3), this remains the basis of most classifications today.

Nevertheless, the Rudereto - Secalinetea in the broad sense, persists as a concept. The syntaxa cited above fall into one or other of two of the formations recognised by Westhoff and Den Held (1969), while authors put different limits to the classes now recognised. Dahl and Hadac (1941) published a table of the Atriplicetum littoralis Feekes 1936 containing Senecio vulgaris, Stellaria media and other typical species of the Stellarietea, and they even included the association in the Chenopodietalia. However, Tüxen (1950) included both the association and their data in the Matricario maritimae - Atriplicetum littoralis (Christiansen 1933) Tx. 50, which he placed in the Cakiletea. Braun-Blanquet and Tüxen (1952), Oberdorfer (1957a)

and Soo (1961) included the Bidentetea in the Chenopodietea, which is here recognised as a sub-division of the Stellarietea, and Doing (1963) adopted the same view, calling the resulting combined class the "Thero - Chenopodietea R. Tüxen". Morariu (1967) transferred the Polygono - Chenopodietalia, including the Chenopodium muralis Br. Bl. 1936, from the Chenopodietea to the Bidentetea, though whether this is nomenclaturally permissible is highly doubtful.

It is clear, then, that these classes are closely related and it is hardly surprising that they have many species in common. While it is possible to define character-species for each class, many such species will occur, with lower frequencies, in other classes, while quite a large number of species can be regarded only as companion species for each class, but would have been character-species of the Rudereto - Secalinetea in its broader senses. The Agropyretea repentis has been omitted from the above discussion since it has only recently been given separate recognition. However, the Convolvulo - Agropyretum has often been placed in the Sisymbrietalia (cf. Westhoff and Den Held, op. cit.) and hence the Agropyretea must also be included in this group of classes.

A nomenclatural problem which remains is the fate of the name "Rudereto - Secalinetea". Though Tüxen's (1950) classification has been followed here, it must be admitted that the name pre-dates any of Tüxen's classes. Furthermore, Braun-Blanquet's original description, as distinct from concepts of later workers, encompasses almost exactly the communities here regarded as belonging to the Stellarietea, as has been detailed above. Since there appears no doubt that the Secalinetalia must be regarded as the type order of the Rudereto - Secalinetea, rules of priority seem to indicate that the name, in emended form, should take precedence over the Stellarietea.

N.B. In the above account, authorities for syntaxonomic names have been omitted where the syntaxon is discussed formally in another section and where the application of the name is clear. This practice has been adopted throughout.

6.2.1 Class: BIDENTETEA TRIPARTITAE Tx., Lohm. et Prsg. 1950

Synonymy

Rudereto - Secalinetea Br. Bl. 1936, p.p. min.

Rudereto - Secalinetea Br. Bl. 1936, em. Siss. 1950, p.p.

Order: BIDENTETALIA TRIPARTITAE Br. Bl. et R. Tx. 1943

Character Species

Current information does not permit the citation of such species for Britain. Continental work suggests the following:- Polygonum * nodosum, P. hydropiper, P. mite, P. persicaria, Bidens tripartita, B. cernua, Rorippa palustris, Rumex palustris, Catabrosa aquatica, Atriplex hastata, Ranunculus sceleratus (Lohmeyer, 1950; Tüxen, 1950; Oberdorfer, 1957a; Westhoff and Den Held, 1969).

European Distribution and Syntaxonomy

The syntaxonomic position of the class, of which the Bidentetalia is the only order, is described in Section 6.1. The order is usually divided into the two alliances described below, both of which appear to be widespread in Europe.

Ecology

The Bidentetea encompasses the annual, terrestrial communities of drying mud, often colonising exposed mud during dry periods but not surviving inundation for long periods, when communities of the classes Isoeto - Nanojuncetea Br. Bl. et R. Tx. 1943 or Littorelletea Br. Bl. et R. Tx. 1943 em. Den Hartog et Segal 1964 would be more likely.

The communities are often nitrophilous, or at least, nitrogen tolerant, and colonise areas of high organic pollution including damp compost heaps. In these situations, or on poorly-drained or flooded farmland, the communities grade into those of the Stellarietea.

Farmland on river flood-plains or in similar situations may sometimes develop characteristic weed communities which lie between the Bidentetea and the Stellarietea in their floristic relationships. Thus Pignatti (1957) described the Malachietum aquatici from Italy and Soo (1961) described the Rorippae - Setarietum from Hungary, both associations being referable to the Centauretalia. K hler (1962) similarly described a Polygono - Chenopodietalia association, the Rorippo - Chenopodietum polyspermi, from East Germany. This has subsequently been recognised by a number of other East German workers.

6.2.2 Alliance: BIDENTION Nordh. 1940 em R. Tx. apud Poli et J. Tx. 1960

Character and Differential Species

Bidens cernua, Alopecurus aequalis (Westhoff and Den Held, op. cit.)

Ecology

Forming stands on wet mud or peat around pools or on wet farmland usually in nitrogen-rich situations.

One association is hesitantly accepted here:-

1. Association: POLYGONO - BIDENTETUM W. Koch 1925 em. Siss. 1946 (Tab. I)

Synonymy

? Bidentetum tripartiti Koch 1925

Diagnostic Species Group

Polygonum hydropiper, P. minus, P. mite (e.g. Westhoff and Den Held, op. cit.). The single aufnahme in Tab. I contains none of these species, but the combination of Polygonum persicaria, Deschampsia cespitosa, Glyceria fluitans, Eupatorium cannabinum, Juncus inflexus and Bidens tripartita suggested affinities with the Bidentetea, and comparison of the aufnahmen with the table provided by Passarge (1959c)

suggested a transition to this community.

European Distribution and Syntaxonomic Position

The basis of this association is a single aufnahme of Koch (1925), containing Bidens tripartita, B. cernua v. radiata, Rorippa "islandica", Polygonum hydropiper and Apium repens, which he named the "Bidentetum triparti". This name has been much used by other workers throughout Europe, not always in the original sense. Thus the name has been applied to differing communities in Hungary (Felföldy, 1943), Rumania (Morariu, 1943; 1967), the Balkans (Horvat et al., 1974) and the Mediterranean region, where Braun-Blanquet (1936) commented that it is very rare.

The Polygono_-Bidentetum is one of several similar communities now known to exist, but it is definitely known from Germany (Passarge, 1959c), France (Gehu, 1961b), the Netherlands (Westhoff and Den Held, op. cit.), Belgium (Lebrun et al., 1949) and no doubt elsewhere.

British Distribution

The single aufnahme of Table I was from Knights Fen, Norfolk. Aufn. 590 (Tab. XIII) which might also have been placed here was from Verwood, Dorset. The pure association is likely to be widespread in Britain, stands likely to be this are common in suitable habitats.

Ecology and Discussion

Westhoff and Den Held give the habitats of this association as including mud by cleaned ditches, eutrophicated fens, wet arable fields and disturbed peat-moors. The Knights Fen site fits this well, the stand being at the edge of a beet-field newly reclaimed from fenland on sandy to silty loam. Aufn. 590 was classified as Spergulo_-Chrysanthemetum segeti, but was dominated by Polygonum hydropiper and clearly transitional to the present association. The site was in a hollow in an arable field on sandy loam. Geologically,

the locality was on Valley Gravel over Bagshot Sands, but the presence of small streams and levants close by suggested impeded drainage.

Neither of these two aufnahmen can be said to be referable to the pure association; their affinities with the Stellarietea are clear. However, Passarge's (op. cit.) data contain Stellarietea species, and so a transitional status does not seem unreasonable.

6.2.3 Alliance: CHENOPODION FLUVIATILE R. Tx. apud Poli et J. Tx. 1960

Character and Differential Species

Chenopodium glaucum, C. rubrum, Erucastrum gallicum (Westhoff and Den Held, op. cit.)

Ecology

On wet mud, fringing rivers and canals, less often on compost heaps and similar nitrogenous sites.

One association is accepted here, as a transitional form

1. Association: CHENOPODIETUM GLAUCO - RUBRI Lohm. 1950 apud Oberd. 1957 (Tab. II)

Synonymy

Chenopodietum glauci (Wenzl. 1934) Raabe 1950, apud Pass. 1964

Chenopodium glaucum - rubrum Ges. Lohm. 1950 apud Poli et J. Tx. 1960

A more complete synonymy is given by Westhoff and Den Held (op. cit.).

Diagnostic Species Group

Chenopodium rubrum, C. glaucum, Atriplex patula, Capsella bursa-pastoris, Solanum nigrum and other Polygono - Chenopodietalia spp.

European Distribution and Syntaxonomic Position

Probably widespread in Europe, certainly recorded from Germany

and the Netherlands. Passarge (1964) recognises two associations, the Chenopodietum glauci and the "Chenopodietum rubri Lohm. 1950". The latter is characterised by a group of thermophilic species including Xanthium riparium, Echinochloa crus-galli and Amaranthus retroflexus.

British Distribution and Ecology

The association is typically developed on compost heaps and other highly nitrogenous sites. The single British stand assigned to this association was on a farm silage heap at Langley, Essex. The stand was an extensive one and was well developed. However, in view of the absence of any unequivocal Bidentetea species, the stand must be regarded as transitional to the Stellarietea, though the association itself represents the approach of the Bidentetea to the Polygono--Chenopodietalia.

Chenopodium glaucum is apparently decreasing in Britain, and is now a very rare plant. However, C. glaucum and C. rubrum were seen growing together on compost heaps elsewhere in Essex prior to the survey.

6.3 Class: STELLARIETEA MEDIAE (Br. Bl. 1931) Tx., Lohm et Prsg.
1950

Synonymy

Rudereto - Secalinetales Br. Bl. 1936 p.p.max.

Chenopodietea Br. Bl. 1951

Secalinetea Br. Bl. 1951

Thero = Chenopodietea Lohm., J. et R. Tx. 1961; non em
 Doing 1963, p.p.

Onopordo - Sisymbrietea G8rs 1966 (prov.)

Character Species

A large number of species could be cited - see tables - all of which are annual species of arable fields and disturbed ground.

European Distribution and Syntaxonomy

This class occurs throughout Europe and probably occurs throughout the world. Most recent accounts (e.g., Westhoff and Den Held, 1969; Lohmeyer et al., 1962; Oberdorfer et al., 1967; Oberdorfer, 1970) have recognised two separate classes, the Chenopodietea and the Secalieta (using modern spelling). The first comprises the vegetation of disturbed ground, root-crops and pioneer communities of ruderal sites while the latter encompasses the usually less nitrophilous communities of cereals. However, a very large number of weed species are common to the two classes and become character species of the combination of the two. Furthermore, many of the character species of the Chenopodietea, e.g. Polygonum spp., Chenopodium album, Stellaria media, Senecio vulgaris, occur frequently in summer cereals. This is a problem on the continent (e.g. Seibert, 1969) but the maritime influence of Britain further spreads the germination ranges of these species (Naylor, 1972a, and see Sect. 4.3). The opinion of many workers

on the continent is that summer cereals should not be included in surveys, the communities being based entirely on winter cereals and root crops. However, to ignore large areas of vegetation, including most fields of cereals in Britain, because their inclusion would upset the established syntaxonomy, seems more than a little unscientific.

The answer, for Britain, is to adopt the classification of Tuxen (1950), and recognise the combined class, the Stellarietea. The problem is not then automatically solved, for the division must still then be made at the order level, but clear differences are perhaps less to be expected when separate classes are not involved. Summer cereals have been investigated, and their weed vegetation has regularly been found to be referable to the order Polygono_-Chenopodietalia, which would be included in a separately recognised Chenopodietea.

This is not to say that the separation of the Chenopodietea and the Secalietea is not perfectly tenable in other parts of Europe. R. Tuxen, himself, (pers. comm., 1972) accepts the two separate classes over much of Europe, but prefers to recognise the Stellarietea in N. W. Europe. This might seem to be Orwellian "double-think", but illustrates the possible flexibility of concepts of the Z-M system. Unlike formal idiotaxonomy, a flexibility of classification in syntaxonomy is quite acceptable, provided the basis of classification is clearly stated.

It should be emphasised that whichever classification is adopted, stubble communities should ideally not be considered. The classification assumes that all stands have reached their peak of development within the crop, assuming a crop is present, and stubble communities represent a late aspect which cannot be directly equated with summer aspect aufnahmen. In cases where data here are from stubble fields, aufnahmen were taken soon after harvest, before a late flush of germination would have altered the community.

industrial areas and extend well into unpopulated areas along the sides of new roads. However, away from arable land, a ready source of Stellarietea species for colonisation is not always available, and disturbed ground in upland or remote areas often supports a vegetation floristically closer to such classes as the Plantaginetea, Molinio - Arrhenatheretea or the Galio - Urticea Pass. 1967. These classes supply many of the companion species in Stellarietea stands.

The action of selective herbicides on arable vegetation is usually to favour grass species (see Sect. 4.5.2.1). This is believed to have resulted in transitional stands to the Plantaginetea, order Agrostietalia and to the Agropyretea, as discussed in Section 4.5.2.3.

6.4 Order: POLYGONO - CHENOPODIETALIA R. Tx. et Lohm. 1950
em. J. Tx. 1961

Synonymy

Chenopodietalia medioeuropaea R. Tx. 1937, p.p.

Eu - Polygono - Chenopodion polyspermi Koch 1926
 em. Siss. 1946

Chenopodietalia Br. Bl. 1936 em. Siss. 1950, p.p.

Chenopodietalia albi Tx. et Lohm. 1950, p.p.,
 non Br. Bl. 1936

Chenopodietea Br. Bl. 1951, p.p.

Spergulo - Erodion J. Tx. 1961, p.p.

Thero - Chenopodietea Lohm., J. et R. Tx. 1961, p.p.

Veronico - Euphorbion pepli Siss. 1942 apud Pass. 1964

Character and Differential Species

<u>Polygonum</u> * <u>tomentosum</u>	<u>Solanum</u> <u>nigrum</u>
<u>P.</u> <u>persicaria</u>	<u>Stachys</u> <u>arvensis</u>
<u>Lamium</u> <u>purpureum</u>	<u>Fumaria</u> * <u>boraei</u>
<u>L.</u> <u>hybridum</u>	<u>F.</u> <u>bastardii</u>
<u>Urtica</u> <u>urens</u>	<u>Brassica</u> <u>campestris</u>
<u>Chenopodium</u> <u>polyspermum</u>	<u>Spergula</u> <u>arvensis</u>
<u>Lycopsis</u> <u>arvensis</u>	<u>Raphanus</u> <u>raphanistrum</u>
<u>Phalaris</u> <u>minor</u>	<u>Ranunculus</u> <u>parviflorus</u>
<u>Misopates</u> <u>orontium</u>	<u>Galeopsis</u> <u>speciosa</u>
<u>Chrysanthemum</u> <u>segetum</u>	

See also the list of character and differential species of the
Fumario - Euphorbion. Many of these species occur in stubble-field
 aspects of the Centauretalia cyani.

European Distribution and Syntaxonomy

The order occurs throughout Europe except in the Mediterranean

region where it is replaced by the Eragrostietalia and the thermophilic alliance Chenopodion muralis of the Sisymbrietalia. Tüxen (1937) recognises this geographical separation by recognising two orders, the Chenopodietalia medioeuropaea of central and northern Europe and the Chenopodietalia mediterranea (Br. Bl. 1936) Tx. 1937 of southern Europe. The latter corresponds with Braun-Blanquet's (1936) original description of the Chenopodietalia containing the thermophilic Sisymbrietalia and Onopordetalia communities.

The separation of the Polygono_-Chenopodietalia from the Eragrostietalia is difficult and has been subject to varying treatments. There appears to be a complete topocline from pure Polygono_-Chenopodietalia communities in the atlantic northwest of Europe, through central Europe, with increasing occurrence of species such as Setaria viridis and Amaranthus retroflexus, to undoubted Eragrostietalia communities in the continental climate of southeastern Europe. The alliance Panico_-Setarion expresses this transition and is variously placed in either of the two orders. Examination of associations described within the Panico_-Setarion suggests that it has slightly greater affinity for the Eragrostietalia, though its only British association, the Echinochloo - Setarietum, comes very close to the alliance Spergulo_-Oxalidion of the present order. Most of the synonyms of the Polygono_-Chenopodietalia, as quoted above, incorporate the Panico_-Setarion.

British Distribution and Ecology

Communities of the order apparently occur throughout Britain, in root-crops, spring cereals and on nitrogenous disturbed ground.

Stands frequently occur which cannot be satisfactorily assigned to any lower syntaxon, 30 such aufnahmen are given in Tab. XXXIV. The table includes not only those aufnahmen deficient in alliance character species, but also those with species both of the Fumario -

Euphorbion and the Spergulo_-Oxalidion. Inclusion of such aufnahmen here maintains the homogeneity of the alliance tables.

There is some structure apparent in the data, for example, possible association of Solanum nigrum with Lamium purpureum, but in the absence of two or more clear-cut divisions within the data, there is no useful purpose in separating out quadrats containing a particular species as a Brun-Hool community.

Aufn. 412 and 413, from Selbourne, Hampshire, are from ground manured with shoddy in hop-gardens. An alien form of Medicago polymorpha, plus other typical wool aliens such as Amaranthus hybridus, Chenopodium probstii and Xanthium spinosum, characterise this pair of aufnahmen.

Apart from the Panico_-Setarion, most workers have recognised only one alliance within the order, the Polygono_-Chenopodion polyspermi. Indeed Westhoff and Den Held (1969) extend the latter to include the former as a suballiance. However, Oberdorfer et al. (1967) recognise two alliances within the concept of the Polygono_-Chenopodion and their approach is followed here, with the addition of a third, provisional, alliance.

6.5 Alliance: FUMARIO - EUPHORBION GÜrs 1966Synonymy

Eu - Polygono - Chenopodion polyspermi Koch 1926
em. Siss. 1946, p.p.

Assoziationsgruppe der Mercurialis annua Gesellschaften
Oberd. 1957

Veroniceto - Euphorbion pepi Siss. 1942 apud Pass. 1964, p.p.

? Veronico - Chenopodion J. Tx. 1961, n.n.

Character and Differential Species

Species with usefully high fidelity to the alliance are:-

<u>Euphorbia helioscopia</u>	<u>Thlaspi arvense</u>
<u>E. peplus</u>	<u>T. alliaceum</u>
<u>Lamium amplexicaule</u>	<u>Polygonum * nodosum</u>
<u>Lepidium campestre</u>	<u>P. * lapathifolium</u>
<u>Fumaria * officinalis</u>	<u>Chenopodium ficifolium</u>
<u>Erysimum cheiranthoides</u>	<u>C. hybridum</u>
<u>Mercurialis annua</u>	

The following four species can be regarded as differential species with respect to the other two alliances of the order:-

<u>Coronopus squamatus</u>	<u>Veronica agrestis</u>
<u>Sonchus oleraceus</u>	<u>Chenopodium rubrum</u>

Species such as Senecio vulgaris, Veronica persica and Polygonum persica are also typical of communities of this alliance.

European Distribution and Syntaxonomy

The alliance contains about thirteen associations, mainly in western and northwestern Europe, but extending east to Poland and Hungary. In south and southeast Europe, the alliance gives way to the Chenopodion muralis and the Eragrostietalia.

Three groups of associations can, perhaps, be distinguished within the alliance:-

i) Veronica group (Tab. VI)

A group of associations typified by the occurrence of Veronica persica, V. agrestis, V. polita or V. opaca, and including:-

Alopecuro - Matricarietum chamomillae Wasscher 1941 (W.Europe)

Falcaria vulgaris - Veronica polita - Ass. Becker 1941 (Alps)

Lamieto - Veronicetum politae Kornas 1950 (E. Europe,

including Veroniceto - Lamietum amplexicauli

Borza 1960)

Setario - Veronicetum politae Oberd. 1957 (Continental Europe)

Soncho - Veronicetum agrestis Br. Bl. 1949 (Alps)

Thlaspio - Veronicetum politae G8rs 1966 (Germany,

including Veronico - Fumarietum Oberd. 1957)

Veronico - Lamietum hybridi Krus. et Vl. 1939 (N. & W. Europe)

ii) Fumaria group (Tab. IX)

Fumarietum bastardii Br. Bl. 1950 (British Isles)

Fumarietum officinalis (Krus. et Vl. 1939) R. Tx. 1950

(widespread in central and W. Europe)

? Thlaspi arvense - Setaria viridis Ges. G8rs 1966 (Germany)

iii) Calendula arvensis group

Aristolochia clematitis - Tulipa silvestris - Ass.

(Issler 1908) R. Tx. 1950 (prov)

Geranium rotundifolium - Allium vineale - Ass.

(v. Rochow 1948) R. Tx. 1950

Muscarieto - Calenduletum Breton 1956

A group of associations, characterised by bulbous spp. and Geranium

spp., from vineyards in southern continental Europe. Associations of the first two groups occur in Britain.

British Distribution

Apparently throughout Britain, but associations of the "Veronica group" are more common on the fertile soils of the south-east, giving way to Spergulo - Oxalidion communities in the north and west.

Ecology

The associations are typically basiphilous, particularly the "Calendula arvensis group". Generally, the associations are developed on heavy or loamy soils, but may occur on sand when this is sufficiently base-rich (cf. Setario - Veronicetum politae).

Many stands of this alliance lack association character-species and cannot be classified further. Table X gives 28 such aufnahmen. Amongst these impoverished or aberrant aufnahmen, two nodum can be distinguished.

A Bryophyte Nodum was found in cornfields and in winter cauliflowers and a neglected flower-bed, where sufficient time had elapsed since cultivation to allow bryophyte development. The nodum is characterised by Taraxacum officinale and Bryum rubens and other typical bryophytes of heavy soils.

The Calystegia sepium Nodum, defined by Calystegia sepium, Polygonum amphibium, Phragmites australis and Mentha aquatica, is based on aufnahmen from four localities in the reclaimed fenlands of Cambridgeshire. The soils in each case are peaty or silt fen deposits, remaining moist despite the extensive series of drainage dykes. Polygonum * lapathifolium and Chenopodium ficifolium show correlation with this nodum.

Aufn. 73, containing only four species, was from a compost heap.

Table 24

Thlaspi alliaceum Community

Aufn. 30. Heterogeneous community along sides of new ditch below hedgerow. Soil very heavy clay (geologically, Weald Clay). Altitude 150 ft 15.5.70.

Alliance Species (Fumario - Euphorbion)

Thlaspi alliaceum

Sonchus oleraceus

Others

Galium aparine

G. mollugo

Rumex crispus

Convolvulus arvensis

Ranunculus repens

Agrostis stolonifera

Alliaria petiolata

Relatively few uncommon species occur in stands of this alliance, but Thlaspi alliaceum, an introduced but apparently non-aggressive weed established in very few localities in Britain, appears to be characteristic of the alliance. Table 24 gives details of a heterogeneous stand containing an abundance of this species along the sides of a ditch adjacent to a ploughed field, in Kent.

1. Association: VERONICO - LAMIETUM HYBRIDI Krus. et Vl. 1939 (Tab.III)

Synonymy

Veronicetum politae Pass. 1959, p.p.

Lamio - Veronicetum politae Pass. 1964, p.p.

Diagnostic Species Group

Veronica polita

Lamium hybridum

V. _____ opaca

Thlaspi arvense

Veronica persica is characteristically abundant in stands of this association.

European Distribution and Syntaxonomy

Differing opinions make it difficult to attach a precise distribution to this association. A narrow view of the association is taken here, and on this basis it would seem to be known from the Netherlands (Kruseman and Vlieger, 1939; Weevers, 1940; Sissingh, 1950; Sissingh and Tideman, 1960), Belgium (Lebrun et al., 1949) and northern Germany (Passarge, 1959b; 1964). Thus it would seem to be restricted to coastal regions of northwest Europe, grading into the Lamieto - Veronicetum politae Kornas 1950 and other associations eastwards. Related associations are compared in Table VI. The Alopecureto - Matricarietum chamomillae is regarded here as a very closely related but separate association; Gehu's (1961b) data from France appear better referred to the Alopecureto - Matricarietum.

British Distribution and Ecology (Map 1)

Stands of this association are best developed on light, loamy soils in East Anglia, but occur in scattered, mainly coastal localities elsewhere. The association appears to be characteristic of reclaimed fenlands, both in Britain and in the Netherlands where it was first described. Thus edaphic factors may be responsible for its mainly coastal distribution in Europe. The apparent widespread distribution in England shown by the map of Sissingh (1950) is, therefore, misleading.

Underlying geological beds do not appear to relate to this association, stands being developed on blown or alluvial deposits over a range of strata from Lower Greensand to Chalk. Most stands are at low altitude, but the association reaches 250 ft. 44% of aufnahmen were associated with root or vegetable crops, 28% with cereals.

Subdivisions

No infra-associational syntaxa have been recognised from British data. Aufn. 199, from a field of broad beans, is transitional to the Centauretalia, or perhaps to the Alopecureto - Matricarietum.

2. Association: SETARIO - VERONICETUM POLITAE Oberd. 1957 (Tab. IV)

Synonymy

? Melandryo - Veronicetum politae Pass. 1959

Oberdorfer et al. (1967) include in this association, the Fumaria-rich communities of intensive cultivation, i.e. the Setario - Fumarietum J. Tx. 1955 and the Amarantho - Fumarietum J. Tx. 1955.

Diagnostic Species Group

<u>Veronica polita</u>	<u>Erucastrum gallicum</u>
<u>Diploaxis muralis</u>	<u>Arenaria serpyllifolia</u>
<u>Reseda lutea</u>	

European Distribution and Syntaxonomic Position

The association is known from southern Germany (Oberdorfer, 1957a) and Switzerland (Brun-Hool, 1963). It is the most "continental" of this group of associations, and in addition to Veronica polita and Erucastrum gallicum quoted above, the association is also characterised by Setaria spp., Echinochloa crus-galli, Amaranthus retroflexus and other thermophiles. The Melandryio - Veronicetum politae, described from northeastern Germany by Passarge (1959b), also possesses these species but lacks Erucastrum. Additionally, it lacks Diplotaxis muralis, Reseda lutea and Arenaria serpyllifolia which, though not emphasised by Oberdorfer, appear to be diagnostic for the association (Tab. VI). As Setaria and associated species appear in virtually all continental and eastern weed communities, their value is usually in separating variants rather than associations. Thus despite clear similarities, it would be unwise on present evidence, to regard the Melandryio - Veronicetum politae as a certain synonym of the Setario - Veronicetum.

The position of the British data is just as difficult. The aufnahmen possess the character species of the association, as defined here, but lack the Setaria group. As Amaranthus retroflexus has been reported as established in a nearby locality (M. Mullin, pers. comm.), their absence may be for geographical rather than climatic or ecological reasons. However, it must be admitted that in view of the frequency of Setaria viridis, Echinochloa crus-galli and Amaranthus retroflexus as bird-seed aliens on refuse tips in Britain, more opportunities for their establishment must have arisen..

Nevertheless, climatological evidence suggests that the existence of the Setario - Veronicetum in Britain is not impossible. The Brecklands, where the single site for this association exists, have a daily fluctuation of temperature at the start of the growing

season which is as high as anywhere in Britain (Meteorological Office, 1952, see Overlay 5) and comparable with continental Europe. Lamb (1970) points out that the rainfall in this area is similar, not to the adjacent coast of the Netherlands, but to inland Europe as far east as Berlin.

In view of the limited phytosociological value of the Setaria - Amaranthus group of species, this association is provisionally accepted for Britain, as a variant lacking the more thermophilic species. G8rs (1966) regards his Thlaspio - Veronicetum politae as the montane and presumably less thermophilic counterpart of the Setario - Veronicetum, but it does not appear, at present, that this would encompass British stands.

British Distribution (Map 1)

Known only from a market garden and associated arable field near Herringswell, Suffolk.

Ecology

The association occurs on sandy calcareous clay soil at the southern fringe of the Brecklands, at an altitude of 100 ft. It is so far recorded from root-crops and fallow ground. It thus appears to occupy the same habitats as originally specified by Oberdorfer (op. cit.).

Subdivisions

Oberdorfer (op. cit.) describes a subassociation of Chenopodium polyspermum, as "Setario - Veronicetum polyspermetosum" containing C. polyspermum and Veronica agrestis. This is not represented in British data. Brun-Hool (op. cit.) describes a subass. of Panicum crus-galli, which contains the thermophilic species discussed above. Thus his concept of subass. typicum, which does not correspond with

Oberdorfer's original data, and does not contain these species, could apply to Britain.

Aufn. 293 of the British data contains a number of bryophytes absent from other aufnahmen, and could thus be the nucleus of a Moss-rich Nodum.

3. Association: ALOPECURO - MATRICARIETUM CHAMOMILLAE Wasscher 1941 (Tab. V)

Synonymy

Veronico - Lamietum Kr. et Vl. 1939 alopecuretosum (Wass. 1941) Siss. 1946

"Veronico - Lamietum" sensu Gehu 1961

non Alopecuro - Matricarietum Meis. 1967

Diagnostic Species Group

Alopecurus myosuroides

Matricaria recutita

Sinapis arvensis

Chenopodium hybridum

Avena fatua

plus typical Fumario - Euphorbion species.

European Distribution and Syntaxonomy

The association was originally described from the Netherlands (Wasscher, 1941) and Gehu's (1961b) table of the Veronico - Lamietum from France seems better placed here. Meisel's (1967) association from Germany is an Aphanion community.

Various authors (e.g., Tüxen, 1950; Sissingh, 1950) regard the Alopecuro - Matricarietum as synonymous with the Veronico - Lamietum, and indeed three aufnahmen from the original table of Kruseman and Vlieger (1939) correspond to the Alopecuro - Matricarietum. Sissingh (op. cit.) regards this association as a cornfield form of the Veronico - Lamietum transitional to the Centauretalia, and this is a valid view,

but virtually all British stands are recorded in root-crops. For the time being it seems better to maintain the associations separately.

British Distribution (Map 2)

Most recorded stands are from the fringes of the East-Anglian fenlands, but the association occurs in other scattered localities in southern England, west to Dorset.

Ecology

Stands of this association have been recorded from sandy loams and light clay loams on a variety of geological strata. These range from the typically base-poor Lower Greensand to Chalky Boulder-Clay and Middle Chalk. Altitude similarly shows a wide range, from 50 to 450 ft. This diversity of habitat is indicated in Table V by a degree of heterogeneity. The alliance character and differential species are not uniformly distributed in the table, but are absent from a number of quadrats. The implications here are that the nucleus of the association is represented by relatively few aufnahmen, primarily columns 5 to 9 of the table, and that other stands deviate to a variable extent from this ideal. The nucleus of the association is from mesic to base-poor strata, fen deposits, boulder clay over Gault Clay, or Lower Greensand. Aufnahmen from more base-rich strata might then take the role given to this association by Westhoff and Den Held (1969), that of a transition from the Veronico - Lamietum to the Linarietum spuriae. Single occurrences of Kickxia spuria and Fumaria officinalis ssp. wirtgenii give some support to this, but generally, any transition is more towards the less calcicolous Alchemillo - Matricarietum chamomillae of the Aphanion.

The association, sensu lato, is recorded mainly from maize, potatoes, broad beans and sugar beet; 78% of the aufnahmen are from

root-crops and vegetables, 16% from cereals. Analyses of the Lower Greensand soils gave:-

Aufn. 741 980 mg /100 g calcium 32 mg /100 g potassium

Aufn. 765 810 mg /100 g " 7 mg /100 g "

Additionally, from the fenland margin of the Brecklands:-

Aufn. 752 1075 mg /100 g calcium 6 mg /100 g potassium

Subdivisions

A Plantago major Nodum can be recognised in the data, differentiated by Plantago major, Poa annua, Geranium dissectum, Matricaria matricarioides, Coronopus squamatus, Agrostis stolonifera, Rumex crispus, Trifolium repens, Taraxacum officinale. The alliance character species are largely confined to this nodum, and Sonchus oleraceus, Lamium purpureum, Urtica urens, Papaver rhoeas, and Matricaria recutita could have been quoted as additional differential species. The nodum is indicative of soil compaction, being defined by species typical of the Plantaginetea.

4. Association: FUMARIETUM OFFICINALIS (Krus. et Vl. 1939)
R. Tx. 1950 (Tab. VII)

Synonymy

- Panico - Chenopodietum polyspermi R. Tx. 1937, p.p.
Mercurialetum annuae Kr. et Vl. 1939
Raphanetum raphanistri G. Knapp 1946, p.p.
Delphinietum consolidae G. Knapp 1946, p.p.
Veronico agrestis - Fumarietum R. Tx. 1950 apud Lohm. 1949
Setario - Fumarietum J. Tx. 1955
 ? Amarantho - Fumarietum J. Tx. 1955
Mercuriali - Fumarietum Kr. et Vl. 1939 em. J. Tx. 1955
 apud Westh. et Den Held 1969

Diagnostic Species GroupFumaria * officinalisMercurialis annuaVeronica agrestisEuphorbia peplusEuropean Distribution and Syntaxonomy

In its broad sense, this is a wide-ranging association, from the atlantic northwest of Europe south and east to southern Germany, Switzerland and northern Italy. Predictably, it shows floristic variation across its range and has been split into various components. The original basis of the association was the Mercurialetum annuae, described by Kruseman and Vlieger (1939). This is now regarded as the atlantic representation of R. Tüxen's (1950) broader concept of the association. J. Tüxen (1955) split the Fumarietum into three associations, the Veronico - Fumarietum of western Europe, incorporating the "Mercurialis - Ausbildung", and the Setario - Fumarietum and Amarantho - Fumarietum of central Europe. He further subdivided each into subassociations, variants and garden forms. Some published data of these associations is summarised in Table IX.

Oberdorfer (1957a) suggested that the Setario - Fumarietum and the Amarantho - Fumarietum should be included in his own Setario - Veronicetum politae, a view repeated by Oberdorfer et al. (1967), but the diagnostic species of the latter are rare in J. Tüxen's data and the Setario - Fumarietum, at least, is better incorporated into R. Tüxen's broad based Fumarietum officinalis as a thermophilic variant. The position of the Amarantho - Fumarietum is rather different; it possesses a number of distinctive species and may deserve separate status, as a transitional association to the Eragrostietalia.

The extreme atlantic counterpart of the Fumarietum officinalis is the Fumarietum bastardii of western Britain and Ireland, which appears to provide a link to the Spergulo - Chrysanthemetum of the

Spergulo - Oxalidion. Similar vegetation may occur in western France (Tüxen, 1950).

British Distribution (Map 3)

The association is widespread in southern England, extending northwards to northeast England and east Scotland. Both subassociations described here occur throughout the range of the association. In the far west the association is replaced by the Fumarietum bastardii and the Stachys arvensis - Community.

Ecology

The typical community of fertile loam soils in intensive vegetable growing areas, on allotments and in market gardens. This is also the typical Fumario - Euphorbion community of dumped top-soil and disturbed earth along new roadsides in lowland areas. The association is typically lowland but extends to 350 ft on the light friable soils of the Permian Yellow Sands in Co. Durham. Stands normally occur on alluvial and other drift deposits, though most Scottish sites are on soils derived from the Lower Old Red Sandstone. The association has been recorded from a range of other strata, including the Lower Greensand in Cambridgeshire (Aufn. 280), where the typically base-poor sand has been modified by fertile fen alluvium, to the Inferior Oolite in Dorset (Aufn. 630) and Chalk in Kent (Aufn. 863).

The site on chalk, however, is very atypical and it is possible that aufn. 863 has been misplaced. The dominance of Mercurialis annua suggests that the stand should be placed here, but the presence of Anthemis arvensis and Avena fatua suggest affinities with the Centauretalia, which would normally be expected on chalk. The anomaly is caused by the existence of a potato field on a chalk down, an unusual event. The association is more or less confined to root-crops

and disturbed ground; 64% of stands are from root and other vegetable crops and 4% (i.e. one aufnahme) from cereals.

Subdivisions

Two subassociations can be distinguished in British data.

Subassociation typicum is represented by the minority of the aufnahmen. Its ecology is described above.

Fumarietum officinalis (Kr. et Vl. 1939) R. Tx. 1950 matricarietosum subass. nov. (prov.) is characterised by the following differential species:

Matricaria matricarioides (on which name is based)

Plantago major

Trifolium repens

Rumex obtusifolius

Lolium perenne ssp. perenne

Taraxacum officinalis

Poa trivialis

Geranium dissectum

Type aufnahme: aufn. 304 (Tab. VII) Beetfield at Reach, Cambridgeshire. This was selected as the type aufnahme as other apparently floristically more complete aufnahmen were from disturbed ground and potentially heterogeneous. Other species which might be differential for this subassociation are Medicago lupulina, Holcus lanatus, Coronopus didymus and Urtica dioica. However, these may be symptomatic of heterogeneity resulting from the inclusion of stands on dumped soil.

This subassociation represents a transition to the Plantaginetea, occurring on more compacted soil than subass. typicum. Most stands on dumped soil belong to subass. matricarietosum.

Tüxen (1955) describes two other subassociations of the Veronico-Fumarietum, subass. sperguletosum, differentiated by Spergula arvensis, Scleranthus annuus, Rumex acetosella, Arabidopsis thaliana, and subass. euphorbietosum, differentiated by Chaenorhinum minus, Euphorbia exigua and Kickxia elatine. Although Spergula arvensis

occurs three times in the British data, and Kickxia elatine once, these subassociations are not tenable here.

5. Association: FUMARIETUM BASTARDII Br. Bl. 1950 (Tab. VIII)

Synonymy

None

Character Species

Fumaria bastardii + Fumario - Euphorbion species

Braun-Blanquet and Tüxen (1952) also give Veronica persica, Fumaria officinalis, Lycopsis arvensis, Chrysanthemum segetum, Euphorbia peplus and Erysimum cheiranthoides as territorial character-species for Ireland, but these are of relatively little diagnostic value in Great Britain.

European Distribution and Syntaxonomic Position

This association was described from Ireland by Braun-Blanquet in Tüxen (1950), full details being given by Braun-Blanquet and Tüxen (1952). Tüxen (op. cit.) claimed that similar vegetation occurs in western France, but so far, this association has not been reported outside Ireland.

The association is represented by only three aufnahmen in Braun-Blanquet's redescription in Braun-Blanquet and Tüxen (op. cit.), which means that the status of this association must be considered with caution. The presence of Chrysanthemum segetum and Lycopsis arvensis suggests a transition to the Spergulo - Chrysanthemetum, while Papaver dubium suggests at least a Spergulo - Oxalidion community. However, Fumaria officinalis, Euphorbia peplus, E. helioscopia, Erysimum cheiranthoides and Sonchus oleraceus point equally to the Fumario - Euphorbion.

The additional data from western England and Wales presented here suggest that the Fumarietum bastardii may indeed be a distinct association within the Fumario - Euphorbion, but grading into the Spergulo - Chrysanthemetum or Stachys arvensis - Community, via a Spergula arvensis - Variet differentiated by Spergula arvensis, Chrysanthemum segetum and, perhaps, Lycopsis arvensis. If this view is accepted, then columns 1 and 2 of Braun-Blanquet's table belong to this variant and only his column 3 represents the typical variant of the association. However, before any decision can be made, further information is needed on the status of the Stachys arvensis - Comm. (q.v.); its relationship to the Spergulo - Chrysanthemetum, and whether either of these syntaxa occurs in Ireland. It is very possible that the Fumarietum bastardii represents a high atlantic association, vicariant to both these syntaxa and to the Fumarietum officinalis.

British Distribution (Map 3)

The association is so far recorded from five localities on the west coast of England and Wales, from the Isles of Scilly and North Devon north via Pembrokeshire and Caernarvonshire to the Wirral Peninsula of Cheshire. It is highly likely to occur on the Scottish coast of the Solway Estuary, Fumaria bastardii being fairly frequent there (O. M. Stewart, pers. comm. 1977).

Ecology

Braun-Blanquet and Tuxen (op. cit.) describe the association as occurring on loamy soils in fields of potatoes and other vegetable crops. British stands are from a more diverse range of crops, potatoes, cabbages, turnips, bulbs in the Isles of Scilly, barley and mixed barley and oats (grown for fodder). The localities enjoy the typical high atlantic conditions of high rainfall, high humidity, mild winter temperatures and scarcity of frosts (see overlays). No soil analysis

data is available but it is reasonable to assume that the association occurs on soils subject to leaching, and since all localities are over base-poor igneous rocks and shales, these soils are likely to be more acidic than is the case for those supporting other Fumario - Euphorbion communities. A floristic transition to the Spergulo - Oxalidion is thus likely to be accompanied by an edaphic transition.

Subdivisions

The Spergula arvensis - Variant, recorded from Wales and Cheshire, has been described above. The typical variant occurs throughout the known British range of the association.

A moss-rich nodum, defined by Bryum rubens and other bryophytes, plus such higher plants as Cirsium arvense and Agrostis stolonifera, occurred in a weedy barley field and where bulbs were dying down, situations allowing development of species normally disturbed or hand-weeded in typical root-crops.

6.6 Alliance: SPERGULO - OXALIDION G8rs apud Oberd. et al. 1967

Synonymy

Eu - Polygono - Chenopodion polyspermi Koch 1926
em. Siss. 1946, p.p.

Spergulo - Erodion J. Tx. 1961, p.p.

Veronico - Euphorbion pepli Siss. 1942 apud Pass. 1964, p.p.

Character and Differential Species

<u>Solanum nigrum</u>	<u>Stachys arvensis</u>
<u>Spergula arvensis</u>	<u>Lycopsis arvensis</u>
<u>Raphanus raphanistrum</u>	<u>Phalaris minor</u>
<u>Ranunculus parviflorus</u>	<u>Misopates orontium</u>
<u>Galeopsis speciosa</u>	<u>Chrysanthemum segetum</u>

Montia perfoliataValerianella locustaPolycarpon tetraphyllumGladiolus byzantinusAdditional differential species from the Fumario - Euphorbion:-Coronopus didymusRumex acetosellaAgrostis tenuisDaucus carotaGeranium molleVicia * angustifoliaCerastium glomeratumPoa trivialisVeronica arvensisSilene albaV. * hederifoliaS. gallicaTrifolium dubiumErodium * cicutariumT. arvenseHolcus mollisAnisantha diandraMedicago polymorphaSenecio sylvaticusAira * multiculmisFilago vulgarisAphanes microcarpaBriza minorOrnithopus perpusillusGnaphalium undulatum (Ch. Is.)Malva neglectaScleranthus annuusMyosotis discolorPapaver dubiumAnthriscus caucalisEchium vulgareBryum micro-erythrocarpum

These are species typical of sandy or acidic ground; many of them are also of differential value for the alliance Arnosolidion of the Centauretalia cyani.

European Distribution and Syntaxonomy

As G8rs (1966) had proposed a subdivision of the Polygono_- Chenopodion to include the associations of base-rich and loamy soils, the Fumario - Euphorbion, a name was needed for the remaining associations of base-poor sandy and peaty soils. Thus the Spergulo_- Oxalidion was validated by Oberdorfer et al. (1967). The concept of the alliance is very similar to that of the Spergulo_- Erodion, proposed by Tüxen (1961) and taken up by Passarge (1964). However,

Tüxen was of the opinion that the Panico_-Setarion could not be maintained separately from the Eu_-Polygono - Chenopodion in Germany, and his alliance includes at least the western European associations of the Panico_-Setarion. If indeed the associations of the Panico_-Setarion were divided between the Eragrostietalia and the Polygono_-Chenopodion, then his alliance might be the correct name for the sandy-ground subdivision of the latter. However, Tüxen (op. cit.) does not specify the associations of his alliance, and quotes only Erodium cicutarium, Spergula arvensis, Rumex acetosella and Scleranthus annuus as character and differential species, so while Passarge's interpretation is sensible and fairly obvious, the original publication could be held to be inadequate.

The Spergulo_-Oxalidion is thus restricted to atlantic and subatlantic Europe. Its southernmost extension is marked by the Lamio_-Panisetum crus-galli and Chenopodio_-Oxalidetum violaceae in Spain, while the Galeopsis speciosa_-G. bifida_-Ass. is the typical if not the only association of root-crops in Scandinavia. Eastwards, the Setario_-Stachyetum arvensis probably represents a transition to the Panico_-Setarion.

Within the alliance, four informal groupings of associations might be discerned, though the placement of individual associations may be arbitrary.

i) Oxalis - Chenopodium polyspermum group, characterised by

C. polyspermum and various Oxalis spp.:-

Chenopodio_-Oxalidetum violaceae Br. Bl. 1967 (Spain)

Lamio (dissectum) - Panisetum crus-galli Tx. et Oberd.
1954 (Spain)

Oxalido - Chenopodietum polyspermi Siss. (1942)
1950 (W. Europe)

Rorippo - Chenopodietum polyspermi Kähler 1962 (E. Germany)

ii) Stachys arvensis group (See Tab. XIX)Oxalis stricta - Stachys arvensis - Ges. Pass. 1964

(N. Germany)

Setario - Stachyetum arvensis Oberd. 1957 (S. Germany)Stachys arvensis - Comm. Silverside (mscr.) (Great Britain)iii) Lycopsis arvensis - Chrysanthemum segetum group (See Tab. XXVI)Chenopodio - Violetum curtisii Silverside (mscr.)

(Scotland)

Descurainio - Lycopsietum Silverside (mscr.) (England)Lycopsietum arvensis (Raabe 1944) Pass. 1964 (N. W. Europe)Medicagini - Ranunculetum parviflori Silverside (mscr.)

(W. Europe)

Spergulo - Chrysanthemetum segeti (Br. Bl. et De L.

1936) Tx. 1937

(N. W. Europe)

(? incl. Chrysanthemum segetum - Oxalis
violacea - Ass. Tx. et Oberd. 1954)iv) Galeopsis groupGaleopsis speciosa - G. bifida - Ass. Tx. et Becking

1950

(N.W. Europe)

Ecology

Edaphic details are described above. The alliance replaces the Fumario - Euphorbion on peaty and podsolised soils in the high rainfall areas of N. W. Europe.

British stands not assigned to any association are shown in Table XXIX. They include heterogeneous stands and impoverished stands lacking association character-species. Some aufnahmen, e.g. 482, 859, could be referable to the Arnosericidion.

A Polygonum aviculare - Nodum defined by Polygonum aviculare, Matricaria matricarioides, Plantago major, Lolium perenne sspp. perenne and multiflorum, Polygonum persicaria and Galeopsis tetrahit s.l.

represents a transition to the Plantaginetea. Within this, a Crepis capillaris - Nodum can be distinguished, on poor, marginal land and probably indicating previous history as pastureland. The presence of species such as Pteridium aquilinum and Leontodon autumnalis reinforces this view.

The Oxalis pes-caprae - Nodum, including species such as Arabidopsis thaliana, Montia perfoliata and Gladiolus byzantinus, characterises warm, dry, sandy soils such as those of the Channel Islands and the Isles of Scilly bulbfields.

Aufn. 416 was from ground manured with shoddy at Blackmoor fruit farms, Hampshire and contains the typical Medicago spp., with Erodium moschatum and Trifolium subterraneum var. majurculum (Adamovic) em. Katzn.

Aufn. 580 represents a coastal garden community from south Devon with Polycarpon tetraphyllum and Oxalis corymbosa.

1. Association: OXALIDO - CHENOPODIETUM POLYSPERMI Siss. (1942)
1950 (Tab. XI)

Synonymy

Panico - Chenopodietum Br. Bl. 1921, p.p.

Oxaleto - Chenopodietum polyspermi medioeuropaeum Tx. 1950

Oxaleto - Chenopodietum polyspermi subatlanticum
(Siss. 1942) Tx. 1950

Galeopsido - Chenopodietum Oberd. 1957

Diagnostic Species Group

Chenopodium polyspermum

Oxalis europaea

As most literature combines Oxalis europaea with O. stricta (see Sect. 1.4.2) it is difficult to be sure that it is always O. europaea which characterises this association. However, Ciba-Geigy, Ltd. (1973) confirm that it is O. europaea that should be considered the character-

species of the association. Sissingh (1950) gives Mentha arvensis ssp. agrestis Briq. (presumably the usual cornfield form of Mentha arvensis) as an additional character-taxon of the Oxaleto - Chenopodietum polyspermi subatlanticum.

European Distribution and Syntaxonomic Position

As accepted here, this is a widespread association in northern, western and central Europe, though Tüxen (1950) separated the central European stands, characterised by Setaria spp., Echinochloa crus-galli, Amaranthus retroflexus and Symphytum officinale, into the clumsily named Oxaleto - Chenopodietum polyspermi medioeuropaeum. In the broad sense, it reaches as far as Italy (Pignatti, 1952), but is replaced by the Panico - Setarion in the south and east. In East Germany, it grades into the Rorippo - Chenopodietum polyspermi with Rorippa sylvestris and other species of wet ground (Köhler, 1962). Braun-Blanquet's (1967) Chenopodio - Oxalidetum violaceae is undoubtedly a vicariant association from Spain, with O. europaea replaced by O. "violacea" and O. corniculata, and a number of Mediterranean species occurring. Quantin (1947) describes an "Ass. a' Polygonum persicaria et Chenopodium polyspermum" from France which appears to connect the Oxalido - Chenopodietum polyspermi with the Panico - Setarion and may be heterogeneous; Tüxen (1950) divides earlier homonyms between these syntaxa.

British Distribution and Ecology (Map 4)

On the continent the association is characteristic of damp, alluvial soils, in root-crops, gardens and nurseries (e.g. Westhoff and Den Held, 1969). However, in Britain, the poorer, wet ground favoured by this association is more economically devoted to grass, and so the association is rare here, and largely confined to gardens. Thus it has been recorded from a few scattered localities in southern

Table 25

OXALIDO - CHENOPODIETUM POLYSPERMI Siss. (1942) 1950

Aufnahme	540	% Cover - Tracheophytes	75
No. of Species	35	% Cover - Bryophytes	n
Area of Quadrat	4m ²	Altitude	100 ft
Area of Stand	20m ²	Month	July
% Cover - Total	75	Soil	cL

Diagnostic Species

Chenopodium polyspermum	1.2	Mentha arvensis	+ .2
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Char. & Diff. Spp. of Alliance

Solanum nigrum	+	Trifolium dubium	(+)
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Char. & Diff. Spp. of Order

Sonchus oleraceus	1.2	Urtica urens	(+)
Polygonum * lapathifolium	(+)	Lamium purpureum	(+)

Char. Spp. of Class

Stellaria media	1.2	Capsella bursa-pastoris	1.2
Senecio vulgaris	1.1	Anagallis arvensis	+ .2
Atriplex hastata	+ .2	Sonchus asper	+
Chenopodium album	+	Veronica persica	+
Polygonum persicaria	(+)		

Companion Spp. - Tracheophyta

Trifolium repens	1.2	Poa annua	1.2
Agropyron repens	1.2	Lathyrus pratensis	1.2
Agrostis stolonifera	+ .3	Rumex obtusifolius	+ .2
Rumex crispus	+ .2	R. acetosa	+ .2
Potentilla reptans	+ .2	Ranunculus repens	+ .2
Geranium dissectum	+ .2	Sisymbrium officinale	+
Epilobium adenocaulon	+	Plantago major	+
Cirsium arvense	(+)	Urtica dioica	(+)

Companion Spp. - Bryophyta

Brachythecium rutabulum	+ .2	Camptothecium lutescens	+ .2
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Table 26

OXALIDO - CHENOPODIETUM POLYSPERMI Siss. (1942) 1950

Two further lists, both from botanists' gardens.

- a) Kindly provided by Mr. T. A. W. Davis
 South Mullock, Haverfordwest, Prembrokehire.
 Grid Ref. SM 818083; altitude 100 ft;
 garden on Red Marl (Devonian) soil; 28.9.1970

Chenopodium polyspermum	Anagallis arvensis
Ranunculus repens	Misopates orontium
Coronopus squamatus	Digitalis purpurea
Silene dioica	Senecio vulgaris
Cerastium fontanum	Sonchus oleraceus
Geranium dissectum	Poa annua
Malva sylvestris	Agrostis tenuis
Rumex acetosella	

- b) Garden of Mr. A. W. Graveson, Beaminster, Dorset.

Aufn. 534

No. of Species	11	Slope	-
Area of Quadrat	10m ²	Exposition	-
Area of Stand	20m ²	Month	May
Cover	low	Soil	cL
Altitude	250 ft	Crop	St

Chenopodium polyspermum	Trifolium repens
Veronica acinifolia	Capsella bursa-pastoris
V. peregrina	Senecio vulgaris
V. polita	Euphorbia peplus
Sagina procumbens	(Scandix pecten-veneris)
Poa annua	

England and Wales. C. polyspermum has also recently been discovered in two localities in the Solway counties of Scotland and both stands could be regarded as referable to the association.

Oxalis europaea was not encountered during the present survey, but in Britain it is primarily a garden weed, perhaps most usually in the Fumarietum officinalis. Consequently, the map of the association in Sissingh (1950), based, for Britain, on the distribution of O. europaea, is misleading.

Table XI contains arable stands of the association, including Aufn. 592 from an area newly, and unsuccessfully, planted with Picea abies. A number of subassociations are described by Sissingh (op. cit.) and Brun-Hool (1963) but more data is needed before infra-associational syntaxa can be recognised in British data. Tables 25 and 26 present data of garden forms of the association, the former from park flowerbeds and the latter from two botanists' gardens. The stand described in Table 26b is of interest in that it includes two rare Veronica spp., V. acinifolia and V. peregrina, both of which were accidentally introduced with shrubs and have maintained themselves for many years (A. W. Graveson, pers. comm.). Scandix pecten-veneris in the same stand was a deliberate introduction, but now also maintains itself by seeding throughout the garden.

2. Association: SPERGULO - CHRYSANTHEMETUM SEGETI (Br. Bl. et De L. 1936) R. Tx. 1937 (Tabs. XII, XIII, XIV, XVI)

Synonymy

? Chrysanthemum segetum = Oxalis violacea = Ass.
Tx. et Oberd. 1954

Chrysanthemo - Lycopsetum Raabe 1944 apud Pass. 1959, p.p.

Diagnostic Species GroupChrysanthemum segetumLycopsis arvensisStachys arvensisRaphanus raphanistrumMisopates orontium

Sissingh (1950) also gives Hypochoeris glabra, but inasmuch as this occurs as an arable weed at all in Britain, it is more likely to be diagnostic of the Arnosericidion.

European Distribution and Syntaxonomic Position

The association is widespread in northwestern Europe, extending west to Poland and south to France and perhaps Spain (Tüxen, 1950; Sissingh, 1950). Sissingh also cites southern Sweden, Britain and Ireland. However, it is not clear on what information Sissingh bases his map of the association, while Tüxen (1950) undoubtedly includes vegetation which could be regarded as Lycopsietum arvensis. The Spergulo - Chrysanthemetum is replaced by the Lycopsietum arvensis in parts of N. Germany (Passarge, 1959b, 1964) and it is possible that the association is primarily restricted to the Atlantic coasts of Europe. It does, however, reach Switzerland (Brun-Hool, 1963), though published tables suggest it is ill-developed there.

The southern limit must also be in doubt, the Variant of Briza minor described here from Guernsey and the Isles of Scilly is not convincingly distinct from the five aufnahmen of the Chrysanthemum segetum - Oxalis violacea - Ass. published by Tüxen and Oberdorfer (1958). Table XV compares these two syntaxa. The distribution of the Spergulo - Chrysanthemetum in France requires reassessment in relation to the Medicagini - Ranunculetum while its relationship with the Fumarietum bastardii in Ireland also needs to be investigated.

British Distribution (Maps 5 and 6)

The maps presented here are very incomplete; the association

appears to be widespread in Britain, with a western tendency and is certainly much more common than the maps suggest. Subsequent to the survey, similar vegetation has been seen repeatedly in central and west Scotland, while Howarth and Williams (1972) give further correctly identified *aufnahmen* from the English midlands. In the far west, the association occurs on a variety of soils, but eastwards it is more restricted to poorly drained areas, typically where bands of clay underly a sandy topsoil. Subassociation ranunculetosum (Map 6) is undoubtedly more frequent than subass. typicum (Map 5) in the Outer Hebrides and in the present survey was not encountered in Lincolnshire, where subass. typicum occurs. However, this possible and predictable western distribution of subass. ranunculetosum is not at all clear, and both Lincolnshire *aufnahmen* of Howarth and Williams (op. cit.) are referable to the latter subassociation.

Ecology

The ecology of Chrysanthemum segetum itself is reviewed by Howarth and Williams (op. cit.), who proved in sand culture the often assumed preference of the plant for nitrogenous conditions and its dislike of calcareous conditions. While in very open conditions, Chrysanthemum segetum will even occur on chalk, e.g. on the Surrey downs, its normal behaviour is certainly calcifuge and this is mirrored by the association as a whole.

In the west, the association typically occurs on peaty, sandy loam or even sandy clay soils over poor sandstones and igneous rocks such as gneiss or granite. Eastwards, the association is most typical of the base-poor Bagshot Sands or plateau gravels, apparently being absent from the Lower Greensand. In Lincolnshire, it is characteristic of the areas where blown fine sand and silt of original alluvial origin (Strahan, 1888) overlies the poorly drained Kimmeridge Clay.

Excluding the Briza minor - Variant, which occurs almost entirely

in bulbfields, 37% of stands were recorded from root-crops, mainly potatoes and turnips, and 49% from cereals. Many of the stands were in rye or oats, including Avena strigosa.

This occurrence in cereals corresponds with the observations of Westhoff and Den Held (1969), who comment that in the Netherlands it occurs in root crops and ryefields and also in summer cereals, where it grades into the Papaveretum argemonis, as it does in Britain. Their other observation, that in the lowlands it completely merges into the Echinochloo - Setarietum, is not so obvious here.

Howarth and Williams (op. cit.) remark on the absence of Chrysanthemum segetum from higher altitudes, and though arable land itself is rare at altitude, the association as a whole does seem to be absent from the small plots of root-crops typical of upland areas. In only three localities, all on the west coast of Cornwall and Wales, does the association reach 300 feet. Where the association is well developed, e.g. on the machairlands of the Outer Hebrides or in the Poole Basin of Dorset, it is near sea-level.

Subdivisions

Subassociation ranunculetosum repentis R. Tx. 1937, of damper ground, differs from subass. typicum R. Tx. 1937 by the presence of Ranunculus repens, Plantago lanceolata, Juncus bufonius, Cerastium fontanum, Potentilla anserina, Bellis perennis, Myosotis arvensis, Plantago major and various bryophyte species such as Bryum rubens (see Tab. XVI). Again, basing calculations on the typical variant only, 30% of stands occur in root-crops and 48% in cereals, suggesting that there is little correlation of the subassociation with either root-crops or cereals, but that it may reflect the invasion of fallow ground by such species as Ranunculus repens, Cerastium fontanum and Potentilla anserina. Virtually all stands in the Hebrides are referable

to this subassociation.

Most of the foregoing remarks refer to the Type Variant (Tabs. XII and XIII). By contrast, the Variant of Briza minor (Tab. XIV) occurs in the Channel Isles and the Isles of Scilly, both as subass. typicum and, again on damper ground, subass. ranunculetosum. It is defined by a group of thermophilic species including Ranunculus muricatus, Briza minor, Oxalis pes-caprae, Gladiolus byzantinus, Aira caryophyllea ssp. multiculmis, Medicago polymorpha, Polycarpon tetraphyllum, Lavatera cretica plus other species listed in Tab. XIV. Widespread native species such as Aphanes microcarpa, Geranium molle and Sagina procumbens also appear to be almost confined to this variant.

Many of these species are natives of the Mediterranean region which have become abundantly established in the Scilly bulbfields. They are adapted to the early flowering and fruiting necessary to survive hot, dry Mediterranean summers, and the practice of delaying weed control in the bulbfields until the bulbs are to be lifted around the end of May thus suits their life-cycles. Also in this variant, however, is the rare endemic fumitory, Fumaria occidentalis.

Reference has already been made to the possible identity of this variant with the Chrysanthemum segetum - Oxalis violacea - Ass. of Spain. This comparison is made in Table XV. The Scillies and Guernsey data are certainly more species-rich and contain a number of species absent from the Spanish data. On the other hand, the Spanish data contain relatively few important species absent from the Scillies, including Picris echioides, Polygonum persicaria, Euphorbia helioscopia, Calendula arvensis, Vicia tetrasperma, Lapsana communis and Phalaris canariensis. Of these, Polygonum persicaria and Euphorbia helioscopia are order character-species present in the typical variant. Separate maintenance of the Chrysanthemum segetum -

Oxalis violacea - Ass. on a basis of only five anfnahmen seems very dubious.

Sissingh (1950) describes two variants based on Rumex acetosella and Anagallis arvensis. Their separation in Britain does not appear possible. J. Tuxen (1958) describes a subass. sperguletosum with Spergula arvensis, Rumex acetosella and Scleranthus annuus as differential species, and occurring on very sandy soils. It does not appear recognisable here, but could conceivably be discernible with more data. Tuxen also provides a very detailed analysis of garden forms of this association.

Minor Noda

Within the subass. ranunculetosum, typical variant (Tab. XIII), noda can be distinguished based on Potentilla anserina, Avena strigosa, and Leontodon autumnalis.

The Potentilla anserina - Nodum occurs in marginal, mostly coastal areas, where the predominance of hayfields and pastureland allows ready invasion by Molinio - Arrhenatheretea species. The Avena strigosa - Nodum and Leontodon autumnalis - Nodum both occur within the previous nodum but are mutually exclusive. The former is typical of the more successfully cultivated machair on the Outer Hebrides, the latter of field edges or where the machair has been less efficiently ploughed.

Within the Briza minor - Variant, the two aufnahmen from Guernsey form a Sisymbrium officinale - Nodum, defined by Sisymbrium officinale, Oxalis articulata, Mercurialis annua and Sinapis arvensis.

Soil analysis data

Analysis of Bagshot Sands soils (including those modified by superficial deposits) gave the following results, amounts expressed in mg per 100 g dry soil. Figures refer to exchangeable fractions.

Subass. typicum

<u>Aufn.</u>	<u>Calcium</u>	<u>Potassium</u>
589	105	2
591	75	4
604	155	6
608	265	1
655	240	12

Subass. ranunculetosum

<u>Aufn.</u>	<u>Calcium</u>	<u>Potassium</u>
343	140	2
590	215	3
603	35	2
658	615	15

The anomalous figure for calcium for aufn. 658 is explained by calcareous water draining from nearby chalk slopes across clay beds within the Bagshot Sands formation.

3. STACHYS ARVENSIS COMMUNITY (Tabs. XVII, XVIII, XIX)Synonymy

? Synonymous with the Oxalis stricta - Stachys arvensis - Ges. Pass. 1964.

Diagnostic Species Group

<u>Stachys arvensis</u>	<u>Spergula arvensis</u>
<u>Euphorbia helioscopia</u>	<u>Misopates orontium</u>
<u>Kickxia elatine</u>	<u>Fumaria bastardii</u>
<u>Euphorbia exigua</u>	

Distribution and Syntaxonomic Position (Map 7)

On present knowledge, this community is endemic to southwest England and Wales, from Dorset to Cheshire, with most stands recorded from Pembrokeshire and Anglesey.

The occurrence together of species such as Stachys arvensis,

Misopates orontium and Spergula arvensis would normally suggest the Spergulo_-Chrysanthemetum, at least on the basis of continental literature. However, during tabulation of western stands first provisionally assigned to the Spergulo_-Chrysanthemetum, it was found that Stachys arvensis and Chrysanthemum segetum were distinctly negatively associated, with the stands containing Stachys arvensis but not C. segetum typically containing some or most of the other species quoted above. That a syntaxon exists which is distinct from typical Spergulo_-Chrysanthemetum, as judged by Dutch data, is virtually unarguable. The status of this syntaxon is, however, much less clear.

The situation is analagous to that found by Passarge (1959b, 1964) where the Spergulo_-Chrysanthemetum in northeast Germany divides into two associations with and without C. segetum, the latter being the Lycopsietum arvensis. More importantly, Passarge (1964) also describes an Oxalis stricta_-Stachys arvensis - Gesellschaft of low-lying marshy soils, containing Stachys arvensis, Misopates orontium and Kickxia elatine as differential species, but lacking Chrysanthemum segetum. Euphorbia helioscopia and Spergula arvensis also occur in this community. Comparison of the British syntaxon with his (Tab. XIX) shows that the syntaxa are closely related floristically though his data lacks Euphorbia exigua, plus Poa annua, Matricaria matricarioides and Plantago major, while British data lacks Oxalis stricta. It seems highly likely that the British stands represent a Matricaria matricarioides Variant of his community. Passarge describes a typical Rasse and a more continental Setaria viridis - Rasse, so the British stands constitute a third, atlantic subdivision.

However, Passarge describes his community as infrequent, and gives only ten aufnahmen. Thus he does not give the community formal rank. In Britain, the community might yet prove to be a variant of

the Spergulo - Chrysanthemetum, or even of the Fumarietum bastardii, so formal rank is again inappropriate. Passarge's name is inapplicable to Britain due to the absence of Oxalis stricta agg. from these stands, so the syntaxon is here named simply after Stachys arvensis. Oberdorfer's Setario - Stachyetum arvensis from southern Germany is also similar to these communities (Tab. XIX), especially to Passarge's Setaria viridis - Rasse, and must clearly be taken into account before any final decision is made as to the status of these syntaxa.

Ecology

The community occurs mainly on loam and clay-loam soils with little evidence of sand. In this, it is suggestive of a Fumario - Euphorbion community, to which it is undoubtedly transitional. (Passarge similarly comments on the transitional nature of his community.) The soils are typically Red Marls, derived from the Lower Old Red Sandstone in Pembrokeshire, while elsewhere it occurs on boulder clays, and on schistose soils in Anglesey. The community reaches 550 ft. in Devon, while a heterogeneous disturbed roadside stand in Cornwall occurred at 650 ft. 23% of stands occurred in root-crops and 62% in cereals, primarily oats and barley.

The only soil analysis data available are for aufn. 659, from the Bagshot Sands formation. The exchangeable calcium level was 545 mg./100 g dry soil and the figure for potassium was 3 mg /100 g dry soil. This figure for calcium is more than three times higher than typical results for the Bagshot Sands and is the result of flushing from a nearby chalk ridge. This is the only recorded occurrence of the community from the Bagshot Sands. The community may well be somewhat basiphilous, being replaced by the Spergulo - Chrysanthemetum where the soils are sandy or peaty. Even where the community does occur on the fringes of moorland, at Dowrog Common, Pembrokeshire, it is probably significant that the only Welsh

locality for the somewhat basiphilous Carex appropinquata is closely adjacent. In the Gower Peninsula it occurs over limestone.

Subdivisions

The Matricaria matricarioides - Variant has already been discussed above. Only two aufnahmen, 122 and 127, from Pembrokeshire fail to fit into this variant. Both are from mixed sowings of oats and barley and it may be that a competitive effect is involved here.

Two subcommunities, perhaps equivalent to subassociations, can also be recognised. Table XVIII shows the Mossy Subcommunity of damper, less-disturbed sites, including stubble communities. It is defined by Cerastium fontanum and Aphanes arvensis, plus the bryophytes Pottia truncata, Dicranella staphylina, Eurhynchium praelongum, Pleuridium subulatum, Brachythecium velutinum and Bryum microerythrocarpum. A substantial number of the sites are from the poorly-drained arable fields in the west of Anglesey.

Within this subcommunity, Bryum klinggraeffii and B. rubens delimit mutually exclusive minor nodes. B. klinggraeffii together with B. violaceum, is typical of more fertile, base-rich sites than B. rubens and this is undoubtedly the basis of the subdivision here.

A Brachythecium rutabulum - Nodum, differentiated by B. rutabulum, Bellis perennis, Trifolium dubium and Leontodon autumnalis occurs on marginal land in Anglesey, including Holy Island. Two aufnahmen from Cornwall also form a possible minor nodum based on Juncus bufonius and Hypericum humifusum.

4. Association: MEDICAGINI - RANUNCULETUM PARVIFLORI ass. nov.
(prov.) (Tabs. XX, XXI)

Synonymy

None

Diagnostic Species Group

<u>Cerastium glomeratum</u>	<u>Ranunculus parviflorus</u>
<u>Medicago arabica</u>	<u>Myosotis discolor</u>
<u>Erodium moschatum</u>	<u>Anisantha diandra</u>

Type Aufnahme and Locality

Aufn. 447 (Tab. XX, Column 3), Gulval, Cornwall.

This aufnahme is one of only three which belong to both the typical variant and subass. typicum and it is chosen for its better representation of alliance differential species. The association name is based on Medicago arabica and Ranunculus parviflorus.

Distribution and Syntaxonomic Position (Map 8)

So far, the association is known with certainty from the British Isles. It is restricted to the extreme south-west of Cornwall, around Gulval and around Trenance and Gweek in the valley of the Melford River, and Guernsey and the Isles of Scilly. The Cornish localities constitute the Type Variant, while the Guernsey and Scillonian stands represent the Gladiolus byzantinus - Variant.

Ranunculus parviflorus occurs in S. W. and Mediterranean Europe and Africa, but is restricted to moist habitats in warmer regions (Salisbury, 1931). As a plant of drier soils it is restricted to the areas of higher humidity or rainfall and thus is likely to be a frequent arable weed only in south-west England, W. France and, perhaps, the west of Spain and Portugal. This might, then, be the range of the association, though its constituent species, including

R. parviflorus, are more widespread in other habitats.

Allorge (1922, pp. 635 et seq.) lists species of sandy soils typically associated with Chrysanthemum segetum and Myosurus minimus in France, including Myosotis discolor and Cerastium glomeratum, but his data are undoubtedly drawn largely from the Spergulo - Chrysanthemetum and the Airo - Arnoseridetum. Neither Tüxen and Oberdorfer (1958) nor Braun-Blanquet (1967) describe similar vegetation from Spain.

The association appears to be a vicariant association to the Spergulo - Chrysanthemetum in warmer and more sheltered localities and apparently occurs only on more fertile soils. In its typical form it is clearly distinct from that association, though in the Isles of Scilly, stands transitional to the Briza minor - Variant of the Spergulo - Chrysanthemetum occur. Transitional aufnahmen are shown in Table XXII; they are notable for the high constancy of Medicago polymorpha. Before bulb-farming replaced virtually all other arable farming in the Isles of Scilly, the association probably occurred in root-crops where the Airo - Arnoseridetum occurred in cereals. However, Lousley (1971) notes that Ranunculus parviflorus and Erodium moschatum have apparently greatly increased with the advent of bulb-farming in the Scillies.

Ecology

Salisbury (1961) specifically cites Ranunculus parviflorus and Medicago arabica as frost-sensitive winter-annuals, which are restricted in Britain by the frequency of hard winters. He notes that both may survive short sequences of hard winters by seed dormancy, so long as the reservoir of dormant seed can be periodically replenished. To be important species within the present association, these two species must survive every winter, and this, no doubt, is the key to the distribution of the association as a whole. Erodium moschatum

is similarly frost-sensitive (Salisbury, 1939). The association is limited to overall areas with less than ten frosts per year (less than five in the Isles of Scilly) - see Overlay 6 - and areas of high relative humidity (Overlay 7). Lousley (op. cit.) notes that the fall in temperature at night is less than in the rest of Britain (see Overlay 5) and that this promotes the early spring growth so typical of the bulbfields. The mainland localities are all in sheltered sites in the southern valleys and are either on level ground or south- or south-east- facing. The average rainfall in the Isles of Scilly is below 33 inches (Lousley, op. cit.), substantially less than the average for western Britain. The association reaches 200 ft on the mainland.

Bulbfields are undoubtedly the main sites for this association, including the Cornish bulb-farms. 59% of aufnahmen were from bulbs and 18% from root-crops, including cauliflowers, cabbages and potatoes. The association is more or less restricted to sandy loams, sometimes with peat as an additional constituent. The sands are blown drift deposits; underlying rocks are usually granites or other igneous rocks which probably do not influence the soils in this case.

Lousley (op. cit.) provides a useful account of the Scillonian bulbfields, including notes on the weed vegetation, some of which might refer to stands of this association.

Subdivisions

The occurrence of two variants has already been discussed. The variant on the Isles of Scilly, and less well developed on Guernsey, is the Variant of Gladiolus byzantinus. 24 differential species are shown in Table XXI, including Gladiolus byzantinus itself, Oxalis pes-caprae, Coronopus didymus, Trifolium dubium, Silene gallica, Rumex acetosella, Spergula arvensis, Aphanes microcarpa, Briza minor,

Valerianella locusta, Geranium molle, Montia perfoliata, Papaver dubium, Trifolium repens, Vicia hirsuta and V. sativa ssp. angustifolia. Additionally, Anagallis arvensis shows a frequency of (V) in this variant, compared with (I) in the type variant. Gladiolus byzantinus has been chosen as the name-giving taxon for its high frequency, lack of obvious correlation with minor nodes and its typical thermophilic ecology, which makes it unlikely to occur outside this variant.

Lamium purpureum, Matricaria matricarioides and Barbula unguiculata have so far been recorded only from the Type - Variant.

Two subassociations can also be distinguished:-

Medicagini - Ranunculetum parviflori typicum subass. nov. (prov.) represents the typical form of the association, type aufnahmen 447, as for the association. It possesses no certain differential species, but Bellis perennis, Ranunculus muricatus and Aira caryophyllea ssp. multiculmis have been recorded only in this subassociation. Higher frequencies of Silene gallica, Rumex acetosella and Trifolium dubium are also noteworthy.

The typical subassociation has not been recorded from Tresco, but otherwise occurs throughout the known range of the association. In the Isles of Scilly, percentage cover values are higher than for subass. pottietosum, but this difference is not noticeable on the mainland. It is absent from peaty soils and occurs on drier ground than subass. pottietosum, or at least on ground which dries out more rapidly during the spring growing season. The two subassociations show no correlation with crops.

Medicagini - Ranunculetum parviflori pottietosum subass. nov. (prov.) is differentiated by:-

Sagina procumbensBryum rubensPottia truncataPhascum cuspidatumPolycarpon tetraphyllumBarbula convolutaRiccia sorocarpa

Type aufnahmen and locality: Aufn. 435 (Table XX, Column 4),

Trenance, Cornwall. Name-giving idiotaxon: Pottia truncata.

Probable additional differential species are Bryum bicolor agg. and Weissia rutilans. Juncus bufonius also shows high constancy in this subassociation.

This subassociation occurs in all three mainland localities and is recorded from Guernsey and from St. Mary's, St. Martin's and Tresco in the Scillies. In contrast to subass. typicum, nearly half the recorded Scillonian stands were from Tresco. This is probably a result of the greater cultivation of peaty soils on Tresco, several aufnahmen being from "sandy peaty loam" soils. The subassociation is presumably characterised by moister soils during the winter or at the start of spring, though other damp-loving species such as Juncus bufonius and Eurhynchium praelongum are not entirely confined to these stands.

Minor Divisions

An Oxalis pes-caprae - Nodum, differentiated by Oxalis pes-caprae and Vicia hirsuta occurs within both subassociations of the Gladiolus byzantinus - Variant. It is recorded mainly from St. Martin's and Tresco, but also occurs on St. Mary's and St. Agnes. The nodum is characterised by carpets of O. pes-caprae, which is often completely dominant, and shows greater frequency on the more peaty soils.

A Ranunculus muricatus - Nodum, differentiated by Ranunculus muricatus, Bellis perennis and Cerastium fontanum, occurs only with subass. typicum, Gladiolus byzantinus - Variant. This and the last minor nodum are mutually exclusive, the Ranunculus muricatus - Nodum

occurring on better drained soils where competition from O. pex-caprae is likely to be less severe. However, one stand of this nodum was dominated by Oxalis articulata (Aufn. 480), its pink flowers giving the stand a distinct physiognomic appearance and perhaps deserving recognition as a separate facies.

The Allium triquetrum - Nodum, differentiated by Allium triquetrum, Lolium * perenne, Bromus * hordaceus and Allium roseum ssp. bulbiferum, occurs within both subassociations of the Gladiolus - Variant. It is recorded from St. Mary's, St. Martin's and Guernsey and is characteristic of neglected corners of bulbfields and those which have been temporarily abandoned. It is thus representative of the first stages of succession and includes such non-weedy species as Endymion non-scriptus, Ranunculus ficaria and Lotus uliginosus as well as A. roseum.

The Erodium maritimum - Nodum is a sharply defined but geographically limited nodum, with Erodium maritimum and Spergularia rupicola as differential species. It is represented by two aufnahmen from bulbfields at Appletree Point, on the south-west coast of Tresco. The two differential species, both normally occurring on rather compacted, gravelly ground and rock crevices close to the sea are here growing and thriving under arable conditions. This is one of the few places on the Isles of Scilly where sea-cliffs are cultivated, so while this nodum is sharply defined in one area, it is unlikely to occur elsewhere in the Scillies, or indeed anywhere else within the known range of the association.

Succession

The Allium triquetrum - Nodum described above has been quoted as representing the first stage of succession. A more advanced stage is shown in Table 27, where an abandoned daffodil field on St. Martin's was becoming dominated by grasses. This was typical of a number of

Table 27

Medicagini - Ranunculetum parviflori

Successional Community

Aufnahme	487		
No. of Species	26	Exposition	s
Area of Quadrat	4m ²	Altitude	50 ft
Area of Stand	L	Month	May
% Cover - Total	100	Soil	sL
Slope (in degrees)	10	Crop	Bu/Fa

Diagnostic Spp. Gp. of Association

Anisantha diandra	2.2	Cerastium glomeratum	+
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Diff. Spp. of Successional Community

Bromus willdenowii	3.2	Pteridium aquilinum	2.2
B. * hordaceus	2.2	Holcus lanatus	2.2
Vulpia bromoides	2.2	Lolium x hybridum	1.2
Hypochoeris radicata	1.2		

Char. and Diff. Spp. of Alliance

Poa trivialis	3.2	Rumex acetosella	1.2
Trifolium dubium	+ .2	Veronica arvensis	+

Char. Sp. of Order

Sonchus oleraceus	1.2
-------------------	-----

Char. Spp. of Class

Viola arvensis	+ .2	Anagallis arvensis	+ .2
Sonchus asper	+		

Diff. Spp. of Gladiolus Variant

Briza minor	2.2	Valerianella locusta	1.2
Aira * multiculmis	+ .2	Polycarpon tetraphyllum	+
Silene gallica	(+)		

Companion Spp.

Trifolium repens	2.3	Crepis capillaris	1.2
Geranium dissectum	+ .2	Vicia hirsuta	+ .2

the smaller bulbfields on St. Martin's which are being abandoned for use as hayfields, Aufn. 469 (Tab. LXXVIII) represents a 2-year fallow bulbfield flora which is referable to the Thero - Airion.

5. Association: CHENOPODIO - VIOLETUM CURTISII ass. nov. (prov.)
(Tab. XXIII)

Synonymy

None

Diagnostic Species Group

<u>Avena strigosa</u>	<u>Viola curtisii</u>
<u>Lycopsis arvensis</u>	<u>Erodium cicutarium</u> ssp. <u>cuticularium</u>
<u>Galium verum</u>	<u>Thalictrum minus</u> ssp. <u>arenarium</u>
<u>Tripleurospermum maritimum</u> s.s.	<u>Honkenya peploides</u>

Chenopodium album also shows high constancy.

Type Aufnahme and Locality

Aufn. 797 (Tab. XXIII, Column 1), Howbeg, South Uist.

The name of the association is based on Chenopodium album and Viola curtisii.

Distribution and Syntaxonomic Position (Map 8)

The association is known only from cultivated machair in the Outer Hebrides. It is described from the islands of North and South Uist, but is to be expected in suitable localities on Harris and perhaps in W. Sutherland.

It is allied to the Spergulo - Chrysanthemetum and the Lycopsietum arvensis, but is distinguished by the presence of Galio - Koelerion species. The Galio - Koelerion (R. Tx. 1937) Den Held et Westhoff 1969 (syn. Koelerion albescentis R. Tx. 1937 - see Westhoff and Den Held (1969) for discussion of this) is the alliance of fixed dune vegetation on the Atlantic coast of Europe.

Westhoff and Den Held (op. cit.) cite Viola curtisii and a maritime variety of Galium verum as character species for it. It is here regarded as belonging to the class Sedo_-Scleranthetea (q.v.).

The uncultivated machair supports Galio - Koelerion vegetation, quite possibly the Viola curtisii - Syntrichia ruralis - Ass. described by Braun-Blanquet and Tuxen (1952) from western Ireland, and several species are able to survive arable conditions. Thus the Chenopodio_-Violetum curtisii forms a distinct community on the shell sand of the true machair, between the Galio - Koelerion on the uncultivated machair and the Spergulo_-Chrysanthemetum segeti on the more peaty soils inland. As would be expected, transitional stands occur to both the Galio - Koelerion and the Spergulo_-Chrysanthemetum; these are also shown in Table XXIII.

Ecology

As described above, the association is so far known only from the Outer Hebrides. These islands are subject to the typical northern high atlantic climate, with high relative humidities, cool summers but relatively mild winters (see Overlays). The physical features of machairs are described by Ritchie (1976), who points out that different machair systems differ substantially in their shell-sand content. No soil analyses were undertaken, but since the sand was often dazzlingly white, it is reasonable to assume the shell-sand content is high, especially in view of the presence of calcicoles such as Carex flacca and Coeloglossum viride. Gimingham et al. (1948) give calcium carbonate analyses of natural calcareous machair in Harris which is likely to be similar to that of N. and S. Uist.

The association, in its pure form, is recorded only in ryefields. Arable fields on the machair are small, and farmed largely without the use of agricultural machinery. It is likely that Avena strigosa,

at least, persists by the resowing of poorly cleaned domestically-collected "seed". It is not clear what effects further mechanisation might have on stands of this association. Development of bulb-farming in N. Uist may also be expected to have interesting effects on the weed flora.

Aufn. 787 was noticeably grazed by rabbits, which would be expected to benefit the weed flora at the expense of the crop. In view of the very high rabbit populations of the machairs, this probably applies to all fields. However, an epidemic of myxomatosis was in unpleasant progress at the time of sampling (1971) and changes in both the natural machair vegetation and the weed flora may be taking place.

Aufn. 796, regarded as transitional to the Spergulo_-Chrysanthemetum, was from a field which was either neglected or abandoned. Thus a noticeable grass sward was developing, including Festuca rubra, Holcus lanatus, Agropyron repens, Poa trivialis and Bromus hordaceus.

Subdivisions

In view of the small number of aufnahmen, no subdivisions are worthy of recognition.

6. Association: LYCOPSIETUM ARVENSIS (Raabe 1944) Pass. 1964
(Tab. XXIV) (Spelling of "Lycopsietum" follows Rauschert, 1963)

Synonymy

Chrysanthemo_-Lycopsetum Raabe 1944, ? p.p.,
apud Pass. 1959

Setario - Lycopsetum Pass. 1959

Diagnostic Species GroupLycopsis arvensisPapaver dubiumRaphanus raphanistrumEuropean Distribution and Syntaxonomic Position

Treating the Spergulo_-Chrysanthemetum as an association-group, Passarge (1959b) examined relevant stands in the north German plains and recognised two associations, the Chrysanthemo_-Lycopsetum and the Setario_-Lycopsetum. The more continental Setario_-Lycopsetum differed from the Chrysanthemo_-Lycopsetum in the absence of Chrysanthemum segetum and in the presence of Setaria viridis, S. lutescens, Digitaria ischaemum, Chenopodium viride, Echinochloa crus-galli and Medicago lupulina. Subsequently (Passarge, 1964) he recombined these under the blanket name of "Lycopsetum arvensis", the name which is taken up here.

This association is closely allied to the Spergulo_-Chrysanthemetum, but lacks Chrysanthemum segetum, Misopates orontium and Stachys arvensis and possesses Papaver dubium. It is apparently a northern European, subatlantic vicariant association, occurring in northern Germany, E. England and E. Scotland. It is compared with the Spergulo_-Chrysanthemetum and related associations of N. W. Europe in Table XXVI.

British Distribution (Map 9)

The association is restricted to eastern Britain, from Surrey and Norfolk north to the Moray Firth.

Ecology

The limitation of the association to eastern Britain is probably due to a combination of low rainfall and relative humidities and to cold winter temperatures. It typically occurs on sand or sandy loams

of a variety of geological origins. Thus it occurs on the Bagshot Sands in Surrey, on the silver sand of the Carstone beds of the Lower Greensand in Norfolk and on blown sand or soils derived from the Lower Old Red Sandstone further north. Its altitudinal range is from 50 ft or less in Norfolk and the Moray Firth area to 300 ft in Co. Durham and East Lothian. 33% of stands were recorded from root-crops, especially turnips, and 40% from cereals, in all cases barley.

Subdivisions

Columns 4 - 10 of Table XXIV are referable to subass. sperguletosum Pass. (1959) 1964. Passarge (1964) gives Spergula arvensis, Raphanus raphanistrum, Rumex acetosella and Scleranthus annuus as differential species. Here, R. raphanistrum is regarded as diagnostic for the association, R. acetosella shows no correlation with Spergula arvensis, while S. annua is unrecorded for the association. However, Chenopodium album shows association with S. arvensis and as the subassociation is clearly distinct from subass. riccietosum described below, it is maintained here, at least provisionally. Passarge (1959b) relates the subassociation to the more acidic soils, and this may be true in Britain.

Lycopsietum arvensis (Raabe 1944) Pass. 1964 riccietosum subass. nov. (prov.) is based on columns 1 - 3 of the table, the type aufnahmen being Aufn. 16 (Tab. XXIV, Column 2) from Durham City. Differential species are:-

Veronica agrestis

Riccia sorocarpa

Eurhynchium praelongum

Pottia truncata

Bryum rubens

Barbula convoluta

B. micro-erythrocarpum

Trifolium pratense

Dicranella staphylina

Pleuroidium subulatum

Phascum cuspidatum and other species given in Table XXIV.

The name-giving idiotaxon is Riccia sorocarpa. The subassociation is recorded from damp fallow and barleyfields in Durham and Angus.

The remaining aufnahmen constitute subass. typicum of drier, more fertile soils throughout the range of the association.

Passarge (1964) recognises a ruderal subvariant named after Urtica urens with U. urens, Sisymbrium officinale and Malva neglecta as differential species. M. neglecta is absent from British data, but an Urtica urens - Nodum based on the other two species is recognisable. His Gnaphalium - Variant is not recognisable in British stands.

7. Association: DESCURAINIO - LYCOPSIETUM ARVENSIS ass. nov. (prov.)
(Tab. XXV)

Synonymy

None

Diagnostic Species Group

<u>Descurainia sophia</u>	<u>Reseda lutea</u>
<u>Lycopsis arvensis</u>	<u>Erodium cicutarium</u> ssp. <u>cutarium</u>
<u>Conyza canadensis</u>	<u>Sisymbrium orientale</u>
<u>Diplotaxis muralis</u>	

The name giving idiotaxa are Descurainia sophia and Lycopsis arvensis.

Type Aufnahme and Locality

Aufn. 259 (Table XXV, Column 9), Felthwell, Norfolk.

Distribution and Syntaxonomic Position (Map 9)

The association is endemic to East Anglia, primarily centred on the Brecklands. No similar vegetation has been found described in European literature and the association is presumably a result of the unique conditions of the Brecklands, with a western flora

occurring under continental climatic conditions on very dry calcareous sand (see Sect. 7.3). It is possible that it represents a variant of the Lycopsetum arvensis but it appears quite distinct in the occurrence of Descurainia sophia, Reseda lutea, Conyza canadensis, Sisymbrium orientale and Diploaxis muralis and in the high constancies of Silene alba, Agrostis tenuis and Solanum nigrum. The introduced species Conyza canadensis, Sisymbrium orientale and Diploaxis muralis are fully established in the Breckland fields; while Conyza canadensis has reached its present wide distribution in Britain during the last decade or so, it was abundant everywhere in gardens, heaths and cultivated fields in the Brecklands seventy years ago (Clarke, 1909). The association is compared with the Lycopsietum arvensis in Table XXVI.

Ecology

The general characteristics of the Brecklands are reviewed in Section 7.3. All but two occurrences of the association have been on Breckland Sands overlying chalk, but aufn. 307, an outlier at Hillington, Norfolk, was on the equally dry but much less fertile Carstone beds of the Lower Greensand, though Valley Gravel was also present at this site and presumably raised the fertility. The other outlier, at Babraham, Cambridgeshire, was directly on Middle Chalk.

Thus most sites of the association are reasonably calcareous; available data are given below. It is possible that this association occurs on deeper, less calcareous sand than the Papaveretum argemonis in the Brecklands, but in general the Papaveretum replaces the present association in cereals. 46% of stands of the Descurainio - Lycopsietum were from root-crops, especially sugar-beet and carrots, and 33% were from cereals, mainly barley. The association has not been recorded above 150 ft.

Subdivisions

Three provisional subassociations can be distinguished.

Descurainio - Lycopsietum arvensis typicum subass. nov. (prov.) has no differential species of its own. The type aufnahme is 259, as for the association.

Descurainio - Lycopsietum arvensis anthriscetosum subass. nov. (prov.) is differentiated by Anthriscus caucalis, Rumex tenuifolius, Carex arenaria, Erodium cicutarium ssp. dunense, Arenaria serpyllifolia, Apera interrupta, Arenaria leptoclados, Aphanes microcarpa and Plantago indica. Other possible differential species are Cerastium semidecandrum, Arabidopsis thaliana and Vicia lathyroides, but these may represent a vernal aspect. The type aufnahme is 47 (Table XXV, Column 16), from Lakenheath, Suffolk. The name-giving idiotaxon is Anthriscus caucalis.

This subassociation occurs on deeper, dryer sands than the last, and occurs in areas where drifting sand from nearby heathland "blow-outs" may have appreciable effects, as at Lakenheath and Wangford. Percentage covers are typically low in this subassociation, and could be symptomatic of grazing by rabbits from the same heathlands.

Descurainio - Lycopsietum arvensis euphorbietosum subass. nov. (prov.) has Euphorbia exigua, E. helioscopia, Kickxia elatine, Chaenorhinum minus and Anthemis cotula as differential species. The type aufnahme is 291 (Tab. XXV, Column 23) from Herringswell, Suffolk. The name-giving idiotaxon is Euphorbia exigua.

The other occurrence of this subassociation is that on chalk at Babraham, Cambridgeshire. This subassociation is developed on calcareous clay soils and represents a transition to the Papaveri - Melandrietum of the Caucalidion.

Results of analyses for exchangeable calcium and exchangeable potassium, expressed in mg per 100 g dry soil, are given below.

Subass. typicum

	<u>Calcium</u>	<u>Potassium</u>
Aufn. 264	105	11
" 265	705	7
" 753	1125	8
" 760	235	1
" 763	670	1

Subass. anthriscetosum

	<u>Calcium</u>	<u>Potassium</u>
Aufn. 250	925	6
" 759	645	3
" 762	215	0.5

As these results are from ammonium acetate extractions, soils with free calcium carbonate may give somewhat exaggerated calcium values (see Appendix II)

8. Association: GALEOPSIS SPECIOSA - G. BIFIDA - ASS. R. Tx. et Becking 1950 (Tab. XXVII)

Synonymy

Polygono - Galeopsidetum speciosae Pass. 1959, p.p.

Panico - Galeopsidetum speciosae Pass. 1959, p.p.

Galeopsietum speciosae sensu Pass. 1964; Oberd. et al. 1967; non Kr. et Vl. 1939.

Diagnostic Species Group

Galeopsis speciosa

Galeopsis bifida

European Distribution and Syntaxonomy

Confusion has, for some time, surrounded the association Galeopsidetum speciosae Kr. et Vl. 1939. Kruseman and Vlieger (1939) described this association from cereals in the Netherlands and both Tüxen (1950) and Westhoff and Den Held (1969) accepted it as belonging to the Centauretalia or Secalietea, though neither accepted it as a valid association. In the same paper, Tüxen (1950) published the Galeopsis speciosa - G. bifida - Ass. as a Polygono - Chenopodion association from N. Sweden and Finland. Thus he understood the existence of two associations, one in the Centauretalia and the other in the Polygono - Chenopodietalia. Passarge (1957b) reported the Galeopsis speciosa - G. bifida - Ass. from northern Germany and Knapp (1959) reported it from southern Sweden.

However, Passarge (1959b) divided N. German stands into two associations, the Polygono - Galeopsidetum speciosae and the Panico - Galeopsidetum speciosae, the latter being the more continental in floristic terms, containing Echinochloa, Setaria viridis, Galinsoga parviflora etc. His data contains Centauretalia spp., and may well be heterogeneous, but it appears to be generally referable to the Polygono - Chenopodietalia. Nevertheless, he revived the Kruseman and Vlieger name by placing both his associations within an association-group "Galeopsietum speciosae". Subsequently (Passarge, 1964), he placed more emphasis on the "Galeopsietum speciosae" as the association name for his data. His 1964 data are clearly heterogeneous, containing both Centauretalia and Polygono - Chenopodietalia components. Oberdorfer et al. (1967) followed Passarge by adopting the name "Galeopsietum speciosae" for the Polygono - Chenopodietalia syntaxon.

Examination of Kruseman and Vlieger's (1939) original data shows that though it might be somewhat heterogeneous, it is undoubtedly referable to the Centauretalia. Comparison of the data of different

authors (see Tab. XXVIII) shows that two different syntaxa are clearly involved. Thus the name "Galeopsis speciosa - G. bifida - Ass." is re-adopted for the Spergulo - Oxalidion community. So far it is known from N. Germany, Finland and Sweden and is reported here from Norway (where it was the only arable association seen) and Britain.

The Galeopsietum speciosae Kr. et Vl. 1939 is known from the data of Kruseman and Vlieger (op. cit.) and Wasscher (1941) for the Netherlands and from the data of Passarge (1964) appears to occur in N. Germany. A very similar syntaxon, the Rumex acetosella - Sinapis arvensis - Ass. Kojic 1961 occurs in the Balkans (Horvat et al., 1974). No similar vegetation has yet been found in Britain. The status of the association is, however, questionable. The original table of Kruseman and Vlieger suggests it is worthy of recognition, but Tüxen (1950) regarded it as merely a local syntaxon, unworthy of wider attention, and referable to the Alchemilla arvensis - Matricaria chamomilla - Ass. Tx. 1937. Westhoff and Den Held (op. cit.) prefer to refer it to the Teesdalia - Arnosericidetum, which may well be the correct decision.

British Distribution (Map 10)

The Galeopsis speciosa - G. bifida - Ass. was probably widespread in northern Britain at one time, at least on peaty soils, but due to the decrease of Galeopsis speciosa it is now difficult to recognise. Consequently, during the survey it was encountered only at two sites in Wales, though Table XXVII incorporates one subsequent aufnahme from disturbed ground amongst shrubs in the Clyde Valley of W. Scotland. Price Evans (1923) gives lists of arable weeds following the ploughing of Carrington Moss in Cheshire which can only have referred to this association, and Birks (1973) gives an aufnahme containing G. bifida from Skye. Fine stands of the association,

dominated by G. speciosa, G. bifida and G. tetrahit, have also been seen recently in upland fields in Glen Isla and Glen Shee in central Scotland, but are not backed by aufnahmen. The association is probably widespread, therefore, in the underworked areas of Scotland, and many northern stands merely identified as "Spergulo - Oxalidion" or "Polygono - Chenopodietalia" are probably impoverished stands of this association.

Ecology

The association is probably the primary association of root-crops on damp, heavy, often peaty soils in the atlantic N. W. Europe. An excellent discussion of its occurrence on peat soils is given by Price Evans (op. cit.). Casual observations of arable land in the Clyde Valley suggests that this association does not develop in cereals even where G. speciosa and G. bifida occur locally on disturbed soil. The association ranges from virtually sea-level in Skye (Birks, op. cit.) to 900 ft in Glen Isla, Angus.

Subdivisions

Tüxen (1950) gives two subassociations, of Spergulo arvensis and of Ranunculus repens. However, these species occur together in British data.

6.7 Alliance: _POO_ - _CARDAMINION_HIRSUTAE_ all. nov. (prov.)

Synonymy

None

Character and Differential Species

Provisional character species:-

<u>Cardamine hirsuta</u>	<u>Oxalis corniculata</u>
<u>Galinsoga ciliata</u>	

Provisional differential species within the Polygono_-Chenopodietalia:-

Arabidopsis thaliana (pref. sp.) Rorippa sylvestris

Epilobium adenocaulon Veronica hederifolia ssp. lucorum

E. montanum ? Oxalis corymbosa

? Veronica peregrina

In addition to these species, the alliance is further characterised by high constancies of Poa annua and Senecio vulgaris.

Name-giving idiotaxa: Poa annua and Cardamine hirsuta

Type Association: Cardaminetum hirsutae ass. nov. (prov.) (Tab. XXX)

Syntaxonomy

This very tentative alliance is proposed to contain the Cardaminetum hirsutae and a few floristically related communities developed in flower-beds and gardens.

Although arable weed communities have been very extensively studied by phytosociologists, related communities of gardens and equivalent habitats have received very little attention. The only detailed study of such habitats is that of J. Tüxen (1958). In a survey primarily of fruit gardens, he regarded the vegetation as being derived from a number of arable associations. Consequently, in his tables garden aufnahmen are assigned to arable associations but distinguished from the typical states of those associations by indicator species. Study of nine of his tables in which he tabulates both arable and garden forms of the same community (associations, using his nomenclature, Veronico_-Lamietum, Panicum crus-galli_-Spergula arvensis = Ass. - two tables, Crus-galli_-Chrysanthemetum, Oxaleto = Chenopodietum, Panicum ischaemum = Ass., Spergula arvensis = Chrysanthemum segetum = Ass. and the Stachys = Fumarietum) results in a total of no less than 52 indicator-species, though citation of some of these appears to be based on somewhat tenuous grounds.

The more important of these indicator-species, based on the number of tables in which they are quoted as such out of the possible nine, are:-

<u>Urtica urens</u>	9	<u>Sisymbrium officinale</u>	8
<u>Malva neglecta</u>	8	<u>Galinsoga parviflora</u>	8
<u>Aethusa cynapium</u> var. <u>domestica</u>	9	<u>Geranium pusillum</u>	7
<u>Lamium album</u>	6	<u>Urtica dioica</u>	5
<u>Aegopodium podagraria</u>	4	<u>Sonchus asper</u>	4
<u>Medicago lupulina</u>	4	<u>Setaria ambigua</u>	4
<u>Euphorbia peplus</u>	3	<u>Chenopodium polyspermum</u>	3
<u>Sonchus oleraceus</u>	3	<u>Echinochloa crus-galli</u>	3
<u>Oxalis "stricta"</u>	3	<u>Setaria viridis</u>	3
<u>Erodium cicutarium</u>	3	<u>Calystegia sepium</u>	3

Other relevant indicator-species are Galinsoga ciliata, quoted in two tables, and Oxalis corniculata, quoted in one.

It is worthy of note that a few of Tüxen's indicator-species are recorded by Saaristo (1968) from flower-beds in Cairo. As her sampling was carried out in January and February, and hence covered only the winter aspect in an area where seasonal aspects show great variation, classification of her stands proved impossible. However, as she herself concluded, her stands show considerable affinity with the alliance Eragrostidion. Hence once again, garden communities have been interpretable as derived from arable syntaxa.

This approach is logical and often undoubtedly correct in Britain as well as elsewhere. An example of this is given in Table 28, where an aufnahme, though of interest in the presence of the rare species Myosurus minimus, is not easily assignable to any association, or even to an alliance. The presence of Aphanes microcarpa and the absence of any character species of the Centauretalia suggest affinities

Table 28

Derived Garden Phytocoenose

Aufnahme	537
No. of Species	12
Area of Quadrat in m ²	4
Area of Stand in m ²	10
% Cover	50
Slope	-
Exposition	-
Altitude in ft	250
Date	30.5.71
Soil	Sandy loam
Crop	Mixed flowers

Poa annua	1.1
Sagina procumbens	+ .2
Myosurus minimus	+
Sonchus oleraceus	+
Euphorbia peplus	+
Aphanes microcarpa	+
Senecio vulgaris	+
Stellaria media	+
Veronica arvensis	+
V. * hederifolia	+
V. serpyllifolia	+
Capsella bursa-pastoris	+

Table 29

Fragmentary Poo - Cardaminion Phytocoenose

Aufnahme	430
No. of Species	12
Area of Quadrat	1m ²
Area of Stand	1m ²
% Cover - Total	65
% Cover - Tracheophytes	65
% Cover - Bryophytes	n
Slope	-
Exposition	-
Date	18.5.71
Soil	Clay-loam
Crop	Tulips

Stellaria media	3.3
Poa annua	2.2
Cirsium arvense	1.2
Ranunculus bulbosus	1.2
Epilobium adenocaulon	1.2
Capsella bursa-pastoris	1.2
Arabidopsis thaliana	1.1
Sonchus oleraceus	1.1
Senecio vulgaris	1.1
Bryum *argenatum	+ .2
B. rubens	+ .2
B. bicolor	+

with the Spergulo - Oxalidion, a not unexpected possibility on a sandy soil derived from the Lower Greensand. Alternatively, Sonchus oleraceus and Euphorbia peplus suggest affinities with the Fumario - Euphorbion, but as both these species, and also Veronica arvensis, are regarded by Tüxen (op. cit.) as indicators of garden conditions, the evidence they provide is not conclusive. Myosurus minimus, Sagina procumbens and Veronica serpyllifolia are indicators of soil dampness rather than of any particular syntaxon and the remaining species are of little classificatory value in the present context. The aufnahmen, therefore, is best regarded as taken from a fragmentary Polygono - Chenopodietalia community, probably derived from the Spergulo - Oxalidion. A second example of a derived phytocoenose has already been given in Table 25.

But what of aufnahmen 430, presented in Table 29? As might be expected of a stand of vegetation developed in a flower-tub set in a car-park, the community is clearly fragmentary. In fact on existing phytosociological knowledge, one could go no further than assigning it to the Stellarietea. Nevertheless, ignoring the bryophytes, there are three unusual species present, Ranunculus bulbosus, Epilobium adenocaulon and Arabidopsis thaliana. The first of these appears to be a genuine "accidental" but the remaining two, though of rare occurrence in most Stellarietea communities, are frequent as weeds of flower-beds. A common accompanying species is Cardamine hirsuta.

It would seem reasonable to regard these species as more indicator-species of horticultural forms of other associations, i.e. "deviate communities" in the sense of Kopecky and Hejny (see Sect. 2.2.2.9.2), and indeed this is done by Häfliger and Brun-Hool (1971) in the case of Cardamine hirsuta, which they regard as characteristic of the "horticultural soil level". But stands of vegetation regularly occur which contain Cardamine hirsuta, Arabidopsis

thaliana and other species, and not merely in the spring, but which cannot be assigned to any described community within the Stellarietea. Nor can they be identified with the Arabidopsidion (q.v.) of the Sedo - Scleranthetea. Within the Z-M system, there is very little alternative but to describe a new syntaxon. In this case the new syntaxon is the association Cardaminetum hirsutae. Since the Cardaminetum, though clearly belonging to the Polygono - Chenopodietalia, does not fit well into either of the existing alliances, it and some related syntaxa are thus the basis of this new alliance, with character and differential-species as listed above.

The validity of this alliance still requires extensive fieldwork. The data presented (Tables XXX - XXXIII) is insufficient for firm judgments to be made, even in the light of the many additional stands seen but not sampled by the author.

1. Association: CARDAMINETUM HIRSUTAE ass. nov. (prov.) (Tab. XXX)

Synonymy

None

Diagnostic Species Group

Cardamine hirsuta

Oxalis corniculata

Type Aufnahme and Locality

Aufn. 113 (Tab. XXX, Column 11), South ~~Mullock~~ Mullock, Pembrokeshire (now in Dyfed).

Distribution and Syntaxonomic Position (Map 11)

The association has been recorded in scattered localities in Britain from Sussex north to Perthshire, and also in Guernsey, but much more data is needed before the range of the association is known. No foreign data has been seen, but the association is likely

to be widespread in at least the atlantic areas of northern Europe.

The syntaxonomy of the association has largely been discussed above in relation to the alliance. The stands shown in Table XXX are not referable to other associations and thus cannot be simply vernal aspects, although the Cardaminetum hirsutae is undeniably better developed in the spring. Late season aspects of the association often contain only an abundance of Poa annua plus class character-species. Aufn. 533 may, however, be transitional to the Oxalido - Chenopodietum, a garden form of which was developed at the same locality (Tab. 26).

The late-season stands of this association may prove to partly correspond to the Poetum annuae Gams 1927, which consists of species-poor stands often dominated by Poa annua. Data from Knapp (1961) is compared with other possible Plantaginetea communities in Table LXXV. Knapp's data give no Poo - Cardaminion species.

The relationship of the association to the Arabidopsidion of the Sedo - Scleranthetea must also be examined further. The Arabidopsidion is an alliance of spring-ephemeral communities and hence is relevant to the Cardaminetum, both floristically and ecologically.

Passarge (1964) quotes Erophila verna, Arabidopsis thaliana and Veronica arvensis amongst his diagnostic species for the Arabidopsidion, though Moravec (1967) shows that E. verna and V. arvensis are poor differential species for the alliance. At the class level, typical Cardaminetum species which are regarded as Sedo - Scleranthetea character-species by Müller (1961) or Krausch (1968) are Rumex acetosella, Ceratodon purpureus and Erophila verna s.s. It may not be coincidence that these last three are differential species of subass. montietosum described below, but the number of Stellarietea spp. in most aufnahmen effectively rules out their identification

with any Sedo_-Scleranthetea community. Nevertheless, this association, particularly its subass. montietosum, could well represent a transition to that class.

Ecology

The association is developed in gardens and nurseries on damp, often sandy or peaty soils, especially in shady situations on fertile, humus-rich ground. The association reaches 800 ft in Perthshire.

Subdivisions

Cardaminetum hirsutae typicum subass. nov. (prov.) is without differential species, though, so far, Oxalis corniculata has been recorded from only this subassociation. The type aufnahmen is Aufn. 113, as for the association. This is the form of the association developed on light clays such as the Red Marl derived from the Lower Old Red Sandstone.

Cardaminetum hirsutae montietosum subass. nov. (prov.) is differentiated by Rumex acetosella, Epilobium adenocaulon, Montia fontana ssp. chondrosperma, Ceratodon purpureus, Juncus bufonius, Eurhynchium praelongum, Riccia sorocarpa, Myosotis discolor and Spergula arvensis. The type aufnahme is Aufn. 32 (Table XXX, Column 2) from Tunbridge Wells, Sussex. The name-giving idiotaxon is Montia fontana ssp. chondrosperma. This subassociation is characteristic of very damp acid sandy soils, especially those developed over the Ashdown Beds or Bagshot Sands. The Tunbridge Wells locality is of interest as the British locality of Spergula morisonii, though as this was not found until 1943 (Clapham et al., 1962) and is absent from adjacent uncultivated heathland, it is hardly likely to be native. Tüxen (1937) regarded it as a character-species of the Corynephoretum canescentis Tx. (1928) 1937, another association best placed in the Sedo_-Scleranthetea, but the associated species do not fit that

association.

Typical stands of this subassociation are often on peat but an Erophila verna - Nodum was developed on the sandy loam derived from the Bagshot Sands in fallow flower-beds at Wisley, Surrey. The nodum has Erophila verna, Aphanes microcarpa, Sphaerocarpos texanus and Bryum argenteum var. lanatum as differential taxa; these are also differential taxa for the subassociation. The undisturbed winter fallow has here allowed vigorous growth of the rare hepatic, S. texanus.

A digressive form of the association, dominated by Marchantia polymorpha, Barbula convoluta and other bryophytes as a result of regular application of "Gramoxone" herbicide, has already been discussed in Sect. 4.5.2.1. (Tab. 23).

2. VERONICA SUBLOBATA - COMMUNITY (Tab. XXXI)

This is a characteristic garden community of clay soils defined by the presence and often dominance of Veronica hederifolia ssp. lucorum (= V. sublobata). Most stands presented in Table XXXI are from S. W. England, but it is widespread in southern England, extending north to Newcastle-upon-Tyne (Aufn. 869) and apparently into southern Scotland. Veronica hederifolia ssp. hederifolia and Plantago lanceolata may be additional differential species from the Cardaminetum hirsutae, but it is very unusual for the two subspecies of V. hederifolia to occur together.

As V. * lucorum is strictly a spring-ephemeral, this community becomes inseparable from impoverished and unclassifiable Stellarietea communities later in the year.

3. GALINSOGA CILIATA - RORIPPA SYLVESTRIS - COMMUNITY (Tab. XXXII)

Diagnostic Species Group

Galinsoga ciliata

Rorippa sylvestris

This is a community of dry, gravelly flowerbeds, known from two localities in Surrey and one in Essex. It probably bears as much relationship to the Sisymbrietalia, e.g. by the presence of Conyza canadensis, Diplotaxis muralis, Chenopodium rubrum, Hordeum murinum and Senecio squalidus, as it does to the Poo - Cardaminion, but it is convenient to place it here on a provisional basis. The presence of the semi-aquatic Rorippa sylvestris in these excessively dry, well drained situations is somewhat enigmatic.

Aufn. 715 was from inside an abandoned, glass-less cold-frame. In these more sheltered conditions, a relatively rich bryophyte flora, dominated by Bryum ruderale, had developed.

4. COCHLEARIA DANICA - COMMUNITY (Tab. XXXIII A)

Diagnostic Species Group

Cochlearia danica

Plantago coronopus

These two species are character-species of the Sagino maritimae - Cochlearietum danicae (R. Tx. 1937) R. Tx. et Gillner 1957 of the class of coastal-rock vegetation, the Saginetea maritimae Westh., Van Leeuwen et Adriani 1962 (Tüxen and Westhoff, 1963; Westhoff and Den Held, 1969). From the tables of Tüxen and Westhoff (op. cit.) the association consists almost entirely of maritime species.

Thus the present community is not that association. It is based on a single stand in a flowerbed close to the sea at Aberystwyth on the Welsh coast. The soil was a clay-loam plus large shale fragments, which might naturally be occupied by the Sagino - Cochlearietum. The stand must be regarded as a transition from the Sagino - Cochlearietum to the Stellarietea, with Senecio vulgaris present and Sagina procumbens and Pottia truncata replacing their more maritime counterparts, S. maritima and P. heimii. Similar vegetation appears to be frequent on the western coast of Wales, grading into

typical Stellarietea communities. The community is not at all certainly referable to the Poo - Cardaminion, as is also the case for the next two syntaxa.

5. DIPLOTAXIS MURALIS - COMMUNITY, non G8rs 1966. (Tab. XXXIII B)

This is a stand dominated by Diplotaxis muralis in an abandoned flower-bed at Leatherhead, Surrey. The site was very dry, with the soil composed partly of concrete chippings.

The systematic position of the community is not clear. It lacks any definite Poo - Cardaminion species but is placed here partly on ecological grounds. G8rs (1966) describes a Diplotaxis muralis - Gesellschaft, but this contains a number of Sisymbrietalia spp. and is clearly referable to that order.

6. IMPATIENS PARVIFLORA - COMMUNITY (Tab. XXXIII C)

Like the last syntaxon, this is based on a single aufnahme from a flowerbed at Leatherhead, Surrey. In this case the stand was dominated by Impatiens parviflora. The site was heavily shaded by a nearby Horse-Chestnut tree (Aesculus hippocastanum) and received litter from that tree. Similar disturbed, shady communities dominated by I. parviflora are of locally frequent occurrence in southern England.

6.8.1 Order: ERAGROSTIETALIA J. Tx. 1961SynonymyChenopodietalia Br. Bl. 1936, p.p.Chenopodietalia mediterranea (Br. Bl. 1936)
R. Tx. 1937, p.p.Chenopodietalia albi Tx. et Lohm. 1950, p.p.Chenopodietea Br. Bl. 1957, p.p.Thero = Chenopodietea Lohm., J. et R. Tx. 1961, p.p.Syntaxonomy

This is the order of thermophilic weed communities of nitrophilous root-crops, mainly in the Mediterranean region and S. E. Europe. It is interpreted here as including the alliance Panico_-Setarion, which extends the order beyond the confines given by J. Tüxen (1961). Many authors have included the Panico_-Setarion in the Polygono_-Chenopodietalia (e.g. Oberdorfer et al., 1967; Westhoff and Den Held, 1969), but while the association Echinochloo = Setarietum of N. and W. Europe could well be incorporated into the Polygono_-Chenopodietalia, other Panico_-Setarion associations show greater resemblance to the Eragrostietalia as defined by the alliance Diplo-taxon. This broader view of the Eragrostietalia has also been adopted by Horvat et al. (1974).

On this basis the order contains two alliances:-

Diplo-taxon Br. Bl. 1936

Adopting the spelling of Rauschert (1963)

(Syn.:- Amarantho = Chenopodion Morariu 1943;Eragrostidion R. Tx. apud Slavnic 1944)Panico_-Setarion Siss. 1946

The Diplo_taxion is the more thermophilic of the two alliances and does not reach Britain. Thus it will not be considered further here. A comprehensive review of Diplo_taxion communities (as Eragrostidion) is given by Poli (1961)

6.8.2 Alliance: PANICO - SETARION Siss. 1946

Synonymy

Polygono - Chenopodion polyspermi Koch 1926 em.
Siss. 1946, denuo em Oberd. 1957, p.p.

Spergulo - Erodion J. Tx. 1961, p.p.

Oberdorfer (1957a) extended the Polygono - Chenopodion of the Polygono - Chenopodietalia to include the Panico - Setarion, hence the complex citation above.

Character and Differential Species

<u>Echinochloa crus-galli</u>	<u>Setaria viridis</u>
<u>Digitaria ischaemum</u>	<u>S. lutescens</u>
<u>D. sanguinalis</u>	<u>Amaranthus retroflexus</u>
<u>Galinsoga parviflora</u>	
<u>Solanum sarachoides</u> (as <u>S. nitidibaccatum</u> - see Sect. 1.4.2)	

Erodium cicutarium ssp. cutarium and Spergula arvensis also occur with high constancy in associations of this alliance. The above species also become order character-species in Britain.

European Distribution and Syntaxonomy

The alliance occurs almost throughout Europe, but grades into the Diplo_taxion in the south and east, and into the Spergulo - Oxalidion in the north and west. The major European associations are summarised in Table XXXVII, though Horvat *et al.* (1974) review further associations in S. E. Europe. The syntaxonomy of the alliance is discussed above.

Pignatti (1952) describes associations from Italy that represent a transition to the Diplo~~t~~axion and which are better referred to that alliance. Morariu (1967) transferred the Panico - Setarion to the Bidentetea, while Soo (1961) places these communities in the Secalinetea.

British Distribution and Ecology

The distribution of the alliance is given in Map 12, which corresponds well to Sissingh's (1950) map of his broad concept of the Echinochloo - Setarietum. However, as Westhoff and Den Held (1969) comment, the alliance is very poorly represented in W. Europe and almost lacking in Britain. Most of the diagnostic species given above are now only rare and ephemeral introductions, only Galinsoga parviflora being widely established. Echinochloa crus-galli, which is likely to be typical of the tribe Paniceae including Digitaria and Setaria, does not begin to germinate until the soil temperature reaches 15°C and its optimum temperatures are between 20 and 30°C (Brod, 1968). It is not surprising that these species rarely survive long in Britain now, and the possibly native Digitaria ischaemum is now on the verge of extinction. Amaranthus species do not germinate until mid-summer (Chepil, 1946a) and even if they could then compete with established crops, the cool, wet British autumns give them little chance to ripen seed.

However, on the dry sands of southeastern England, notably the Bagshot Sands, soil temperatures rise early in the year and some of these species are able to persist. Gilbert and Pember (1935) found that both the Digitaria species are tolerant of high levels of aluminium, which will be an advantage on these soils of low pH and consequent liability to aluminium-toxicity.

1. Association: ECHINOCHLOO - SETARIETUM Kr. et Vl. 1939, em.
Kr. et Vl. apud Siss. Vl. et Westh. 1940 (Tab. XXXV)

Synonymy

Panico - Chenopodietum polyspermi (Br. Bl. 1921)
R. Tx. 1937, p.p.

Panicum crus-galli - Spergula arvensis - Ass.
(Kr. et Vl. 1939) R. Tx. 1950

Diagnostic Species Group

As for alliance, in Britain. Tüxen (1950) also gives Lamium amplexicaule, Galinsoga ciliata, Spergula arvensis, Rumex acetosella and Scleranthus annuus as regional "Kennarten" for the Panicum crus-galli - Spergula arvensis - Ass. Westhoff and Den Held (op. cit.) add Polygonum lapathifolium ssp. tomentosum. Solanum nigrum may be another differential species.

European Distribution and Syntaxonomic Position

This association and related communities are compared in Table XXXVII. The Panicum ischaemum - Ass. Tx. et Prsg. (1942) 1950 is undoubtedly very closely related to the present association and may well, as Westhoff and Den Held (op. cit.) consider, be no more than a form of it. Digitaria ischaemum, given by Tüxen (op. cit.) as a character-species of the Panicetum ischaemi is regarded here as part of the diagnostic species group of the Echinochloo - Setarietum. Passarge (1964) recognises three associations within this complex, by separating the Chenopodietum albi Pass. (1955) 1964 off from the Panicetum ischaemi, though his Chenopodietum seems to be no more than a species-poor variant of the Panicetum ischaemi. He separates the Echinochloo - Setarietum from the Panicetum ischaemi by the presence of Echinochloa crus-galli and Setaria pumila, plus Amaranthus retroflexus and Digitaria sanguinalis in some data. His Panicetum

ischaemi table shows no diagnostic species of its own, D. ischaemum occurring equally in the Echinochloo - Setarietum.

The overall situation appears to be that of a widespread association, the Echinochloo - Setarietum, extending throughout northern Europe from the Atlantic coasts to Poland (Kornas, 1950; Sychowa, 1959). In northern Germany it is replaced by the species-poor vicariant association, or mere variant, the Panicetum ischaemi. However, the Galeopsio - Panicetum Oberd. et Hüg. 1957, described by Oberdorfer (1957a) from S. W. Germany, is also placed in the Panicetum ischaemi by Oberdorfer et al. (1967). As they describe it as a montane form, it may well be climatically equivalent to northern Germany.

British stands are so poorly developed that they add little to the argument. They seem to be no more than impoverished versions of Dutch stands of Echinochloo - Setarietum sensu stricto, and they are treated as such here. However, aufnahme 708 differs from the others in the presence of Digitaria sanguinalis and Amaranthus retroflexus, albeit as crop-seed impurities, and in the absence of D. ischaemum. It could represent true Echinochloo - Setarietum whereas the other five aufnahmen may be Panicetum ischaemi. Without better developed stands this separation would be purely academic.

Southwards and eastwards the complex grades into the equally poorly defined Setaria glauca - Galinsoga parviflora - Ass. (Tx. et Becker 1942) Tx. 1950. However, Knapp and Knapp recorded similar data from Sweden.

British Distribution and Ecology (Map 12)

The association is restricted to exposures of the Bagshot Sands in Surrey, where it occurs only on the almost pure quartz-sands uncontaminated by beds of clay. It is best developed on the extensive grounds of a shrub nursery but has also been recorded from barley and carrots. All stands were recorded at an altitude of 100 ft.

Table 30

Echinochloo - Setarietum

Fragmentary Community

Aufn. 342

No. of Species	5	Exposition	-
Area of Quadrat	4m ²	Altitude	100 ft
Area of Stand	L	Month	8
% Cover - Total	70	Soil	S
Slope	-	Crop	2B

Chenopodium album	3.3
Erodium * cicutarium	3.2
Polygonum aviculare	+ .2
Geranium molle	+
Stellaria media	(+)

but D. ischaemum was not visible and the stubble field was occupied by a fragmentary community dominated by Chenopodium album and Erodium cicutarium. The community is described in Table 30.

Soil Analyses

The following results were obtained from analyses of exchangeable calcium and potassium contents, expressed in mg per 100 g dry soil.

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>	
344	125	2	(<u>Ornithopus perpusillus</u> - <u>Nodum</u>)
708	110	68	
710	165	7	
711	165	5	

The calcium result for aufn. 344 was one of the lower recorded for the Bagshot Sands, thus bearing out the floristic evidence discussed above. Aufn. 708 had an even lower calcium level; substantial application of potash fertiliser is also very evident.

2. SPERGULA ARVENSIS - LAMIUM AMPLEXICAULE - COMM. Siss. 1950 (Tab. XXXVI)

Synonymy

None

Diagnostic Species Group

<u>Urtica urens</u>	<u>Lamium amplexicaule</u>
<u>Galinsoga parviflora</u>	<u>Spergula arvensis</u>
<u>Solanum nigrum</u>	<u>Erodium cicutarium</u> ssp. <u>cutarium</u>
<u>S. _____ sarachoides</u> (? as <u>S. nitidibaccatum</u>)	

European Distribution and Syntaxonomy

Sissingh (1950) described a late-season community of harvested turnip-fields on sandy diluvial soils, the "Spergula arvensis -

Lamium amplexicaule - Gezelschap", as a replacement community of the Echinochloo - Setarietum. He emphasised the abundance of Spergula arvensis, Senecio vulgaris, Euphorbia helioscopia and Lamium amplexicaule and published a typical aufnahme. Apart from this one reference to Dutch vegetation, this community does not appear to have been recognised by continental workers.

In Britain, this community is widespread in its own right, apparently as an impoverished form of the Echinochloo - Setarietum sensu stricto. The presence and vigour of Galinsoga parviflora and Solanum sarachoides suggest that the community has affinities with the Panico - Setarion, although it could easily be classified within the Spergulo - Oxalidion. Though better developed in late summer, the community co-exists with growing crops and cannot be regarded as a stubble aspect.

Euphorbia helioscopia, important in the Dutch vegetation, occurs only once in the British data (Tab. XXXVI). However, comparison of Sissingh's aufnahme with British data in Table XXXVII leaves little doubt that British vegetation is referable to Sissingh's syntaxon.

British Distribution (Map 12)

The community is widespread on sandy soils, especially exposures of the Lower Greensand, in south and south-east England.

Ecology

Out of 22 aufnahmen, 16 occurred on soils directly derived from the Lower Greensand formation. Two more stands were on soils modified by drift deposits but overlying Lower Greensand. Three more stands were on soils directly or indirectly derived from the Bagshot Sands, in the same area of Surrey from which the Echinochloo - Setarietum was recorded, and the remaining stand was on the Thanet Sands of Kent, which appears to support very similar plant communities to the

Bagshot Sands. Thus all occurrences of the community are from base-poor geological sands; the community has not been found on the calcareous "Ragstone" of the Lower Greensand formation.

This correlation with geology is no doubt a function of the types of agriculture on these soils, for the community is characteristic of market gardens and strip-farmed vegetable fields. Thus 73% of aufnahmen were from root and vegetable crops, especially cabbages and lettuces but including such market garden crops as beetroots, marrows, cucumbers, strawberries, etc. Only one aufnahme (i.e. "4.5%") was from a cereal, barley, where it provided the best development of the Bryum rubens - Subcommunity.

The community reaches altitudes of 400 ft in Kent and Wiltshire.

Subdivisions

The major subdivision is the Bryum rubens - Subcommunity. This has Bryum rubens and Gnaphalium uliginosum as the main differential species, plus Polygonum lapathifolium sensu lato, several other bryophytes and a blue-green alga resembling Nostoc. Its best development was at the edge of the one barley field found to be referable to this community (and then only on the presence of Galinsoga) where the ground would be less disturbed than in root crops. The remaining two aufnahmen were from unplanted edges of arable fields and had again avoided major disturbance.

Aufnahme 415 was from ground in a fruit-farm previously manured with shoddy. Medicago polymorpha and M. arabica were persisting to form a Shoddy - weed - Facies.

6.9 Order: CENTAURETALIA CYANI R. Tx., Lohm. et Prsg. 1950SynonymySecalinon medioeuropaeum R. Tx. 1937Secalino - Violetalia arvensis Siss. 1943 apud Br. Bl.
et R. Tx. 1943, p.p.Secalinetea Br. Bl. 1951, p.p.Secalinetea (Br. Bl. 1931) Soo 1961, p.p.Including: Secalinetalia Br. Bl. 1931; Aperetalia J. et R. Tx. 1960Character and Differential Species

While, as with other orders, few species show very high fidelity to the Centauretalia, the following may be regarded as character-species for the order, and in many cases for alliances within it.

<u>Anthoxanthum puelii</u>	<u>Aphanes arvensis</u>
<u>Vicia hirsuta</u>	<u>Myosotis arvensis</u>
<u>Matricaria recutita</u>	<u>Apera spica-venti</u>
<u>Scleranthus annuus</u> s.s.	<u>Centaurea cyanus</u>
<u>Kickxia elatine</u>	<u>Viola arvensis</u>
<u>K._____ spuria</u>	<u>Papaver rhoeas</u>
<u>Avena fatua</u>	<u>P._____ hybridum</u>
<u>Agrostis gigantea</u>	<u>P._____ argemone</u>
<u>Anthemis cotula</u>	<u>Euphorbia exigua</u>
<u>A._____ arvensis</u>	<u>E._____ platyphyllos</u> .
<u>Veronica polita</u>	<u>Sinapis arvensis</u>
<u>Sherardia arvensis</u>	<u>S._____ alba</u>
<u>Valerianella dentata</u>	<u>Legousia arvensis</u>
<u>Agrostemma githago</u>	<u>Alopecurus myosuroides</u>
<u>Silene noctiflora</u>	<u>Fumaria officinalis</u> ssp. <u>wirtgenii</u>
<u>Adonis annua</u>	<u>Lithospermum arvense</u>

The following species are of additional differential value for separating this order from the Polygono - Chenopodietalia:

Veronica arvensis

Lapsana communis

Sonchus arvensis

Atriplex patula

Chaenorhinum minus

Aethusa cynapium

Mentha arvensis

Valerianella locusta

Odontites verna ssp. verna

European Distribution and Syntaxonomy

The Centauretalia cyani is envisaged here as composed of three suborders:

Suborder: Aperetalia (R. Tx. 1950) J. et R. Tx. 1960 (as order)

Suborder: Secalinetalia Br. Bl. 1931 em. J. et R. Tx. 1960
(as order)

Suborder: Tritecetalia orientalia Zohary 1950

This is a broad view of the order. Tüxen (1950) included in it the communities of the suborder Aperetalia plus the alliance Caucalidion lappulae here regarded as belonging to the suborder Secalinetalia. He also included the alliance Lolio remoti-linion R. Tx. 1950 which since been upgraded to the order Lolio - Linetalia. Soo (1961) took a much wider view, including all the Mediterranean Secalinetalia communities, the Lolio - Linetalia and a number of associations intermediate between the Secalinetalia and the alliance Diplofaxion of the Eragrostietalia. Thus the view of the order taken here is midway between these two extremes. Strict application of rules of priority would mean that the order would have to be called the Secalinetalia Br. Bl. 1931, perhaps in emended form.

The suborder Aperetalia includes most of the communities, excluding the alliance Caucalidion, included by Tüxen (1937) in the Secalinion medioeuropaeum R. Tx. 1937, and is based on the communities included in the Agrostidion spicae-venti (Kr. et Vl. 1939) R. Tx.

apud Oberd. 1949 by Tüxen (1950). It thus includes the north-European communities of cereal crops, especially on sandy and non-calcareous soils.

The suborder Secalinetalia, by contrast, is centred on the Mediterranean region, extending northwards on calcareous soils as the alliance Caucalidion lappulae. Tüxen (1937) distinguished the associations of southern Europe as belonging to the alliance Secalinion mediterraneum (Br. Bl. 1931) R. Tx. 1937 as distinct from his Secalinion medioeuropaeum which included the Caucalidion. In the eastern part of the Mediterranean region, the communities grade into the Diplofaxion and Oberdorfer (1954) distinguished some of these under the alliance Secalinion orientale Oberd. 1954. He grouped this with the Secalinion mediterraneum under a new order, the Secalinetalia mediterranea (Br. Bl. 1931) Oberd. 1954. This presumably excludes the Caucalidion. Soo (1961) recognises a number of additional alliances which have clear affinities to the Secalinion orientale and to the Diplofaxion.

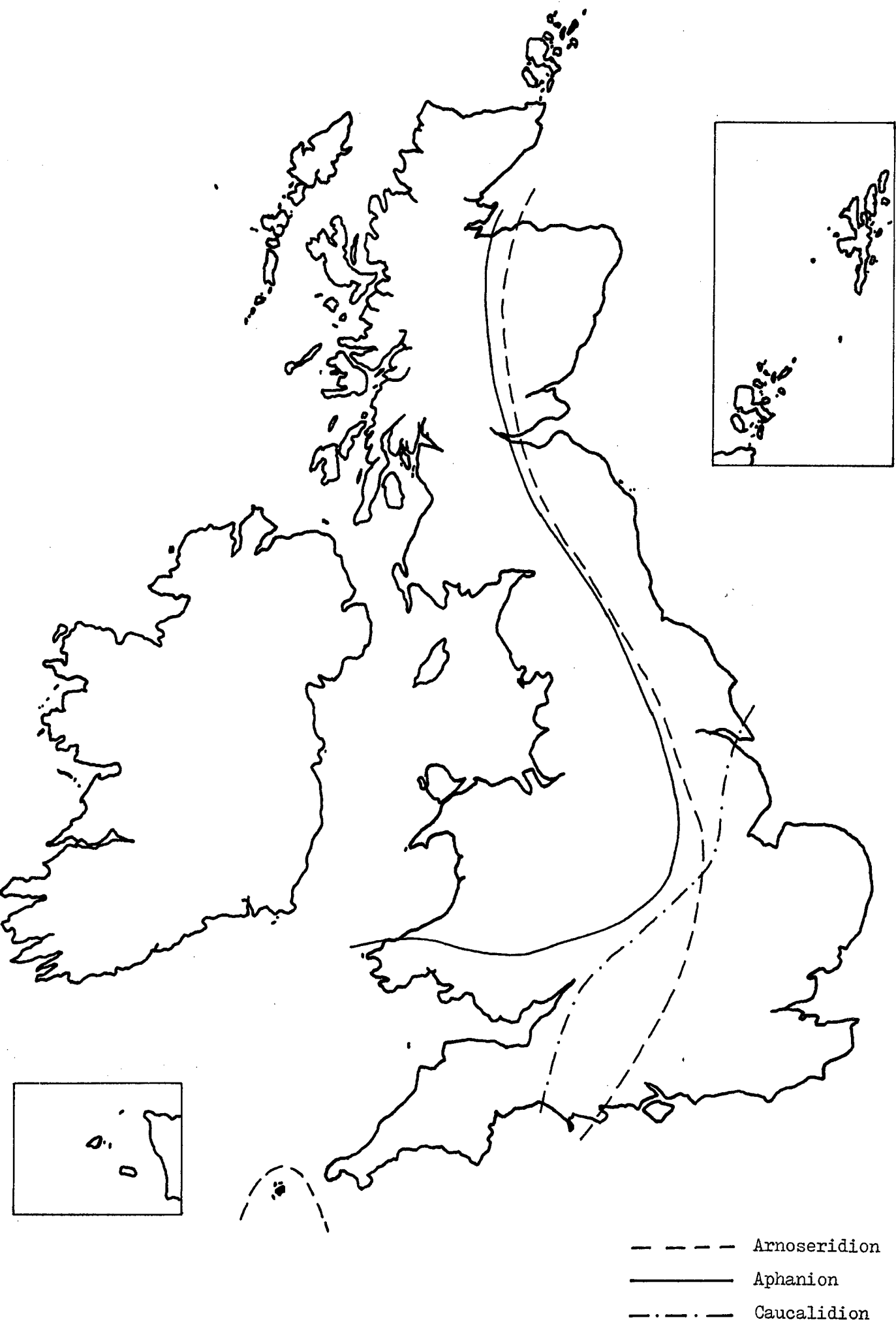
The weed vegetation of the Middle-East is very distinct, despite being reputedly the original source of many of our weed species, and probably deserves recognition at the order level rather than the suborder status, as the Tritecetalia orientalia, given to it by Zohary (1950). Zohary described four alliances from Palestine and Kosinova (1975) described further vegetation from Egypt which probably belongs here. No associations of this suborder have been reported within Europe, but some may extend to Turkey - in - Europe.

British Distribution

The order shows a southern and eastern distribution in Britain; provisional northern and western limits of the three British alliances are shown in Fig. 35. More fieldwork, especially in S. W. Scotland

Fig. 35

Provisional northern and western limits of
alliances of the Centauretalia cyani



might result in alterations to knowledge of these limits.

Ecology

The order is classically that of cereals, though in Britain, stands may be developed in root and other vegetable crops, especially broad-beans. The great majority of Centauretalia species are thermophilic and thus the order is poorly represented in northern Europe. Many of these species undoubtedly had their origins in natural communities of cereal-ancestors in the Mediterranean and the Middle East and still occur as natural constituents of such communities (Kühn, 1972). Kühn observed that on calcareous soils the communities had distinct affinities to the Secalinetalia as distinct from the Aperetalia.

The poor separation of the Centauretalia from the Polygono--Chenopodietalia in the atlantic regions of N. W. Europe has already been discussed, as has the equally blurred division between the Centauretalia and the Eragrostietalia in S. E. Europe. On the saline soils of E. Europe, the order also shows transitional communities to the Cakiletea maritimae (Timar, 1954).

As many of the order character-species are particularly herbicide-sensitive, impoverished stands are common. Some stands that can be identified only to the order level, or are heterogeneous, are given in Table LIII.

Suborder: _APERETALIA SPICA-VENTI (R. Tx. 1950) J. et R. Tx. 1960

6.10 Alliance: _ARNOSERIDION MINIMAE Malato - Beliz, J. et R. Tx. 1960

Synonymy

Scleranthion annuae Krus. et Vl. 1939, p.p.

Agrostidion spicae-venti (Krus. et Vl. 1939)

R. Tx. apud Oberd. 1949, p.p.

Arnosseris minima - Gruppe Pass. 1957

Character and Differential Species

Arnosseris minima

Galeopsis segetum

Aphanes microcarpa

Anthoxanthum puelii

Aira caryophyllea ssp. multiculmis

Scleranthus annuus

Ornithopus perpusillus

Trifolium arvense

Species such as Spergula arvensis, Rumex acetosella and Holcus mollis are also typical of this alliance. Most of the species quoted above are of occasional occurrence in stands of the association Papaveretum argemonis of the next alliance.

European Distribution and Syntaxonomy

Associations of this alliance occur throughout most of Europe, except the extreme south and south-east. Malato-Beliz et al. (1960) recognise five associations, though this figure might be enlarged. The major association of central, north and north-west Europe is the Teesdalis - Arnoseridetum minimae, which is, indeed, the only association present in N. W. Europe. Eastwards it gives way to the species-poor and doubtfully distinct Scleranthetum annui baltorossicum Prsg. 1950 and to the Setario - Arnoseridetum minimae Pass. 1957. Although both of these associations are recognised by Malato-Beliz et al., they seem to merit no higher status than variants of the

Teesdalia - Arnoseridetum, as judged from the tables of Passarge (1957a). In S. W. Europe the Teesdalia - Arnoseridetum is replaced by the Airo_multiculmis - Arnoseridetum and the Bucephalophori - Arnoseridetum minimae Malato-Beliz 1960, the latter encompassing the Spanish associations described by Tüxen and Oberdorfer (1958). The most southerly representation of the alliance appears to be the Scleranthus annuus - Legousia speculum - veneris - Ass. (Br. Bl. 1915) R. Tx, 1950, though this is not recognised by Malato-Beliz et al. Other associations probably worthy of recognition are described by Morariu (1943) and Quantin (1946) but the syntaxonomy of this alliance is relatively uncomplicated. The associations are typically poor in species and hence often difficult to separate, but they form a very characteristic and easily distinguishable alliance. Generally, only one association occurs in one area and hence identification is often on geographical grounds.

Most associations of the Aphanion are clearly distinct from the Arnoseridion, but the Papaveretum argemonis may sometimes grade into the Teesdalia - Arnoseridetum, and the Holco - Galeopsietum Hilbig 1967 may also represent a transition to the Arnoseridion. The status of the Galeopsietum speciosae Krus. et Vl. 1939, which might also be classified either in the Arnoseridion or in the Aphanion, has already been discussed in relation to the Galeopsis speciosa - G. bifida - Ass. of the Spergulo - Oxalidion. Krausch (1969) describes an Ornithopus perpusillus - Scleranthus annuus - Ass. in fields of rye undersown with Festuca ovina, linking the alliance with the Corynephorretalia canescentis R. Tx. 1933 em. Krausch 1962.

Ecology

The alliance is characteristic of very base-poor sandy soils. In Britain, fertilisation of such soils to the level at which other weed species move in and conversion of unprofitable arable land to

permanent pasture have resulted in the virtual elimination of this alliance and the near extinction of its most characteristic species.

1. Association: TEESDALIO NUDICAULIS - ARNOSERIDETUM MINIMAE
(Malcuit 1929) R. Tx. 1950 (Tab. XXXVIII)

Synonymy

Scleranthus annuus - Arnoseris minima - Ass. R. Tx. 1937

? Setario - Arnoseretum Pass. 1957

Diagnostic Species Group

The association is now too poorly represented in Britain for any definite listing of its character species here. Tüxen (1950) gives:-

Arnosseris minima

Anthoxanthum puelii

Galeopsis segetum

but all three of these species are very close to extinction in Britain. Westhoff and Den Held (1969) also give Aphanes microcarpa, but this is of little diagnostic value on its own.

Other differential species include:

Scleranthus annuus

Spergula arvensis

Rumex acetosella

Teesdalia nudicaulis

Ornithopus perpusillus

Hypochoeris glabra

Spergularia rubra

Holcus mollis

(Tüxen, 1950; Oberdorfer, 1957a; Passarge, 1957a). Other species of base-poor sandy soils have been regarded as additional differential species in Table XXXVIII.

European Distribution and Syntaxonomic Position

The association is the most widespread of the alliance, extending northwards from France and Belgium (Lebrun et al., 1949) and eastwards to Poland (Kornas, 1950). It is discussed more fully above, in

relation to the alliance.

British Distribution (Map 13)

Very poorly developed stands have been recorded in a few localities in S. and E. Britain, north to Angus. Despite several searches, Arnoseris minima was not found during the survey, but Aufn. 712, from Burrows Cross, Surrey, was from the site of a recent record, Aufn. 52 and 54, with Anthoxanthum puelii, were from Gamlingay, Cambridgeshire. The one remaining British locality for Galeopsis segetum at Bangor, N. Wales, where the plant is very uncertain in its appearance and regularly reported as extinct, does not appear to be in Teesdalia - Arnoseridetum. Howarth and Williams (1972) give a correctly identified though heterogeneous aufnahme from wasteground in Lincolnshire; it includes Arnoseris minima, Galeopsis segetum and Hypochoeris glabra, but is undated.

Ecology

As discussed above, the association is restricted to the poorest soils and, judging by old records of A. minima, occurred particularly on the Lower Greensand. It marks very unproductive land (Walther, 1953) and most former sites for A. minima are now down to permanent pasture or heavily fertilised and supporting weeds of the Spergula arvensis - Lamium amplexicaule - Comm. On the continent the association is regarded as typical of soils fit only for poor rye crops, often in rotation with lupins (Borowiec, Grinn and Kutyna, 1972; Kuzniewski, 1975). Perhaps the most similar British stand to these conditions was Aufn. 832, on almost pure sand adjacent to heathland, Spalford Warren, in Nottinghamshire. This was the only ryefield encountered during the entire survey, other than those on the Outer Hebrides. Localities at Gamlingay (aufn. 52, 54), Forfar (aufn. 773, 774) and Wisley (aufn. 812) were also adjacent to heathland.

Table 31

Non-arable site of Anthoxanthum puelii

Aufnahme	355	Slope, in degrees	45
No. of Species	15	Exposition	S
Area of Quadrat	4m ²	Altitude	150 ft
Area of Stand	L	Month	8
% Cover	80	Soil	sL

Anthoxanthum puelii 1.2

Holcus lanatus	4.3	Hypochoeris radicata	3.2
Trifolium pratense	2.2	Plantago lanceolata	2.2
Ranunculus repens	2.2	Leucanthemum vulgare	2.2
Juncus effusus	1.2	Equisetum arvense	1.2
Agrostis tenuis	1.2	Festuca rubra	1.2
Anthoxanthum odoratum	+.2	Senecio jacobaea	+
Taraxacum officinale	+		
Brachytheций rutabulum	+.2		

Conversion of suitable arable-land to pasture will automatically lead to poor grassland containing Festuca rubra, Agrostis tenuis, Hypochoeris radicata, etc. A formerly disturbed roadside bank on the Bagshot Sands in Surrey still has Anthoxanthum puelii, an Aufnahme from the site is given in Table 31.

Subdivisions

Numerous infra-associational syntaxa have been recognised by continental workers (see, e.g., Sissingh, 1950; Passarge, 1964; Schubert and Mahn, 1968) but no nodes are distinguishable in the limited British data.

2. Association: AIRO MULTICULMIS - ARNOSERIDETUM MINIMAE
(Allorge 1922) R. Tx. 1950 (Tab. XXXIX)

Synonymy

Allorge (1922) records similar vegetation from:-

"Moissons silicieuses a Chrysanthemum segetum
et Myosurus minimus".

Diagnostic Species Group

Aira caryophyllaea ssp. multiculmis Briza minor
Silene gallica

Tüxen (1950) also gives Arnosseris minima, Anthoxanthum puelii, Filago gallica, Galeopsis segetum and the non-British Anthemis mixta, but there is no record of any of these from the Isles of Scilly (Lousley, 1971) where the association is known. As the conversion of cornfields to bulbfields substantially predated systematic botanical recording in the Scillies, too much importance should not be attached to this.

Tüxen (op. cit.) further gives Trifolium arvense, Hypericum humifusum and Sagina apetala as differential species. Additionally

it is supposed to differ from the Teesdalia - Arnoseridetum in the absence of Scleranthus annuus, Rumex acetosella, Spergula arvensis and Teesdalia nudicaulis, but R. acetosella occurs in all three British aufnahmen.

European Distribution and Syntaxonomic Position

The association replaces the Teesdalia - Arnoseridetum in S. W. Europe. Tüxen (op. cit.) gives its distribution as W. France and N. W. Spain.

British Distribution (Map 13)

The association is known only from three aufnahmen from the islands of St. Mary's and St. Martin's in the Isles of Scilly.

Ecology

As the growing of cereals has completely given way to bulb-farming on the Isles of Scilly, this association is now represented only by the presence of occasional Centauretalia spp. in the bulbfields. However, it is possible to visualise formerly well-developed stands of this association on the warm, dry, very sandy soils in which the cereals would have been grown. Lousley (op. cit.) records that oats were grown up until 1966.

6.11 Alliance: APHANION ARVENSIS J. et R. Tx. 1960

Synonymy

Scleranthion annuae Kr. et Vl. 1939, p.p.

? Triticion sativae Kr. et Vl. 1939, p.p. min.

Agrostidion spicae venti (Kr. et Vl. 1939)

R. Tx. apud Oberd. 1949

Sherardion Kropac et Hejny 1975

Character and Differential Species

<u>Aphanes arvensis</u>	<u>Vicia hirsuta</u>
<u>Myosotis arvensis</u>	<u>Matricaria recutita</u>
<u>Papaver argemone</u>	<u>Alopecurus myosuroides</u>
<u>Poa trivialis</u>	

Additionally, the Aphanion differs from the Arnoseridion by the occasional presence of Caucalidion species, and from the Caucalidion by the presence of Arnoseridion species.

European Distribution and Syntaxonomy

The Aphanion probably occurs throughout the range of the suborder Aperetalia, extending south to Italy, as the Papaveretum argemonis (Pignatti, 1952; 1957 - on the present author's interpretation of his data) and into the Balkans as the Rumex acetosella - Sinapis arvensis - Ass. Kojic 1961 (see Horvat et al., 1974). The alliance may, however, be absent from parts of the British Isles and Scandinavia.

As would be expected of such a far-ranging alliance, many associations have been described within it and different phytosociologists have held substantially different views on the number of associations to be recognised and their respective limits. Excluding Arnoseridion associations, Tüxen (1950) recognised six associations:-

- Valerianello olitoriae - Arabidopsetum thalianae
R. Tx. 1950
- Alchemilla arvensis - Matricaria chamomilla - Ass.
R. Tx. 1937
- Bromus secalinus - Delphinium consolida - Ass.
(Denissow 1930) R. Tx. et Prsg. 1950
- Lathyrus aphaca - Agrostis spica venti - Ass.
R. Tx. et v. Rochow 1950

Papavereto - Melandrietum noctiflori Wasscher 1941

Linaria elatine - Scutellaria hastifolia - Ass.

Pauca 1941

Tüxen's (1937; 1950) concept of the Alchemillo - Matricarietum was a very broad one; in it he included the Papaveretum argemonis of sandy ground, at the level of a subassociation group. He emphatically resisted separate recognition of this association, pointing out that to separate it from the Alchemillo - Matricarietum would leave the latter without individual character species, a point which has since proved very valid. He also included a number of other described associations within his Alchemillo - Matricarietum as being of no more than local significance, including the calcicolous associations Vicietum tetraspermae Kr. et Vl. 1939 (i.e. Legousietum speculi-veneris (Kr. et Vl. 1939) Siss. 1950) and Linarietum spuriae. His Alchemillo - Matricarietum was thus the central concept of what was to become the Aphanion.

In a systematic account of Agrostidion spicae venti communities in N. E. Germany, Passarge (1957a) showed that the Alchemillo - Matricarietum could stand by itself even after separation of the sandy-ground syntaxon as the Papaveretum argemonis. Thus when Tüxen, in company with J. Tüxen and Malato-Beliz, came to split the Agrostidion spicae venti into the two alliances Aphanion and Arnosetidion (Malato-Beliz et al., 1960), he accepted Passarge's emendation of the Alchemillo - Matricarietum.

Malato-Beliz et al. therefore recognised four associations within the Aphanion.

Valerianello olitoriae - Arabidopsetum thalianae

Bromus secalinus - Delphinium consolida - Ass.

Papaveretum argemone (Libb. 1932) Kr. et Vl. 1939

Alchemilla arvensis - Matricaria chamomilla - Ass.

R. Tx. 1937 em. Pass. 1957

The last three associations quoted above from Tüxen (1950) were not included in the Aphanion at this time and were presumably regarded as better transferred to the Caucalidion. Passarge's concept of the Alchemillo - Matricarietum excluded the Linarietum spuriae and presumably data belonging to this were also transferred to the Caucalidion, though it was not until later (Burrichter, 1963) that the Linarietum spuriae (q.v.) gained full recognition.

The classification of Malato-Beliz et al. is a very conservative treatment of the associations then described. The Alchemillo - Matricarietum was the widespread association on loamy soils while the Papaveretum argemonis was the almost equally widely distributed association of fertile sandy soils. In the extreme east of Europe, primarily within the U.S.S.R., the Papaveretum argemonis was replaced by the Bromo - Delphinietum. The Valerianello - Arabidopsetum, a non-arable therophyte community remains of doubtful status in the absence of full published data.

Meisel (1962) established the existence of another association of more base-poor sandy soils, the Galeopsio - Alchemilletum (Oberd. 1957) Meis. 1962, which was recognised by Oberdorfer et al. (1967). However, excluding associations which might be placed in the Caucalidion, approximately nine further associations seem worthy of recognition, and seven calcicolous associations seem better placed in the Aphanion than the Caucalidion (or Secalinion orientale) (see Kruseman and Vlieger, 1939; Lebrun et al., 1949; Tüxen, 1950; Sissingh, 1950; Pignatti, 1957; Soo, 1961; Müller, 1963; 1964; Hilbig, 1967a; Horvat et al., 1974; Kropac and Hejny, 1975). West European associations of possible relevance to British vegetation are reviewed in Table XLIV.

It is clear that a major revision of Aphanion communities is needed. Not only do the described associations require re-examination,

but the limits of the Alchemillo - Matricarietum are also still far from clear. Meisel (1967) analysed over 2,000 aufnahmen of this association and the Papaveretum argemonis and revealed a very complex situation. He split Tüxen's (1950) subassociation-group of Alopecurus myosuroides off from the Alchemillo - Matricarietum as a new association, the Alopecuro - Matricarietum, which he wrongly equated with Wasscher's (1941) association of the same name. Just as Tüxen (op. cit.) predicted, this splitting of the Alchemillo - Matricarietum left the core of the association without any character-species of its own. Over 6% of Meisel's aufnahmen could not be referred to any of the three associations he recognised and these formed his basic Aphanes - Gesellschaft. Both his central "Aphano - Matricarietum" (the Alchemilla of "Alchemillo - Matricarietum" is Alchemilla arvensis, = Aphanes arvensis) and his Alopecuro - Matricarietum had "Arenaria - Rassen" containing the character and differential species of the Papaveretum argemonis and intergrading completely with that association. Numerical analysis of Aphanion vegetation throughout Europe is called for, though limitations of matrix size, computer-time and even of phytosociologist-time apparently present insuperable difficulties.

The separation of the alliance from the Arnosseridion is remarkably distinct, even though both alliances were formerly united. Meisel (1967) describes subassociations of Scleranthus annuus of each of his associations which are transitional to the Arnosseridion, accounting for 31% of his aufnahmen. However, their affinities with the Aphanion are clear. More debatable is the Holco - Galeopsietum Hilbig (1966) 1967 which might be placed in either alliance.

The demarcation between the Aphanion and the Caucalidion is much less clear; a number of associations exist which might be classified in either. Kropac and Hejny (1975) propose a new alliance,

the Sherardion, which contains four such marginal associations in eastern Europe. This might usefully be extended to include some western European associations, e.g. the Legousietum speculi-veneris (Krus. et Vl. 1939, p.p.) Siss. 1950 and the Euphorbia exigua - Avena fatua - Comm. described here, perhaps best as a suballiance.

A very similar concept is the Triticion sativae Kr. et Vl. 1939. This was based by Kruseman and Vlieger (1939) on two associations, the Linarietum spuriae and the Vicietum tetraspermae. As already noted, the Vicietum tetraspermae is no longer recognised but regarded as more or less synonymous with the Legousietum speculi-veneris. However, it also shows similarities to the Papaveretum argemonis. As the Linarietum spuriae unquestionably belongs to the Caucalidion rather than to the Aphanion, the Triticion sativae thus becomes another transitional alliance which could be used for these intermediate associations, including the Linarietum. Kropac and Hejny exclude both the Linarietum spuriae and the Vicietum tetraspermae from their Sherardion but their alliance would probably best be regarded as a synonym of the Triticion. Kornas (1950) adopted the Triticion to cover a range of Caucalidion and Secalinion s.l. associations, excluding the Vicietum tetraspermae.

Brun-Hool (1963) and Meisel (1967) solved the problem in a different way by recognising Euphorbia exigua - subassociations of Aphanion communities. Some transitional aufnahmen are recognised here as the Euphorbia exigua - Avena fatua - Comm.; they are not referable to any Aphanion association and may be impoverished Caucalidion stands.

British Distribution

Communities of the alliance are best developed on the light soils of the south-east but extend to S. Wales and E. Scotland

(Fig. 35). No stands have been recorded from N. Wales, N. W. England and W. Scotland.

Ecology

As explained above, the alliance is the characteristic alliance of winter cereals on loamy soils, being replaced by the Arnosericidion on base-poor sands and by the Caucalidion on calcareous soils.

Some aufnahmen unassignable beyond the alliance level are presented in Tables XLV and XLVI. The stands containing bryophytes (Tab. XLV) are marked by the exclusive occurrence of Juncus bufonius and higher frequencies of Veronica arvensis, Poa annua, Trifolium repens and Heracleum sphondylium. Stands lacking bryophytes show similarly higher frequencies of Atriplex patula, Chenopodium album and Urtica dioica and exclusive occurrence of Chaerophyllum temulentum.

Some of these stands occur at relatively high altitudes, to 750 ft in Dorset, and could thus be "Rumpfgesellschaften" of Brun-Hool (see Sect. 2.2.2.9.2). All stands were recorded in cereals except aufn. 568 which was in a fallow, unplanted strip, still in a barley-field.

1. Association: PAPAVERETUM ARGEMONIS (Libb. 1932) Kr. et Vl. 1939 (Tab. XL)

Synonymy

Scleranthus annuus - Myosurus minimus - Ass.
Libb. 1932, p.p.

Avenetum fatuae Kr. et Vl. 1939, p.p.

- ? Vicietum tetraspermae Kr. et Vl. 1939, p.p. min.

Alchemilla arvensis - Matricaria chamomilla - Ass.

R. Tx. 1937, Subass. - Gruppe von Veronica hederifolia

R. Tx. 1950

Filagini - Aperetum Oberd. 1957

Alopecuro - Matricarietum (R. Tx. 1950) Meisel 1967,
p.p., non Wass. 1941

? Ornithopus perpusillus - Scleranthus annuus - Ges.
Krausch 1969, p.p.

Diagnostic Species Group

Medicago lupulina

Papaver argemone

Arenaria serpyllifolia

P. dubium

A. leptoclados

Lycopsis arvensis

Erodium cicutarium ssp. cutarium

Anthemis arvensis

Arabidopsis thaliana

Myosotis discolor

Veronica triphyllos

Stellaria pallida

Veronica hederifolia ssp. hederifolia

Amsinckia spp., increasingly established in cereals on sandy soils may also become diagnostic for this association. Other species of diagnostic value in Europe are shown in Table XLIV.

European Distribution and Syntaxonomic Position

The association occurs throughout northern, western and central Europe, extending to Italy (Pignatti, 1952; 1957), Sweden (Merker, 1961) and Poland (Sychowa, 1959). Its relationship to other associations is discussed in relation to the alliance and summarised in Table XLIV. Rodi (1967) fully examines its relationship to the other Aphanion association of rather base-poor sandy ground, the Galeopsio - Alchemilletum (as the Galeopsido - Matricarietum Oberd. 1957).

Libbert's (1932) original data are either heterogeneous or represent poorly developed stands.

British Distribution (Map 14)

The association is widespread on suitable soils in southern England and S. Wales, extending north to Montrose, Angus.

Ecology

As would be expected, British occurrences are on sandy and sandy-loam soils. It is absent from the base-poor Lower Greensand soils, but occurs on the Bagshot Sands, in the Brecklands and on alluvium and sandy glacial drift elsewhere. Occasionally it occurs on the more calcareous sands, or directly on chalf as at Piddlehinton, Dorset, but it is typically replaced by the Papaveri - Melandrietum as the calcium carbonate content increases. Analyses for exchangeable calcium and potassium gave the following results:

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>	
51	615	4	(Figures in
755	990	4	mg /100 g dry soil)
764	300	10	

All three aufnahmen were from the Brecklands and referable to subass. typicum.

The association is recorded from close to sea-level in Devon to altitudes of 400 ft in Dorset. 15% of stands were recorded from root-crops, sugar-beet and bulbs, and 50% from cereals.

Subdivisions

Subass. typicum Siss. 1946 has so far only been recorded from eastern Britain, primarily in Suffolk and including most Breckland occurrences.

Subass. juncetosum Siss. 1946 is differentiated by Sissingh (1950) by the occurrence of Juncus bufonius, Gnaphalium uliginosum, Galium aparine, Cerastium fontanum, Oxalis "stricta", Lapsana communis and Ranunculus repens, to which Sissingh and Tideman (1960) add Sagina

procumbens. It is recognisable in Britain though C. fontanum does not appear to be of diagnostic value. A number of additional differential species are provisionally given in Table XL, including Bryum rubens, Pulicaria dysenterica, Heracleum sphondylium, Valerianella locusta, Eupatorium cannabinum, Epilobium hirsutum, Polygonum amphibium, Bryum sauteri, B. bicolor and Phascum cuspidatum. Other species such as Convolvulus arvensis, Poa trivialis and Vicia angustifolia could also be grouped here, but are of more general occurrence in Sissingh's data.

The subassociation is characteristic of damp ground and is best developed on fallow ground at the Branton Bulb Farm in N. Devon. Here the fields are on estuarine alluvium behind extensive sand-dunes. The farm was being run down and aufn. 562, 563 and 566 are from 2-year fallow fields, explaining the predominance of Marchantia polymorpha in one field. While one stand was recorded from Suffolk, all others were distributed from Surrey, westward, in marked contrast to subass. typicum.

An Ornithopus perpusillus - Nodum was recorded in different years from one site in Surrey, in a shrub-nursery on the Bagshot Sands. It is characterised by Rumex acetosella, Ornithopus perpusillus, Holcus mollis, Aira caryophyllea and Trifolium arvense. These are native species of the surrounding heathland recolonising the relatively undisturbed bare ground. The situation is similar to that described by Krausch (1969), whose Ornithopus perpusillus - Scleranthus annuus - Gesellschaft has affinities to both this association and to the Arnosericidion.

2. Association: ALCHEMILLO - MATRICARIETUM CHAMOMILLAE R. Tx. 1937
em. Pass. 1957 (Tab. XLI)

Synonymy

Alchemilla arvensis - Matricaria chamomilla - Ass.
 R. Tx. 1937, p.p.

Aphano - Matricarietum R. Tx. 1937 em. Meis. 1967, p.p.

Alopecureto - Matricarietum (R. Tx. 1950) Meis. 1967,
 p.p., non Wass. 1941

Aphano - Matricarietum R. Tx. 1937 em. Schubert et
 Mahn 1968, p.p.

Diagnostic Species Group

Matricaria recutita Raphanus raphanistrum

Alopecurus myosuroides (and Diff. Sp. of variant)

As discussed under the syntaxonomy of the alliance, this association lacks satisfactory character species. R. raphanistrum is included here following Schubert and Mahn (1968).

European Distribution and Syntaxonomic Position

The association occurs throughout most of the range of the alliance, though Westhoff and Den Held (1969) note its absence from the Netherlands. The syntaxonomy of the association has been extensively discussed in relation to that of the alliance.

British Distribution (Map 15)

The association occurs in scattered localities in southern England, with a number of stands recorded from Essex. Additional stands have been recorded from N. Yorkshire and S. Durham and it is likely that other impoverished Aphanion communities in the north should be referred here. Most stands are poorly developed.

Ecology

The association is recorded from heavy loam and clay soils, especially on the London Clay and boulder clays, though these are often modified by river terraces or other alluvial deposits. Locally it occurs on calcareous strata, Chalky Boulder Clay in Essex, Chalk in Buckinghamshire, Magnesian Limestone in Durham and Coral Rag in Dorset. One aufnahmen is from the typically base-poor Upper Greensand in Dorset, but the site is more calcareous than normal (see below); one aufnahmen is also from the Lower Greensand in Dorset.

A poorly developed stand is recorded from an altitude of 650 ft in north Yorkshire, though well developed stands are confined to much lower altitudes, mainly in Essex and Surrey. All stands were recorded from cereals, either 2-rowed barley or wheat, or from fallow ground. The following soil data were obtained for exchangeable calcium and potassium expressed in mg per 100 g. dry soil. Both aufnahmen are from the type_variant, Gnaphalium - Bryophyte - Nodum.

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>	<u>Geology</u>
649	390	13	Lower Greensand
651	665	20	Upper Greensand, close to boundary with Lower Chalk and chalk fragments present.

Subdivisions

Stands containing Alopecurus myosuroides have been grouped together as the Alopecurus myosuroides - Variant. This corresponds to the subassociation group of A. myosuroides described by Tüxen (1950) treated by many other workers. As additional differentials, Tüxen gives Atriplex patula, Anthemis cotula and Kickxia elatine, while Oberdorfer (1957a) adds Sinapis arvensis and Sherardia arvensis. The single occurrence of K. elatine in Tab. XLI corresponds to the variant, but A. cotula and Sinapis arvensis occur outside the variant and the other cited species are lacking from recorded British stands

of the association. Avena fatua shows some correlation with this variant, suggesting effects of selective herbicides, but other grass species do not show a similar trend and herbicide-sensitive species are generally rare in or absent from the entire table. The variant is recorded only from Essex and Buckinghamshire and shows greater association with clay soils than the type variant.

The Type - Variant occurs throughout the range of the association, on loam and sandy soils as well as clays.

The Gnaphalium - Bryophyte - Nodum is distinguished by the presence of Gnaphalium uliginosum, Juncus bufonius and a number of bryophytes including Bryum rubens, B. klinggraeffii, B. microerythrocarpum, Phascum cuspidatum, Barbula unguiculata, B. convoluta, Dicranella staphylinia and D. varia. It may correspond to the ill-defined Gnaphalium - Variant described by Passarge (1964) and also containing G. uliginosum and Juncus bufonius. The nodum is characteristic of damper soils but not, apparently, related to soil type. Bornkamm and Köhler (1969) distinguish three variants based on Ranunculus repens, Gnaphalium uliginosum and Juncus bufonius, indicating increasing moisture; bryophytes occur in all three of their divisions. British data do not fit their classification.

3. EUPHORBIA EXIGUA - AVENA FATUA COMMUNITY (Table XLII)

Diagnostic Species Group

<u>Euphorbia exigua</u>	<u>Avena fatua</u>
<u>Mentha arvensis</u>	<u>Alopecurus myosuroides</u>
<u>Silene noctiflora</u>	<u>Kickxia elatine</u>

Syntaxonomy and Ecology

The problems of classifying communities of moderately calcareous soils have already been discussed above. Euphorbia exigua has an

optimum pH-range of 6.4 to 6.7 (Ellenberg, 1948) and hence tends to characterise such communities, notably the Euphorbio - Melandrietum, described by Müller (1963) from East Germany. In view of Lamb's comparison of the climate of Berlin with East Anglia, the occurrence of this association in Britain is not impossible. However, comparison of the present community with the Euphorbio - Melandrietum (see Table XLIV) shows that while they have common diagnostic species, E. exigua, A. fatua and Silene noctiflora, there are also many differences. Species typical of the Euphorbio - Melandrietum and not yet recorded for the E. exigua - A. fatua - Comm. include Veronica hederifolia, Lithospermum arvense, Medicago lupulina, Lamium amplexicaule, Sherardia arvensis and Lathyrus tuberosus. Herbicides permitting, there is no reason why any of these should not be included in more comprehensive British data, though the last-named is a rare introduction and probably no longer occurs on arable land in Britain. However, the absence of Kickxia elatine, K. spuria, Anthemis cotula and Stachys arvensis from the Euphorbio - Melandrietum appears genuine.

This community is also close to the Alchemillo - Matricarietum, especially the Alopecurus - Variant. In particular it parallels the subass. euphorbietosum Brun-Hool 1963. However, the British community lacks Matricaria chamomilla and Raphanus raphanistrum, plus Sherardia arvensis of Brun-Hool's subassociation. The data given by Brun-Hool (1963) and Meisel (1967) of the subassociation lack Silene noctiflora and Avena fatua. The Euphorbia exigua - Caucalion - Gesellschaft Brun-Hool 1963 differs in its higher content of true Caucalidion species.

The community is recorded primarily from barley, but also from cabbages and broad-beans on heavy calcareous soils. Most stands are from Essex, on the Chalky Boulder Clay, but the community occurs in

other scattered localities in S. England and S. Wales (Map 16). The Essex sites are all from an altitude of 400 ft.

Soil analysis at one Breckland site (Aufn. 754) gave 985 mg / 100 g. dry soil of exchangeable calcium and 5 mg / 100 g. dry soil of exchangeable potassium.

4. Brun-Hool Community: KICKXIA ELATINE - APHANION (Tab. XLIII)

Differential Species

Kickxia elatine

Stachys arvensis

Veronica agrestis

Sherardia arvensis

Anagallis arvensis shows high constancy.

Syntaxonomy and Ecology

The community is a rather heterogeneous assemblage of aufnahmen all characterised by the presence of Kickxia elatine. Stands are recorded from several localities in S. England and S. Wales (Map 17) but especially from Pembrokeshire (Dyfed) and Dorset. It is likely that some aufnahmen represent a replacement community of the Linarietum spuriae on the less calcareous, more highly leached soils of the west. All stands are recorded from cereals.

Subdivisions

Several noda can be distinguished in the data. A Ranunculus repens - Nodum is restricted to western localities and represents the invasion of arable land by Molinio - Arrhenatheretea species. Veronica persica and Lamium purpureum show strong negative correlation with this nodum.

In damper localities, bryophyte communities are developed, characterised by Eurhynchium praelongum and Pottia truncata. Subdivisions of the general Bryophyte Nodum are further characterised

by Dicranella staphylina on mesic soils and Bryum microerythrocarpum on presumed base-poor soils. Agrostis stolonifera shows high cover-abundance values in these noda. Aufnahmen 594 and 595, containing Juncus bufonius, Riccia glauca (as var. subinermis), Physcomitrella patens and Ephemerum serratum, suggest a transition to the Isoeto_- Nanojuncetea Br. Bl. et R. Tx. 1943.

The Plantaginetea species, Poa annua, Trifolium repens and Matricaria matricarioides form the typical nodum of compacted soils.

The Polygono_-Chenopodietalia species, Polygonum persicaria and Euphorbia helioscopia are associated in stands on the Pembrokeshire coast and with Stachys arvensis show a transition to the Stachys arvensis_-Comm.

6.12 Suborder: SECALINETALIA Br. Bl. 1931 em. J. et R. Tx. 1960

Alliance: CAUCALIDION LAPPULAE R. Tx. 1950

Synonymy

Triticion sativae Kr. et Vl. 1939, p.p.

Triticion sativae Kr. et Vl. 1939 em. Kornas 1950, p.p.

"Eu_-Secalinion Br. Bl. 1936" in Sissingh (1950), p.p.

? Veronico politae_-Taraxacion Kropac et Hadac 1971

Character and Differential Species

<u>Legousia arvensis</u>	<u>Valerianella dentata</u>
<u>Papaver hybridum</u>	<u>Fumaria officinalis</u> ssp. <u>wirtgenii</u>
<u>Sinapis alba</u>	<u>Kickxia spuria</u>
<u>Scandix pecten-veneris</u>	<u>Adonis annua</u>
<u>Agrostemma githago</u>	<u>Lithospermum arvense</u>
<u>Anagallis foemina</u>	<u>Ranunculus arvensis</u>
<u>Euphorbia exigua</u>	<u>Fumaria vaillantii</u>
<u>E. platyphyllos</u>	<u>F. parviflora</u>

Some of these species are less calcicolous on the continent and occur more generally in Centauretalia communities. Under atlantic conditions they are more restricted to dry, calcareous soils.

Additional differential species from the Aphanion are:

Chaenorhinum minus

Veronica polita

Reseda lutea

Papaver somniferum

Galeopsis angustifolia

Species of the bryophyte union Phascetum floerkeani (q.v.) primarily Dicranella varia, Pottia davalliana, Phascum floerkeanum and Bryum klinggraeffii are also differential for the Caucalidion.

European Distribution and Syntaxonomy

The general syntaxonomy of the alliance and suborder have already been discussed in relation to the order. The separation of the alliance from the Aphanion and the synsystematic positions of the alliances Triticion sativae and the Sherardion have also already been discussed.

The alliance is the northern counterpart of the Secalinion mediterraneum of the Mediterranean area and the northern and western counterpart of the Secalinion orientale of the Balkans and southeast of Europe. With the weed vegetation thus divided on rather arbitrary geographical boundaries it is to be expected that some associations are difficult to classify. Pignatti (1957) describes associations from Italy that might be included either in the Secalinion mediterraneum or in the Caucalidion and Soo (1961) similarly lists a number of Hungarian associations which fall between the Caucalidion and the Secalinion orientale.

The Caucalidion extends north to N. E. Germany (Passarge, 1964) but grades into the Aphanion via the moderately calcareous associations already discussed in relation to the Triticion and Sherardion. Kropac et al. (1971) proposed the alliance Veronico-Taraxacion for one

rather ill-defined association of moderately calcareous sandy soils which did not fit easily into the Caucalidion. Their alliance also appears to be part of the complex of transitional associations to the Aphanion.

The most calcareous section of the Caucalidion is marked by a group of associations based, nomenclaturally at least, on Adonis species. Tüxen (1950) accepts only two of these:

Adonis autumnalis - Iberis amara - Ass. (Allorge 1913)
R. Tx. 1950

Caucalis latifolia - Adonis flammea - Ass. (Zeiske 1898) R. Tx. 1950

The first of these, Tüxen gives for France and S. Belgium, while the second is its counterpart in central Europe. On the most calcareous soils to the north of these was Tüxen's

Caucalis lappula - Scandix pecten - Veneris - Ass. R. Tx.
(1928) 1950

However, a substantial number of associations have since been described within this complex. Taxonomic confusion within the genus Adonis has further complicated the situation. It is likely that nearly all of the additional associations should be reduced to synonymy under the associations quoted above, though the Galio - Adonidetum Schub. et Köhler 1964 described from East Germany has gained full acceptance with East-European workers (see Schubert and Mahn, 1968). This, of course, may be partly political! The emendation of Tüxen's Caucalido - Scandicetum by Schubert and Köhler (1964) may also be an improvement on Tüxen's (1950) classification, as discussed under the Linarietum spuriae.

Tüxen recognised several less calcicolous associations, of which the Lathyrus aphaca - L. tuberosus - Ass. (Kuhn, 1937) Tx. 1950, of the Alps, appears to be one of the better marked. He placed the Papaveri - Melandrietum, described below, in the Agrostidion spicae

venti, while he regarded the Linarietum spuriae as a mere stubble-community, referable partly to the Alchemillo - Matricarietum and partly to his concept of the Caucalido - Scandicetum. Several further similar associations have been described in this part of the alliance, in addition to the recognition of the Linarietum spuriae as an association in its own right. The alliance reaches its northern limit as the Ranunculetum arvensis Pass. 1964 and a poor form of the Papaveri - Melandrietum, both of which are placed by Passarge (1964) in the Triticion sativae.

Doing (1963) divides the Caucalidion by recognising a "Linarion spuriae Sissingh". He gives no further details and this must be regarded as a nomen nudum.

British Distribution and Ecology

The alliance is restricted to southern and southeastern England (Fig. 35) extending north to Lincolnshire. It is strictly confined to calcareous soils in Britain, primarily on chalk, including where chalk is thinly covered by sand in the Brecklands, but also occurring on oolitic limestone and other strongly calcareous rocks.

Herbicides and the climatic deterioration have largely eliminated fully developed stands of this alliance in Britain. A number of aufnahmen not clearly referable to any association are given in Table LI. They include the only site where Agrostemma githago is still established in Britain; a Cambridgeshire farmer allows the plant to survive in the corner of one field and at the time the site was visited a few plants were also in a neighbouring field. The continued existence of several other Caucalidion species is similarly precarious.

1. Association: LINARIETUM SPURIAE Kr. et Vl. 1939 (Tabs. XLVII, XLVIII)

Synonymy

? Caucalis daucoides - Scandix pecten veneris - Ass.
(Zeiske 1897) Tx. 1937, p.p.

Kickxio - Aperetum Oberd. 1957

Lathyro - Aperetum sensu Oberd. 1957, non R. Tx.
et v. Rochow 1950

"Kickxietum Krus. et Vlieg. 39". in Oberdorfer et al.
(1967)

Diagnostic Species Group

<u>Kickxia elatine</u>	<u>Kickxia spuria</u>
<u>Chaenorhinum minus</u>	<u>Legousia hybrida</u>
<u>Anagallis foemina</u>	<u>Phascum floerkeanum</u>
<u>Dicranella varia</u>	<u>Pottia davalliana</u>
? <u>Barbula fallax</u>	? <u>Phascum curvicollum</u>

European Distribution and Syntaxonomic Position

Since it was first described in 1939, the association has been subject to varying syntaxonomic opinions, as discussed above. In particular, its relationship to the differing concepts of Tüxen's (1937, 1950) Caucalido - Scandicetum has been a point of dispute. Burrichter (1963) reviewed all available data and justified the existence of the association, since when it has been generally accepted.

The limits of the association are still, however, not at all clear. As Kropac and Hejny (1975) point out, the species of Kickxia have been used to characterise several associations across Europe, and they thus have little diagnostic value on their own. Table L shows the related associations most relevant to discussion of British vegetation. Sissingh (1950) compares the Linarietum spuriae with

other "Eu - Secalinion" communities, showing Legousia hybrida to be a character species of the Caucalido - Scandicetum (sensu Tüxen, 1937) and declaring it to be absent from the Linarietum. However, L. hybrida is often an important constituent of British stands.

The Netherlands almost lack markedly chalky ground, with the Linarietum a community of calcareous clays (Westhoff and Den Held, 1969) and so the situation there is somewhat different from Britain. With the much larger exposures of pure chalk in England, species such as Legousia hybrida can occur.

Two choices are thus available. Legousia hybrida can be accepted as a constituent of a better developed English Linarietum, perhaps differentiating a distinct variant, or two associations could perhaps be recognised. The impoverished English Caucalidion hardly merits recognition of further associations, besides which the status of the Caucalido - Scandicetum is itself in doubt following Burrichter's work. The more sensible approach is to include all British data in the Linarietum, but to recognise that there is a transition across Europe, with the Caucalido - Scandicetum best developed in East Europe, in the sense of Schubert and Köhler (1964).

Oberdorfer (1957a) gives details of impoverished montane Kickxia elatine communities from southern Germany. He quotes von Rochow's data of the Lathyrus aphaca - Agrostis spica venti - Ass. R. Tx. et v. Rochow 1950, which may well be a parallel association. His own data for this association, plus his Kickxio - Aperetum, are not convincingly distinct from the Linarietum, a view also taken by Oberdorfer et al. (1967).

The association thus occurs in the Netherlands, Belgium and Germany. Sissingh (op. cit.) also includes France in the distribution of the association.

British Distribution (Maps 18 and 19)

The Linarietum is frequent on the chalk and calcareous boulder-clays of south-east England, extending west to Dorset, where it also occurs on the Cornbrash, Lower Purbeck and Inferior Oolite.

Ecology

Much of the general ecology of the association has been discussed above. It occurs on calcareous clays and loams, often on pure chalk or on chalky rendzinas. On mature calcareous brown-earth soils the association is, or was, replaced by the Adonido - Iberidetum.

Subass. sherardietosum has been recorded several times at 500 ft and reaches an altitude of 600 ft on the Upper Chalk at Litton Cheney, Dorset. Subass. equisetetosum and the unclassified aufnahmen generally occur at lower altitudes.

With the exception of one aufnahme from fallow ground, one from broad-beans and one from a strip of potatoes at the edge of a wheat-field, all aufnahmen were from cereals. Over 65% of all aufnahmen were from barley, and 76% of aufnahmen from subass. sherardietosum were from this crop.

In the higher rainfall areas in western Britain, the Linarietum appears to be replaced by the Kickxia elatine - Aphanion (q.v.).

Subdivisions

Westhoff and Den Held (1969) recognise two subassociations, based on Sherardia arvensis and Equisetum arvense, on chalk and alluvial clays, respectively. Full treatment of these and other infra-associational taxa is given by Sissingh (1950).

Subass. equisetetosum is differentiated by Equisetum arvense, Polygonum amphibium, Lathyrus tuberosus, Stachys palustris, Galeopsis tetrahit and Matricaria recutita (Sissingh, op. cit.; Westhoff and Den Held, op. cit.). The subassociation is not recognisable in

Britain, only Equisetum arvense having been recorded in the association. With the exception of one occurrence in subass. sherardietosum, the aufnahmen containing E. arvense have been brought together in Table XLVII. The nodum thus differentiated is confined to Essex and Norfolk.

Subass. sherardietosum (Tab. XLVIII) is differentiated in the Netherlands by Mentha arvensis, Silene vulgaris, Achillea millefolium, Cerastium arvense, Galeopsis angustifolia, Centaurea scabiosa, Campanula rapunculoides, Poa compressa, Knautia arvensis, Saxifraga tridactylites, Legousia speculum-veneris (not British), Valerianella dentata and Lathyrus aphaca (Sissingh, op. cit.; Westhoff and Den Held, op. cit.). Many of these species do not occur in British data, but the subassociation is still recognisable. Sherardia arvensis, Valerianella dentata, Silene vulgaris, Mentha arvensis and Centaurea scabiosa are of diagnostic value in British stands. Additional differential species in Britain are Potentilla anserina, which occurs once, in the same subassociation, in Sissingh's data, and Reseda lutea, Agrostis tenuis, Linaria vulgaris, Ajuga chamaepitys, Filago pyramidalis, Silene alba and, perhaps, Althaea hirsuta, which do not occur in Sissingh's data. Papaver hybridum is almost confined to this subassociation. Aphanes arvensis is entirely confined to this subassociation in Britain, but is of more general occurrence in Sissingh's table.

The subassociation is typically developed along the top edges of steeply sloping chalky fields, especially below the woods that are often left on the cappings of gravel or clay-with-flints on many chalk hills. In these situations, crops are often subject to rabbit attack while the soil remains very immature, humus being washed out leaving compacted clayey chalk. The margin is often relatively undisturbed, being shallow-ploughed or missed altogether and a smooth,

hard crust forms on the soil surface. Most species of the subassociation are tough perennials, e.g. Reseda lutea, Centaurea scabiosa, or low-growing, spreading annuals, e.g. Ajuga chamaepitys, Sherardia arvensis, Filago pyramidalis and Mentha arvensis which can occupy the ground despite the low number of germination sites. A.chamaepitys and F. pyramidalis appear to be particularly restricted to such bare, compacted field edges where competition from the crop is minimal (see Sect. 4.1.1). Althaea hirsuta in its long-established Kent site shows the same ecology and grows with the previous two species.

A group of unclassified aufnahmen remain that could be regarded as a "typical subassociation". However, no such subassociation has been described. It would no doubt be possible to select a type aufnahme, preferably from the original data of Kruseman and Vlieger, but this would be better done by someone with a knowledge of the association on the continent. Nevertheless, this group of aufnahmen should be regarded as basic to the association in Britain, since they practically lack any differential species of their own.

Heracleum sphondylium, Urtica dioica and Atriplex hastata are restricted to this "typical group", but none of them are of high frequency. This un-named subassociation is typical of more level ground at lower altitudes, though aufn. 834 from the Barton Hills, Hertfordshire is from the top edge of a field below a beechwood. However, the aufnahme was taken six metres into the crop and the field edge in this instance was dominated by Mentha arvensis. Here, at least, subass. sherardietosum formed a boundary community to the typical subassociation. Aufnahme 619 is of interest as being from a continuing mediaeval strip-farming system on terraces on Portland Bill, Dorset. The fields were markedly weedy due not only to the impossibility of applying mechanised weed-control methods but also

to the much greater proportion of field edge to total area. Legousia hybrida and Chaenorhinum minus are apparently correlated in this subassociation.

A Bryophyte - Nodum of damper fields can be distinguished in both main subassociations. The calcicolous species of the Phascetum floerkeani form a distinct nodum in subass. sherardietosum and a more diffuse nodum in the "typical subassociation".

A most interesting wet-ground community is described by Coombe et al. (1959). They report a flooded field containing Lythrum hyssopifolia, in a community which they refer to the Nanocyperion flavescens Koch 1926, of the Isoeto - Nanojuncetea Br. Bl. et R. Tx. 1943 (following the classification of Westhoff and Den Held, op. cit.). The affinity of their phytocoenose to that alliance is clear, but the presence of Kickxia elatine, Euphorbia exigua, Dicranella varia and Pottia davalliana plus other Stellarietea species shows that the stand is derived from Linarietum.

2. Association: PAPAVERI - MELANDRIETUM NOCTIFLORI Wasscher 1941
(Tab. XLIX)

Synonymy

Lathyro = Melandrietum Oberd. 1957

Descurainio = Delphinietum Schub. et Mahn 1959, ? p.p.

"Melandrietum noctiflorae Wasscher 1941" in Passarge (1964), ? p.p.

Euphorbio = Melandrietum G. Müll. 1963, sensu Schubert et Mahn (1968), p.p.

"Melandrietum noctiflori Oberd. 57" in Oberdorfer (1970)

Diagnostic Species Group

Silene noctiflora

Papaver rhoeas

S. alba

P. hybridum

Nepeta catariaPapaver argemoneArenaria leptocladosValerianella dentataA. serpyllifoliaEuropean Distribution and Syntaxonomic Position

The association was originally described from the Netherlands (Wasscher, 1941) and is accepted by Westhoff and Den Held (1969) in their review of Dutch vegetation, though it was rejected as a dubious community by Sissingh (1950) in his monograph on Dutch arable vegetation. It was briefly accepted by Tüxen (1950) on the basis of the Dutch data, and Oberdorfer (1957a) described a similar association, the Lathyro - Melandrietum, from southern Germany. Oberdorfer et al. (1967) reduced this to synonymy under the Papaveri - Melandrietum, though Oberdorfer, himself (1970), later maintained the separate identity of his association. Passarge (1964) accepted the association for north-east Germany, though his data is atypical and perhaps partly referable to the Galeopsietum speciosae. The association thus appears to be the standard association of calcareous sands and loams in N. W. Europe south of the Baltic. As Westhoff and Den Held (op. cit.) comment, it is the last outlier of the Caucalidion in the north-west.

The E. European equivalent on sandy and loamy calcareous soils is the Euphorbio - Melandrietum. When describing the association, Müller (1963) commented on its similarity to Oberdorfer's association and related C. European communities. Subsequent East German workers (e.g. Hilbig, 1967a; Schubert and Mahn, 1968) have taken a broader view of the Euphorbio - Melandrietum, quoting the Lathyro - Melandrietum as a synonym and suggesting that it also includes the Papaveri - Melandrietum. In this they may well be right, much of the data of Schubert and Mahn (op. cit.) is very close to the Papaveri - Melandrietum, even at the subassociation level (see below), but if

it should be shown that one association stretches across northern Europe, Wasscher's name must take priority.

British Distribution (Map 20)

The association occurs in association with chalk in S. E. England and E. Anglia, extending north to Lincolnshire and west to Dorset and Wiltshire.

Ecology

As described above, the association occurs on light, well-drained calcareous soils. The absence of bryophytes from all stands is probably characteristic. Many sites are directly on chalk, with the Lower, Middle and Upper Chalk formations all represented. Additionally the association occurs in the Brecklands in the Eriswell area, where only thin layers of sand overlies the chalk, and on gravel over chalk elsewhere. One Lincolnshire site at Elsham (Aufn. 825) is on the Lower Greensand but very close to the boundary with the chalk. The soil at this site contains chalk fragments, perhaps as a result of regular liming, and is highly calcium-rich (see below). The association reaches an altitude of 350 ft on the chalk at Buzbury Rings, Dorset.

63% of stands are in cereals, mainly 2-rowed barley, while four aufnahmen (21%) were in root crops: beet and potatoes.

Subdivisions

Neither Wasscher (op. cit.) nor Westhoff and Den Held (op. cit.) describe any subassociations, though Passarge (op. cit.) recognises two subassociations from a total of eight aufnahmen. Barring one occurrence of Ranunculus repens itself, the species of his subassociation of R. repens are absent from British stands. In any case, it is far from certain that his data of that subassociation

should be included in the Papaveri - Melandrietum. With the exclusion of these aufnahmen, his subassociation of Euphorbia exigua breaks down, being representative of the association as a whole.

However, two clear subassociations exist in British data and are described below.

Papaveri - Melandrietum noctiflori Wass. 1941 tripleurospermetosum subass. nov. (prov.) is differentiated by Veronica persica, Tripleurospermum inodorum and Stellaria media. The type aufnahme is Aufn. 558 (Tab. XLIX, Column 11), from Odstock, Wiltshire. The subassociation occurs throughout the British range of the association and is apparently also represented in the data of Wasscher and Passarge. It probably characterises the more nitrogenous soils. A possible synonym is the Euphorbio - Melandrietum G. Müll. 1963, Rasse von Tripleurospermum inodorum in Hilbig (1967a), p.p.

Papaveri - Melandrietum noctiflori Wass. 1941 descurainietosum subass. nov. (prov.) is differentiated by Anthemis arvensis, Descurainia sophia, Echium vulgare, Lycopsis arvensis, Diploaxis muralis and Cynoglossum officinale. The type aufnahme is Aufn. 245 (Tab. XLIX, Column 18), from Eriswell, Suffolk. The subassociation is only known from sandy Breckland fields in the type locality, where it may be a transitional community to the Descurainio - Lycopsietum (q.v.). The Descurainio - Delphinietum may be partly synonymous. This association was reduced to the status of a Rasse of the Euphorbio - Melandrietum by Hilbig (1967a). All aufnahmen of this subassociation are referable to the Reseda lutea - Nodum described below. They refer to stands in barley or Dactylis, undersown with lucerne in three cases.

A Reseda lutea - Nodum, differentiated by R. lutea, Myosotis arvensis, Plantago lanceolata and Carduus nutans occurs on dry, loams and sands.

An Agrostis stolonifera - Nodum, differentiated by A. stolonifera and Matricaria matricarioides may indicate soil compaction, but other such indicators, e.g. Poa annua, Plantago major, do not correlate with this nodum.

Soil Analyses

The following results were obtained for exchangeable calcium and potassium, expressed in mg./100 g. of dry soil. Solution of calcium carbonate solids in the ammonium acetate extractant may have resulted in higher values for calcium.

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>	<u>Subassociation</u>	<u>Geology</u>
248	1120	5	<u>descurainietosum</u>	Brecklands Sands over Chalk
758	1150	7	"	"
825	1035	27	<u>tripleurospermetosum</u>	Lower Greensand (see above)

3. Association: ADONIDO AUTUMNALIS - IBERIDETUM AMARAE (Allorge 1913) R. Tx. 1950 (Table LI)

Synonymy

Moissons calcaires a Caucalis daucoides et Stachys annua Allorge 1922, p.p.

Groupe ment a Iberis amara et Galium tricorné
Lebrun et al. 1949

Ass. a Caucalis daucoides et Scandix pecten-veneris
Lebrun et al. 1949, p.p.

? Adonideto - Delphinietum consolidae Br. Bl. 1949

Diagnostic Species Group

Adonis annua

Iberis amara

Tüxen (1950) also gives:

Bunium bulbocastanum

Torilis arvensis

Valerianella carinata

European Distribution and Syntaxonomic Position

The complexity of the Adonis-group of associations has already been discussed in relation to the alliance. The Adonido - Iberidetum is the community of western Europe, known from Belgium, France and N. W. Switzerland (Tüxen, 1950; Brun-Hool, 1963). The Adonido - Delphinietum consolidae, described by Braun-Blanquet (1949) from Switzerland, may also belong here (but see Tüxen, 1950, for an alternative view). Breton (1956) describes a subass. iberidetosum of the Adonido - Delphinietum from France which appears to link the two associations.

British Distribution (Map 21)

The association is very poorly developed in Britain, but stands identified as this have been recorded in Buckinghamshire, Wiltshire and Dorset. Perring and Walters (1976) show other localities where Adonis annua has been established; most of these sites are likely to have belonged to the present association. Iberis amara is primarily a plant of calcareous banks in Britain and hence its distribution is no guide to the distribution of the association. In fact I. amara is shown by Perring and Walters to be centred on the Chiltern Hills, north of the main areas of (past) distribution of A. annua. Within the last ten years, A. annua has certainly occurred on arable land in fair quantity in Gloucestershire, Hampshire and Berkshire (Miss D. E. de Vesian, in litt., 1970; Lady Brewis, in litt., 1970) and these sites can be added to the distribution of the association with fair confidence.

Ecology

The association is highly sensitive to herbicides and generally no longer recognisable in Britain. Occurrences have been on mature calcareous loams over chalk or soft southern limestones. Salisbury (1939) reviews the ecology of A. annua, pointing out that it is a summer annual requiring warm conditions for germination. Thus it germinates late and may not produce mature fruit before the first autumn frosts. It is restricted to areas with a September mean maximum day temperature above 65°F. Salisbury (1961) reviews the history of this plant in Britain.

The three aufnahmen containing A. annua in Table LI are all from 2-rowed barley. Aufn. 335, from cabbages, is included in the table on the basis of the presence of Iberis amara, but this may prove to have been misplaced. At an altitude of 550 ft, it might be regarded as an impoverished stand.

Aufn. 559 was from disturbed ground laid bare during motorway construction. A. annua here can only have been from buried dormant achenes, though Horton et al. (1972), in a description of the site, point out that no previous records of A. annua existed for the area.

Analysis of the soil for Aufn. 586, from Dorset, gave a value of 1160 mg /100 g dry soil of exchangeable calcium and 5 mg of exchangeable potassium expressed on the same basis.

Subdivisions

Brun-Hool (1963) describes a subassociation of Kickxia spuria, with Chaenorhinum minus as one of the additional differential species. This could apply to aufnahme 586, but there is insufficient information to justify dividing up the minimal British data.

6.13 Order: SISYMBRIETALIA J. Tx. 1961 em. G8rs 1966SynonymyChenopodietalia Br. Bl. 1936, p.p.Chenopodietalia medioeuropaea R. Tx. 1937, p.p.Arction lappae R. Tx. 1937, p.p.Chenopodietalia Br. Bl. 1936 em. Siss. 1950, p.p.Chenopodietalia albi R. Tx. et Lohm. 1950,
p.p., non Br. Bl. 1936Chenopodietea Br. Bl. 1951, p.p.Thero = Chenopodietea Lohm., J. et R. Tx. 1961, p.p.Sisymbrietalia J. Tx. 1961, p.p.Onopordo - Sisymbrietea G8rs 1966, p.p.Syntaxonomy

This is the order of annual pioneer communities of ruderal habitats throughout Europe. Tüxen's (1961) concept of the Sisymbrietalia included the thermophilic biennial communities here recognised as the separate order, the Onopordetalia.

The order is regarded here as composed of three alliances:

Sisymbriion officinalis R. Tx., Lohm. et Prsg. 1950Chenopodion muralis Br. Bl. 1936Hordeion murini Br. Bl. 1936 (= "Hordeion leporini")

The last two are confined to southern Europe and hence the sole alliance of Britain and N. Europe is the Sisymbriion.

Westhoff and Den Held (1969) recognise two further alliances other than the Onopordion excluded above. The Polygono - Coronopion (Br. Bl. 1931) Siss. 1969 is an ill-defined alliance of communities intermediate between the Stellarietea and the Plantaginetea best classified under the latter class. The Helminthion echioidis

Westhoff 1968, if worthy of recognition, seems closer to the Onopordetalia. Timar and Bodrogkőzy (1959) place the Sisymbrium itself in the Plantaginetea, though not all Sisymbrium communities are so transferred.

After about two years, if succession proceeds unhindered, Sisymbrietalia communities give way to vegetation of the classes Artemisietea vulgaris Lohm., Prsg. et R. Tx. 1950 em. Lohm. et al. 1962 and Agropyretea repentis.

Alliance: SISYMBRION OFFICINALIS R. Tx., Lohm. et Prsg. 1950

Synonymy

Hordeion murini auct., non Br. Bl. 1936

Arction lappae R. Tx. 1937, p.p.

Character and Differential Species (Alliance and Order)

The following can be regarded, loosely, as character-species:

<u>Diploxys tenuifolia</u>	<u>Reseda lutea</u>
D. _____ <u>muralis</u>	R. _____ <u>luteola</u>
<u>Senecio vulgaris</u> f. <u>radiatus</u>	<u>Linaria vulgaris</u>
S. _____ <u>viscosus</u>	L. _____ <u>purpurea</u>
<u>Lycopersicum esculentum</u>	<u>Hordeum murinum</u>
<u>Anisantha sterilis</u>	<u>Sisymbrium officinale</u>
A. _____ <u>diandra</u>	S. _____ <u>altissimum</u>
<u>Conyza canadensis</u>	S. _____ <u>orientale</u>
<u>Chenopodium rubrum</u>	S. _____ <u>loeselii</u>
C. <u>murale</u>	<u>Lactuca serriola</u>
<u>Epilobium adenocaulon</u>	<u>Vulpia myuros</u>
<u>Chicorium intybus</u>	<u>Tanacetum parthenium</u>
<u>Trifolium hybridum</u>	<u>Linum usitatissimum</u>
<u>Lepidium sativum</u>	<u>Papaver somniferum</u>

Lepidium ruderalesPapaver lecoqiiVicia luteaMalva neglectaCalendula officinalisMelilotus indicaBarbarea vulgaris

A large proportion of these species are introductions. By the very nature of the communities, a number of these are of transient occurrence at any one site.

Species of the Onopordietales, Artemisietea and other higher syntaxa entering the Sisymbrietales also act as differential species with respect to the Polygono - Chenopodietales and Centauretales, e.g.

Artemisia vulgarisBromus * hordaceusSenecio squalidusEpilobium angustifoliumBallota nigraMalva sylvestrisCrepis vesicariaVerbascum thapsusDatura stramoniumNicandra physalodesAsparagus officinalisRumex patientia

Syntaxonomy

Tüxen (1950) recognised 10 associations within the Sisymbriion. Since then, many more associations have been described, certainly at least trebling Tüxen's total. Since every stand of Sisymbriion vegetation is unique in view of the uncertain availability of seed of each species and also unique in the precise combination of anthropic influences acting on the vegetation, the limits of each of these many associations are bound to be uncertain. Indeed even more than in arable-weed vegetation, it is debatable whether discrete associations can be distinguished. It is also debatable whether it is worth attempting to do so. Unusual combinations of species may have vanished by disturbance or succession even before the new

"association" has reached print. A very conservative approach would seem to be best.

As a basis, Tuxen's (op. cit.) classification is still viable and useful. Oberdorfer (1957a) provided a systematic account of nine associations recognisable in S. W. Germany, while Gütte (1972) provided an excellent review of twelve associations from E. Germany. Gütte's review may well lead the way to greater understanding of the alliance; not only does he provide an acceptable classification but he also fully surveys infra-associational variation.

As priority has been given to arable vegetation, the vegetation of this alliance in Britain is not fully surveyed here. However, a number of aufnahmen have been collected and it is possible to recognise a number of syntaxa, mostly of uncertain status.

Main Syntaxa

Three broad-based associations undoubtedly occur in Britain, though definitely identified aufnahmen can be presented for only one of these here.

1. Hordeo - Brometum sterilis (Allorge 1922) Lohm. 1950

The synonymy of the Hordeum murinum group of associations is very complex, with association names being commonly misapplied. Tuxen (1950) provides a full summary. The association is characterised by Hordeum murinum and Anisantha sterilis, with Bromus hordaceus ssp. hordaceus also of diagnostic value. It occurs on light soils on dry wasteground and apparently has an eastern tendency in Britain.

2. Sisymbrietum sophiae Kreh 1935, sensu lato

British character species given by Tuxen are Descurainia sophia, Sisymbrium altissimum and S. loeselii. The association has been variously divided up (see Passarge, 1964; Westhoff and Den Held, 1969; Gütte, 1972), but it is not yet possible to apply these results

to British data, Well developed stands, dominated by S. altissimum, S. loeselii and S. orientale occur around London. Some of the aufnahmen in Table LVII almost certainly belong here but cannot yet be positively identified. The Salsola pestifer - Nodum (Tab. LVI) should probably be placed here.

3. Chenopodio - Urticetum urentis (Br. Bl. et De Leeuw 1936) Siss. 1946

Diagnostic species given by Westhoff and Den Held (op. cit.) are Urtica urens, Chenopodium murale, C. ficifolium and Lycopersicum esculentum. The association is partly based on the original data of Braun-Blanquet and De Leeuw (1936) who gave one aufnahme of their Chenopodio - Atriplicetum hastatae from the Dutch island of Ameland and further gave a heterogeneous aufnahme from Harwich, Essex. As they commented, the Essex aufnahme clearly shows the influence of the Hordeo - Brometum. Sissingh (1950) recognises two subassociations, typicum Siss. 1946 and atriplicetosum (Br. Bl. et De L. 1936) Siss. 1946. Thus the Harwich heterogenous aufnahme, and British stands generally, referable to the latter subassociation, differentiated by Atriplex hastata, A. patula and Chenopodium rubrum. The typical subassociation, of warmer conditions, is apparently very rare on the British mainland, but Tab. LIV gives an aufnahme from Guernsey which is closer to the ideal than most mainland stands. Atriplex hastata is, however, present in this case, though Sissingh (op. cit.) does accept this occasionally in subass. typicum.

The association is characteristic of compost heaps and similar nitrogenous situations. A very unusual community is shown in Table 32. This shows the species growing on a heap of shoddy, with most or all of the species present having germinated from seeds in the wool waste. Only Sonchus asper is not listed by Lousley (1961) as a known wool alien, though species such as Holcus lanatus and

Table 32

Aliens on Shoddy Heap

Aufnahme	417		
No. of Species	17	Slope	55
Area of Quadrat in m ²	4	Exposition	NW
Area of Stand in m ²	7	Altitude in ft	300
% Cover	60	Month	10
Medicago laciniata	2.2	Xanthium spinosum	+
M. polymorpha	2.2	Chenopodium probstii	+
Lolium * multiflorum	2.2	Erodium * cicutarium	+
Erodium moschatum	1.2	Sonchus asper	+
Medicago arabica	1.2	Malva parviflora	+
Amaranthus hybridus	1.1	Chenopodium album	(+)
Hordeum histrix	+.2	Brassica tournefortii	(+)
Holcus lanatus	+.2	Sisymbrium erysimoides	(+)
Silybum marianum	+		

Lolium * multiflorum may have arrived by other means. Chenopodium murale is common in such situations, and the stand has a strong ecological, if not floristic, relationship to the Chenopodio_-_-Urticetum.

Gütte (1972) places this association in his provisional suballiance, the Malvion neglectae. This appears a suitable basis for dividing the Sisymbrium into manageable sections.

4. Hordeum jubatum - Atriplex hastata - Community (Tab. LV)

This is a very distinct community developed on drifting fine saline sand on reclaimed industrial land in the Tees Estuary. The diagnostic species group is Atriplex hastata, Puccinellia distans and Hordeum jubatum. The vegetation is unusual in that H. jubatum, normally a casual, here binds the drifting sand. A native of saline soils in N. America, it is becoming established along the sodium-rich verges of motorways and in other suitable situations. The community may be expected to occur in other industrial estuarine localities.

The community is very species-poor; Aufn. 850 containing only two species in 9 m².

5. Salsola pestifer - Nodum (Tab. LVI)

Diagnostic Species Group: Salsola pestifer, Amaranthus albus, Solanum sarachoides sensu stricto. This is based on two aufnahmen from an industrial ash tip at Dagenham, Essex. Combustion is still taking place within the tip, the warmth maintaining this remarkable community dominated by hundreds of square metres of S. pestifer.

Minor Noda (Tab. LVII)

A number of additional noda can be recognised, some no doubt worth separating in the same way that the Hordeum jubatum - Atriplex hastata - Comm. and the Salsola pestifer - Nodum have been given separate status above. Not all noda, however, are mutually exclusive.

1. Bird-seed aliens are characteristic of refuse tips, e.g. Aufn. 806 from Kent, on wasteground where bird-seed has been accidentally or deliberately scattered, e.g. Aufn. 2 and 4 from Romford, Essex.
2. A Diploaxis tenuifolia - Nodum, differentiated by D. tenuifolia, Reseda luteola, Solanum nigrum and Carduus acanthoides occurs on chalk rubble in Essex and on sandy and gravelly industrial wasteground in Co. Durham (especially the new political county of Cleveland). Sulphur pollution is heavy at all these sites. The nodum may prove to be identical to the Resedo - Carduetum nutantis Siss. 1950.
3. A Reseda lutea - Nodum, overlapping the last, is differentiated by Reseda lutea, Senecio vulgaris f. radiatus, Linaria vulgaris, Convolvulus arvensis, Ranunculus sceleratus, Puccinellia distans and Cerastium diffusum. It occurs on compacted ground overlain by sand in three localities in the geographical county of Durham. Most sites are close to the sea and known to be in their second year of colonisation. Sulphur pollution is again very heavy at these sites.
4. A Tussilago - farfara - Nodum, differentiated by T. farfara and Barbula unguiculata, occurs locally on compacted wasteground containing builders' rubble. It is syntaxonomically close to the Bryum caespitium - Tussilago farfara - Comm. of the Plantaginetea.
5. A Funaria hygrometrica - Nodum, which includes the previous nodum, is differentiated by F. hygrometrica, Bryum argenteum and Ceratodon purpureus. It occurs on compacted gravel, rubble or cinders in numerous localities from Cornwall north at least to Newcastle-upon-Tyne. The nodum is close to the Sagino - Bryetum argentei Diem., Siss. et Westh. 1940, variously referred to the Sisymbrietalia or the Plantaginetea.

6. The Trifolium repens - Nodum, differentiated by T. repens, Rumex crispus, Achillea millefolium and Geranium dissectum, is recorded mainly from south-east England on heavier ground.
7. The Poa trivialis - Nodum, differentiated by P. trivialis, Urtica dioica and Polygonum arenastrum occurs within the previous nodum in Kent and Essex on damper, more compacted sites.
8. The Agrostis stolonifera - Artemisia vulgaris - Nodum, differentiated by these two species, occurs widely within the above nodum. It may be the beginnings of a successional stage towards the Artemisietea; most of the aufnahmen from more established vegetation belong here.
9. The Plantago major - Nodum, differentiated by P. major, Matricaria matricarioides and Barbula convoluta, shows the typical transition to the Plantaginetalia on trampled areas.

Heterogeneous Stands (Tab. LVIII)

Sisymbrietalia stands (presumably of the Sisymbrium in Britain) of refuse-tips, disturbed roadsides, new building sites and similar situations show colonisation heterogeneity (see Sect. 2.2.2.10) in addition to the inevitable site heterogeneity and defy classification. Aufnahmen from such vegetation are given in Table LVIII without further sorting into nodum. The first three columns of the table are from a refuse tip and contain typical bird-seed aliens.

6.14 Order: ONOPORDETALIA Br. Bl. et R. Tx. 1943 em. G8rs 1966SynonymyChenopodietalia Br. Bl. 1936, p.p.Chenopodietalia mediterranea R. Tx. 1937, p.p.Artemisietea vulgaris Lohm., Prsg. et R. Tx. 1950, p.p.Chenopodietea Br. Bl. 1951, p.p.Thero - Chenopodietea Lohm., J. et R. Tx. 1961, p.p.Sisymbrietalia J. Tx. 1961, p.p.Onopordo - Sisymbrietea G8rs 1966, p.p.Syntaxonomy

This is a rather thermophilic order of large annual and biennial communities of ruderal habitats. Floristically, if not always ontogenetically, the order links the Sisymbrietalia with the Artemisietea. Indeed it is often placed in the Artemisietea (c.f. Tuxen, 1950), though the emendation of Lohmeyer et al. (1962) excluding the Onopordetalia from the Artemisietea now seems generally accepted.

Three alliances can be recognised within the order:

Onopordion acanthii Br. Bl. 1926Marrubion peregrini Slavnic 1951Dauco - Melilotion G8rs apud Oberdorfer et al., 1967

The Onopordion is the basic and widespread alliance, occurring throughout southern and central Europe, though it is doubtful if it reaches Britain. Stands of Onopordum acanthium, Silybum marianum etc. in southern England may belong here.

The Marrubion is an alliance of S. E. Europe (see Horvat et al., 1974) and is of no relevance to British vegetation.

The Dauco - Melilotion is of uncertain limits, but probably

replaces the Onopordion northwards. However, though this alliance reaches the north of Germany (Passarge, 1964), it, too, is moderately thermophilic. Boerboom (1960), writing of the Echio - Melilotetum in the Netherlands, comments that representatives of the association appear separately and often more or less irregularly in open ruderal vegetation in sunny habitats. This applies generally to the alliance and order in Britain.

Alliance: DAUCO - MELILOTION Görs apud Oberdorfer et al. 1967
(Tab. LIX)

Synonymy

Onopordion acanthii auct., p.p.

Character and Differential Species (Alliance and Order)

<u>Echium vulgare</u>	<u>Oenothera biennis</u> etc.
<u>Nicandra physalodes</u>	<u>Datura stramonium</u>
<u>Verbascum thapsus</u>	<u>Melilotus albus</u>
<u>V. phlomoides</u>	<u>M. officinalis</u>
<u>V. pulverulentum</u>	<u>M. altissima</u>
<u>Picris hieracioides</u>	<u>Pastinaca sativa</u>
<u>Cynoglossum officinale</u>	<u>Anchusa officinalis</u>
<u>Galega officinalis</u>	<u>Rhynchosinapis cheiranthos</u>
<u>Hyoscyamus niger</u>	<u>Onopordum acanthium</u>

1. Association: ECHIO VULGARIS - MELITOTETUM ALBI R. Tx. 1942
(Tab. LIX)

Synonymy

Echieto - Verbascetum (R. Tx. 1942, p.p.) Siss. 1950

Melilotetum albo - officinalis Siss. 1950

Melilotetum (R. Tx. 1942) Th. Müll. apud Oberd. et al. 1967

Diagnostic Species GroupMelilotus officinalisVerbascum thapsusEchium vulgareSyntaxonomy, Distribution and Ecology

This association is developed in sunny situations on sandy or gravelly soils on wasteground, in sandpits and on disturbed sand-dunes in scattered localities in southern England and Wales. The association occurs widely in N. Europe.

Sissingh (1950) recognises two associations, as quoted in the synonymy above. Columns 1 - 7 of Table LIX are referred to the Echio - Melilotetum, but Aufn. 185 and 256, from gravel mounds in Essex and Suffolk, fit the Echio - Verbascetum. They lack Melilotus officinalis and one has Echium vulgare and the other Verbascum thapsus, given as character species by Sissingh (op. cit.). Furthermore, Aufn. 256 contains Sedum acre and Arenaria serpyllifolia, given as additional differential species for the Echio - Verbascetum by Westhoff and Den Held (1969). Thus these two aufnahmen are referable to this association, while the remainder are presumably referable to the Melilotetum albo-officinalis. However, these associations do not appear separable elsewhere in Europe and so are not given separate recognition here. More British data on this complex are needed.

Columns 8 - 10 of the table cannot be certainly referred to the Echio - Melilotetum, but probably belong here.

Subdivisions

Three minor noda are distinguishable in the data.

A Tripleurospermum inodorum - Nodum, differentiated by T. inodorum, Plantago major, Atriplex hastata and Diploaxis tenuifolia forms a link to the Sisymbrietalia, in the neighbourhood of refuse

tips.

On heavier soils, an Agrostis stolonifera - Nodum occurs, differentiated by A. stolonifera, Medicago lupulina and Holcus lanatus.

A Bryum bicolor - Nodum, differentiated by B. bicolor, B. argenteum and Funaria hygrometrica, is a clear link to the Sagino - Bryetum argentei, corresponding to the Funaria hygrometrica - Nodum described in the Sisymbrietalia.

6.15 UNCLASSIFIED STELLARIETEA PHYTOCOENOSES

A number of stands have not been identified with any of the Stellarietea syntaxa described above. Either they lack character-species of the syntaxa, or else they contain inconvenient mixtures of these species, usually due to colonisation heterogeneity.

Table LX consists primarily of aufnahmen from impoverished arable-weed communities, plus some which fall between the Centauretalia and the Polygono - Chenopodietalia. No convenient Brun-Hool community is apparent in the data, but the simple classification into stands with and without bryophytes has been made. A "Bryum rubens - Nodum" is thus recognised.

Table LXI gives unclassifiable aufnahmen from Stellarietea species assemblages on dumped soil, disturbed roadsides and similar recently created habitats.

6.16 Class: AGROPYRETEA REPENTIS Oberd., Müll. et Görs 1967

(Given as "Agropyretea intermedii - repentis" in Müller and Görs (1969))

Syntaxonomy

Müller and Görs (op. cit.) provide a full review of this relatively new class of dry ruderal grassland. It is composed of syntaxa from the Sisymbrietalia, the Artemisietea, the Plantaginetea and the Festuco - Brometea Br. Bl. et R. Tx. 1943.

It contains one order:-

Order: AGROPYRETALIA REPENTIS Oberd., Müll. et Görs 1967

(Given as "Agropyretalia intermedii - repentis" in Müller and Görs (op. cit.))

Syntaxonomy

Müller and Görs give two alliances:

Convolvulo (arvensis) - Agropyron repentis Görs 1966

Artemisio - Agropyron intermedii Müll et Görs 1969

Only the first of these is relevant to British arable-weed vegetation.

Alliance: CONVOLVULO - AGROPYRION REPENTIS Görs 1966

Müller and Görs recognise six associations plus one other equivalent community in this alliance, including the variously interpreted Poo (compressae) - Tussilaginatum R. Tx. (1928) 1931. Most of their associations belong to a complex of Agropyron repens - communities which may not be genuinely distinct from the following:

Association: CONVOLVULO - AGROPYRETUM REPENTIS Felf. (1942) 1943

Synonymy

Agropyretum repentis Felf. 1942

"Ass. Gr.: Convolvuletum arvensis Felföldy (42) 43"
in Passarge (1964)

Diagnostic Species Group

Convolvulus arvensis

Agropyron repens

Equisetum arvense

Table LXIII gives the relevant character and differential species of the order and class.

Syntaxonomy

Originally described from Hungary, this association has since been reported in various parts of N. Europe. Prior to the description of the Agropyretea, it has normally been placed in the Sisymbrium (e.g. Soo, 1961; Westhoff and Den Held, 1969).

As accepted by Müller and Görs (op. cit.) this association is a rather dubious entity. Felföldy (1943), Passarge (1964) and Görs (1966) all describe effectively the same syntaxon (see Tab. LXIII) despite the expected geographical variation. However, by recognising a number of closely related associations, Müller and Görs leave the Convolvulo_-Agropyretum without character species of its own. The maintenance of the association then becomes questionable; it could be regarded as a collection of species-poor stands referable only to the alliance. Alternatively, there may be perhaps just one far ranging association with a number of variants and subassociations.

However in Britain, there are no real problems. In the absence of related associations, the Convolvulo_-Agropyretum has real meaning, though the data presented here is inevitably transitional to the Stellarietea.

Typically, the association is developed on banks, road-verges, margins of arable fields and in fallow fields themselves. In the last case, Stellarietea species are bound to be still present. Such

stands could be considered heterogeneous, but Felföldy's original table contains a number of Stellarietea species. British data are quite comparable with the tables of other workers (Tab. LXIII) but the view is taken here that the community is developed in a purer form on dry banks such as railway embankments, and that the arable stands should be denoted as a transitional "Convolvulo - Agropyretum - Stellarietea". The following discussion refers to this transitional community, presented in Table LXII.

British Distribution (Map 22)

The syntaxon, as a community within arable crops, is recorded from a few scattered localities in south and east England, from Wiltshire to Suffolk.

Ecology

The diagnostic species of the syntaxon are moderately herbicide-resistant, and as has been suggested in Section 4.5.2.3., this syntaxon may be the result of regular herbicide application, probably over a number of years. It is recorded from a range of geological strata, from Lower Greensand to Chalk, reaching an altitude of 700 ft on the Upper Greensand as a species-poor stand. Aufn. 155 probably represents a typical fallow-field development, though Aufn. 156 from the same locality, but in a growing crop, has also been referred here.

When growing well, Agropyron repens is a vigorous competitor to both crop and other weed-species. Hamilton and Buchholtz (1955) and Thurston and Williams (1968) give full accounts of its competitive effects.

6.17 Class: PLANTAGINETEA MAIORIS Tx. et Prsg. 1950

Synonymy

Rudereto - Secalinetales Br. Bl. 1936, p.p.

Chenopodietalia medioeuropaea R. Tx. 1937, p.p. min.

Arction lappae R. Tx. 1937, p.p. min.

Potentillo - Polygonetalia avicularis R. Tx. 1947

Molinio - Arrhenatheretea R. Tx. 1937 em. R. Tx. 1970, p.p., non R. Tx. 1937

Character and Preferential Species

Plantago major

Potentilla anserina

Agrostis stolonifera

Lolium perenne

Poa annua

Matricaria matricarioides

Coronopus didymus

Polygonum arenastrum

Syntaxonomy

The Plantaginetea is a natural class which has been subject to very little syntaxonomic change since its creation. It comprises vegetation of irregularly fluctuating conditions, particularly with reference to water-table levels and trampling.

However, despite its almost universal acceptance, it is difficult to maintain as a purely floristically-based syntaxon. While a number of species are certainly very characteristic of Plantaginetea vegetation, notably those cited above, it virtually lacks character-species. Tüxen (1970d) pointed out the difficulty of separating the class from the Molinio - Arrhenatheretea on floristics alone, and thus combined the two classes into an emended Molinio - Arrhenatheretea. Doing (1963) earlier appreciated this difficulty, especially the similarity of the Cynosurion R. Tx. 1947 to the Plantaginetea. Thus he transferred the Cynosurion and other Molinio - Arrhenatheretea syntaxa to the Plantaginetea. However, as Gutte

(1972) comments, the Plantaginetea is distinct ecologically, physiognomically and sociologically, and is maintained in the sense Tüxen (1950) here.

Two orders can be recognised:

Plantaginetalia maioris R. Tx. (1947) 1950 em.
Oberd. et al. 1967

Agrostietalia stoloniferae Oberd. et al. 1967

Both of these orders doubtless occur throughout Europe.

Ecology

With reference to arable vegetation, the most important feature of the Plantaginetea is its association with soil compaction and consequent anaerobic conditions. The communities thus develop along footpaths, in farm gateways and in similar trampled places. However, the preceding account of Stellarietea communities on arable land has repeatedly included noda transitional to the Plantaginetea. Not only do these transitional stands occur within arable fields, but pure Plantaginetea communities are also developing actually on the cultivated land in some areas. This is a symptom of a serious problem involved with modern agricultural methods.

Soil fertility depends not only on the nutrients present but also on the soil structure. Small pores are needed for retention of water, while large pores are essential for adequate drainage and soil aeration. Organic matter favours the maintenance of a suitable soil structure, but cultivation leads to rapid decomposition of organic matter and a degree of soil deterioration results.

However, the increases in soil density resulting from cultivation are being magnified by the use of heavy agricultural machinery (Neal, 1953; Agricultural Advisory Council, 1970). Compaction of dry soils may lead to increased water content while compaction

of moist soils causes a decrease in water content (Liddle, 1975) as pore size is reduced. Oxygen diffusion is substantially decreased and oxygen shortages may result (Grable and Siemer, 1968). Heavy machinery has a more damaging effect on moist soils than on dry soils (Agricultural Advisory Council, 1970) and so this effect would seem more likely in the higher rainfall areas of the west. It is in western Britain that Plantaginetea, especially Agrostietalia communities are most marked on arable land.

Interpretation of Plantaginetea stands is, however, complicated by the fact that the component species tend to be herbicide-resistant. Thus regular application of herbicides may be promoting species such as Agrostis stolonifera and selecting for Plantaginetea-type communities even on soils of good structure. As species such as Lolium perenne and Trifolium repens are natural members of Plantaginetea communities, it would be logical that such communities would also be favoured in cereals undersown with these species.

Fragmentary Stands

As in the case of the Stellarietea, not all Plantaginetea stands can be identified beyond the class level. Such impoverished communities have sometimes been given names, e.g. the Poetum annuae Gams 1927, but they do not merit general recognition. Table LXXV gives two British aufnahmen and compares them with named species-poor syntaxa. Knapp's (1961) data of the Polygonetum avicularis appears to consist, at least in part, of stands of the generally accepted Lolio - Plantaginetum.

6.18 Order: AGROSTIETALIA STOLONIFERAE Oberd. et al. 1967

Synonymy

Plantaginetalia maioris R. Tx. (1947) 1950, p.p.

Festucetalia arundinaceae Doing 1963, p.p.

Honkenyo - Elymetea arenariae R. Tx. 1966, ? p.p.

Honkenyo - Elymetalia arenariae R. Tx. 1966

Trifolio fragiferi - Agrostietalia (Oberd. et al. 1967)
R. Tx. 1970, p.p.

Character and Differential Species

Potentilla anserina

Rumex crispus

Leontodon autumnalis

+ Agropyro - Rumicion spp. inland

Syntaxonomy

The Agrostietalia stoloniferae is a relatively recent syntaxon created within the Plantaginietalia to contain the alliance Agropyro - Rumicion. Oberdorfer et al. (1967) also tentatively include the Honkenyo (peplodes) - Elymion arenariae R. Tx. 1966, which Tüxen (1966) had placed in its own order and class. After examination of Tüxen's data, the treatment of Oberdorfer et al. is followed here. However, the Honkenyo - Elymion is an alliance of nitrophilous coastal strand-line vegetation and except, perhaps, on the machair of the Hebrides, need not be considered in relation to arable vegetation. Thus character and differential species of the Agropyro - Rumicion become diagnostic for the order. Some impoverished stands (Tab. LXIX) have been referred simply to the order, though, on ecological grounds at least, they should doubtless be referred to the Agropyro - Rumicion. Müller and Górs (1969) review other vegetation which could be included in the Agrostietalia.

Ecology

The order contains vegetation subject to intermittent disturbance, particularly with respect to the height of the water table. Arable vegetation is discussed under the Agropyro - Rumicion.

Alliance: AGROPYRO - RUMICION CRISPI Nordh. 1940 em. R. Tx. 1950

Character and Differential Species

<u>Ranunculus repens</u>	<u>Trifolium hybridum</u>
<u>Pulicaria dysenterica</u>	<u>T. _____ fragiferum</u>
<u>Rorippa sylvestris</u>	<u>Festuca arundinacea</u>
<u>Mentha arvensis</u>	<u>Odontites verna ssp. serotina</u>
<u>Polygonum amphibium</u>	<u>Calystegia sepium</u>
<u>Carex hirta</u>	<u>Juncus articulatus</u>
<u>Filipendula ulmaria</u>	<u>J. _____ effusus</u>
<u>Lythrum salicaria</u>	<u>Alopecurus geniculatus</u>
<u>Symphytum x uplandicum</u>	<u>Stachys palustris</u>
<u>Epilobium hirsutum</u>	<u>Rumex conglomeratus</u>
<u>Lotus uliginosus</u>	

Agropyron repens and Agrostis stolonifera typically occur with high constancy.

Syntaxonomy and Ecology

A full review of the relationship of this alliance to other higher syntaxa is given by Westhoff and Den Held (1969). As the Agropyro - Rumicion frequently forms boundary communities to other vegetation-types, stands may contain a diverse range of species. Only the relationship of the alliance to arable vegetation will be discussed here.

Other associations no doubt surround arable land, as communities of ditch-sides or poorly drained marginal vegetation, but only four associations need be considered in relation to the development of Agrostietalia stands on arable land itself:

Rumici - Alopecuretum geniculati R. Tx. (1937) 1950
em. Oberd. 1957

Ranunculetum repentis Knapp 1946

Potentilletum anserinae Rapaics 1927 em Pass. 1964

Dactylido - Festucetum arundinaceae R. Tx. 1950

These form a group of closely related associations, the first three all being referable to the Rumici - Alopecuretum in the sense of Tüxen (1950). However, Oberdorfer (1957a) showed that they could stand as independent associations and his treatment, if not his nomenclature, is followed here. These four associations are reviewed in Table LXVIII. It will be seen that they are floristically very closely related, to the extent that Tüxen's (1950) treatment may very well be correct, but for the time being they are being maintained separately. The separation of the Ranunculetum repentis from the Potentilletum anserinae may yet prove to be impossible in Britain.

All four associations may occur on damp arable land. The Dactylido - Festucetum (syn. Potentillo - Festucetum arundinaceae sensu Westhoff and Den Held, 1969, p.p., non Nordhagen 1940) is described by Tüxen (1950) as occurring on the borders of arable fields and almost certainly does so in Britain, though such vegetation has not been included in the present survey.

The other three associations, characteristic of wet farm gateways, land subject to frequent flooding and similar habitats, have all been recorded from arable land, though usually as stands transitional to the Stellarietea. As explained above, this may well be a symptom of soil compaction to produce heavy, poorly drained land. The individual associations are mapped in Maps 23 and 24, but all Agrostietalia records are shown on Map 25. The concentration of records in Dorset is partly a result of the extensive fieldwork there, but unquestionably there is a greater concentration of Agrostietalia records in the higher-rainfall areas of the west. Table LXIX shows a number of unclassified Agrostietalia or Agropyro - Rumicion stands, ordered on the basis of increasing numbers of Stellarietea species.

Some or many of these stands may have resulted from herbicide effects rather than edaphic factors. However, a number of the stands were from reclaimed marshland or close to drainage ditches. The usual association between bryophyte species is visible in the table.

Westhoff and Den Held give details of a species-poor Agropyro_-_-Rumicion syntaxon under the name of "Poo - Lolietum D. M. de Vries et Westhoff n.n. apud A. Bakker 1965". It is said to be a community of intensively grazed, heavily manured pastures. However, Bakker (1965) mentions the association in a single sentence, confining himself to the derivation of the name, which is based on Poa trivialis and Lolium perenne. This can hardly be accepted as a validation of a nomen nudum. If the association be accepted as having been validly described, it must be on the brief description of Westhoff and Den Held (op. cit.). In any case, it seems poorly differentiated, and may be identical with some of the impoverished Agrostietalia stands of Table LXIX. Its relationship to the Ranunculetum repentis might be worthy of investigation. Westhoff and Den Held regard it as derived from the Molinio - Arrhenatheretea, but Foerster (1968) reports that heavy application of nitrogenous fertilisers to the Lolio - Cynosuretum (Br. Bl. et De L. 1936) R. Tx. 1937 converts that association to the Lolio - Plantaginetum. The Poo - Lolietum may merely be an intermediate stage.

1. Association: - RUMICI - ALOPECURETUM GENICULATI R. Tx. (1937)
1950 em. Oberd. 1957 (Tab. LXIV)

Synonymy

Ranunculus repens - Alopecurus geniculatus - Ass.
R. Tx. 1937, p.p.

Rumex crispus - Alopecurus geniculatus - Nodum
Ivimey-Cook and Proctor 1966, p.p.

Character SpeciesAlopecurus geniculatusDistribution and Ecology (Map 24)

The association is recorded from the churned up soil next to a damp, rather peaty cart-track at Ridge, Dorset and from the corner of a wheatfield close to a gateway at Thorpe Willoughby, Yorkshire. In the latter case, the crop was over-run by grasses suggesting a recent history as a hay-field. The soil here was visually compacted.

This minimal amount of data does not allow further ecological or phytosociological conclusions, though the Ridge site is of great botanical interest in the presence of Chenopodium urbicum in what may be its only remaining British locality.

Ivimey-Cook and Proctor (1966a) give five aufnahmen in their Rumex crispus - Alopecurus geniculatus - Nodum of which four are best placed here. Column 3 of their table appears to be referable to the Potentilletum anserinae. Their single list which they refer to the Bidentetalia also appears to be better placed here. Their stands are recorded from the floors of the Burren turloughs of western Ireland where the rapid fluctuations in water level provide the conditions suitable for the development of Agropyro - Rumicion communities. Table LXVIII shows the interpretation given to the data published by Braun-Blanquet and Tüxen (1952) under this association from Ireland.

2. Association: RANUNCULETUM REPENTIS Knapp 1946 (Tabs. LXV, LXVI)

Synonymy

Given by Oberdorfer et al. (1967) and Oberdorfer (1970) as:

"Agrostio - Ranunculetum repentis"

Diagnostic Species GroupRanunculus repensPoa trivialisVeronica serpyllifolia

(after Oberdorfer, 1957a)

Distribution and Ecology (Map 23)

Relatively pure stands and those transitional to the Stellarietea are shown in Tables LXV and LXVI, respectively. Arable stands have a scattered, possibly coastal distribution; purer stands have a more discernible western tendency. Aufn. 150 is from a heterogeneous stand on a moorland roadside in S. Wales.

The association occurs on loam and clay soils, especially near drainage ditches, gateways and on land in river flood-plains, on soils over a variety of base-poor geological strata. 80% of arable stands were recorded in cereals. (Excluding stands transitional to the Potentilletum anserinae also shown in Tab. LXVI.)

An Urtica dioica - Nodum, differentiated by V. dioica, Bryum rubens and Dicranella staphylina, of barleyfields, can be discerned amongst the "pure" stands of the association.

It is noteworthy that the Stellarietea species present are mostly those which are more spray resistant, including Stellaria media.

3. Association: POTENTILLETUM ANSERINAE Rapaics 1927 em. Pass. 1964 (Tab. LXVII)

Synonymy

Ranunculus repens - Alopecurus geniculatus - Ass.
R. Tx. 1937, p.p.

Rumex crispus - Alopecurus geniculatus - Ass.
R. Tx. (1937) 1950, p.p.

and including: Lolium Potentilletum anserinae Knapp 1948

Diagnostic Species GroupPotentilla anserinaTrifolium repens

The only character-species of the association is Potentilla anserina. Knapp (1961) gives Matricaria matricarioides, Gütte (1972) gives Trifolium repens and both these species clearly separate the Lolio - Potentilletum anserinae from the Ranunculetum repentis in the tables of Oberdorfer (1957a). M. matricarioides does not occur in the four aufnahmen here assigned to this association (but is constant in the transitionary stands to the Ranunculetum repentis - Tab. LXVI) but T. repens does occur and is accordingly included in the diagnostic species group of the association.

Syntaxonomy

Passarge (1964) described two subassociations:

Subass. lolietosum (syn. Lolio - Potentilletum anserinae), differentiated by Plantago lanceolata, Lolium perenne, Matricaria matricarioides and Polygonum aviculare.

Subass. polygonetosum, differentiated by Polygonum hydropiper, Rumex conglomeratus and Bidens tripartitus.

Three of the four British arable stands can be referred to subass. lolietosum. Passarge (op. cit.) and Gütte (op. cit.) give other infra-associational syntaxa.

Distribution and Ecology (Map 24)

The association is recorded on arable land from three localities in Dorset and one in Norfolk. The Norfolk site (Aufn. 234) is at the edge of a cornfield on a river flood-plain. Aufn. 667 was from near a ditch in a poorly drained field choked with weeds in the damper areas. The remaining two aufnahmen, 692 and 728, were from a field gateway and a field corner, respectively, again on poorly drained

land. The sites are on more base-rich geological strata than are the sites for the Ranunculetum repentis.

Braun-Blanquet and Tüxen (1952) recorded a stand of this association from Ireland (their table 10, column 1, sub. nom. Rumex crispus - Alopecurus geniculatus - Ass.) from a riverside where it is flooded at high water. Ivimey-Cook and Proctor (1966a) also give one aufnahme from the floor of a Burren turlough. This is their List 88, included in their Rumex crispus - Alopecurus geniculatus - Nodum.

6.19 Order: PLANTAGINETALIA MAIORIS R. Tx. (1947) 1950 em.
Oberd. et al. 1967

Synonymy

Chenopodietalia medioeuropaea R. Tx. 1937, p.p. min.

Arction lappae R. Tx. 1937, p.p. min.

Lolietalia perennis Doing 1963

Syntaxonomy

This is the order of vegetation of footpaths and other trampled situations. It occurs throughout Europe, with many described associations. All British associations are here regarded as belonging to the following alliance.

Alliance: POLYGONION AVICULARIS Br. Bl. 1931

Synonymy

Polygono - Coronopion (Br. Bl. 1931) Siss. 1969

Lolio - Plantaginion Siss. 1969

Preferential Species of Alliance and Order

Plantago major

Lolium perenne

Polygonum aviculare (optimal)Cynodon dactylonP. arenastrumJuncus tenuisCoronopus squamatusSyntaxonomy and Ecology

The alliance is accepted here in the sense of Tüxen (1950) as a broad-based alliance containing many associations throughout Europe. An alliance of such a size is syntaxonomically cumbersome and needs subdivision. Sissingh (1969) divided the alliance into two, the resulting syntaxa being quoted in the synonymy above. The division has been accepted by other leading workers (e.g. Westhoff and Den Held, 1969; Tüxen, 1970d) but, on the limited British data available, it seems better for the time being to retain the Polygonion avicularis. Sissingh places his Polygono - Coronopion in the Sisymbrietalia, but while the stands described in the present work inevitably contain a number of Stellarietea species, the homogeneous stands of most workers indicate a much greater affinity to the Plantaginetea of the communities in question.

Communities of this alliance are unquestionably favoured by trampling and soil compaction. Most of the typical species are either tough, flexible and resistant to mechanical damage (e.g. Lolium perenne, Juncus tenuis) or rosette or mat-forming (e.g. Plantago major, Coronopus squamatus). They appear in Stellarietea associations on slightly compacted soils, perhaps forming distinct subassociations of gateway areas, or on the more heavily trampled sites they replace most of the Stellarietea species. It is clear that a single traverse of a field by heavy machinery in damp weather can be enough to create these conditions. Examination of the communities of stubble fields immediately after harvest often shows long strips of Plantaginetea vegetation, well away from field edges, where the soil had been

sufficiently damp at one place for the passage of the seed-drill or spraying machinery to leave a lasting impression. A subjective impression is that crop-remains at these spots are weaker, suggesting a poorer yield. Certainly most Stellarietea species are reduced or absent, though some, such as Capsella bursa-pastoris, appear unaffected.

Such modifications of Stellarietea associations have been described under those associations and little effort has been made to sample "pure", i.e. theoretically homogeneous, Plantaginetalia stands from footpaths. Thus a full account of these associations cannot be given here. Study of these communities in their own right must precede any satisfactory systematic treatment.

The following syntaxa have been recorded:

1. POO - CORONOPETUM SQUAMATI (Oberd. 1957) Gütte 1966 (Tab. LXX)
(Syn.: Coronopo - Matricarietum Siss. (1966) 1969, subass. of
coronopus squamatus Siss. 1969)

Diagnostic species group: Coronopus squamatus, C. didymus, Polygonum aviculare, Matricaria matricarioides.

This association is recorded in scattered localities, mainly in S. England (Map 26). It is a highly nitrophilous community, occurring on ground near manure heaps, silage storage areas and along cart-tracks and in gateways where manures are spilt. It sometimes forms a narrow and heterogeneous zone between Polygono - Chenopodietalia communities of heavily manured root crops and Lolio - Plantaginatum on adjacent cart-tracks. It thus fulfils the role of Plantaginetea communities as discussed by Westhoff and van Leeuwen (1966). Sissingh (op. cit.) places the association in the Polygono - Coronopion.

Gütte (1966) describes a variant, perhaps better regarded as a subassociation, of Juncus bufonius, differentiated by J. bufonius, Agrostis stolonifera, Spergularia rubra, Rumex crispus, Chenopodium

glaucum and Potentilla anserina. It appears to be distinguishable on damper land in Britain.

2. MYOSURETUM MINIMI (Diem., Siss. et Westh. 1940) R. Tx. 1950
(Tab. LXXI)

This association occasionally occurs on wet arable land, but the single aufnahme presented here is from a non-arable site, a gravel track in the New Forest, Hampshire. Water collects on the track forming pools and a thin layer of fine mud has resulted. The diagnostic taxon, Myosurus minimus is well established in the locality, in contrast to its sporadic appearances in most of its sites. Juncus bufonius and Veronica serpyllifolia form part of the diagnostic species group, but are of little value on their own. Sissingh (op. cit.) places the association in the Polygono - Coronopion. Westhoff and Den Held (op. cit.) place it in the Isoeto - Nanojuncetea, to which it can undoubtedly be transitional.

3. SPERGULARIA BOCCONII - COMMUNITY (Tab. LXXII)

This is based on a single stand, containing Spergularia bocconii, S. rupicola and Agrostis semi-verticillata, on a track into a quarry at Mont Cuet on the coast of Guernsey. The soil was very compacted and dry. Similar vegetation was seen at other coastal sites in Guernsey.

4. LOLIO - PLANTAGINETUM (Link. 1921) Beger 1930 em. Siss. 1969
(Tab. LXXIII)

(Including Coronopo - Matricarietum Siss. (1966) 1969 subass. typicum Siss. 1969)

Diagnostic species group: Plantago major, Lolium perenne, Trifolium repens.

This is much the most common association of the alliance in Britain, occurring everywhere at the margins of footpaths, on trodden waste-

ground, bare patches in lawns, field gateways and even in arable crops in cases of severe soil compaction. It has been recorded from Britain and Ireland by Ivimey-Cook and Proctor (1966a) and Birks (1973) and summaries of their data are incorporated in Table LXXIII. Birks' data from Skye are exceptional in their high proportion of Molinio - Arrhenatheretea species, a general feature of communities in northwestern Britain. Sissingh (op. cit.) places the association in the Lolio - Plantaginion.

Most stands are referable to subass. typicum R. Tx. 1937 em. Siss. 1969 but subass. puccinellietosum R. Tx. (1931) 1950 em. Westhoff 1969 has been recorded from a muddy lorry-track across wasteland close to the sea at Seaton Carew, Durham (Cleveland). It seems to be common on cart-tracks behind saltmarshes in S. England. Sissingh (op. cit.) describes several other subassociations.

5. BRYUM CAESPITICIUM - TUSSILAGO FARFARA - COMM. (Tab. LXXIV)

This is apparently synonymous with the Tussilagineta sensu Westhoff and Den Held, 1969, non Oberdorfer 1949. Oberdorfer's (1957a) table of the Tussilagineta represents a heterogeneous community of uncertain affinities; it does not belong to the Plantagineta. The Poo (compressae) - Tussilagineta R. Tx. (1928) 1931 is another distinct community of calcareous ground, belonging to the Agropyrete (see Müller and Görs, 1969). The British community is a ruderal syntaxon, differentiated by Tussilago farfara, Bryum bicolor and B. caespitium and occurring on very hard, compacted rubble or cinders mixed with clay. It is close, floristically and ecologically, to the Sagino - Bryetum argentei. Records are from Essex and Co. Durham.

Other Polygonion associations

Though not sampled during the survey, at least the following

two associations occur in Britain:

Sagino - Bryetum argentei Diem., Siss. et Westh. 1940

Juncetum tenuis (Diem., Siss. et Westh. 1940)

Schwick. 1944

6.20

Class: MOLINIO - ARRHENATHERETEA R. Tx. 1937SynonymyMolinio - Juncetea Br. Bl. 1947Arrhenatheretea Br. Bl. 1947Typical SpeciesThe following enter Stellarietea communities:

<u>Poa trivialis</u>	<u>Ranunculus repens</u>
<u>Dactylis glomerata</u>	<u>Holcus lanatus</u>
<u>Phleum pratense</u>	<u>Cerastium fontanum</u>
<u>P. bertolonii</u>	<u>Arrhenatherum elatius</u>
<u>Trifolium pratense</u>	<u>Plantago lanceolata</u>
<u>T. repens</u>	<u>Prunella vulgaris</u>
<u>T. dubium</u>	<u>Heracleum sphondylium</u>
<u>Bromus * hordaceus</u>	<u>Rumex acetosa</u>
<u>Taraxacum officinale</u>	<u>Bellis perennis</u>
<u>Pastinaca sativa</u>	<u>Festuca * rubra</u>
<u>Lathyrus pratensis</u>	<u>Stellaria graminea</u>
<u>Anthriscus sylvestris</u>	

The above species are taken from Table LXXVI, discussed below. Many of these species are typical of Stellarietea communities in Britain, exemplifying the general tendency of Molinio - Arrhenatheretea species to enter open communities in N. W. Europe (see, e.g., Birks, 1973).

Syntaxonomy and Ecology

The Molinio - Arrhenatheretea is the class of grasslands, including hay-meadows, pastures and other types of grassland subject to modification and disturbance. Perhaps of greatest relevance to arable vegetation is the alliance Cynosurion R. Tx. 1947, of the order Arrhenatheretalia Pawlowski 1928, and notably the association

Lolio - Cynosuretum (Br. Bl. et De L. 1936) R. Tx. 1937. This association and the alliance in general are characteristic of disturbed grassland and form a transition to Plantaginetea communities.

Oberdorfer et al. (1967) give Lolium perenne, Cynosurus cristatus, Phleum pratense, Trifolium repens, Bellis perennis and Leontodon autumnalis as Kennarten of the alliance. This alliance is the closest ecologically and floristically to the Stellarietea and its typical species are common in Stellarietea communities. Westhoff and Den Held (1969) give a review of the several subassociations of their broad concept of the Lolio - Cynosuretum.

Many arable communities contain such a proportion of Molinio - Arrhenatheretea species that the following informal syntaxon has been recognised:

MOLINIO - ARRHENATHERETEA - STELLARIETEA (Tab. LXXVI)

This syntaxon has been formed from stands containing Stellarietea species, not always very many, and typical species of the Molinio - Arrhenatheretea is listed above. Other species which appear to be preferential to this syntaxon are Agropyron repens, Convolvulus arvensis, Lolium * perenne, L. * multiflorum and Agrostis stolonifera. Thus this syntaxon also shows a trend towards the Convolvulo - Agropyretum and the Agrostietalia.

While selective herbicides undoubtedly have a major influence on the formation of this syntaxon, it is particularly associated with arable land in rotation with short term grassland. Jones (1966) showed that five weeks after drilling, a former grassland site had a significantly higher population of grass weeds and a lower population of broad-leaved weeds in spring barley in comparison with land with a continuous arable history. At harvest time he found no difference between the sites with respect to grasses, but broad-leaved weed

populations remained significantly higher on the arable site. The results presented here suggest that grass weeds can persist to remain abundant on arable land in hay-growing areas. Table LXXVI has been ordered on the basis of a decreasing proportion of Molinio - Arrhenatheretea species in comparison with character-species of the Stellarietea.

The syntaxon has been recorded from scattered localities (Map 27) north to the Hebrides but shows strong association with hay-growing rather than predominantly arable areas. Thus several records are from the inland areas of Dorset, while the syntaxon is absent from East Anglia. 63% of aufnahmen were from wheat, and all but one aufnahme were from cereals. The average altitude was over 250 ft and one aufnahme was from an altitude of 750 ft at Up Sydling, Dorset. Some stands were from poorly-drained land or near gateways, supporting the floristic trend towards the Agrostietalia.

The extreme form of the occurrence of grassland species on arable land must be the case where only grass species are present. Table LXXVII shows an Unclassified Grass Community from a wheatfield in Dorset. Both selective sprays and a hayfield history must be involved here. Table 8 also gives an aufnahme of four grass-species from the interior of a barley field.

6.21.1 Class: SEDO - SCLERANTHETEA Br. Bl. 1955 em. Th. Müll. 1961SynonymyKoelerio - Corynephoretea Klika 1941, p.p.Festuco - Brometea Br. Bl. et R. Tx. 1943,
auct. mult., p.p.Corynephoretea Br. Bl. et R. Tx. 1943Brometo - Corynephoretea Siss. et Westh. 1946, p.p.Bryo - therograminetea Pignatti 1953Festuco - Sedetea Oberd. 1957Caricetea arenariae Doing 1963Xerobrometo - Sedetea Doing 1963, p.p.Tuberio (guttati) - Corynephoretea Hohenester 1967Character and Differential Species (provisional)Sedum acrePolytrichum piliferumS. albumCeratodon purpureusS. telephiumTortula ruralisS. sexangulareCerastium semidecandrumScleranthus perennisTrifolium arvenseRumex acetosellaT. striatumR. tenuifoliusEchium vulgarePotentilla argenteaJasione montanaVeronica vernaMyosotis ramosissimaV. praecoxHypochoeris glabraMibora minimaArenaria serpyllifoliaErophila verna s.s.A. leptocladosBrachythecium albicansCladonia furcataCornicularia aculeataFestuca ovinaPilosella officinarumRhacomitrium canescensLotus angustissimusTaraxacum officinale Sect.Erythrosperma

Additionally, the following species of the Mediterranean

Helianthemetalia reach Britain and become class character-species:

Briza maxima

Ornithopus pinnatus

Silene gallica

Trifolium bocconeii

Trifolium glomeratum

T. _____ subterraneum

Syntaxonomy and Ecology

This is the class of dry grassland and natural therophyte communities. No full account exists for Europe, but an overall scheme of classification is badly needed. Accounts by Oberdorfer (1970), Moravec (1967) and Westhoff and Den Held (1969), for example, are excellent for their own areas. Unfortunately they do not agree.

The class has not been extensively studied in Britain, and most of its vegetation lies well outside the theoretical limits of the present survey, but the scheme of classification presented here, based largely on Krausch (1968) and Oberdorfer (1970), seems viable.

As interpreted here, the class contains five orders:

1. Sedo - Scleranthetalia Br. Bl. 1955

(Syn.: Sempervivo - Sedetalia albi Th. Müll. 1961)

2. Festuco - Sedetalia R. Tx. 1951 em. Krausch 1961

(Syn.: Koelerietalia Doing 1963, p.p.)

3. Corynephoretalia canescentis R. Tx. 1933 em. Krausch 1962

(Syn.: Caricetea arenariae Doing 1963, p.p.;

Koelerietalia Doing 1963, p.p.

Festucetalia tenuifoliae Doing 1963

Thero - Airetalia Oberd. apud Oberd.
et al., 1967

Corynephoretea canescentis Br. Bl. et Tx.
1943 em. Tx. 1962

Corynephoretalia canescentis Klika 1934
EM. Tx. 1962

Trifolio - Festucetalia Moravec 1967)4. Festucetalia vaginatae Soo 19575. Helianthemetalia guttati Br. Bl. 1940

The Festuco - Sedetalia is the order of closed grassland, transitional to the Festuco - Brometea, and is mainly central European (see Hohenester, 1967b; Krausch, 1968). The Festucetalia vaginatae is an east European order of steppe grasslands (Soo, 1957) and the class is represented in the Mediterranean area by the Helianthemetalia (see Hohenester, 1967a).

The remaining two orders are relevant to data collected during the present survey and are discussed below.

6.21.2 Order: CORYNEPHORETALIA CANESCENTIS R. Tx. 33 em. Krausch 1962Character SpeciesCarex arenariaCorynephorus canescensSyntaxonomy and Ecology

The synonymy of the order is given above. The syntaxonomy of the order is reviewed by Hohenester (1967a) and Krausch (op. cit.); Hohenester combines this order with the Helianthemetalia (as "Tuberietalia guttatae") into a new class, the Tuberio - Corynephoretea. Tüxen (1967) considers the Corynephoretalia alone to be a separate class. The order as interpreted here contains five alliances, characteristic of open, sandy, often coastal situations in west and central Europe. Some arable communities are referable to, or at least, transitional to, the following alliance.

Alliance: Thero - Airion R. Tx. 1951 (Tab. LXXVIII)

Synonymy

Sedion anglici Br. Bl. 1952

Veronicion Oberd. 1957

Plantagini - Festucion Pass. 1964, p.p.

Character and Differential Species

<u>Aira caryophyllea</u> ssp. <u>caryophyllea</u>	<u>Filago vulgaris</u>
<u>A. caryophyllea</u> ssp. <u>multiculmis</u>	<u>F. minima</u>
<u>A. praecox</u>	<u>F. gallica</u>
<u>Ornithopus perpusillus</u>	<u>F. pyramidata</u>
<u>Vulpia bromoides</u>	<u>Myosotis discolor</u>
<u>V. myuros</u>	<u>Moenchia erecta</u>
<u>Scleranthus polycarpus</u>	<u>Sedum anglicum</u>
<u>Tuberaria guttata</u>	

(After Müller, 1961, and Krausch, 1968)

Syntaxonomy and Ecology

Communities of this alliance form spring therophyte communities of very dry, sandy, usually rather base-poor ground, occurring also as fragmentary communities on dry rocks which may be more base-rich, though not calcareous. Despite their occurrence in such dry habitats, or perhaps because of it, Thero - Airion communities appear to have a requirement for high humidity or regular rainfall and are predominantly coastal. Thus exceptionally fine stands are developed on the Lizard Peninsula (see Malloch, 1971) and the Mull of Galloway.

Table LXXVIII shows aufnahmen assigned to this alliance, though on current knowledge of British communities they cannot be assigned to any association. Aufnahme 370 is an inland stand on an old railway track at Bordon, Hampshire. The other aufnahmen are from

cultivated coastal bulbfields in the Isles of Scilly, where Thero - Airion and Stellarietea species become completely intermingled. The presence of Cerastium diffusum in one aufnahme would suggest the related coastal alliance, the Galio - Koelerion (R. Tx. 1937) Den Held et Westh. 1969, but the abundance of Thero - Airion species in the same aufnahme makes its position clear. Polycarpon diphylum and Trifolium suffocatum have been taken to be local differential species for the Thero - Airion.

6.21.3 Order: SEDO - SCLERANTHETALIA Br. Bl. 1955 (Tab. LXXIX)

Character Species

Sedum album

Sempervivum tectorum

(After Krausch, 1968)

Syntaxonomy and Ecology

This is the order of vegetation on open, calcareous soils. The communities discussed below are of uncertain affinities, and not all certainly belong to the Sedo - Scleranthetalia, or even the Sedo - Scleranthetea. However, two alliances appear to be relevant:

1. Alysso - Sedion Oberd. et Th. Müll. 1961

(Syn.: Sedo - Teucrion Doing 1963; Alysso - Sedetalis Moravec 1967)

Char. Spp.: - Alyssum alyssoides, Saxifraga tridactylites, Thlaspi perfoliatum, Teucrium botrys, Poa bulbosa, Acinos arvensis, Cerastium pumilum, Medicago minima, Asperula cynanchia, Carex humilis.
(Müller, 1961; Moravec, 1967; Krausch, 1968) Also of diagnostic value may be Iberis amara, Minuartia tenuifolia and Nardurus maritimus.

2. Arabidopsidion Pass. 1964

Char. Spp.: - Arabidopsis thaliana, Veronica hederifolia,
V. triphyllos, Holosteum umbellatum,
Scleranthus annuus (or S. polycarpus?)
Agropyron repens (Passarge, 1964;
 Moravec, 1967)

Of these two alliances, the Alysso_-Sedion is the more calcicolous.

Table LXXIX contains the following syntaxa which seem best classified under the Sedo_-Scleranthetalia. Most aufnahmen have been collected incidental to the main survey, because they contained rare arable species or because it was thought they might be relevant to "weed vegetation". No attempt has been made to survey these communities on a systematic basis. To some extent they have proved irrelevant to the aims of the survey.

1. Euphorbia cyparissias - Cynoglossum officinale - Nodum
 (Columns 1, 2)

An interesting community, defined by these two species, formed on a reconstruction of the "brecks" of the Breckland heaths, small fields cultivated for a short time and then allowed to revert to fallow for a number of years (see Sect. 7.3). In this case, the brecks are being maintained on calcareous sand at Tuddenham, Suffolk, conserving rare Breckland species. This nodum is formed on the fallow phase of the cycle.

2. Veronica praecox - Nodum (Columns (3), 4, 5)

V. praecox occurs on calcareous gravel at Standlake, Oxfordshire. Arenaria serpyllifolia and Myosotis ramosissima are present, but the vegetation does not otherwise resemble the presumed Arabidopsidion community in which V. praecox occurs in the Brecklands.

3. Thlaspi perfoliatum - Nodum (Column 6)

This therophyte vegetation formed on mole hills at Linch Hill, Oxfordshire, on the same calcareous gravel which supports the Veronica praecox - Nodum nearby.

4. Iberis - Filago - Nodum (Column 7)

It is far from certain that this community should be classified here, as can be judged by the number of additional species in the table supplement. Iberis amara grows with a Filago species on sand and gravel in part of an Oxfordshire chalk-pit. The identity of the Filago is disputed, and its name changes each time a new "expert" visits the site. As far as the author is concerned, it is F. lutescens, but others claim it to be F. pyramidata. The peculiar habitat is suitable for either. The nodum is probably no more than an unusual heterogeneous stand, of interest only for its two rare species.

5. Teucrium botrys - Nodum (Columns 8, 9)

This is developed on chalk spoil-heaps at Micheldever Station, Hampshire. It is of interest for the presence of the rare arable weed of the Caucalidion, Teucrium botrys, plus other rarities such as Nardurus maritimus. Less open sites are colonised by Potentilla tabernaemontani. The site probably has little resemblance floristically to arable sites for T. botrys, which no longer appears to occur on arable land in Britain.

A once cultivated site, now permanent chalk grassland, at Chipstead, Surrey, still has T. botrys and, reputedly, Nardurus maritimus. Strips of ground are periodically ploughed to maintain T. botrys, and Table 33 gives an aufnahme from this site. At the time of the visit, the strips had largely reverted to grassland, though T. botrys is still relatively frequent in the strips. The community is apparently referable to the Festuco - Brometea.

Table 33

Teucrium botrys Comm.

Aufnahme	364	% Cover - Bryophytes	n
No. of Species	31	Slope	10
Area of Quadrat in m ²	4	Exposition	S
Area of Stand in m ²	L	Altitude in ft	450
% Cover - Total	85	Month	8
% Cover - Tracheophytes	85	Soil	cLS

Festuco - Brometea Spp.

Thymus pulegioides	3.4
Anguisorba minor	3.3
Auphrasia pseudokernereri	3.2
Viola hirta	2.2
Teucrium botrys	1.2
Helianthemum chamaecistus	+ .2
Camptothecium lutescens	+

Diff. Festuco - Brometea + Sedo - Scleranthetea

Erigeron acer	1.1
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Companions

Agrostis stolonifera	4.4
Ranunculus repens	2.2
Fragaria vesca	2.2
Medicago lupulina	2.2
Leontodon taraxacoides	2.2
Linum catharticum	2.1
Briza media	1.2
Epilobium angustifolium	1.1
Potentilla reptans	+ .2
Cerastium fontanum	+ .2
Dactylis glomerata	+ .2
Brachypodium sylvaticum	+ .2
Agrostis tenuis	+ .2
Holcus lanatus	+ .2
Clinopodium vulgare	+ .2
Plantago lanceolata	+
Hypericum perforatum	+
Pastinaca sativa	+
Senecio erucifolius	+
Rosa sp.	+
Echium vulgare	+
Rubus fruticosus	+
Centaureum erythraea	+

6. ? Arabidopsidion Pass. 1964 (Columns 10 - 15)

Stands referred here are from three areas of the Brecklands where soils are calcareous. However, the levels of available calcium vary substantially, from 210 mg /100 g. dry soil at Maidcross Hill (Aufn. 44) to 645 mg /100 g. at Tuddenham (Aufn. 48) and 950 mg./100 g at Eriswell (Aufn. 816). Exchangeable potassium values on the same basis are 1 mg., 1 mg. and 9 mg. respectively, showing remarkably low levels of this nutrient. Thus the calcium content of the sand is probably of little importance above a certain minimum value and other factors such as low amounts of organic matter and minimal disturbance are of greater relevance. The last point is important, all sites are from ground undisturbed in spring, either fallow or with an established lucerne or Dactylis ley. This spring therophyte community cannot develop in spring cereals since they would be destroyed by spring cultivations. Several species are winter annuals (Ratcliffe, 1961).

Its identity with the Arabidopsidion must remain doubtful. Arabidopsis thaliana, Veronica hederifolia ssp. lucorum, Agropyron repens and Scleranthus annuus are present in one or more of the stands, but these species are hardly of high fidelity to the alliance. An association Arabidopsietum thalianae Siss. 1942 is quoted in the literature (see Passarge, 1964) but it is doubtful if the place of publication can be accepted as a valid scientific journal. The association name is not in general usage. Gehu (1961a) gives details of the Poa compressa - Saxifraga tridactylites - Ass. Gehu et Lericq 1957 (see also, Westhoff and Den Held, 1969) which is undoubtedly related to the syntaxon but differs in the presence of Poa compressa, Anisantha sterilis and Poa nemoralis at high constancy and in the absence of Arabidopsis thaliana, Veronica praecox and others.

The syntaxon might be regarded as a spring aspect of some other community but at the reconstructed Tuddenham "brecks" (see Euphorbia - Cynoglossum - Nodum above) no other distinct community develops to replace the missing spring therophytes later in the year. Aufnahme 49 was adjacent to the Tuddenham breck but in a pig-run and subject to greater disturbance, the old Dactylis ley persisting. Except that a pig ate the vegetation of the aufnahme while recording was still in progress, it does not appear that the extra disturbance was having any appreciable effect.

Chapter Seven

Chi-Squared Analyses of Individual Areas

7.1 The methodology on which this chapter is based is extensively reviewed in Section 2.3. Sets of data, especially from sandy soils, have been analysed for inter-specific associations with the aim of expressing the association structure by plexus diagrams. The areas chosen have been the Hebrides (Sect. 7.2), the Brecklands of Norfolk, Suffolk and Cambridgeshire (Sect. 7.3), combined data from the base-poor exposures of the Lower Greensand and the Bagshot Sands (Sect. 7.4), Dorset (Sect. 7.5) and the Isles of Scilly (Sect. 7.6). Bryophyte communities are considered in Chapter 8.

The number of species involved in each diagram makes it impossible to include specific names in the diagrams themselves (c.f. Agnew, 1961) so standard abbreviations have been used for each species, listed in Table 34.

The Index of Potential Association has been introduced and described in Section 2.3.3. Table 35 gives the values of the I.P.A. for each set of data. It will be seen that the Hebrides data set consists of the smallest number of quadrats and also has the lowest I.P.A. Hence this data has a low total number of interspecific associations, as discussed in Section 2.3.3., and a very fragmented plexus diagram (Fig. 36). It is tempting to suggest that this is a very uniform data set, with virtually all the fields being from machair, However, as the number of quadrats is reduced, the effect of Yates' Correction on the observed deviation from the expected number of joint occurrences of a species-pair becomes progressively more important. By assuming that each species occurs in 50% of the

Table 34

Abbreviations used for Species in Plexus Diagrams

Aav	Artemisia vulgaris	Brm	Bryum microerythrocarpum
Acm	Achillea millefolium	Brr	B. rubens
Agr	Agropyron repens	Brv	B. violaceum
Ags	Agrostis stolonifera	Bsc	Brassica campestris
Agt	A. tenuis	Btr	Brachythecium rutabulum
Ahc	Anthriscus caucalis	Bzm	Briza minor
Aic	Aira * caryophyllea	Cah	Cardamine hirsuta
Aim	A. * multiculmis	Cbp	Capsella bursa-pastoris
Aip	A. praecox	Cdp	Ceratodon purpureus
Alr	Allium roseum ssp. bulbiferum	Cef	Cerastium fontanum
Alt	A. triquetrum	Ceg	C. glomeratum
Ama	Anthemis arvensis	Ces	C. semidecandrum
Amc	A. cotula	Cha	Chenopodium album
Ana	Anagallis arvensis	Cia	Cirsium arvense
Apa	Aphanes arvensis	Civ	C. vulgare
Apm	A. microcarpa	Cod	Coronopus didymus
Are	Arrhenatherum elatius	Cos	C. squamatus
Ars	Arenaria serpyllifolia	Cre	Crepis capillaris
Art	Arabidopsis thaliana	Css	Chrysanthemum segetum
Asd	Anisantha diandra	Ctl	Camptothecium lutescens
Ath	Atriplex hastata	Cva	Convolvulus arvensis
Atp	A. patula	Czc	Conyza canadensis
Avf	Avena fatua	Dac	Daucus carota
Avs	A. strigosa	Dcg	Dactylis glomerata
Bac	Barbula convoluta	Des	Descurainia sophia
Baf	B. fallax	Dic	Ditrichum cylindricum
Bah	B. hornschurchiana	Dib	Dicranella schreberana
Bau	B. unguiculata	Dis	D. staphylina
Bep	Bellis perennis	Div	D. varia
Bic	Bilderdykia convolvulus	Dpm	Diploaxis muralis
Bmh	Bromus *hordaceus	Eba	Epilobium adenocaulon
Bra	Bryum argenteum	Epe	Euphorbia exigua
Brb	B. bicolor	Eph	E. helioscopia
Brc	B. caespitium	Eqe	Equisetum arvense
Brk	B. klinggraeffii	Erc	Erodium * cicutarium

Eup	Eurhynchium praelongum	Oda	Odontites * serotina
Fer	Festuca rubra	Orp	Ornithopus perpusillus
Fuh	Funaria hygrometrica	Oxp	Oxalis pes-caprae
Fum	Fumaria * boraei	Pad	Papaver dubium
Gaa	Galium aparine	Par	P. rhoeas
Gav	G. verum	Pcs	Pastinaca sativa
Ged	Geranium dissectum	Pda	Pteridium aquilinum
Gem	G. molle	Pga	Polygonum aviculare
Glb	Gladiolus byzantinus	Pgl	P. * lapathifolium
Gnu	Gnaphalium uliginosum	Pgn	P. * nodosum
Gsp	Galinsoga parviflora	Pgp	P. persicaria
Hes	Heracleum sphondylium	Phc	Phascum cuspidatum
Hol	Holcus lanatus	Phf	P. floerkeanum
Hom	H. mollis	Pie	Picris echioides
Jub	Juncus bufonius	Pll	Plantago lanceolata
Kie	Kickxia elatine	Plm	P. major
Kis	K. spuria	Pma	Pleuridium acuminatum
Laa	Lamium amplexicaule	Pms	P. subulatum
Lah	L. hybridum	Pna	Potentilla anserina
Lap	L. purpureum	Poa	Poa annua
Lda	Leontodon autumnale	Pot	P. trivialis
Leh	Legousia hybrida	Prv	Prunella vulgaris
Liv	Linaria vulgaris	Psm	Phalaris minor
Lom	Lolium * multiflorum	Pti	Pottia intermedia
Lop	L. * perenne	Pts	P. starkeana s.l.
Lpc	Lapsana communis	Ptt	P. truncata
Lya	Lycopsis arvensis	Pup	Phleum pratense
Mam	Matricaria matricarioides	Pyt	Polycarpon tetraphyllum
Mda	Medicago arabica	Rab	Ranunculus bulbosus
Mdl	M. lupulina	Raf	R. ficaria
Moc	Montia * chondrosperma	Ram	R. muricatus
Mop	M. perfoliata	Rap	R. parviflorus
Mya	Myosotis arvensis	Rar	R. repens
Myd	M. discolor	Rel	Reseda lutea
Myr	M. ramosissima	Ris	Riccia sorocarpa

Rpr *Raphanus raphanistrum*
 Rua *Rumex acetosella*
 Ruc *R. crispus*
 Ruo *R. obtusifolius*
 Rup *R. pulcher*
 Rut *R. tenuifolius*
 Sap *Sagina procumbens*
 Sca *Scleranthus annuus*
 Sda *Sedum acre*
 Sej *Senecio jacobaea*
 Sev *S. vulgaris*
 Sha *Sherardia arvensis*
 Sia *Silene alba*
 Sig *S. gallica*
 Sin *S. noctiflora*
 Siv *S. vulgaris*
 Sln *Solanum nigrum*
 Snl *Sinapis alba*
 Snv *S. arvensis*
 Soa *Sonchus asper*
 Soo *S. oleraceus*
 Sov *S. arvensis*
 Spa *Spergula arvensis*
 Sso *Sisymbrium officinale*
 Stm *Stellaria media*
 Sxt *Saxifraga tridactylites*
 Sys *Stachys sylvatica*
 Tao *Taraxacum officinale*
 Tha *Thalictrum * arenarium*
 Tpi *Tripleurospermum inodorum*
 Trd *Trifolium dubium*
 Trp *T. pratense*
 Trr *T. repens*

Urd *Urtica dioica*
 Uru *U. urens*
 Val *Valerianella locusta*
 Vca *Vicia * angustifolia*
 Vch *V. hirsuta*
 Vea *Veronica arvensis*
 Veh *V. * hederifolia*
 Veo *V. polita*
 Vep *V. persica*
 Via *Viola arvensis*
 Vic *V. curtisii*
 Vub *V. bromoides*
 Wer *Weissia rutilans*

Table 35

Relation of No. of Quadrats and I.P.A. to No. of observed Associations

	<u>No. of Quadrats (4m²)</u>	<u>No. of Species</u>	<u>Percentage of Species showing no Associations</u>	<u>I.P.A.</u>	<u>Maximum Value of I.P.A. with Yates' Correction</u>	<u>I.P.A. without Yates' Correction</u>
Hebrides	24	34	41.2	.808	.840	.962
Brecklands	48	56	10.7	.861	.918	.937
L. Greensand and Bagshot Sands, I.	96	80	0	.888	.959	.926
L. Greensand and Bagshot Sands, II. (Including occurrences close to quadrat)	96	91	0	.891	.959	.929
Dorset	114	87	1.1	.908	.965	.941
Isles of Scilly	68	90	5.6	.889	.942	.944
Total Bryophyte Data	221	31	6.5	.929	.982	.946
Arable Bryophytes	184	26	11.5	.934	.978	.955

Table 36

Effect of enlarging quadrat size on total number
of significant associations

A - Quadrat size of 4m²

B - Including extra occurrences close to the quadrat location

<u>Species</u>	<u>Total occurrences</u>		<u>Total A</u> <hr/> <u>Total B</u>	<u>No. of Associations</u>	
	<u>A</u>	<u>B</u>		<u>A</u>	<u>B</u>
Papaver rhoeas	6	12	.500	1	6
Crepis capillaris	8	14	.571	10	17
Dactylis glomerata	6	10	.600	7	2
Rumex obtusifolius	13	21	.619	5	8
R. crispus	6	9	.667	5	3
Eurhynchium praelongum	7	10	.700	12	14
Lamium purpureum	7	10	.700	3	3
Sonchus oleraceus	13	18	.722	4	6
Taraxacum officinale	13	18	.722	10	8
Raphanus raphanistrum	8	11	.727	8	14
Sisymbrium officinale	9	12	.750	1	4
Lycopsis arvensis	9	12	.750	6	14
Polygonum persicaria	17	22	.773	3	11
Solanum nigrum	19	24	.792	4	4
Bilderdykia convolvulus	26	32	.813	8	10
Veronica persica	23	28	.821	4	8
Chenopodium album	44	51	.863	13	15
Agropyron repens	43	48	.896	<u>4</u>	<u>7</u>
	Totals			108	154

quadrats, it is a simple matter to calculate the maximum possible I.P.A. for a given number of quadrats with Yates' Correction operating. It is then equally simple to express the I.P.A. as a proportion of the maximum value it could take and so isolate the effect of Yates' Correction. This has been done for each data set and the results are given in Table 35. Interestingly, the Hebrides would have the highest potential association but for Yates' Correction, suggesting a greater number of species with a frequency approaching 50%. It could thus be argued that the 41% of Hebridean species showing no positive or negative associations is due to the use of Yates' Correction, or from another viewpoint, that Yates' Correction has prevented the recognition of a substantial proportion of spurious associations. However, while more experience is needed of the behaviour and significance of the I.P.A. and its modifications, and indeed whether the I.P.A. is of any value at all, it seems likely that the low number of quadrats has the greatest direct effect on the observable structure in the data. Without more sets of data based on 24 quadrats, inferences as to the real amount of structure in the Hebridean fields would be largely speculative.

7.2 The Hebrides

The data set for this analysis was derived from arable fields on the islands of North Uist, Benbecula and South Uist, in the Outer Hebrides, plus a single aufnahme from N. W. Skye. All the fields were close to the sea, many from coastal machairs. Soils thus ranged from almost pure shell sand to sandy peat. The underlying rock in most cases was Lewisian Gneiss, but this would have made no direct contribution to the soils of the area.

The climate is typically northern oceanic, with generally low

temperatures but only about 25 frosts per year, little diurnal fluctuations of temperature, high relative humidity and moderately high rainfall (see overlays).

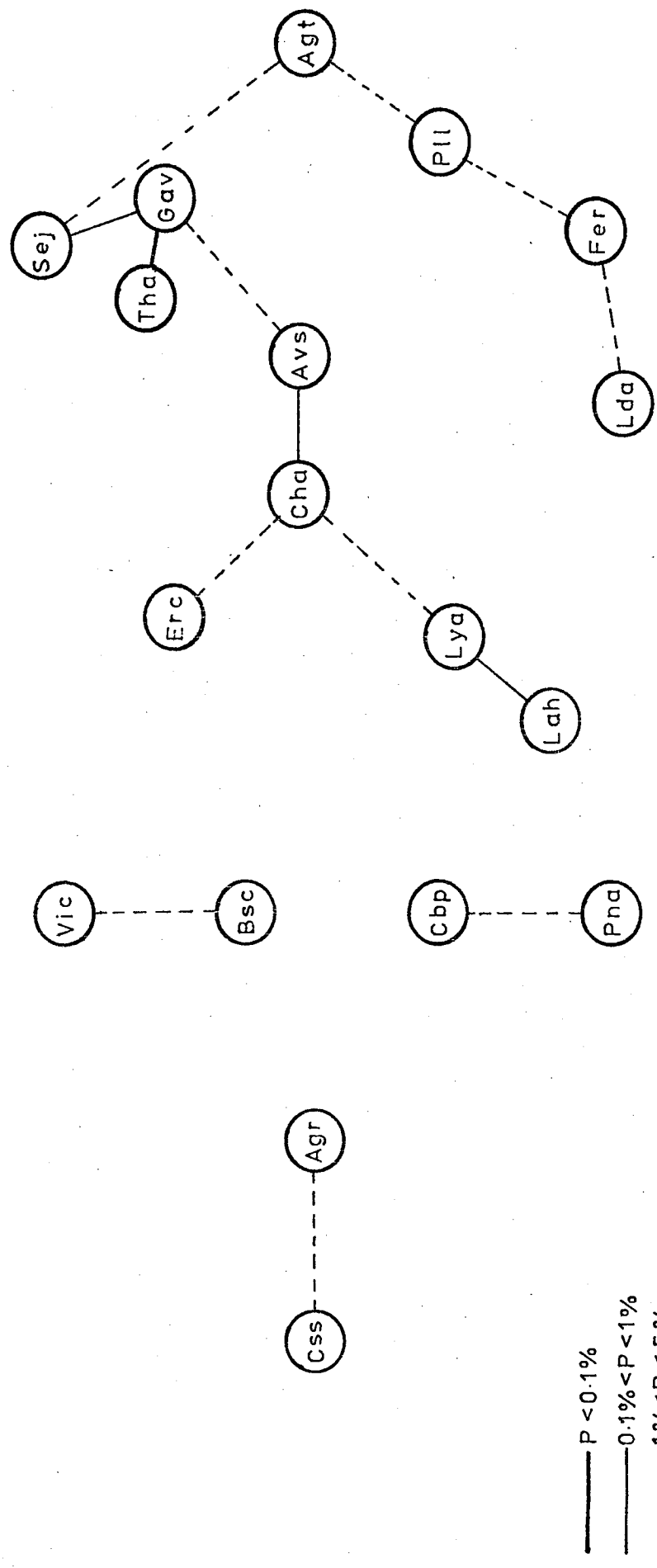
Farming is mostly, by modern standards, primitive. Large areas of land suitable for economic use of machinery are rare and mainly in the new bulb-growing area of N. Uist. Most plots on the communally owned machair are small and cultivated entirely by manual methods, with the seed sown by hand, i.e. broadcasting, and the crops harvested by scything in the case of cereals. Rye is the main crop, but black oats are also grown in the poorer areas, and the latter crop remains a persistent weed in most rye fields. On the peatier soils inland from the machair, potatoes and turnips are grown. Sand is often added to the pure peat soils to provide a better texture and presumably some lime. Crops are for domestic consumption, including as fodder. Hay is a major crop in the area.

While there has been a very recent wave of interest in the Hebridean machairs, little of this has yet been represented in print. Ritchie (1976) gives a very good account of machair vegetation and reviews previous work, some of it unpublished. Randall (1976) describes the zonation of undisturbed machair on the Monarch Islands, which might be taken as a guide to the original state of the Uist coast. Gimingham et al. (1948) give calcium carbonate analyses from the nearby island of Harris, which apparently supports very similar natural vegetation and very likely the same weed flora.

Z-M analysis has revealed the occurrence of the Chenopodio_-
Violetum curtisii on the true machair soils and the Spergulo_-
Chrysanthemetum on the peatier soils at the landward margins of the machairs.

Fig. 36 shows the results of the chi-squared analysis. A very fragmented diagram has resulted, with no fully formed clusters, all

Fig. 36 Species Association: Outer Hebrides



indices of cohesiveness being zero (see Sect. 2.3.1). The natural machair species Thalictrum minus ssp. arenarium, Galium verum and Senecio jacobaea form a group at the $P = 0.01$ level and connected to these, loosely, are the other species of poor, sandy ground, Agrostis tenuis, Plantago lanceolata, Festuca rubra and Leontodon autumnale. Agrostis tenuis and Galium verum of this group show negative association with Chrysanthemum segetum of the peatier soils.

An axis is thus deducible from the diagram, from C. segetum of the cultivated non-machair soils across to Agrostis tenuis and its associated species of the fallow machair plots. Midway between are the two most abundant species of the machair cereal fields, Avena strigosa and Chenopodium album, plus Lycopsis arvensis and Lamium hybridum in a connected pair.

Polygonum persicaria, of peaty plots inland, shows no positive associations, but is negatively associated with Chenopodium album and Avena strigosa with the latter at the $P = 0.01$ level. Agropyron repens also shows only negative associations, with Bellis perennis ($P = 0.01$) and Lolium perenne ($P = 0.05$).

While fallow and cultivated ground have been recognisable in the results of this analysis, the low number of quadrats has meant that associations between weed species have generally reached only marginal significance. Thus the two main weed associations cannot be clearly recognised in the plexus diagram.

7.3 The Brecklands

The Brecklands area of East Anglia, covering N. W. Suffolk, S. W. Norfolk and a small adjacent area of Cambridgeshire, is famous as an ecologically unique area with a very unusual flora. Much of the area was once heathland on sand overlying chalk. Locally, beds of chalky boulder clay lie between the sand and the chalk. It has long interested ecologists and classic accounts of the ecology of

the area have been provided by Clarke (1908), Farrow (1915; 1925b) and Watt (1936). At one time, the area was a barren, treeless area (see Clarke, op. cit.) supporting only local and sporadic arable farming. On the poor heathland soils, often base-poor by leaching despite the chalk below, ground would be ploughed and planted with crops, but after a year or so, the land would become depleted of nutrients and the land would eventually be abandoned, leaving a broken open landscape of "brecks". Hence the area has become known as "Breckland", a term attributed to W. G. Clarke by Forman et al. (1963). More recent usage has pluralised the name.

At the time Clarke was writing of the area, it was still substantially open. He was already recording the enclosure of parts of the heathland, the planting of conifers as windbreaks and the beginnings of the modern arable revolution in the area. However, he was still able to spend a week wandering across the heathlands, hardly meeting another person (Clarke, 1909). One wonders how he would react if he could return to see the area today. Vast areas have become covered by dreary conifer plantations, destroying many of the areas of the greatest ecological interest. Much formerly barren heathland now provides high yields of barley and if he were to return to wander the remaining fragments of heathland he would have to be an accomplished negotiator of barbed wire and need to cheerfully disregard the hosts of notices forbidding entry. Only in the north of the area, on land occupied by the army, do large areas of original heathland remain. Here, as elsewhere, the army has proved an unwitting but highly successful conservation organisation.

The origin of the Brecklands is still something of a mystery. Farrow (1925a) suggested that the heathlands were not natural, but had supported woodland until the advent of Neolithic Man. Clearing and burning had destroyed the forest and sheep and rabbits had

maintained the treeless area since. Clarke (1908) had reported large numbers of oak seedlings on the heaths during a reduction in rabbit populations and Farrow (1941) reported good growth of birch in rabbit-proof cages. Godwin (1944) put the matter beyond doubt, providing palynological proof that the Brecklands had indeed been covered by forests until Neolithic Man arrived.

However, the unusual nature of the Brecklands today is concerned with its geology. Even drift geological maps mark the area as chalk, with the local occurrence of boulder clay and alluvial deposits. The sand overlying everything is ignored. Even Harmer's (1910) account of the glacial deposits of the area makes no mention of the Breckland sand. Forman et al. (op. cit.) attribute the sand to the weathering of boulder clay with chalk and clay being removed from the upper horizons. However, it is difficult to imagine that this can explain the Breckland "warrens", which have all the appearance of coastal sand-dunes and even support such coastal species as Carex arenaria, Vulpia ambigua and Corynephorus canescens (the last according to Clarke, 1908; Watt, 1971). In fact, despite the opinions of Watt (1936), it seems certain that this is exactly what the warrens are. The sea unarguably once extended further into the Wash area and the Breckland warrens fringe this area. Significantly, on the north side of the Wash lies the forgotten "second Breckland", an area of sandy calcareous heaths in Lincolnshire, now almost entirely destroyed. The Lincolnshire heaths lack most of the rare Breckland species, but have their own equivalent speciality in Armeria maritima ssp. elongata. The Breckland sand, then, can be considered as blown coastal sand.

The climate of the Brecklands, reviewed by Watt (1936) is usually described as "continental". Certainly the area is marked by relatively

hot summers, cold winters, and marked diurnal temperature fluctuations (see Overlay 5). Furthermore, as Watt remarks, the area is subject to very severe frosts. The higher day temperatures in winter compared with continental Europe mean that snow does not lie long, and thus does not insulate the ground from night frosts. This undoubtedly benefits hardy winter annuals such as Saxifraga tridactylites.

The combination of calcareous sand, "continental" temperatures but oceanic humidity means that the Brecklands are effectively unique. The area is commonly related to the Steppes of central and eastern Europe (c.f. Salisbury, 1932) but while the area does have species in common with, for example, the Hungarian Steppes (see Borhidi; 1956), the resemblance is minimal. Salisbury's (op. cit.) comparison with areas of France and Germany described by Allorge (1921/1922) and Volk (1931) is a lot more valid.

The main crops of the area were once rye and oats (Clarke, 1908), but barley and, to a lesser extent, sugar-beet are now much the most grown. Calcareous clay, as marl, was added to the sandy soils to increase their water retention and fertility, but the above-mentioned arable revolution occurred with the introduction of lucerne, especially on the Elveden estates of Lord Iveagh (Russel, 1967). Rotation of cereals and sugar-beet with up to five years of deep-rooting lucerne or cocksfoot leys has maintained the soil and formerly barren lands have become highly profitable. The low water content of the sandy soils means that they warm up rapidly in the spring, producing early crops. Heavy applications of potash fertilisers may be needed, however, and boron, copper and magnesium deficiencies have been recorded (Shirlaw, 1966).

Characteristic Breckland weed associations are the Descurainio - Lycopsietum in root-crops and the Papaveretum argemonis and the Papaveri - Melandrietum in cereals. Therophyte communities have

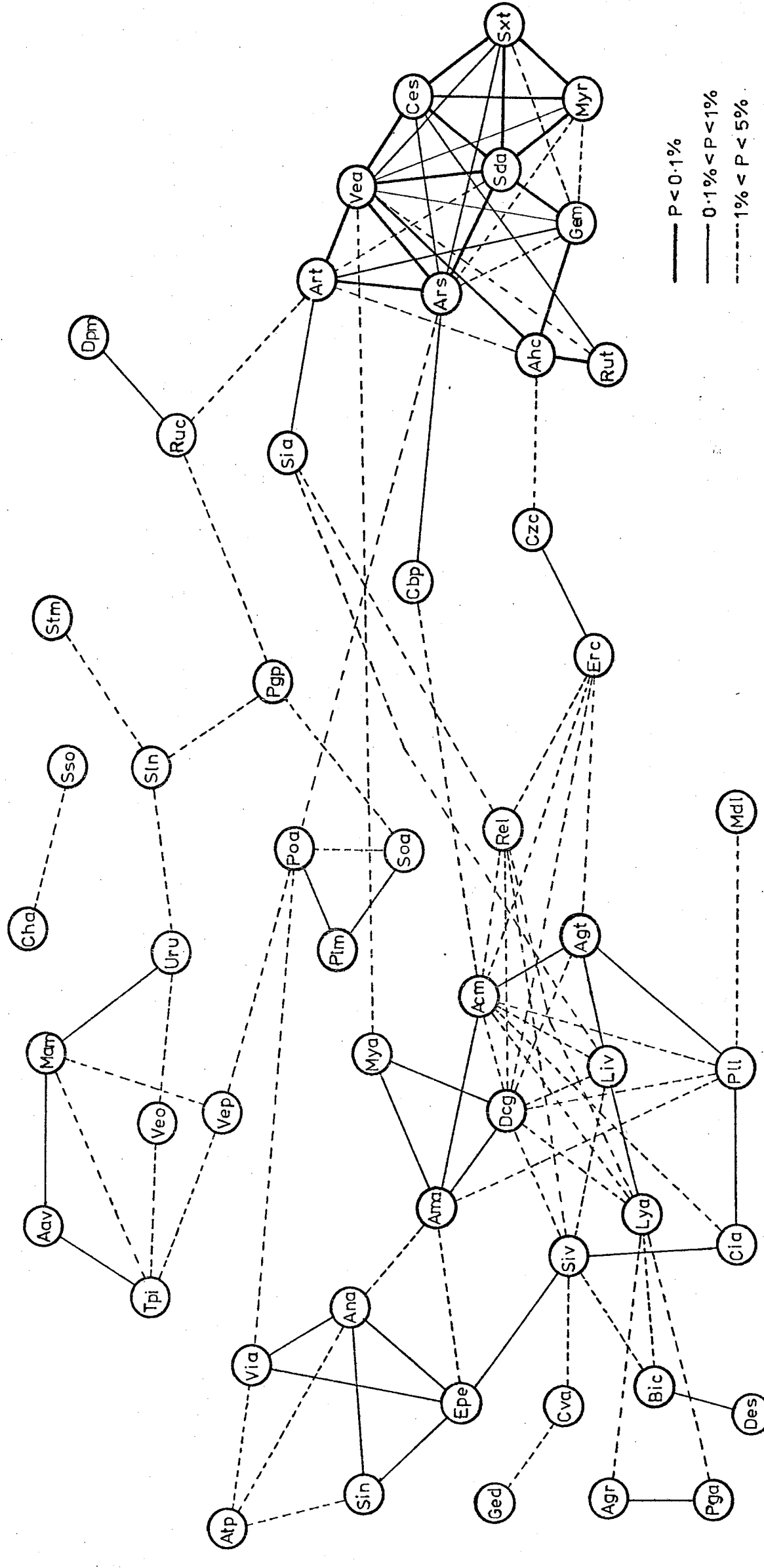
been referred to the Arabidopsidion, though such communities on less calcareous ground, not recorded here from arable land, may well be referable to the Veronico-Corynephoretum, described by Passarge (1960) and containing Veronica verna and typical Breckland species. Brenchley (1913a) commented on the unusual combinations of calcicolous and calcifuge weeds, suggesting that the calcifuges were shallow-rooted, whereas the calcicoles were deeper-rooted to reach the chalky horizons. Ratcliffe (1961) reviewed the ecology of a number of the spring therophytes, listing Arabidopsis thaliana, Arenaria serpyllifolia, Erophila verna, Saxifraga tridactylites, Veronica arvensis, Cerastium semidecandrum and Myosotis ramosissima as winter annuals requiring a period of temperatures below 15°C. before flowering is possible. Afforestation has meant that several therophytes, notably the Veronica species, as well as other Breckland species are now restricted to very few localities. Selective herbicides have further seriously endangered the Veronica species and others (Forman *et al.*, *op. cit.*).

This group of therophytes is very distinct in the plexus diagram (Fig. 37). Saxifraga tridactylites, Cerastium semidecandrum, Sedum acre, Myosotis ramosissima, Geranium molle, Veronica arvensis, and Arenaria serpyllifolia form a closely knit cluster, with an index of cohesion of 0.928, a very high value for seven species. Peripheral to the group are Arabidopsis thaliana, Anthriscus caucalis and Rumex tenuifolius, which indicate less calcareous sandy ground than the main cluster. Their inclusion in the overall therophyte cluster gives an index of cohesion of 0.526, a substantially lower figure.

In contrast to the therophyte cluster in the loose arrangement of mainly Polygono-Chenopodietalia spp., consisting of Tripleurospermum inodorum, Artemisia vulgaris, Matricaria matricarioides, Veronica polita, V. persica, Urtica urens, with Solanum nigrum linking these to Stellaria media and Polygonum persicaria. This can be

Species Association: Brecklands

Fig. 37



regarded as a nitrophilous group, derived from root-crop aufnahmen. The cereal species show a similar grouping, with Atriplex patula, Silene noctiflora, Viola arvensis, Anagallis arvensis, Euphorbia exigua and Anthemis arvensis.

The field edge perennials Linaria vulgaris, Dactylis glomerata, Agrostis tenuis, Plantago lanceolata, Achillea millefolium, Reseda lutea and Silene vulgaris form another group, mainly at the $P = 0.05$ level, though the annuals Lycopsis arvensis and Anthemis arvensis are also part of this grouping. Table 19 shows the association of some of these with lucerne.

Plantago major, Poa annua and, perhaps a little more surprisingly, Sonchus arvensis represent a Plantaginetea influence.

An overall axis in the diagram thus appears to be from true arable weeds, through species of field edges and fallow ground to the therophyte communities of the "breck" fields. A second axis is probably based on soil nitrogen.

Negative associations back up the groupings described above. The therophytes in general show negative associations with a Stellarietea grouping consisting of Descurainia sophia, Bilderdykia convolvulus, Chenopodium album, Agropyron repens and, especially, Polygonum aviculare. The dissociation with Agropyron repens is particularly interesting, since A. repens is supposed to characterise the Arabidopsidion (q.v.). Erodium cicutarium of poor, sandy ground also shows negative association with Tripleurospermum inodorum of fertile, heavier ground, as does Silene alba with Matricaria matricarioides.

7.4 Lower Greensand and Bagshot Sands Formation

The soils of the Lower Greensand have a characteristic appearance throughout the exposures of this Formation across southern England north to Lincolnshire. Typically they are ferruginous sands, often

with concretions of the same material and sometimes with additional clay. They often support heathland, or Sphagnum bogs where drainage is impeded by the formation of iron pans.

The impression is that of a very uniform rock, far more constant over a large area than most other geological strata. However, lithologically the formation is not nearly so uniform as the soils suggest. Numerous subdivisions of the formation have been made, though these do not always correlate from one locality to another. The lower levels of the formation are recognised as the Atherfield Clay, a narrow band of yellowish-brown sandy clay, with local somewhat calcareous concretions (Crosfield, 1931). Above this are a series of sands which have been variously classified. In ascending order, strata have usually been differentiated as the Hythe Beds, Bargate Beds and Folkstone Beds, though upper levels may be termed the Carstone, after harder bands of sandstone rock of that name. Typical of the very extensive outcrop of Lower Greensand in Surrey is the description of the strata above the Atherfield Clay in the Leith Hill area given by Leighton (1895) and summarised below.

Folkstone Beds

Ferruginous sands with layers of Carstone	More than 10 ft
Junction beds - ferruginous sand, pebbles and layers of dark glauconitic sand	4 ft

Bargate Beds

Glauconitic sands with thin layers of clay and clayey sandstone	3 - 6 ft
Calcareous grit beds with pebbles, passing down into coarse calcareous sandstone and calcareous sands	25 ft
Junction bed - ironstone and sandy chert	Less than 1 ft

Hythe Beds

Rubbly beds of sandy chert interbedded with layers of glauconitic quartz-sand, with occasional bands of massive brown chert	60 ft
Massive greensand and chert, generally containing thick beds of hard rocks, with softer beds of sandy chert in places	80 ft
Ferruginous sands	100 - 130 ft

The thicknesses of these strata vary considerably, even over small areas, while Leighton's section is incomplete at the top. Crosfield (op. cit.) gives the thickness of the Folkstone Beds as around 160 ft, and attributes the existence of the extensive heaths of W. Surrey to the very base-poor ferruginous sands of this division.

Further east, the Hythe Beds become substantially calcareous, forming the "Kentish Rag" building stone. Worrall (1954) describes the Hythe Beds of Kent as being made up of seams of ragstone alternating with "hassock". The ragstone is a compact, hard rock containing grains of glauconite in a matrix of calcite and quartz. The percentage of calcium carbonate is very high, averaging around 85%. The "hassock" is a loamy sand containing much glauconite together with clay, silt and variable quantities of calcium carbonate. The proportion of ragstone to hassock increases eastwards.

In Norfolk, where the Lower Greensand outcrops extensively around Sandringham and King's Lynn, the lithology is very different. The southern divisions are unrecognisable, and indeed north of Norfolk, the Lower Greensand formation itself is difficult to differentiate from other Cretaceous formations. Larwood (1961) gives three divisions which might be regarded as Lower Greensand. At the base of the formation are the beds of the Sandringham Sands, white and pale-brown quartz sands with layers of ironstone and very little glauconite.

Above these lies the Snettisham Clay, a stiff sandy clay. It occurs only in the north of the area, where its outcrops are small. The Carstone forms the top division; consisting of hard, coarse sandstones, gritstones and conglomerates. Botanically the Sandringham Sands have the most obvious effects, supporting very dry Calluna-dominated heathlands very similar to those over the Bagshot Sands in Surrey, described below. They provide an interesting contrast to the calcareous heaths of the Brecklands which are at no great distance. Some Breckland rarities, notably Silene otites and Scleranthus perennis, have also been recorded from these heathlands (Perring and Walters, 1976).

An anomalous situation in this area is that some of the most "typical Lower Greensand" arable soils are shown on geological maps as being directly on chalk. The account of the area by Whitaker and Jukes-Browne (1899) makes no direct reference to these soils, but it seems likely that they are derived from the "brown boulder clay" recognised elsewhere in the area. Presumably this boulder clay represents glacial movement of Lower Greensand soils from their exposures to the west. Although the arable land on the West Norfolk chalk could thus be regarded as derived from the Lower Greensand, it has not been included in this analysis.

The overall picture, then, is of considerable thicknesses of base-poor ferruginous sands, supporting the typical Lower Greensand heathlands and poor arable fields, though use of fertilisers can transform the latter into highly profitable land. However, apart from the ragstone and related deposits in Kent, calcareous strata do occur. Crosfield (op. cit.) reports that the limestone bands of the Bargate Beds locally support a "chalk flora" in Surrey. Calcium montmorillonite ("fullers' earth") bands also occur locally in Surrey and Berkshire (Cox, 1918; Poole and Kelk, 1971). Heavy minerals

are surveyed by Wood (1956), but it seems unlikely that these will have any appreciable effect on the flora; certainly no serpentine species occur on the Lower Greensand.

The other major geological formation supporting acid, sandy heathlands and associated infertile sandy arable land is the Bagshot Sands. The results presented here are from an analysis of data from the Lower Greensand and Bagshot Sands taken together.

Geologically the Bagshot Sands also give the impression of great uniformity. As used here, the name is restricted to the lowest part of the old Bagshot Series; the Bracklesham and Barton Beds which are now given separate recognition are excluded from this analysis. Thus the strata giving rise to the soils considered here consist primarily of yellow and white quartz sand, with bands of clay. Generally they lack calcium carbonate (Crosfield, op. cit.). The Bagshot Sands support extensive heathlands in the western part of the London Basin, notably in E. Surrey, and in the Poole Basin of Hampshire and Dorset. Westwards the formation becomes more gravelly and less distinct from adjacent formations (Chatwin, 1960).

In view of the very high proportion of pure sand in the horizons of both the Lower Greensand and Bagshot Sands formations, the overall uniformity of the soils is not surprising. Rigg (1916) recognised two types of sandy soil derived from the Lower Greensand in Bedfordshire, a "Dark Sand Formation" in the Sandy Heath area and a "Brown Sand Formation" around Potton and extending to Gamlingay. He regarded the Dark Sands as very nutrient poor, whereas the Brown Sands are richer in silt, clay and mineral nutrients. Then, as now, the Brown Sands areas were more extensively cultivated, but no obvious differences in the weed floras have been noted. The Spergula - Lamium amplexicaule - Comm. occurs in both areas. Beavington (1972), in a very full review of Lower Greensand soil in Bedfordshire, claimed that Rigg's two

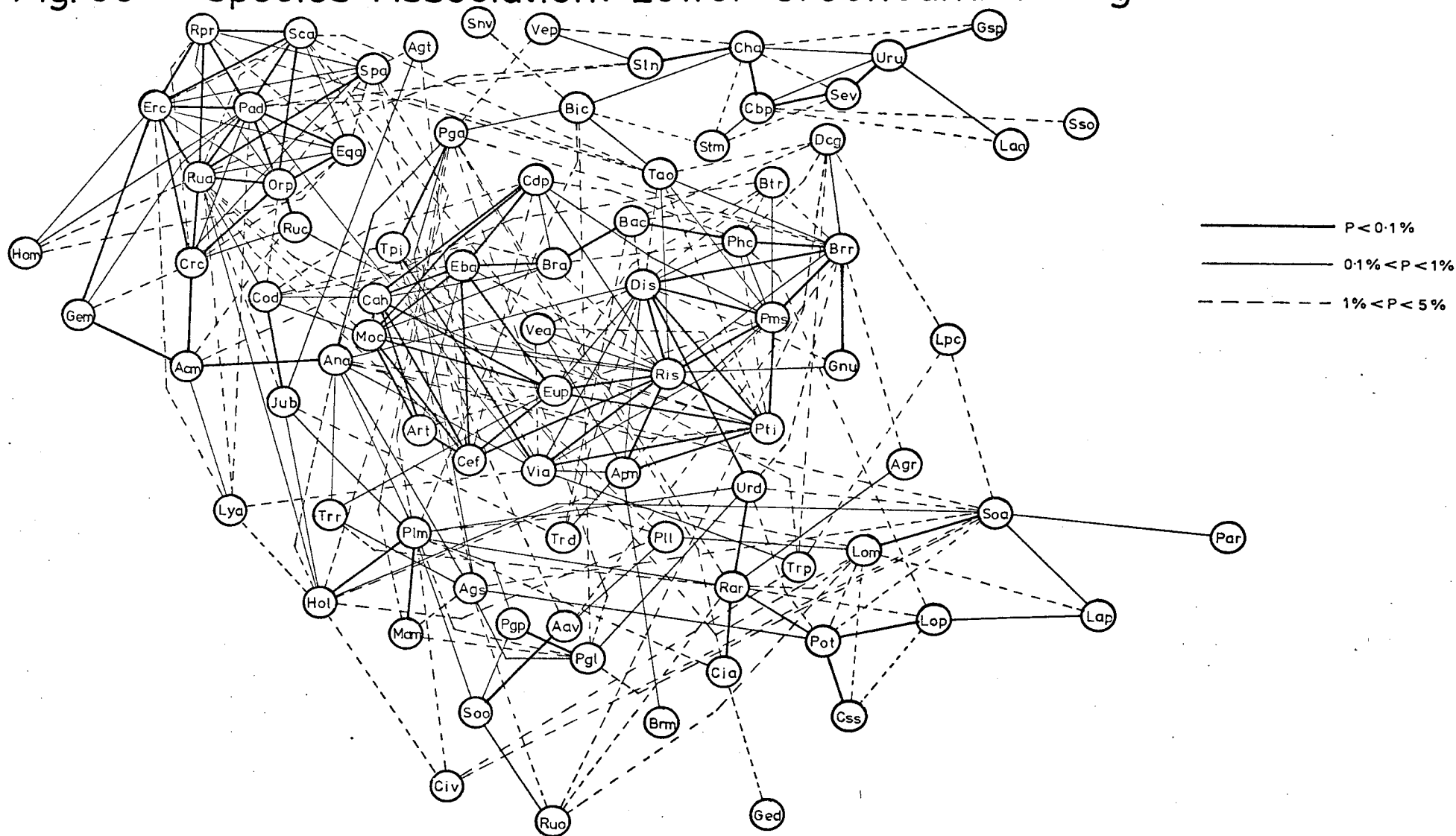
categories of soil are not clear today. He found that most arable soils could be classified as "loamy sand", a number could be classified as "sand" while only a few could be termed "sandy loam". The initial choice of the Lower Greensand as giving very uniform soils appears to be justified.

Both geological formations support extensive areas of market gardening, with vegetables often being intensively grown on a strip-farming system. The light soils are well suited to early vegetables despite the natural infertility of the soils. However, Beavington (1963) relates that increased use of chemical fertilisers in place of manures is accompanied by a deterioration of soil structure and reduced water-retaining capacity. Rain after fertiliser dressings leads to a caking of the surface, while summer droughts produce loose, dusty soil in which plants wilt and may even wither in the reflected heat. Shoddy was formerly used to improve soil structure, but its use has been largely abandoned due to transport costs; none of the alien "shoddy weeds" has been recorded sufficiently often to be included in this analysis. Plant (1956) reports that the continued cultivation and decrease in organic matter in Lower Greensand soils is leading to molybdenum deficiency and manganese toxicity.

One of the most serious weeds of the nursery and market gardening areas is Galinsoga parviflora, while Solanum nigrum and Urtica urens can be major problems. Mann and Barnes (1949) regarded Agrostis gigantea as the most serious perennial grass weed on the most acidic soils of the Lower Greensand, where the pH may fall to 4.2. On the less acid plots, Holcus mollis becomes more serious.

Fig. 38 shows the association between species on these soils. The situation is a very complex one, and difficult to reduce satisfactorily to a two-dimensional diagram. The species of sandy ground in nurseries, as might be expected from the deliberate sampling

Fig. 38 Species Association: Lower Greensand & Bagshot Sands



of these habitats, form a very distinct cluster. Papaver dubium could be taken as the key species of a group containing Raphanus raphanistrum, Scleranthus annuus, Erodium cicutarium, Spergula arvensis, Equisetum arvense, Ornithopus perpusillus, Rumex acetosella and Crepis capillaris. The index of cohesion for the group is 0.929 at $P = 0.05$, a high value. They indicate pure sand. Rumex crispus, Holcus mollis, Geranium molle and Achillea millefolium are peripheral to this group.

Associated with this group are the therophytes of nursery and horticultural conditions, Cardamine hirsuta, Montia fontana ssp. chondrosperma, Arabidopsis thaliana, Epilobium adenocaulon and Cerastium fontanum, of the Cardaminetum hirsutae. A number of bryophytes, notably Eurhynchium praelongum, Ceratodon purpureus and Bryum argenteum, are also closely associated with this group.

The bryophytes of damper ground also form their own very distinct cluster, with Riccia sorocarpa as a central species. Dicranella staphylina, Pottia intermedia, Eurhynchium praelongum, Pleuridium subulatum, Phascum cuspidatum, Bryum argenteum and, to a lesser extent, B. rubens are part of this group, as are the angiosperms Aphanes microcarpa, Gnaphalium uliginosum, Viola arvensis and Veronica arvensis. The cluster is closely linked to the therophyte cluster via Eurhynchium praelongum, Cerastium fontanum and Ceratodon purpureus.

The species of the Spergula - Lamium amplexicaule - Comm. form an isolated grouping, involving Lamium amplexicaule, Urtica urens, Galinsoga parviflora, Senecio vulgaris, Capsella bursa-pastoris, Chenopodium album, Solanum nigrum and Veronica persica. Only the last three species show positive association to species outside the group. Inconveniently, from a nomenclatural point of view, Spergula arvensis is not associated with this group, showing that while it can be considered typical of the syntaxon, it cannot be regarded

as a character species of it.

Other groupings are more diffuse. Plantago major is associated with Matricaria matricarioides, Polygonum aviculare, Holcus lanatus and Juncus bufonius in an ill-defined Plantaginetea grouping, while P. major also joins a grouping including Ranunculus repens, Urtica dioica, Cirsium arvense and Polygonum lapathifolium suggesting a nitrophilous field-edge community.

A number of negative associations have also been found to be significant. At $P = 0.001$, the following species pairs show significant dissociation:

Senecio vulgaris - Polygonum aviculare
 " " - Tripleurospermum inodurum
Capsella bursa-pastoris - Phasium cuspidatum
Chrysanthemum segetum - Stellaria media

At $P = 0.01$, the following pairs can be added to this list:

Poa annua - Bilderdykia convolvulus
 " " - Chenopodium album
Phasium cuspidatum - Chenopodium album
Agrostis stolonifera - Urtica urens

Individually these pairs show the separation of species which are kept apart on the positive association diagram, without there being any series of significant dissociations between members of any two groupings. Poa annua does not show any significant positive associations; it is the most frequent species in the data set, with its small number of absences being the equivalent of a low number of occurrences.

The following species show significantly greater occurrence on the Lower Greensand soils:

Stellaria media ** Veronica persica *

A number of species show association with the Bagshot Sands:

<u>Spergula arvensis</u> ***	<u>Rumex acetosa</u> ***
<u>Chrysanthemum segetum</u> ***	<u>Agrostis tenuis</u> **
<u>Erodium cicutarium</u> *	<u>Crepis capillaris</u> *
<u>Ornithopus perpusillus</u> *	<u>Coronopus didymus</u> *

Conventional signs for significance levels are used as explained in Table 17. It will be seen that the species associated with the Bagshot Sands are those characteristic of drier ground in nurseries.

Table 18 shows the association of species with crops. The ill-defined group of Chrysanthemum segetum, Poa trivialis, Lolium * perenne, Lolium * multiflorum and Ranunculus repens is seen to be associated with wheat. The Papaver dubium cluster is associated with nurseries, as discussed above, and the cluster around Capsella bursa-pastoris is associated with cabbages and root-crops in general, showing strong negative association with cereals.

Soil data for some aufnahmen included in this analysis are given in Appendix II.

As was explained in Section 2.3., the recording units for the chi-squared analyses have been 4 m^2 , with occurrences outside the quadrats disregarded. However, an amended form of the Lower Greensand/ Bagshot Sands investigation was carried out adding such occurrences where they had been used for Z-M analysis. A full association plexus diagram has not been drawn, but the alteration in method does not seem to have had much effect, except that a few more species occurred five times or more and were thus included. However, some species thus occurred in the data set with much greater frequency and the effect this has had on the total number of associations, positive and negative, that they have formed, is shown in Table 36. This can be seen to have had a substantial effect on the total number of associations shown, for example, by Papaver rhoeas (isolated in

Fig. 38), Lycopsis arvensis, Polygonum persicaria and Crepis capillaris. As shown by Dactylis glomerata, this total is not always increased.

7.5 Dorset

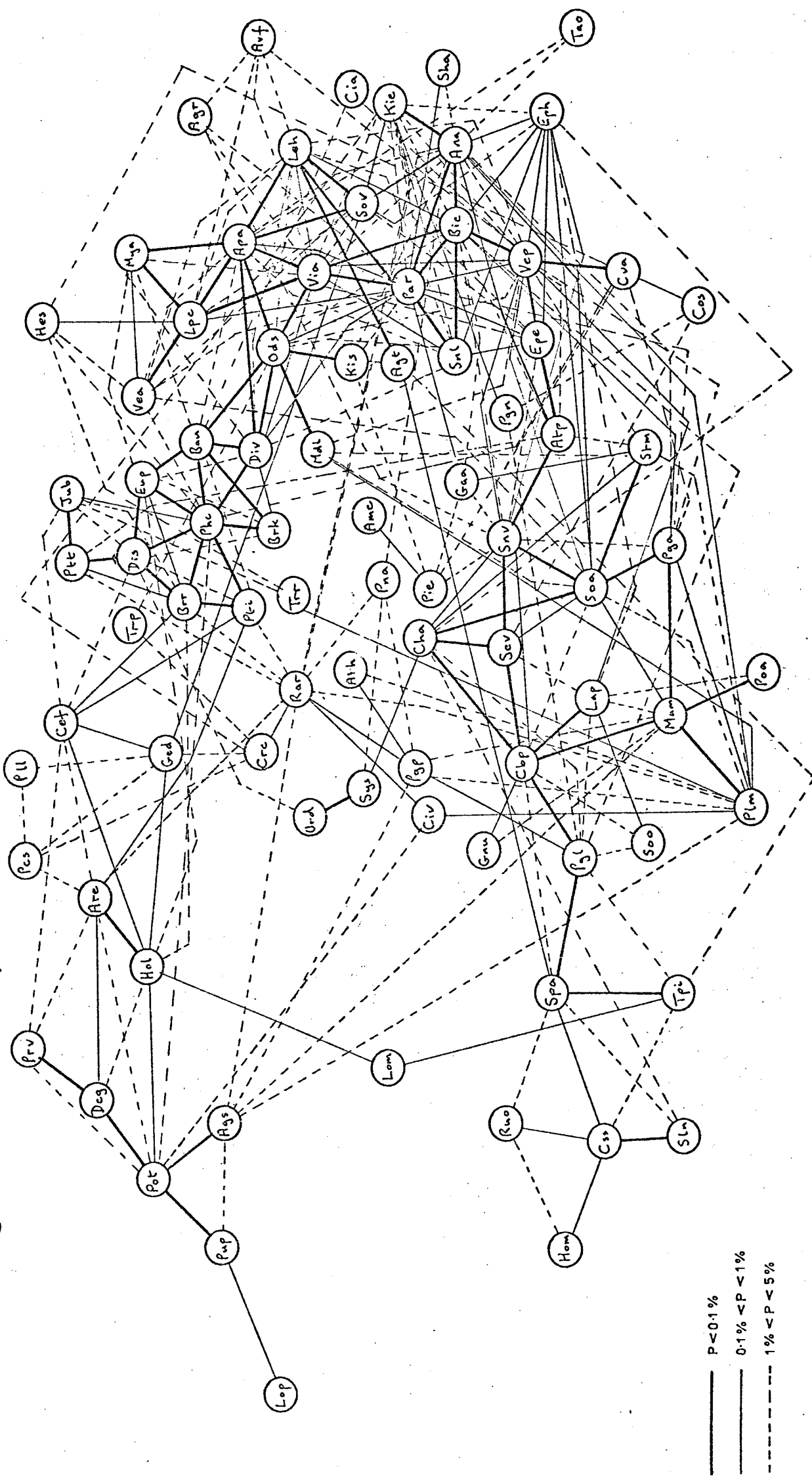
In contrast to the preceding section, in which data from uniform soils were analysed, the Dorset data set is derived from just one area of diverse geology. Dorset was chosen for a detailed study in view of its very substantial range of geological strata, ranging from the acid Lower Greensand to chalk and limestones. Not all of these formations carry significant amounts of arable land; generally speaking, arable farming is restricted to coastal areas and to the lighter soils inland. Thus while an effort was made to include all the major strata, geological maps being used in the field for this purpose, lack of significant amounts of arable land in many areas has inevitably resulted in unevenness of treatment of different strata. A concise summary of the main geological formations of Dorset, from an ecological viewpoint, is given in Appendix III.

An excellent account of the meteorology, topography and vegetation of Dorset is given by Good (1948), including an account of the soils by K. L. Robinson. The county is excellently placed for a general survey of weed communities since it is within the range of the south-eastern alliance, the Caucalidion, yet sufficiently far west for the occurrence of oceanic elements of the British flora. While drift deposits locally obscure solid geology, the county is too far south for its rocks to have been blanketed by boulder clay.

Positive interspecific associations are shown in Fig. 39. Bryophytes once again form a very distinct cluster from their joint occurrence in damp, less disturbed quadrats. Phascum cuspidatum is the central species of a cluster including Pottia intermedia, Bryum rubens, Dicranella staphylina, Eurhynchium praelongum, Barbula

Fig. 39

Species Association: Dorset



unguiculata, Dicranella varia and Bryum klinggraeffii, plus other peripheral species. This cluster of species is not, however, quite as cohesive as it might first appear. Its index of cohesion is only 0.619. This is by no means a low figure, but further examination of the cluster reveals two sub-divisions. Dicranella varia, Barbula unguiculata and Bryum klinggraeffii form a small grouping of calcicolous species, whereas Bryum rubens, Dicranella staphylina, Pottia intermedia, with Pottia truncata and Juncus bufonius represent more base-poor ground. The distinction here represents the bryophyte unions Phascetum floerkeani and Pottietum truncatae. Phascum cuspidatum and Eurhynchium praelongum, characteristic of both unions, here form link-species to produce the bryophyte cluster.

Cerastium fontanum and Geranium dissectum link this bryophyte group with a loose grouping of Molinio - Arrhenatheretea species, containing Prunella vulgaris, Dactylis glomerata, Poa trivialis, Phleum pratense, Agrostis stolonifera, Holcus lanatus and Arrhenatherum elatius. This represents the inland fields of the mainly hay-growing areas.

A major grouping in the diagram is that of the Centauretalia species of predominantly calcareous soils. Viola arvensis is an important species, for like Phascum cuspidatum described above, it can be regarded either as the central species of a large grouping, or else as a link species between two subgroups. To one side are the species of light calcareous soils, primarily chalk and limestones, encompassing Odontites * serotina, Aphanes arvensis, Veronica arvensis, Myosotis arvensis, Lapsana communis, Avena fatua, Legousia hybrida, Agrostis tenuis, Kickxia spuria and Medicago lupulina. The other sub-group consists of species of heavier calcareous soils and extending to the lighter, fertile clays such as the sandy Dorset facies of the London Clay. They comprise Papaver rhoeas, Bilderdykia convolvulus,

Anagallis arvensis, Kickxia elatine, Sherardia arvensis, Sinapis alba, Euphorbia helioscopia, Euphorbia exigua, Veronica persica, Convolvulus arvensis and Atriplex patula.

The Polygono - Chenopodietalia species, Chenopodium album, Senecio vulgaris, Sonchus asper, S. oleraceus, Capsella bursa-pastoris, and Lamium purpureum form another distinct group of mainly herbicide-resistant species of summer cereals and root-crops. They are linked to the preceding group by Sinapis arvensis.

Polygonum lapathifolium links this group to the species of base-poor sandy soils, Spergula arvensis, Tripleurospermum inodorum and especially Chrysanthemum segetum, Solanum nigrum, Rumex obtusifolius and Holcus mollis. The Spergulo - Chrysanthemetum is suggested here.

In Chapter 6, Capsella bursa-pastoris was named as a typical Stellarietea species also occurring in the Plantaginetea. This is seen again here where it is linked to the Plantaginetea grouping of Matricaria matricarioides, Poa annua, Plantago major and Polygonum aviculare.

Urtica dioica and Stachys sylvatica form an isolated pair from nitrophilous field-edge stands adjacent to hedges.

The overall trend of the plexus diagram is that of a left to right base-poor to base-rich gradient. Superimposed on this is another diagonal gradient from true arable species at the right of the diagram through marginal species to the grassland species of the top left. Negative associations between Chrysanthemum segetum and Stellaria media, and between Holcus lanatus and Veronica persica, both at the $P = 0.001$ level, reinforce the arrangement of the diagram. Additional negative associations are Picris echioides (no positive associations) with Poa annua, at $P = 0.001$, and the following with a probability of $P = 0.01$ or less:

Agrostis stolonifera - Sherardia arvensis

Poa trivialis - Atriplex patula

Chrysanthemum segetum - Sonchus asper

Convolvulus arvensis - Tripleurospermum inodorum

Poa annua - Euphorbia exigua

" " - Kickxia spuria

Association with geological formations

The following species showed positive or negative associations with one or more of the more widely occurring formations.

Chalk: (all strata)
(Positive)

<u>Bilderdykia convolvulus</u>	***	<u>Veronica persica</u>	***
<u>Dicranella varia</u>	***	<u>V. _____ arvensis</u>	***
<u>Viola arvensis</u>	***	<u>Sinapis alba</u>	***
<u>Sherardia arvensis</u>	***	<u>Papaver rhoeas</u>	***
<u>Kickxia elatine</u>	**	<u>Euphorbia helioscopia</u>	**
<u>Legousia hybrida</u>	**	<u>Polygonum aviculare</u>	*
<u>Myosotis arvensis</u>	*	<u>Phasium cuspidatum</u>	*
<u>Euphorbia exigua</u>	*	<u>Aphanes arvensis</u>	*
<u>Medicago lupulina</u>	*	<u>Odontites * serotina</u>	*

Lower Purbeck:
(Positive)

<u>Kickxia spuria</u>	***	<u>Avena fatua</u>	***
<u>Picris echioides</u>	***	<u>Anthemis cotula</u>	**
<u>Veronica persica</u>	*	<u>Anagallis arvensis</u>	*
<u>Sinapis arvensis</u>	*		

(Negative)

<u>Poa annua</u>	1	<u>Agrostis stolonifera</u>	*
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Limestones - general: (including Cornbrash, Portland Stone, Forest Marble, Lower Purbeck, Middle Purbeck, Inferior Oolite and Coral Rag, but excluding Chalks)

(Positive)

<u>Kickxia spuria</u>	***	<u>Convolvulus arvensis</u>	***
<u>Picris echioides</u>	***	<u>Veronica persica</u>	**
<u>Sinapis arvensis</u>	**	<u>Anthemis cotula</u>	*
<u>Coronopus squamatus</u>	*		

(Negative)

<u>Polygonum lapathifolium</u>	*	<u>Ranunculus repens</u>	*
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London Clay:
(Positive)

<u>Holcus lanatus</u>	**	<u>Pottia intermedia</u>	*
<u>Cerastium fontanum</u>	*	<u>Juncus bufonius</u>	*

Oxford Clay + Kimmeridge Clay:
(Positive)

<u>Arrhenatherum elatius</u>	**	<u>Geranium dissectum</u>	**
<u>Galium aparine</u>	*	<u>Crepis capillaris</u>	*
<u>Pastinaca sativa</u>	*		

(Negative)

<u>Polygonum aviculare</u>	*	<u>Anagallis arvensis</u>	*
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Lower Greensand:
(Positive)

<u>Urtica dioica</u>	*
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Valley Gravel:
(Positive)

<u>Chrysanthemum segetum</u>	***	<u>Solanum nigrum</u>	*
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Gravel drift deposits - general:
(Positive)

<u>Gnaphalium uliginosum</u>	**	<u>Solanum nigrum</u>	**
<u>Chrysanthemum segetum</u>	*		

Bagshot Sands:
(Positive)

<u>Agrostis tenuis</u>	***	<u>Chrysanthemum segetum</u>	***
<u>Rumex obtusifolius</u>	**	<u>Spergula arvensis</u>	**
<u>Polygonum lapathifolium</u>	*	<u>Lolium * multiflorum</u>	*
<u>Solanum nigrum</u>	*		

(Negative)

<u>Stellaria media</u>	*	<u>Myosotis arvensis</u>	*
<u>Anagallis arvensis</u>	*	<u>Convolvulus arvensis</u>	*

Table 17 gives the weed species associated with particular crops in Dorset.

7.6 The Isles of Scilly

With the exception of the Channel Isles, which are geographically more part of France than of Britain, the Isles of Scilly provide the most favourable conditions of any part of the British Isles for the growth of thermophilic species. Indeed the Scillonian winters are even milder than those of the Channel Islands, with an average of only four air frosts per year on St. Mary's, compared with an average of eleven on Jersey (Lousley, 1971). Summer temperatures, however, are rather lower, with the islands subject to the full force of the Atlantic winds and possessing relatively little natural cover.

Though there is local development of peat, virtually all parts of the island are reached by wind-blown maritime sand and the resulting soils are primarily sandy loams. The underlying rocks, granites of varying texture, make virtually no direct contribution to these soils.

Thus the light sandy soils are well suited to the production of early horticultural crops, especially bulbs. Tall Pittosporum hedges act as very efficient windbreaks, maintaining sufficiently higher temperatures for significantly earlier crops (Pollard et al., 1974). The delaying of effective weed control until the bulb foliage has died down, around the end of May, suits those species, native and introduced, which can function as spring therophytes. Thus the flora of the bulbfields has a Mediterranean character, comparable to the weed communities of Teneriffe described by K. Meisel (1969).

During a week in May, 1971, the weed flora was investigated on the main inhabited islands, St. Mary's, St. Martin's, St. Agnes and Tresco. Aufnahmen were mainly from bulbfields, including those being abandoned as hayfields in uneconomic areas, notably the higher ground on St. Martin's, but some fields of potatoes and cabbages were also included in the survey. The results of a chi-squared analysis of this data are shown in Fig. 40.

The two major weed associations of the Scillies are the Spergulo-Chrysanthemetum and the Medicagini-Ranunculetum, but the main axis of floristic variation suggested by Fig. 40 is the gradient from damp to dry common to both associations. The damp end of this gradient is signified by Sagina procumbens, Juncus bufonius and a cluster of bryophyte species comprising Riccia sorocarpa, Bryum rubens, Pottia truncata, Phascum cuspidatum, Ceratodon purpureus, Eurhynchium praelongum and Dicranella staphylina. Peripheral to this group are other bryophytes, Barbula convoluta, Weissia rutilans, Pleuridium subulatum and Ditrichum cylindricum. From these groups, a transition through important link species such as Veronica arvensis, Spergula arvensis, and Rumex acetosella leads to the group of very dry sandy ground, comprising Anisantha diandra and the therophytes Aira praecox, A. caryophyllea ssp. caryophyllea and Myosotis ramosissima.

On the drier, temporally fallow areas, grass-rich communities develop with Vulpia bromoides, Bromus hordaceus, Pteridium aquilinum, Allium triquetrum and the typical presence of species such as Briza minor, Aira caryophyllea ssp. multiculmis, Crepis capillaris and Trifolium dubium which also occur in the more intensively farmed areas. T. dubium is also closely linked to Silene gallica and Rumex acetosella in a cluster characteristic of bulbfields on drier but fertile ground.

A small root-crop grouping of Capsella bursa-pastoris, Chenopodium album and Urtica urens can be distinguished, with Veronica persica perhaps also part of this group. This diffuse cluster is further linked via Senecio vulgaris to Fumaria * boraei and Oxalis pes-caprae of damper, fertile soils. On possibly less fertile soils, Cerastium fontanum is the central species in a grouping consisting also of Stellaria media, Trifolium repens, Bellis perennis, Ranunculus ficaria and perhaps Lolium perenne, Geranium dissectum and Spergula arvensis. Most of these species are characteristic of field edges.

The pattern of positive associations is also borne out by the significant negative associations. At the significance level of $P = 0.01$ or less, the following significant dissociations were recorded:

<u>Vulpia bromoides</u>	-	<u>Senecio vulgaris</u>
"	"	- <u>Poa annua</u>
"	"	- <u>Fumaria * boraei</u>
<u>Silene gallica</u>	-	" "
<u>Rumex acetosella</u>	-	<u>Galium aparine</u>
"	"	- <u>Bryum rubens</u>
<u>Aira * caryophyllea</u>	-	<u>Poa annua</u>
<u>Valerianella locusta</u>	-	<u>Stellaria media</u>
<u>Poa trivialis</u>	-	<u>Aphanes microcarpa</u>

Chapter EightBryophyte Communities

8.1 Up till now, bryophytes have been considered as a part of the total weed flora of arable land. However, they form a distinct layer within arable phytocoenoses which can also be studied in its own right. Some angiosperm species, notably Sagina procumbens, are also characteristic components of this layer. This bryophyte - small angiosperm synusia or collection of synusiae is, however, not always easy to define, with species such as Juncus bufonius linking it to the main herb layer. Consequently, it is convenient to consider only the bryophyte species as a "taxocoenosis" as defined by van der Maarel (1965). This chapter considers arable bryophyte taxocoenoses.

As the fieldwork was carried out during the summer months, arable bryophytes were not always well developed. Very often, fields would contain only poorly developed Bryum rubens or immature Pottia, presumably always P. truncata. Such fields can make no contribution to an understanding of bryophyte communities and have not been considered further. All data presented in this chapter refer to aufnahmen containing at least two identifiable species. Table LXXXI gives the arable aufnahmen.

Fig. 41 is a plexus diagram showing association between arable bryophyte species, using the same approach as in Chapter 7. Explanations of species abbreviations and the I.P.A. and related data are given in Tables 34 and 35. The overall ecological gradient defining arable bryophyte synusiae appears to be that of pH or calcium levels. Most distinct is the grouping of species of chalky fields, comprising Dicranella varia, Pottia davalliana, Phascum floerkeanum, Bryum klinggraeffii, Barbula unguiculata and Phascum cuspidatum.

Fig. 41

Species Association: Arable Bryophytes

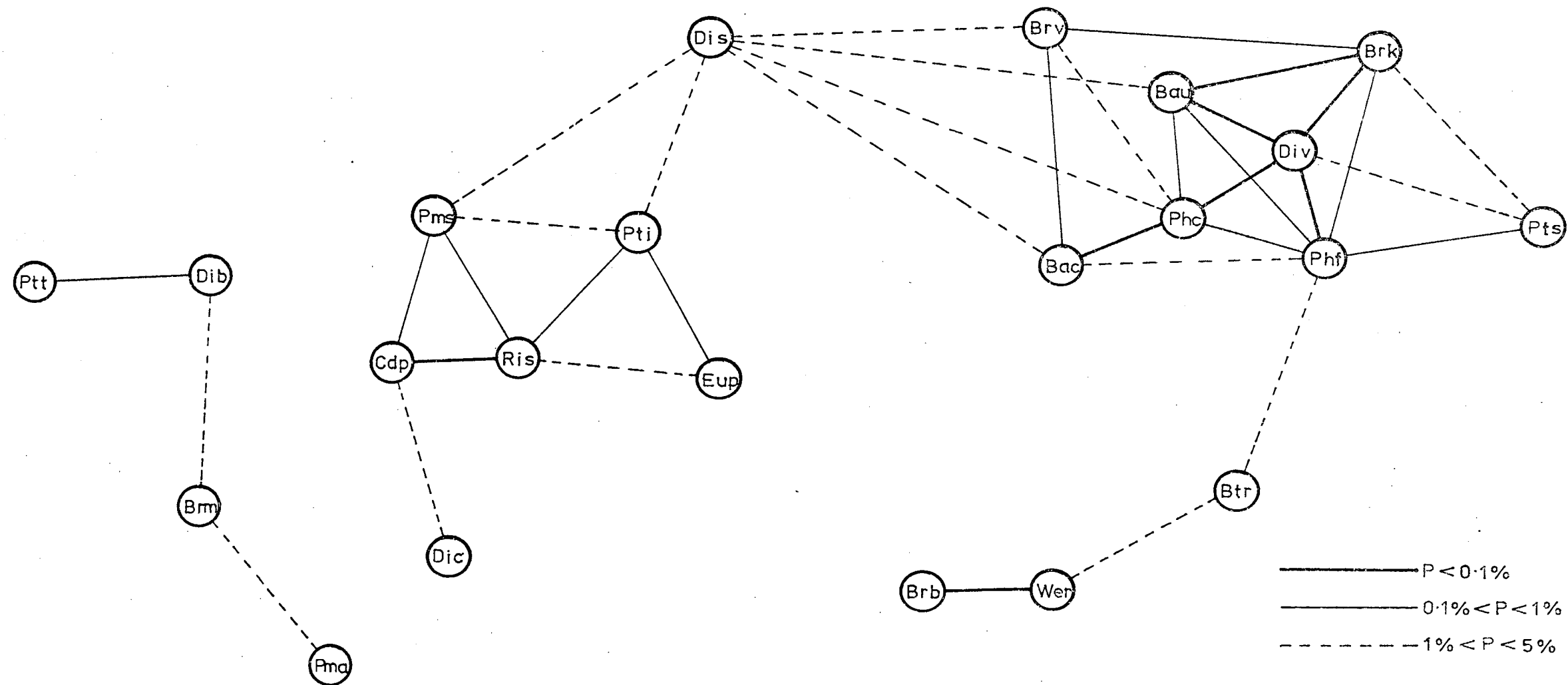
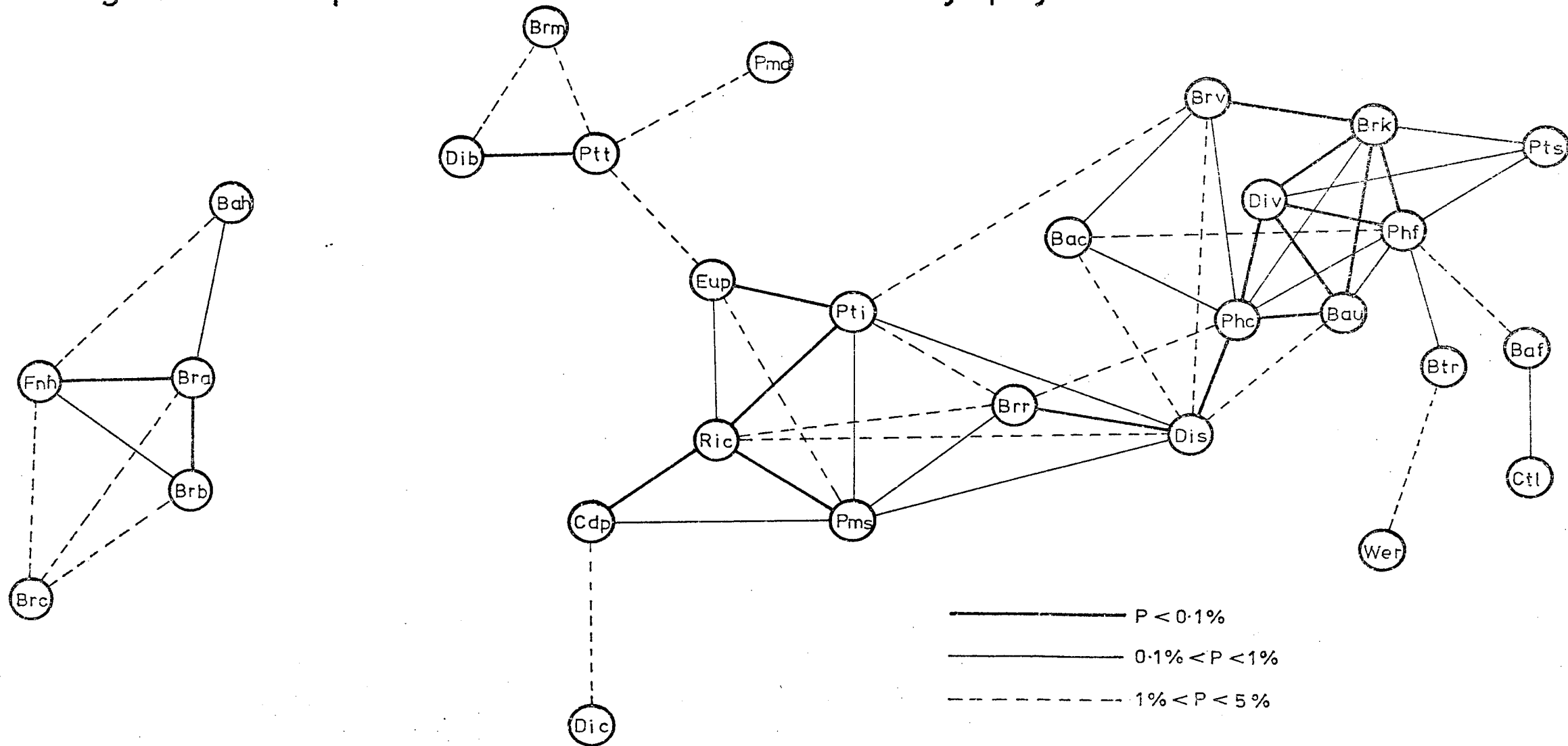


Fig. 42

Species Association: Total Bryophyte Data



Of these, P. cuspidatum and B. unguiculata are by no means restricted to chalky soils but occur also on fertile clays, where Bryum violaceum and Barbula convoluta are common associates. Dicranella staphylina, which, though described only relatively recently (Whitehouse, 1969), is one of the most widespread geographically and ecologically of British arable species, forms an important link-species between the synusia of chalky ground and those of more acidic substrata. On base-poor soils, the typical species are represented by the cluster of Riccia sorocarpa, Pottia intermedia, Eurhynchium praelongum, Pleuridium subulatum and Ceratodon purpureus. Ditrichum cylindricum occurs locally in this grouping, though it is just possible that some records may refer to the recently described D. pusillum. On damper or even more acidic ground, Bryum microerythrocarpum, Dicranella schreberana and Pleuridium acuminatum occur, with Pottia truncata showing affinities with these soils though not confined to them. Where arable data are considered alone, this grouping shows no positive associations with members of other clusters. The inclusion of a disproportionate amount of data from Cornwall and the Isles of Scilly is reflected in the clear association of Weissia rutilans and Bryum bicolor, two typical species of the sandy bulbfields.

Figure 42 shows the effects of including bryophyte data from the ruderal aufnahmen. Bryum rubens, the most abundant arable species, which showed no significant associations in the arable analysis, becomes a central species in the revised arable grouping. The Pottia truncata - Dicranella schreberana grouping becomes linked to the main arable cluster via P. truncata and Eurhynchium praelongum. In contrast to the arable group, and significantly dissociated from it, is the ruderal cluster of Funaria hygrometrica, Bryum argenteum, B. bicolor, B. caespitium and, locally, Barbula hornschuchiana.

It is interesting to note that the inclusion of data from its more typical ruderal habitats has masked the arable association of B. bicolor with Weissia rutilans described above. Barbula fallax and Camptothecium lutescens, colonists of disturbed, open chalky habitats, are shown to be linked with the chalk-arable grouping, B. fallax occurring occasionally in chalky arable fields.

8.2 The arable data of Table LXXXI have also been analysed for associations between bryophyte species and crops. The results are presented in Table 21 (see Sect. 4.4.3), but it must be emphasised that the results apply only to fields suitable for bryophyte growth and NOT TO ARABLE FIELDS GENERALLY. Normally barley is less suited to bryophytes than wheat since it is a spring crop, and this is indicated in Table 21. However, barley is still far more suitable for the development of summer bryophyte communities compared with root crops, which are hardly represented in the data.

8.3 Some workers, notably A. von Hübschmann, have applied Z-M methods and nomenclature to communities of small, annual bryophytes. However, since arable bryophyte communities form synusia within higher-plant communities, it is better to apply a classification which recognises this. Accordingly, the synusial classificatory system of Barkman (1969, 1973) is adopted below. The syntaxonomic units are conceptually equivalent to those of the Z-M system.

<u>Synusial Unit</u>	<u>Z-M Equivalent</u>
union	association
federation	alliance
ordulus	order
classicula	class

Barkman (1973) gives further ranks below that of union. As Wilmanns

(1970) shows, such a system allows ready comparison with Z-M syntaxa but emphasises the existence of synusiae as one-layered communities which may be part of more complex vegetation. The term "synusia" is used here in the abstract sense, comparable with a "nodum" or a "phytocoenon". Justification for the study and recognition of bryophyte synusiae lies in the existence of very similar vegetation, more or less devoid of higher-plant species, on wet mud. Westhoff and Den Held (1969) include such vegetation in the Isoeto_- Nanojuncetea Br. Bl. et R. Tx. 1943, notably the association Centunculo_- Anthocerotetum punctati (W. Koch 1926) Moor 1936. Westhoff (1967) provides a full discussion of the problems caused by groups of species which occur as understory layers and also as independent stands elsewhere.

Insufficient data are available for further discussion of the ruderal bryophytes separated in Fig. 42. Gilbert (1971) describes several urban bryophyte communities from Newcastle-upon-Tyne, including a species poor Ceratodon_- Bryum argenteum provisional nodum. Though characteristic of rather dry, sandy arable land, hence its position in Fig. 42, Ceratodon purpureus is typical also of the ruderal data and some stands may be referable to Gilbert's nodum. However, before formal recognition could be given to any such syntaxon, it would have to be shown to be distinct from the Sagino_- Bryetum argentei of the Plantaginetalia. Gams (1927) describes presumably monospecific stands including the "Bryetum argentei", "Funarietum hygrometricae" and "Leptobryetum".

Waldheim (1944) described the federation Phascion, apparently based on P. cuspidatum, containing three unions of small annual bryophytes:

Pottietum lanceolatae - containing Barbula hornschuchiana,
Encalyptra vulgaris, Phascum curvicolium, Pottia bryoides,

P. lanceolata, P. intermedia, Tortula subulata and others, and including seven socions (i.e. lower syntaxa dominated by a single species, adopting Barkman's nomenclature - Waldheim gave "societies").

Pottietum truncata - with such species as Funaria fascicularis, Phascum floerkeanum, P. cuspidatum, Physcomitrella patens, Physcomitrium pyriforme, Ephemerum spp., Acaulon muticum, Pottia davalliana, P. truncata and Weissia crispa, and composed of six socions.

Aloinetum - based on Aloina spp., with three socions including one of Barbula fallax.

Von Krusenstjerna (1945) adopted the Phascion, recognising within it the Pottietum truncatae, the Aloinetum and a further union, the Astometum based on Weissia crispa (= Astomum crispum).

Waldheim (1947) more specifically referred to the Phascion as the "Phascion mitriformis", based on Phascum mitriforme which is usually regarded as an intraspecific variant of P. cuspidatum. However, von Hübischmann (1960) adopted the name "Phascion cuspidatae", which would seem more in keeping with Waldheim's (1944) implied usage. However, von Hübischmann maintains separately a "Phascion mitraeforme" and an Aloinion, which he groups with the Phascion cuspidatae in the Barbuletalia unguiculatae v. Hutsch. 1960. Both of the unions described below can be regarded as belonging to the Phascion cuspidatae.

Being based on summer aufnahmen, most of the recorded bryophyte stands are more or less unclassifiable. However, arable stands rich in bryophytes allow the following unions to be recognised:

1. POTTIETUM TRUNCATAE (Gams 1927) Waldheim 1944 (Tab. LXXXIII)

Synonymy: Winter ephemeral community Richards 1928

"Pottietum truncatulae" in v. Hübischmann (1960)Diagnostic Species Group:Pottia truncataFunaria fascicularisPhyscomitrella patensDicranella staphylinaEcology and Distribution:

This union is represented by the main cluster of Fig. 42, excluding the calcicolous species. While including a number of distinct subunions, hence the fragmentation of Fig. 41, the union in general can be regarded as characteristic of mesic to base-poor damp ground. Map 29 shows the union to be widespread, though with concentrations of records on base-poor soils in the Hampshire Basin, Dorset and Anglesey. Richards (1928) described similar bryophyte vegetation from fields and disused allotments, the communities reaching maximum development in February. His data from the late-summer ephemeral communities of exposed mud also show similarities to this union though are probably not referable to it.

The aufnahmen given in Table LXXXIII include those referable to two new provisional subunions:

- i) Subunion of Bryum klinggraeffii, subunion nov. (prov.)
differentiated by Bryum klinggraeffii and B. violaceum. The type aufnahme is 389 (Tab. LXXXIII, Col. 20), from Rhoscolyn, Holy Island, Anglesey. The subunion appears to be characteristic of the more fertile soils.
- ii) Subunion of Pleuridium subulatum, subunion nov. (prov.),
differentiated by Pleuridium subulatum. The type aufnahme is 405 (Tab. LXXXIII, Col. 32), from Chwillog, Caernarvonshire. The subunion is characteristic of sandy, base-poor ground. Von Hübischmann (op. cit.) describes a floristically similar subassociation of Dicranella varia. However, examination of his tables shows that he uses the

name "Pleuridium subulatum" for P. acuminatum (see Sect. 1.4.2).

Nevertheless, if his records of Dicranella varia should now be referred to D. staphylina (the relative European distributions of these species are, as yet, poorly known), then this subunion may not be distinct from his subassociation.

Von Hübschmann also describes a subassociation of Bryum argenteum, some aufnahmen which might be referred to this are given in Table LXXXI. This table also suggests the existence of a further subunion differentiated by Ditrichum cylindricum.

2. PHASCETUM FLOERKEANI union nov. (prov.) (Tab. LXXXII)

Synonymy:

? Association à Riccia crystallina et Siphonées Allorge
1921, p.p.

Diagnostic Species Group:

Phascum floerkeanum

Dicranella varia

Bryum klinggraeffii

Pottia davalliana

Barbula fallax

Phascum curvicollum

Syntaxonomy:

This group of species is distinct in Figures 41 and 42 and clearly deserves separate recognition. Waldheim's (1944) rather heterogeneous Pottietum truncatae includes Phascum floerkeanum and Pottia davalliana. However, his data, from Scandinavia, do not appear to include this community, as such, of the southern chalk. Van Melick (1975) records Phascum floerkeanum as new to the Netherlands with associated species undoubtedly referable to the Pottietum truncatae. Thus the present union appears to be an undescribed syntaxon of areas south of these workers. The type aufnahme is Aufn. 168 (Tab. LXXXII, Col. 1), from Shoreham, Kent.

Ecology and Distribution:

The union is restricted to the chalk of southern England (Map 28) where it typically forms part of Linarietum spuriae stands.

As well as the two unions described above, the Riccia glauca - Anthoceros - Gesellschaft Koppe 1955 appears to occur in Britain as a rare development on clayey fallow fields. It is characterised by the combined occurrence an Anthoceros spp. and Riccia spp.; descriptions are given by Koppe (1955) and von Hübschmann (op. cit.) No stands were encountered during the survey, but Aufn. 516 (Tab. XXIX) may approach it. Westhoff and Den Held (op. cit.) place this community in the Centunculo - Anthocerotetum.

Chapter NineDiscussion

The final question which must always be asked following a classificatory survey is the simple one of has the classificatory technique worked? This cannot be answered without further fieldwork to test the validity of the syntaxa recognised, but Table LXXX provides a summary of the classification of the data of the current survey. All arable communities of the Stellarietea are tabulated.

It is remarkable just how much a weak association table can be strengthened by drawing boxes around the constancy values which it is desired to emphasise. Table LXXX certainly contains inconveniently low constancy figures within some boxes, and inconveniently high constancy values outside others. Nevertheless, if the manipulation of the collected data has resulted in a scheme applicable to all British arable vegetation, then undoubtedly arable weed associations genuinely exist. Admittedly, some associations are poorly defined, and would not have been recognised but for the influence of continental work. No apology is made for this; the Zürich-Montpellier system requires that only well developed stands of vegetation be examined. A circular argument exists here, the syntaxon must be established before the quality of development of its stands may be judged. Nevertheless, it is indisputable that modern arable weed stands are for the most part not well developed. This survey should have been carried out forty years earlier.

A noteworthy feature of any comparison between the Z-M classification and the results of the objective chi-squared analyses is that they do not agree. At least, the diagnostic species groups

of several associations do not show up in the plexus diagrams. In many cases, data sets contained insufficient aufnahmen of any one association for this to be possible, but the more basic explanation lies in the lack of weighting in the chi-squared analyses.

Repeatedly, the most prominent clusters in plexus diagrams represented factors such as soil moisture levels. However, the Z-M classification of arable communities across Europe has, over the years, found it more convenient to give a low weighting to such indicator species, with climate, geology and farming methods, or at least the species characteristic of these, given more weight. Thus each association occurs on soils of varying moisture.

The clusters of the plexus diagrams are thus often more usefully recognised at infra-associational levels, though clusters merely represent groups of species with approximately the same distributions and in some cases represent groups of alliance, order or class differential-species. Most obvious in the Z-M classification are the series of subassociations of damper ground. The names vary, but the differential species, e.g. Juncus bufonius, Gnaphalium uliginosum, remain typical of these parallel subassociations.

Häfliger and Brun-Hool (1971) remark on their similarly clear sets of parallel subassociations in Swiss data. It should be added that the ordination tables produced for different areas during the early stages of the Z-M analyses were also too geographically restricted to show many of the associations eventually recognised, but corresponded extremely well to the final plexus diagrams for the same areas.

Any future work clearly must include further consideration of the four new associations provisionally described here. The three Spergulo - Oxalidion associations are very restricted geographically and despite their floristic distinctness, a conservative view of

European associations might still, on present knowledge, demand they be sunk into the Spergulo - Chrysanthemetum. The relationship of the fourth association, the Cardaminetum hirsutae, to spring aspects of other communities still requires clarification. Nevertheless, the overall classification given here is presented with confidence.

Chapter TenProposals for the conservation of arable communities

The approach to arable weed vegetation adopted here is very much that of the ecologist studying an interesting set of communities containing a number of rare species. It is perhaps irrelevant to the aims of the survey that the owners or users of the land regard most components of these communities with considerable disfavour. Conservation of arable weed communities is not, therefore, a simple problem. Indeed, a government-financed body, the Weed Research Organisation, exists solely to find the best ways of further destroying this vegetation.

The author is just as interested in obtaining good quality vegetables at reasonable prices as is any other member of the public and for virtually all arable land, further depletion of arable weed communities is not only inevitable but desirable, so long as eliminated species are not replaced by others which are even more competitive to crops. It does seem that in some cases, the heavy applications of selective herbicides, encouraged, naturally, by intensive advertising in farming journals, is not always benefiting the farmer even where he is succeeding in pushing yet another weed species to the brink of extinction.

Conservation of weed vegetation has not, until very recently, been even considered by many influential ecologists. An important review of conservation needs in Britain by the British Ecological Society (1944) emphasised only "natural" vegetation; arable land did not rate a mention. Very recently, the Nature Conservancy Council (1976) has been much more concerned with the arable habitat. They

report on the decline of populations of birds such as goldfinches and linnets which depend on weed seeds for food. Others, such as young partridges, depend on insects which in turn depend on weed populations. A specific instance is the decline of a turtle dove population in Oxfordshire following spraying of fumitory on which they specifically depended. This consideration of entire arable ecosystems is to be applauded, but one is left in little doubt that turtle doves are regarded as substantially more important than fumitory, despite the fact that most species of fumitory are rarer and declining considerably more rapidly than turtle doves.

The future, then, is bleak for many arable weeds, with a considerable number very close to extinction and some apparently already gone. Many of the remaining sites are conserved almost by accident. The Kent locality for Althaea hirsuta, which also has Ajuga chamaepitys, Filago pyramidata and an abundance of Anagallis foemina along with other local calcicoles, happens to be adjacent to woods conserved for game-birds. Current policy happens to be that game-birds are more important, hence herbicides are not used. Elsewhere, Agrostemma githago persists only because a farmer is sufficiently nostalgic to allow it to remain in the corner of one of his fields. Veronica acinifolia and Galium tricornutum remain in what may be their only remaining sites because the gardens in which they have spontaneously appeared happen to be owned by botanists.

Any rational conservation of weed species must be on a community basis. While all associations are depleted of species in most of their stands, the extreme associations are the most affected. On very base-poor, sandy ground, the Teesdalia - Arnoseridetum minimae has all but disappeared while on the most fertile chalky loams of the south, the Adonido - Iberidetum amarae has fared no better.

The clue to the conservation of the Teesdalia - Arnoseridetum is provided by the activities of the Suffolk Naturalists' Trust in conserving the rare Breckland therophytes of the Sedo - Scleranthetea. By management of small plots, the Veronica species and others are being maintained under conditions similar to the former "brecks". Watt (1971) gives an account of the conservation of Breckland species. Similarly, reploughing of small areas of grassland or heath at old Surrey sites for Arnoseris minima could well result in the appearance of the association, and perhaps A. minima itself. Such plots could be maintained with very little labour, and the absence of fertilisers would exclude those species which have generally replaced Arnoseris and its associates. Cultivations could be timed to benefit winter annuals.

Calcicolous species may be less easy to preserve in a natural state. Fallow chalky plots do not necessarily resemble any particular association, and it could well be that the rarer species require the presence of the crop. Some local naturalists' trusts now have agreements with local farmers that portions of fields remain unsprayed, but financial losses on someone's part can easily result. More promising are the recreations of historic farms, mainly for historical or archeological objectives. Old farming methods are being reimposed and this must benefit some of the declining species. Introduction of Adonis annua to such a site on chalk could recreate the Adonido - Iberidetum. A problem, however, is that A. annua and some others are only doubtfully native. A truly authentic reconstruction of early agriculture could demand the elimination of some of these species along with Veronica persica, Matricaria matricarioides and other certain introductions.

Appendix I

Distribution Maps

The following maps must be carefully interpreted with reference to the areas surveyed (Fig. 1; Overlay 1). Thus concentrations of records in East Anglia and Dorset may partly be artifacts of the uneven sampling. Similarly, the lack of records from Central England, Central Wales and S. W. Scotland may in some cases be due to the poor coverage of these areas.

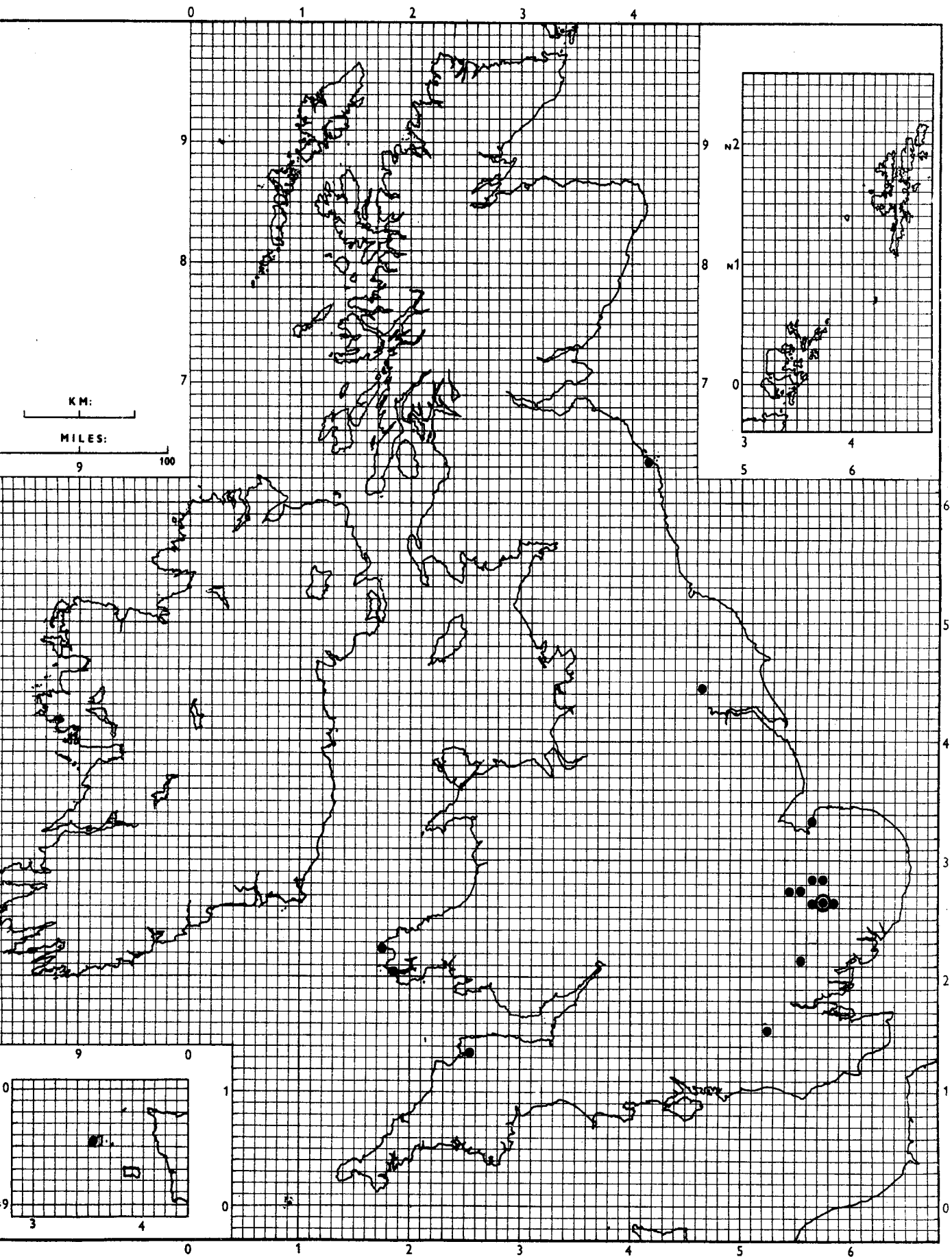
The position of the Isles of Scilly on the base-map is inconsistent with the National Grid as marked on the relevant Ordnance Survey map. Records from the Isles of Scilly are plotted in their true position.

The Channel Islands are also incorrectly placed on the base-map used. Only Guernsey was visited during the survey and records have been plotted such that they coincide with the island as drawn on the base-map. The convention of Perring and Walters (1976) whereby all Guernsey records are plotted in one square, allowing Herm records to be recognised separately, has not been followed here.

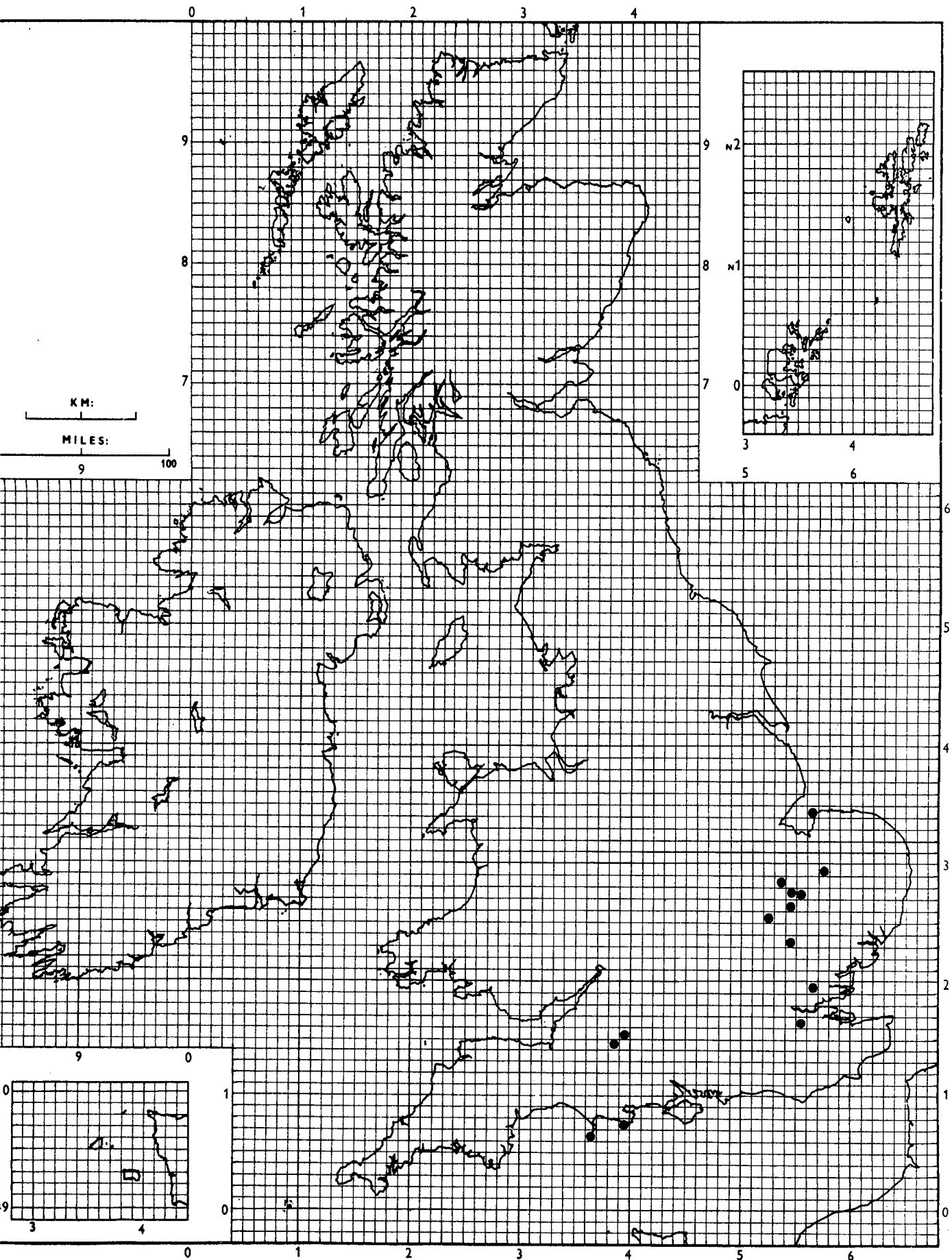
Overlays to these maps are to be found in the folio volume.

• Veroniceto-Lamietum

○ Setario-Veronicetum politae

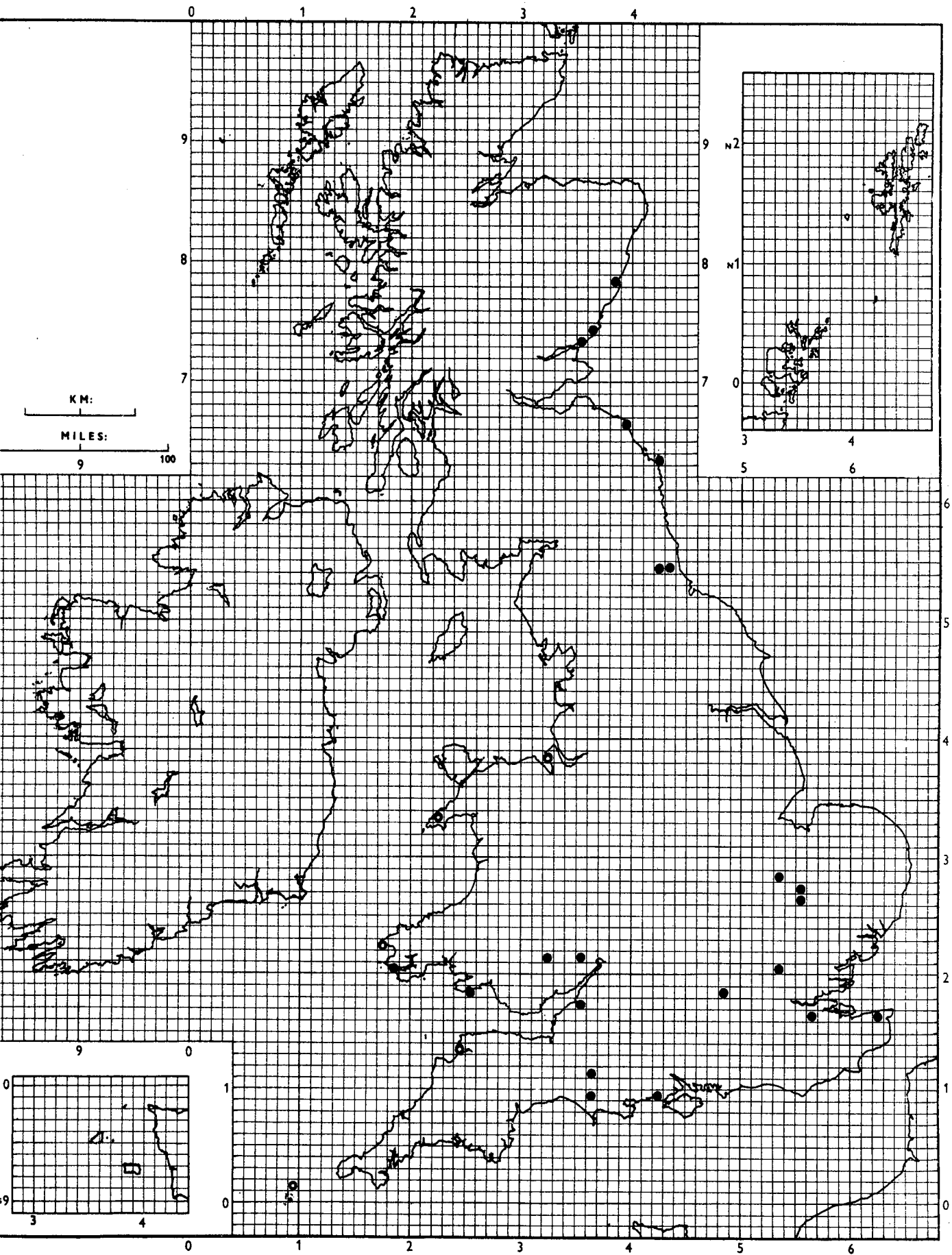


● Alopecureto-Matricarietum

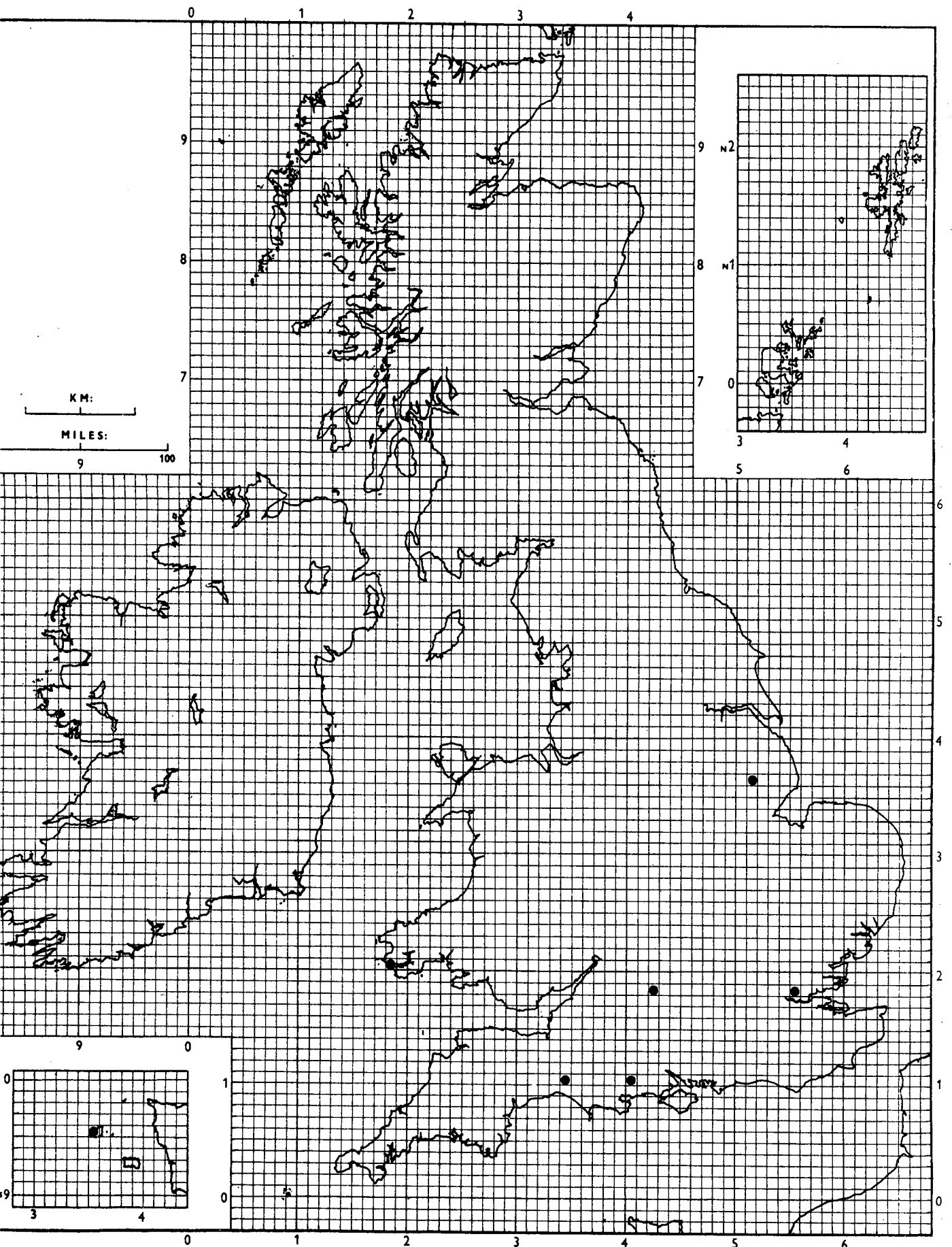


● *Fumarietum (officinalis)*

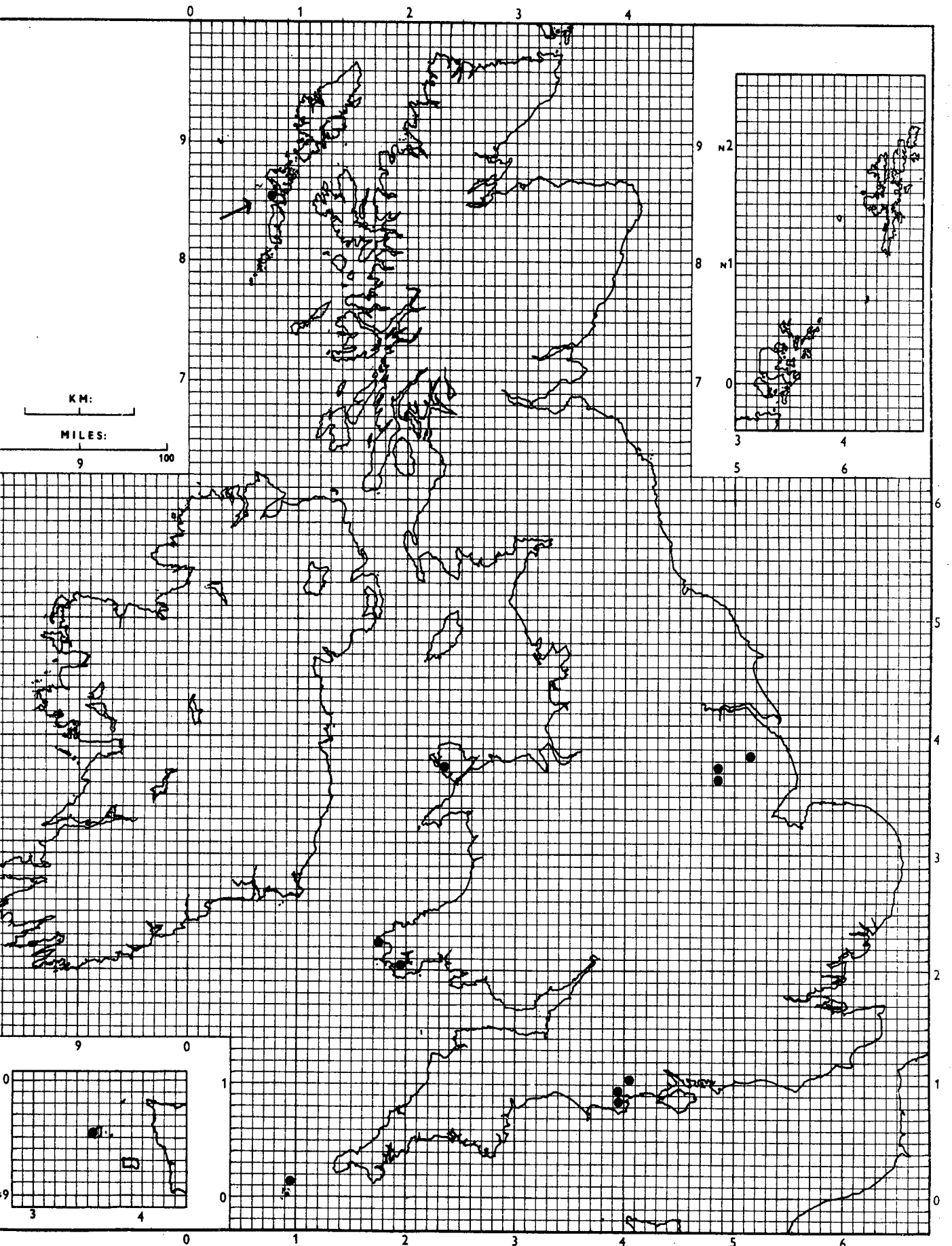
○ *Fumarietum bastardii*



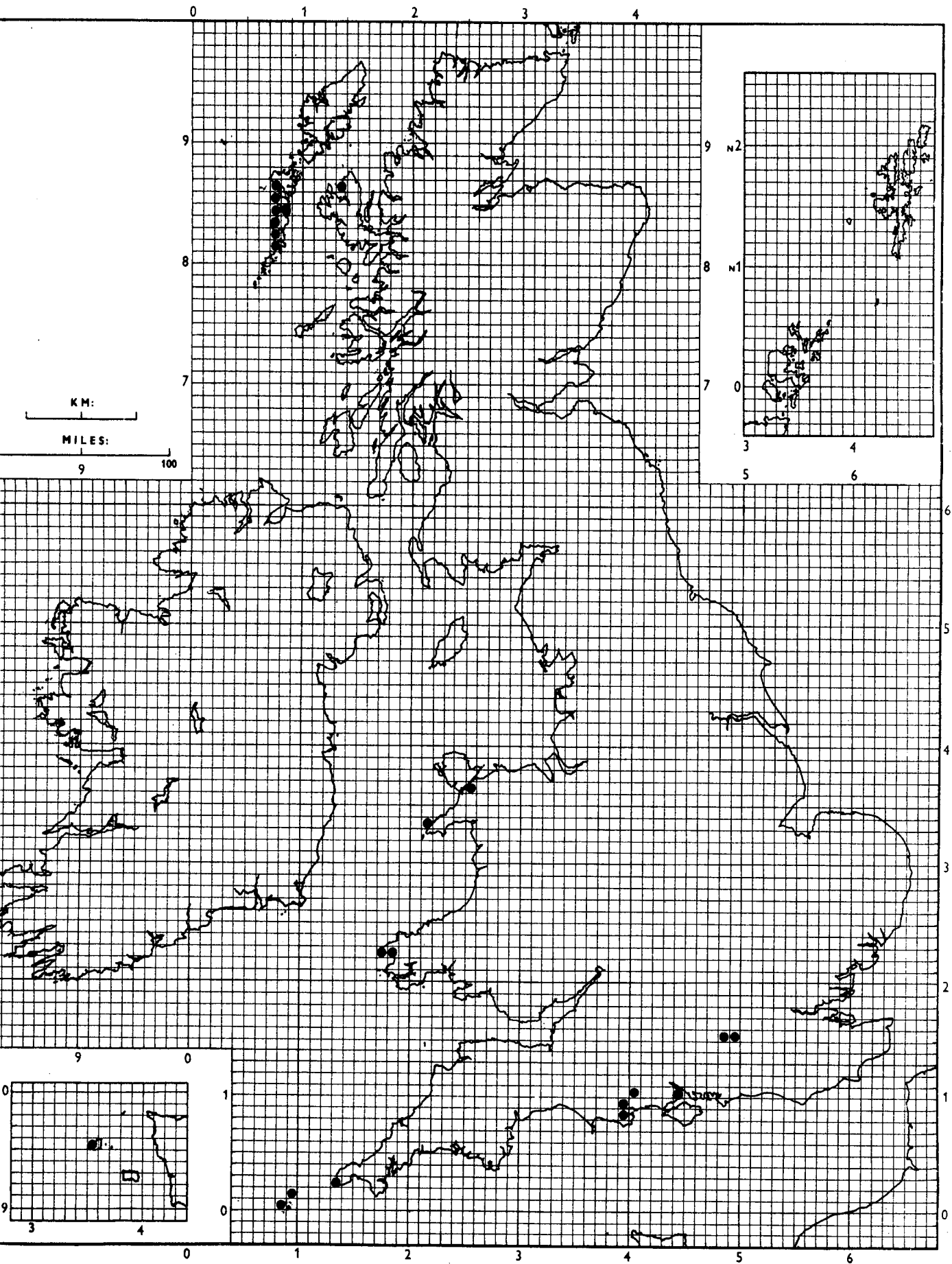
● *Oxalido-Chenopodietum polyspermi*



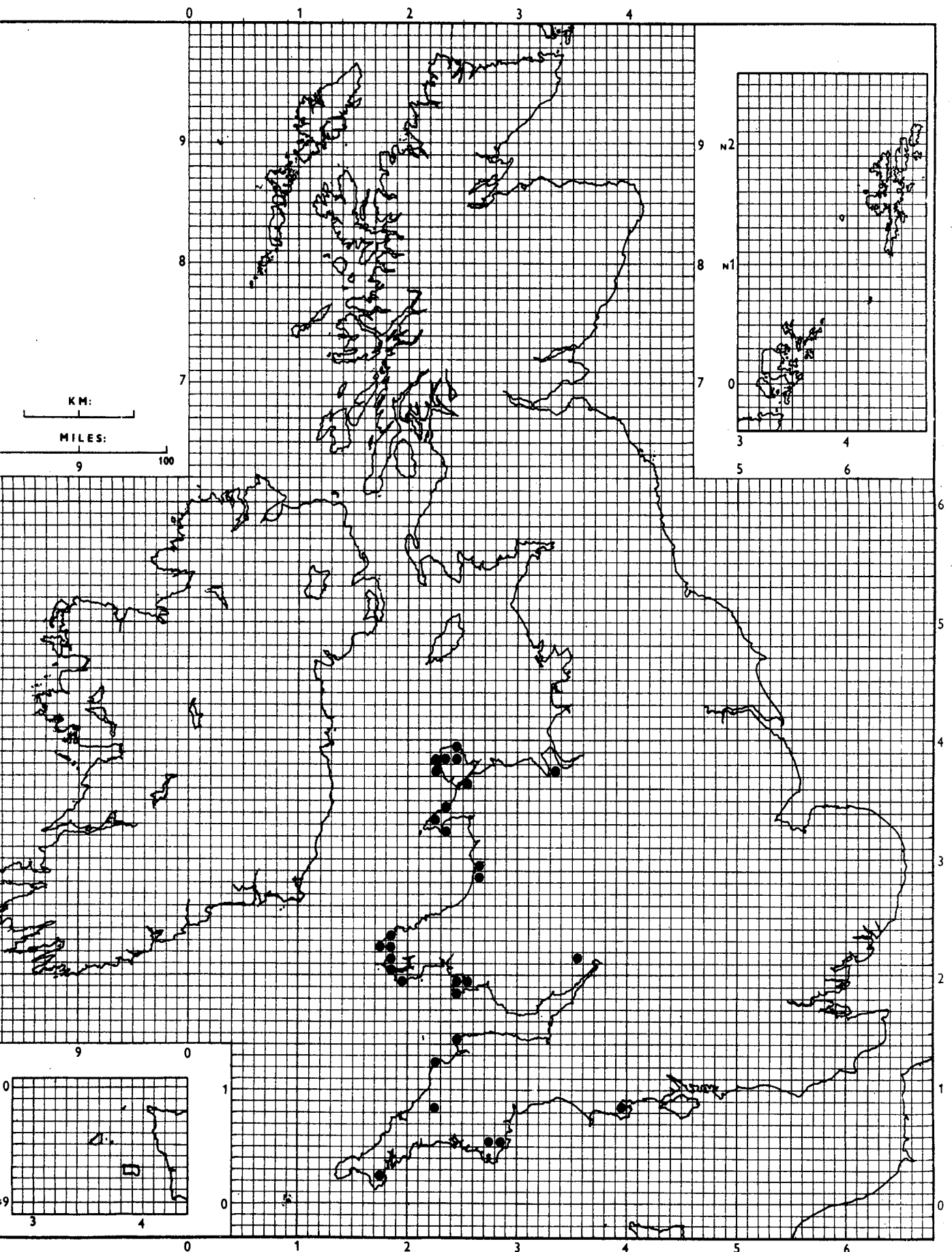
• *Spergulo-Chrysanthemetum subass. typicum*



● Spergulo-Chrysanthemetum subass.
ranunculetosum

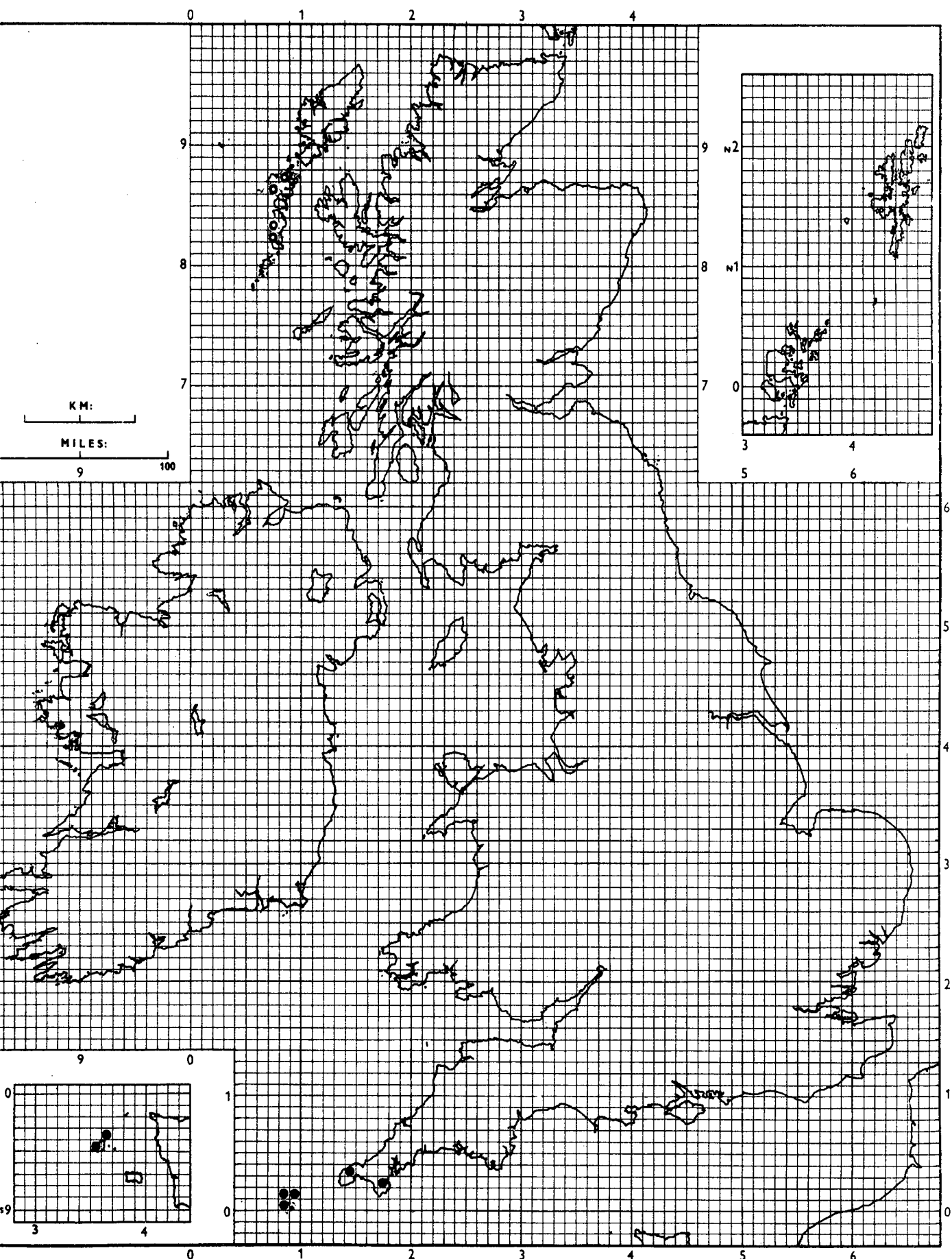


● *Stachys arvensis* Comm.



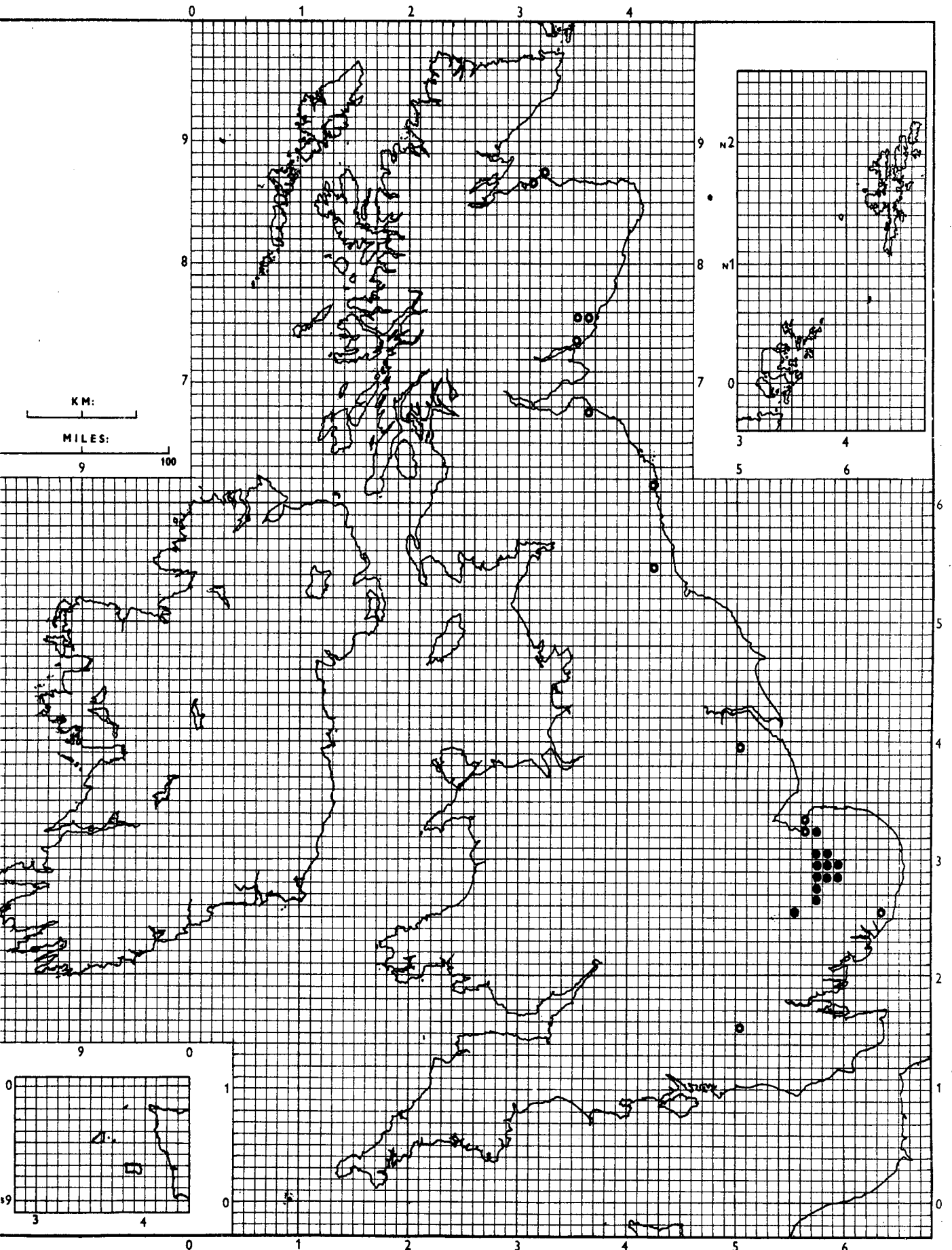
- Chenopodio-Violetum curtisii,
including transitions to the Galio-Koelerion.

- Medicagini-Ranunculetum

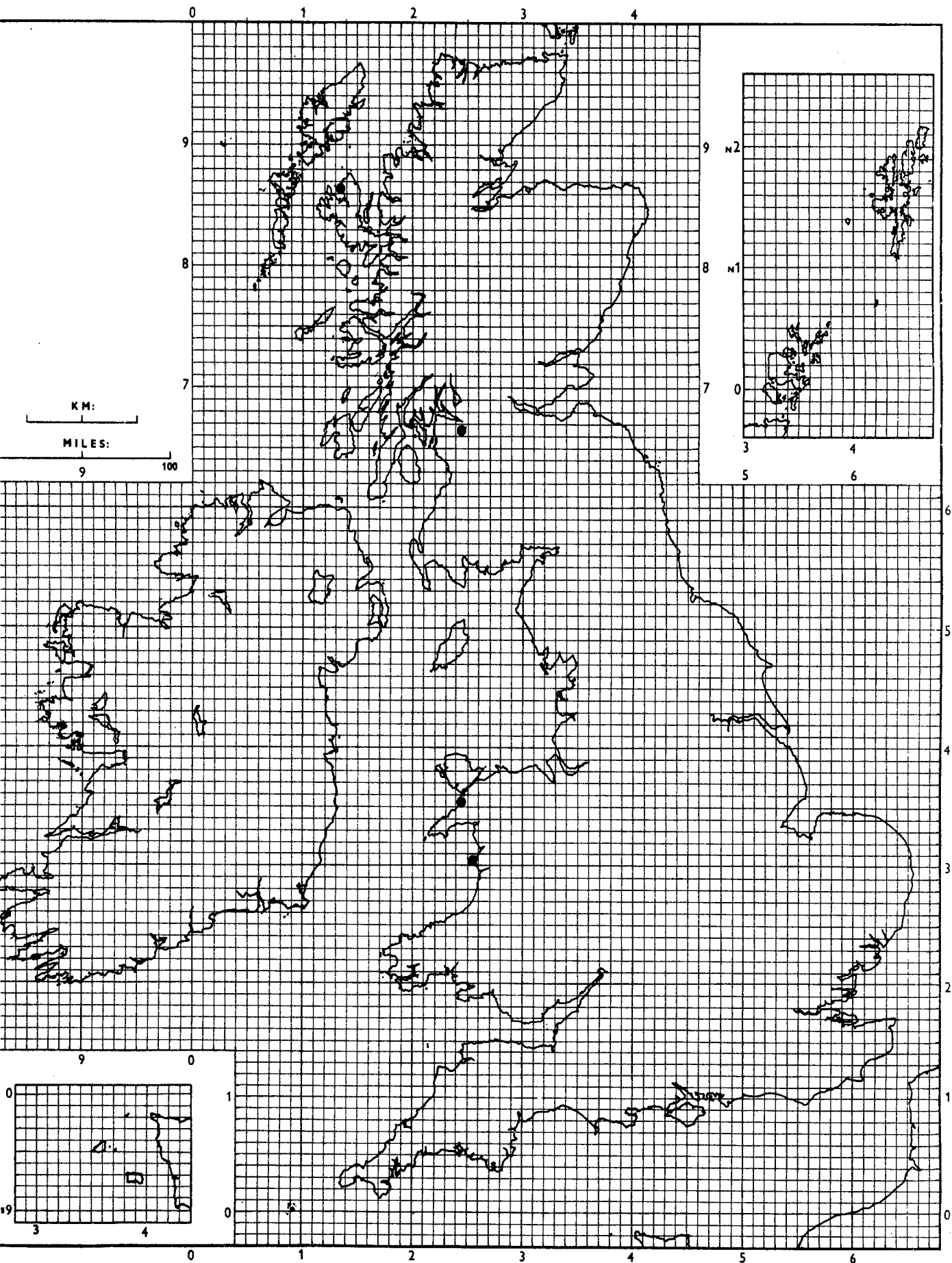


• *Descurainio-Lycopsetum*

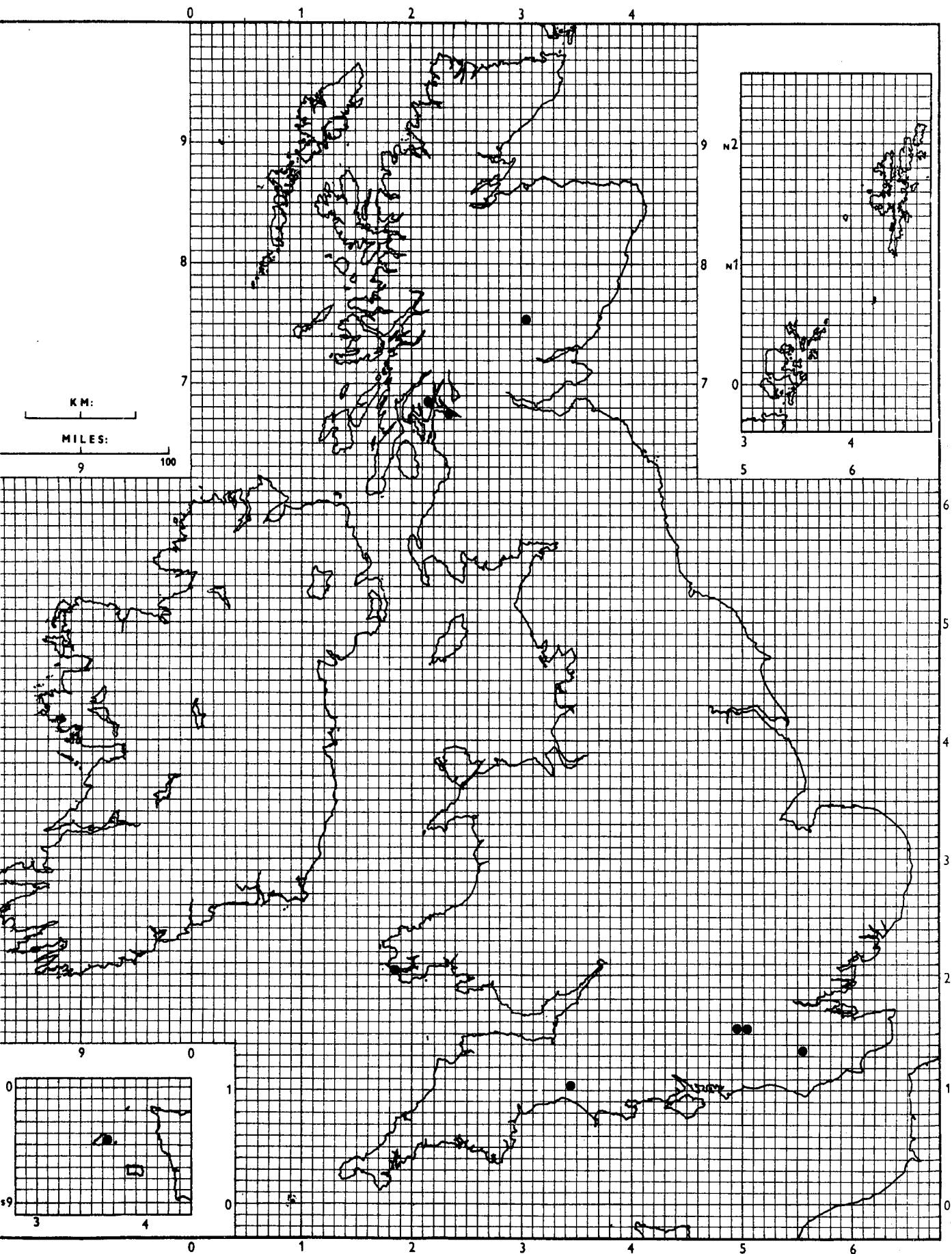
• *Lycopsetum arvensis*



- Galeopsis speciosa - G. bifida Ass.,
including record of Birks (1973) from Skye.

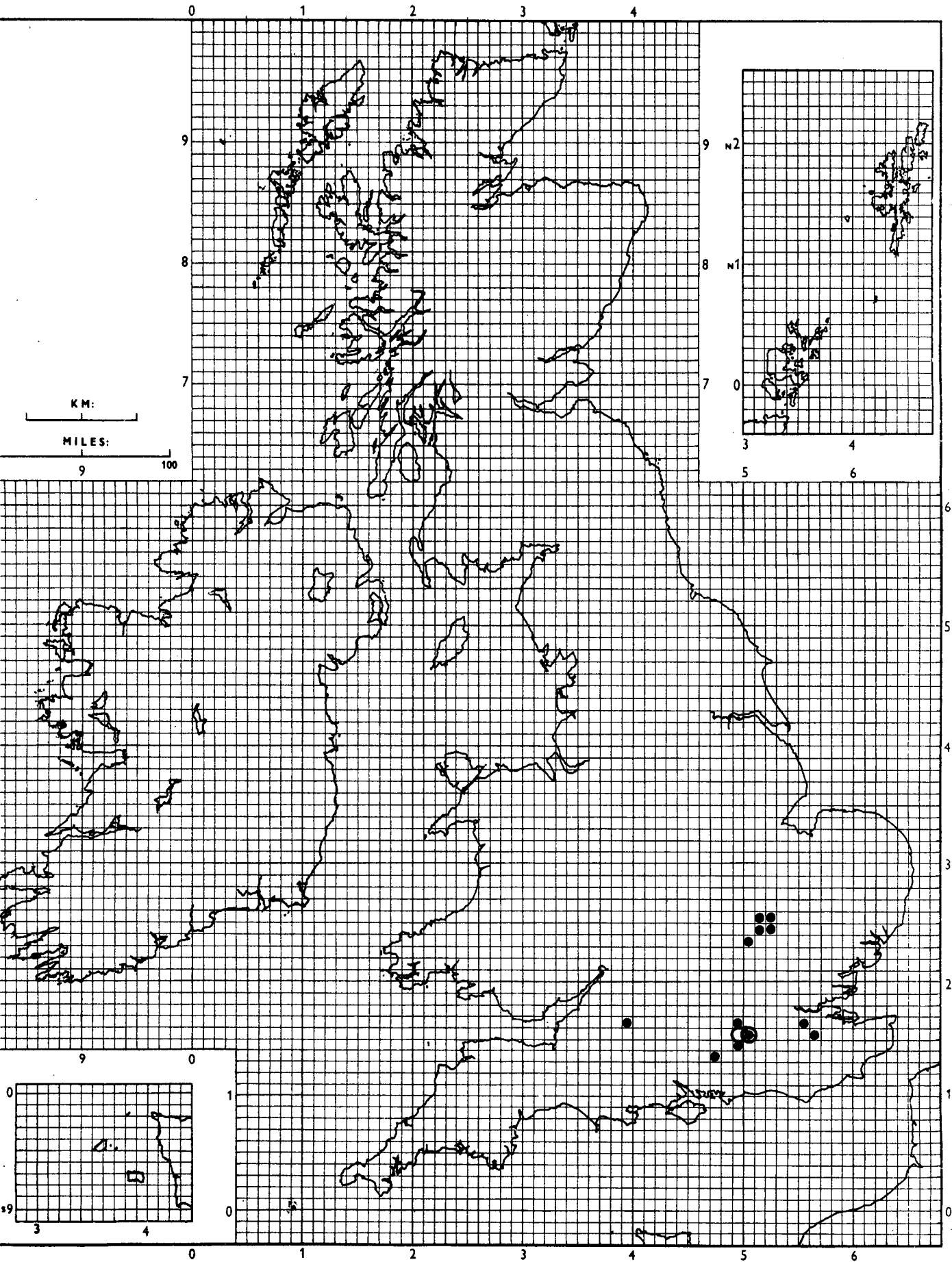


● *Cardaminetum hirsutae*

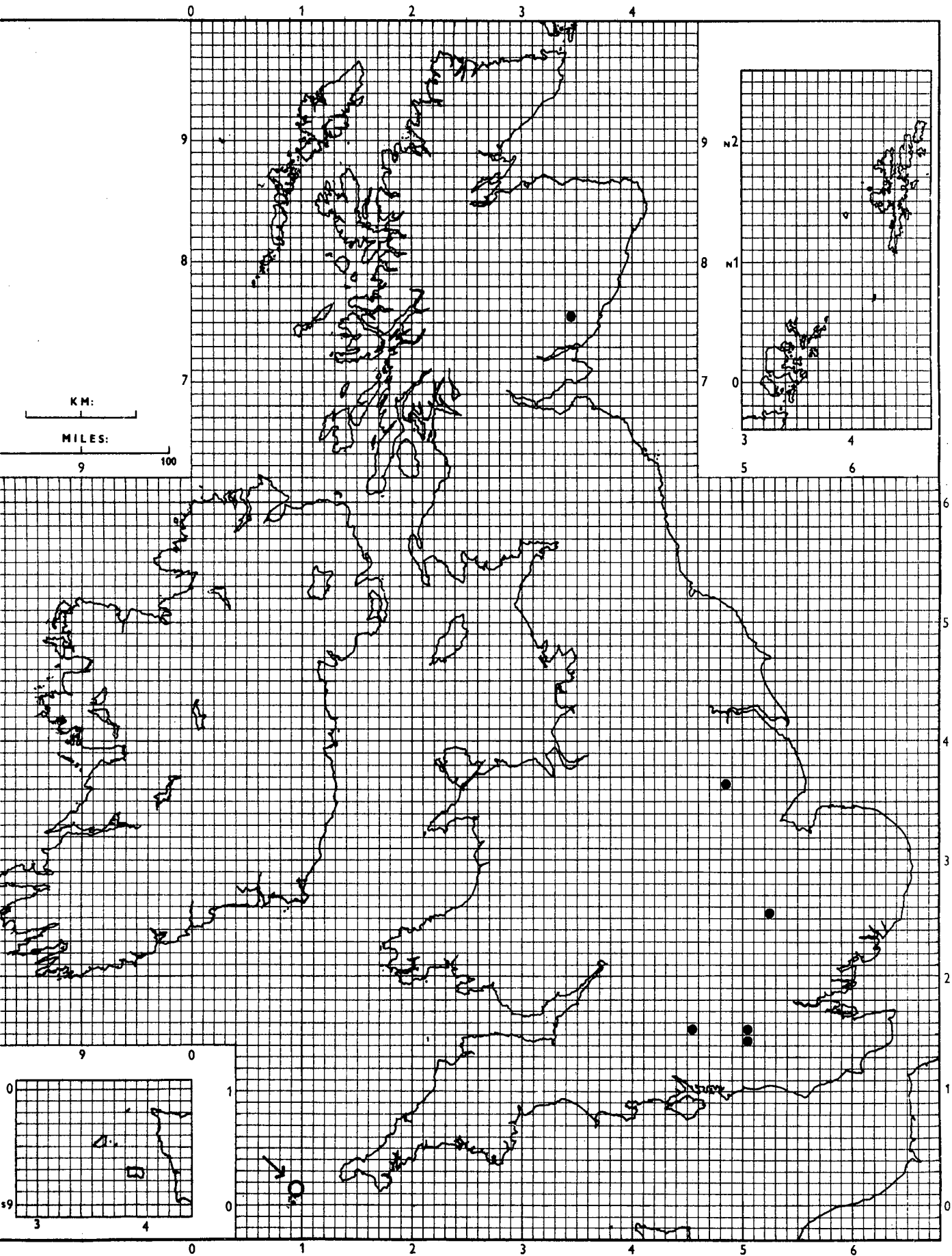


○ Echinochloeto-Setarietum

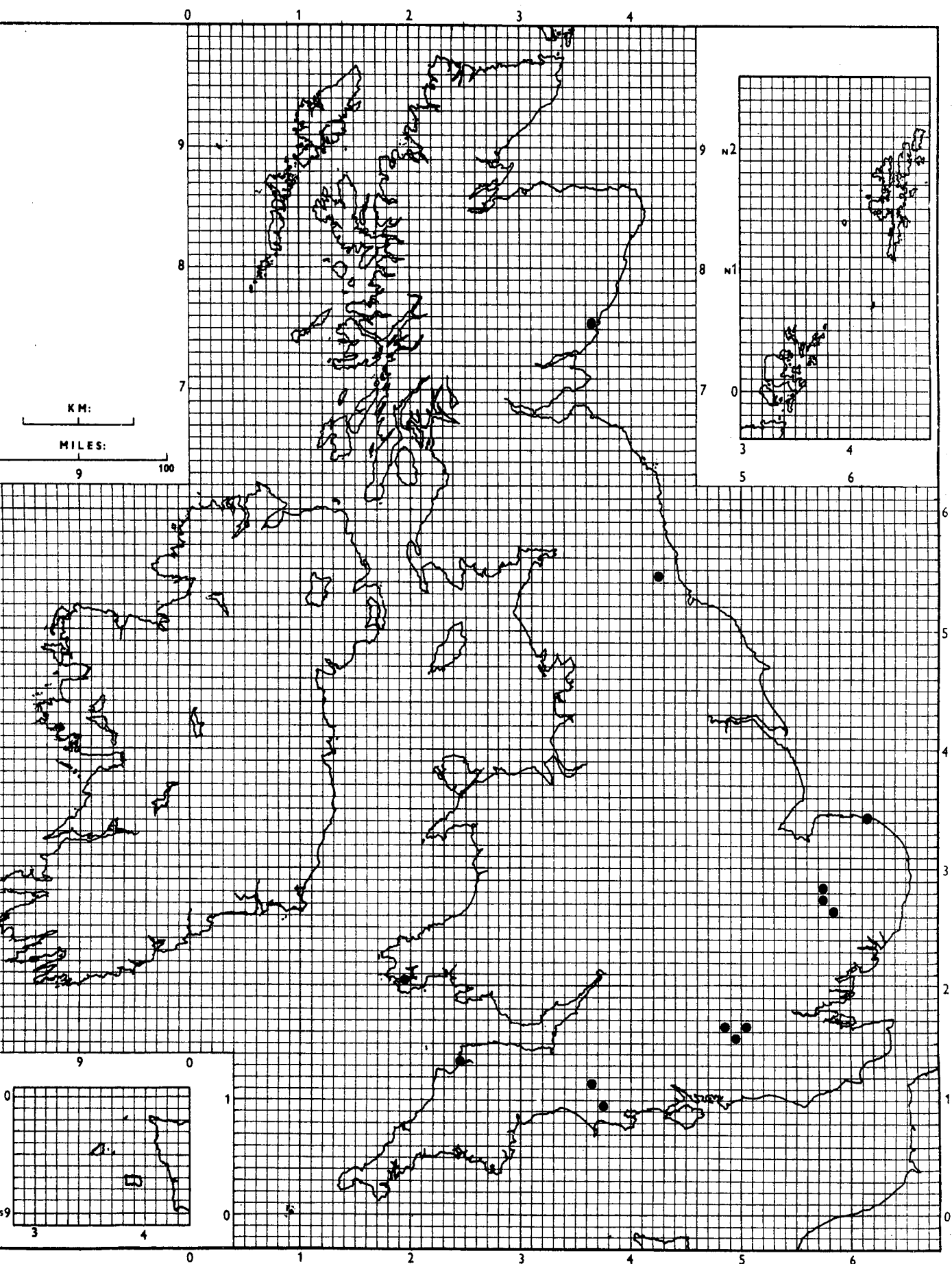
● *Spergula arvensis* - *Lamium amplexicaule* Comm.



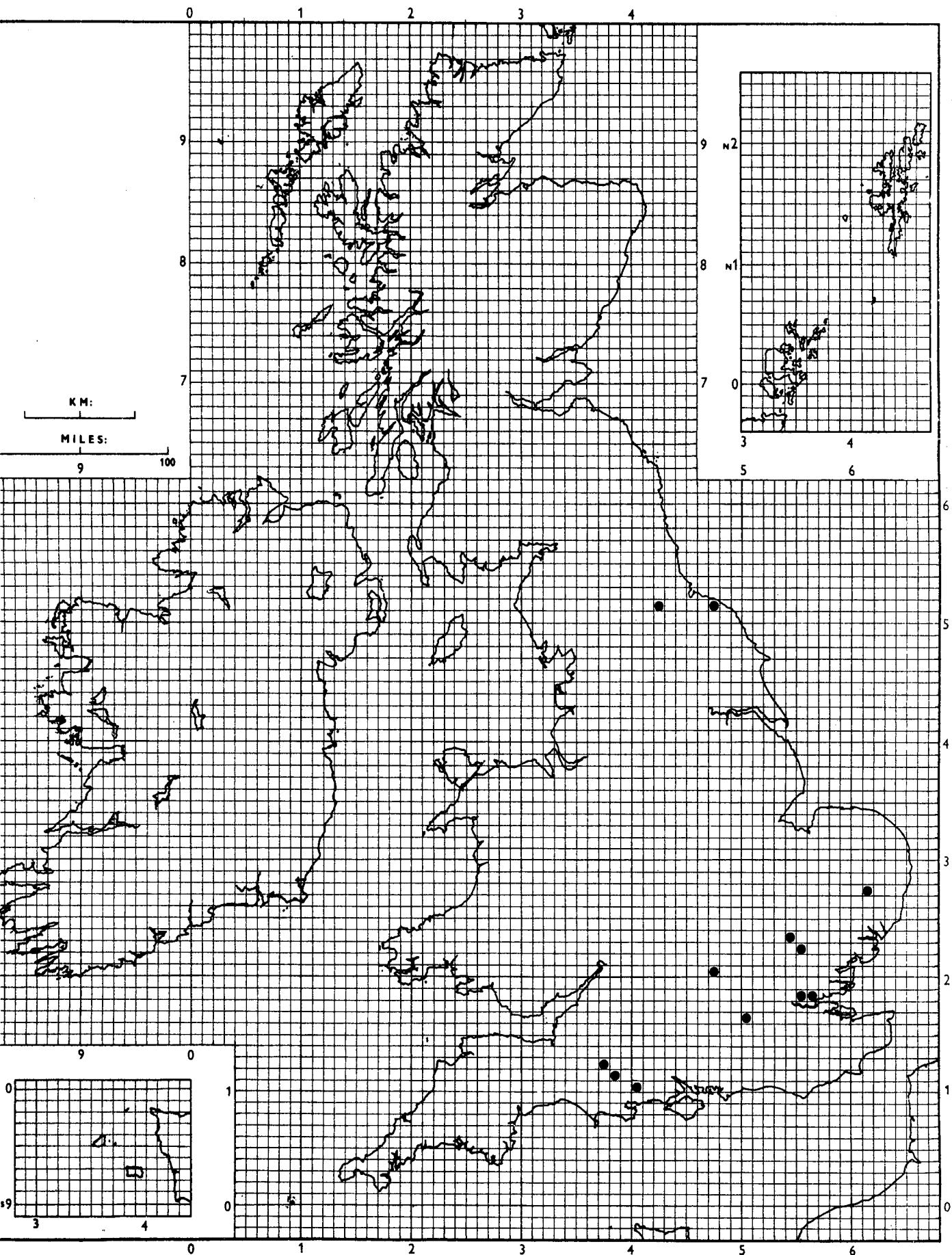
- Teesdalio-Arnoseridetum minimae
- Airo (multiculmis)-Arnoseridetum minimae



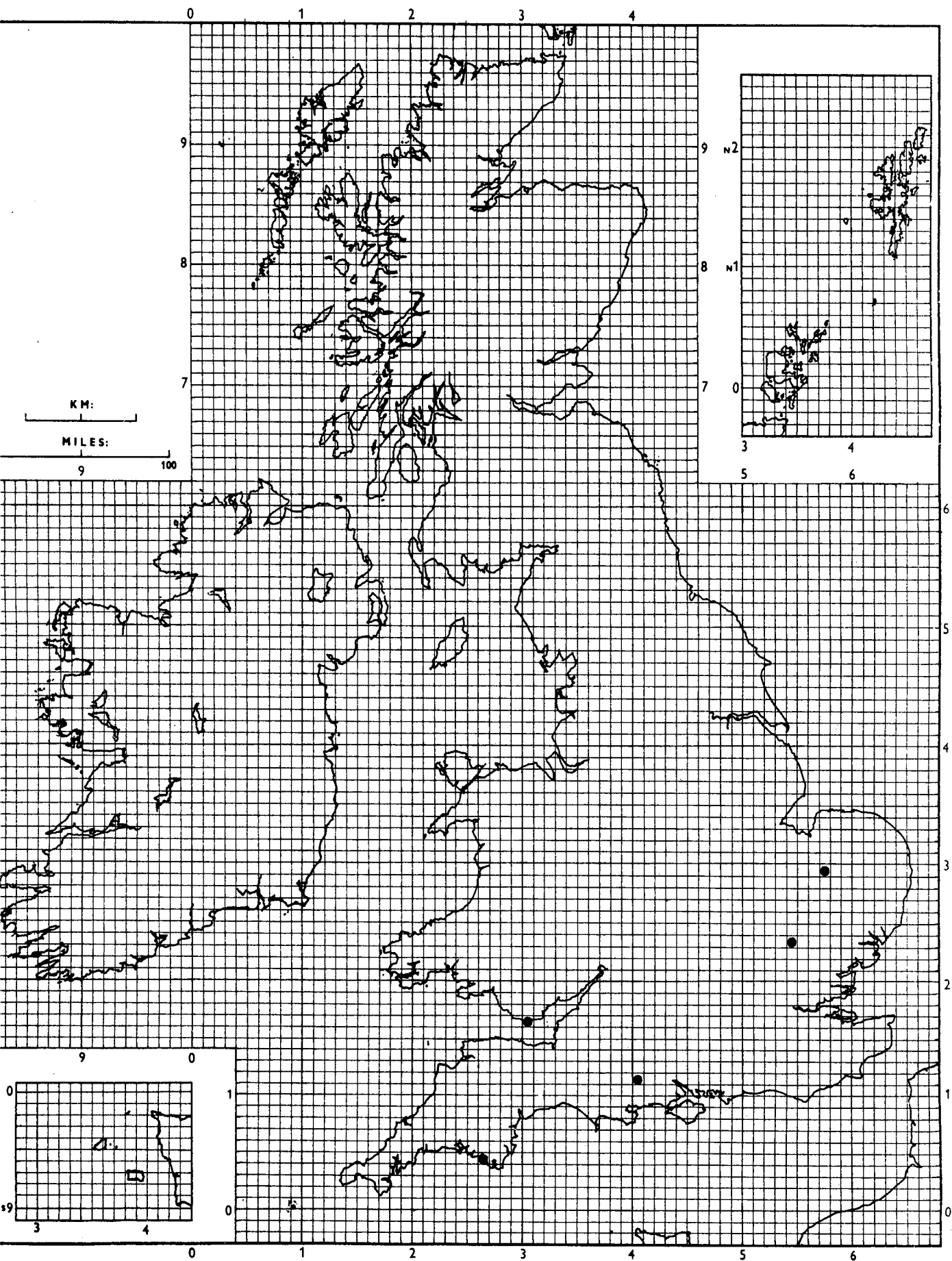
• *Papaveretum argemonae*



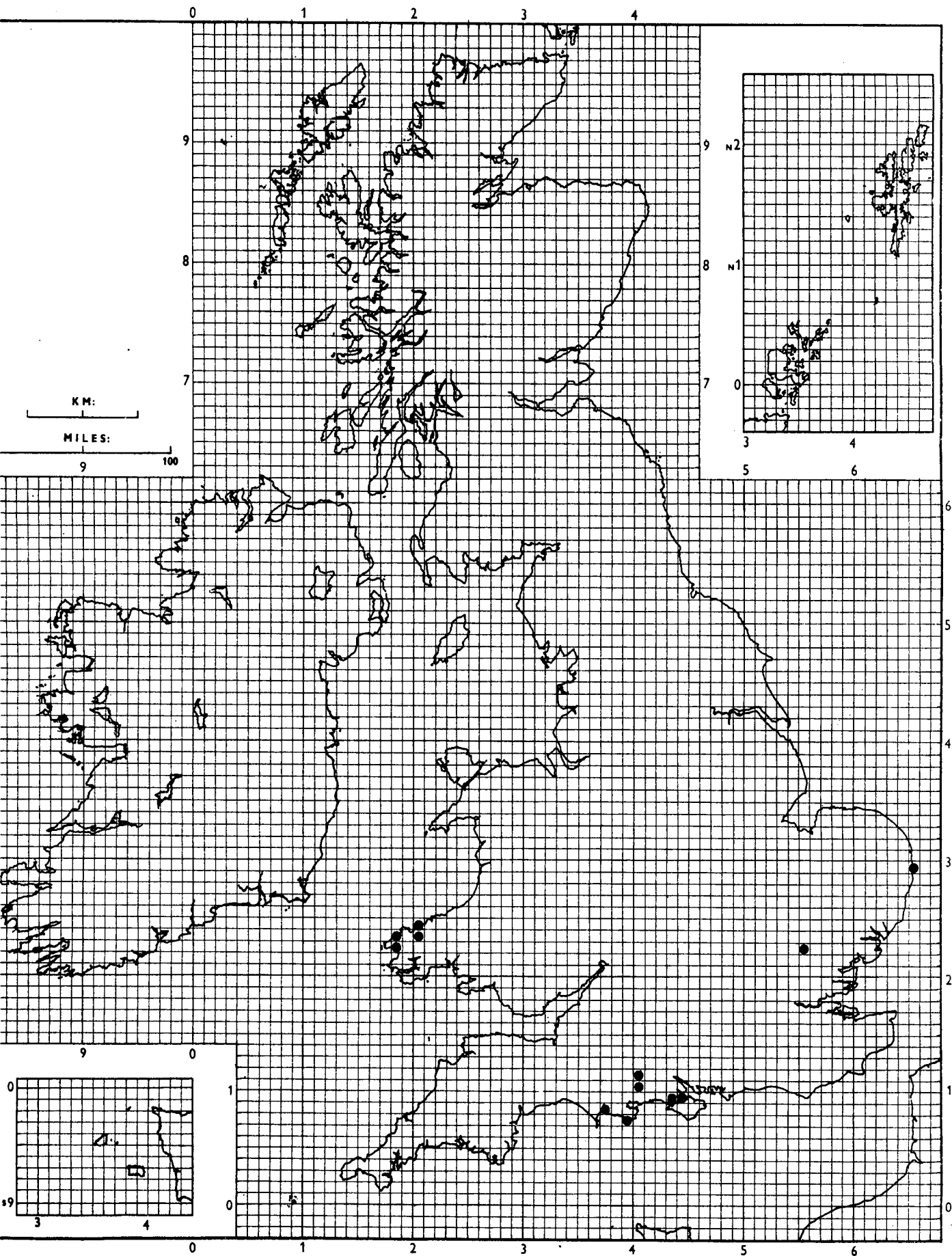
● *Alchemillo-Matricarietum chamomillae*



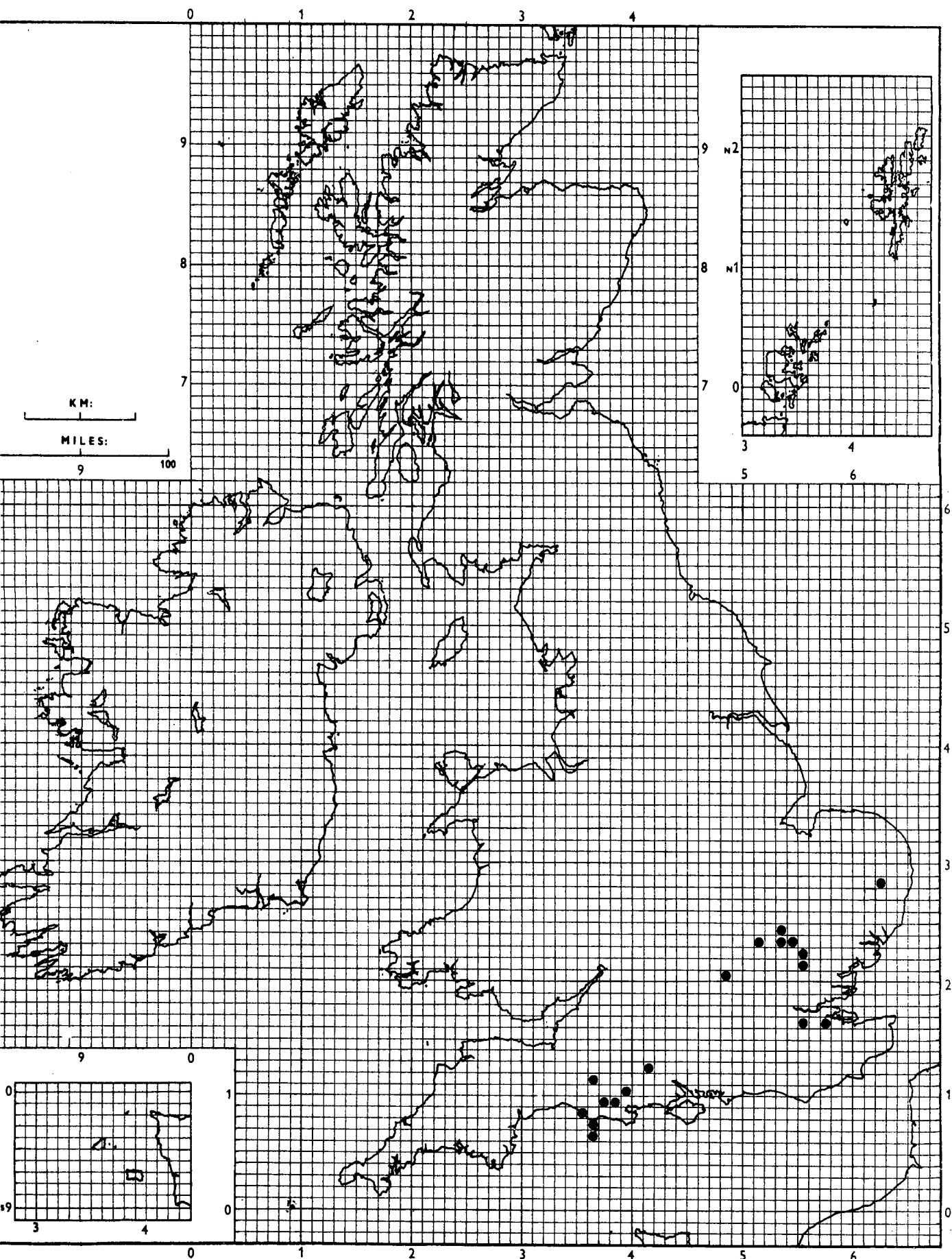
• *Euphorbia exigua* - *Avena fatua* Comm.



● Kickxia elatine - Aphanion

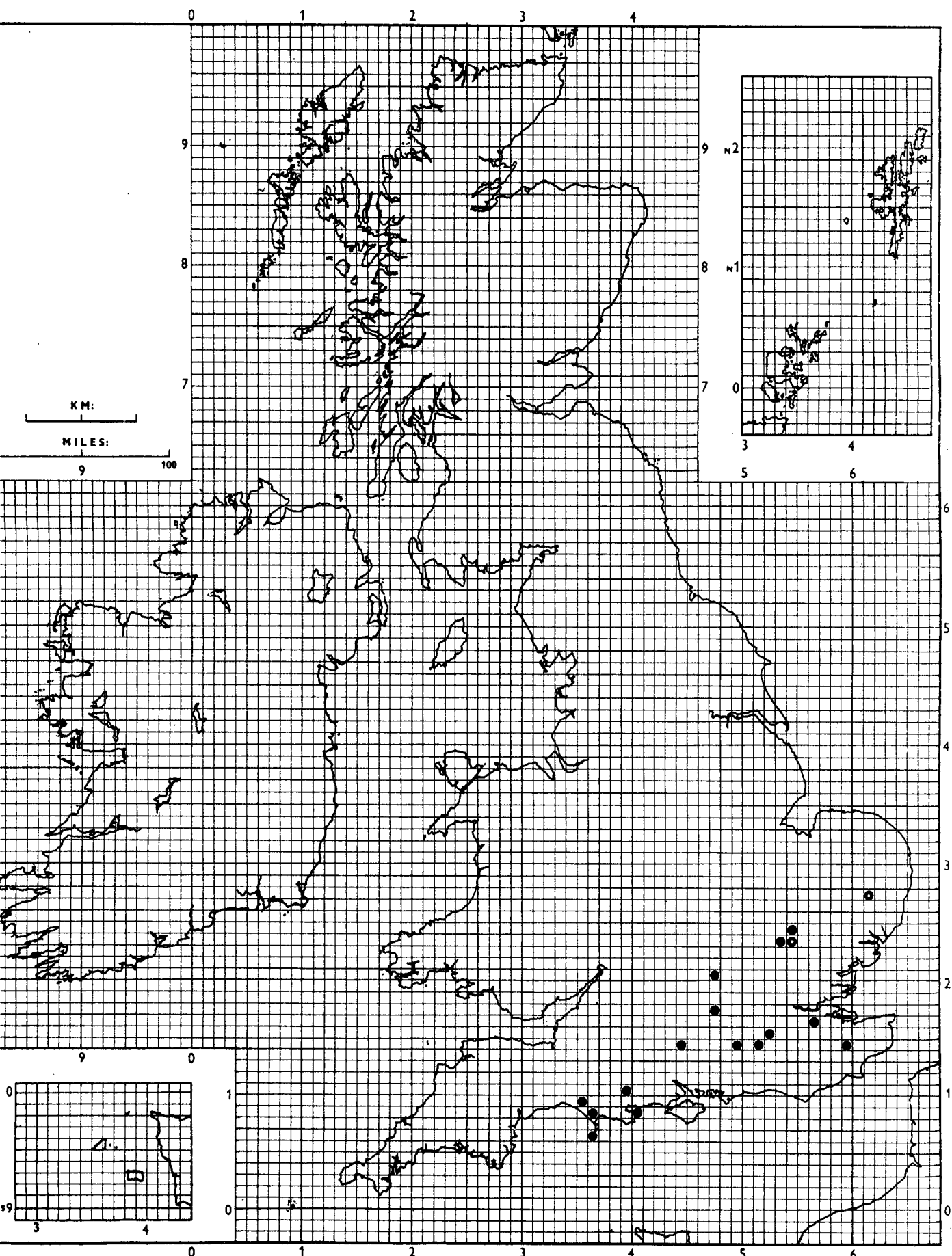


- Linarietum spuriae: stands not assigned to a subassociation.

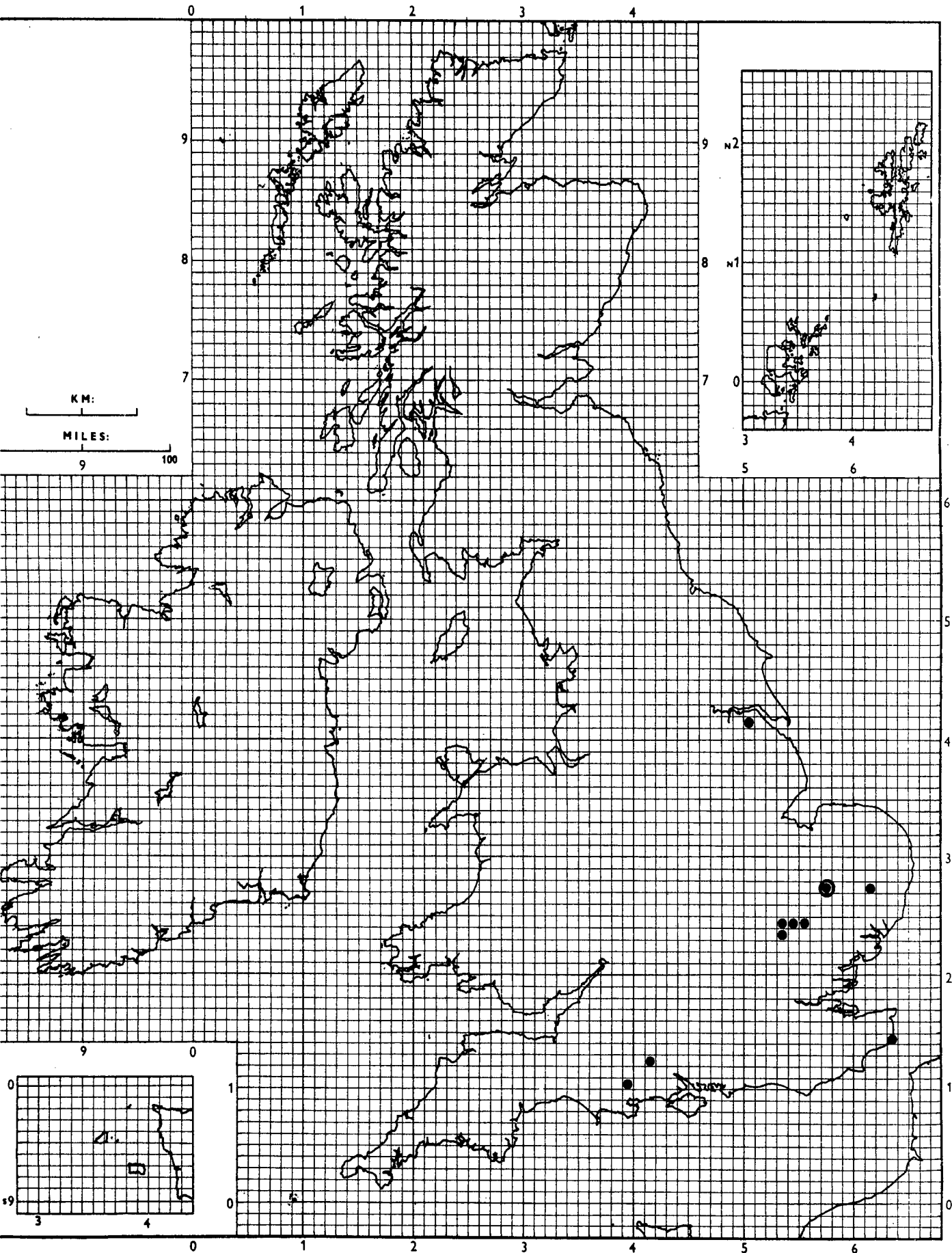


● *Linarietum spuriae* subass. *sherardietosum*

○ *Linarietum spuriae* subass. *equisetetosum*

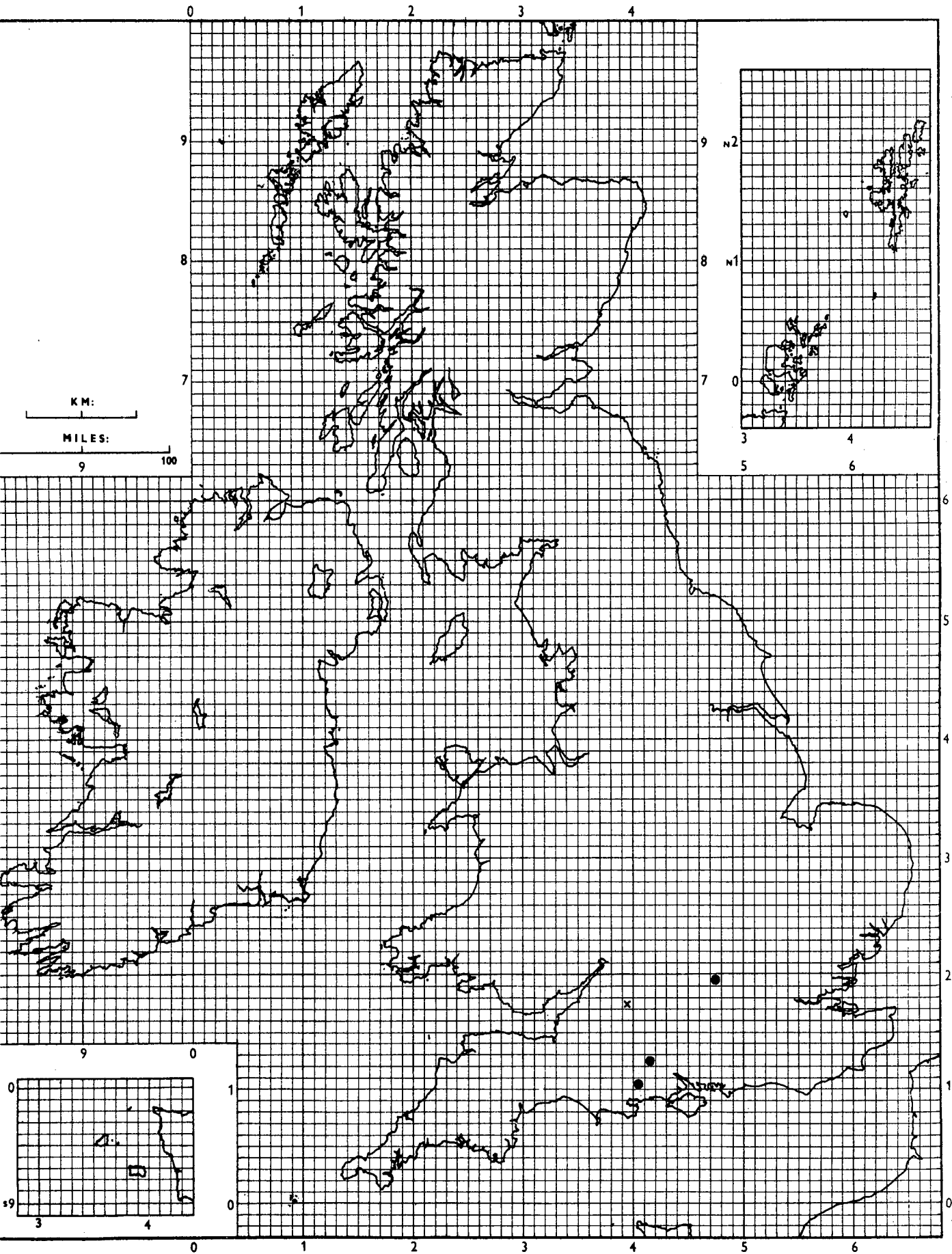


- Papaveri-Melandrietum subass. tripleurospermetosum
- Papaveri-Melandrietum subass. descurainietosum

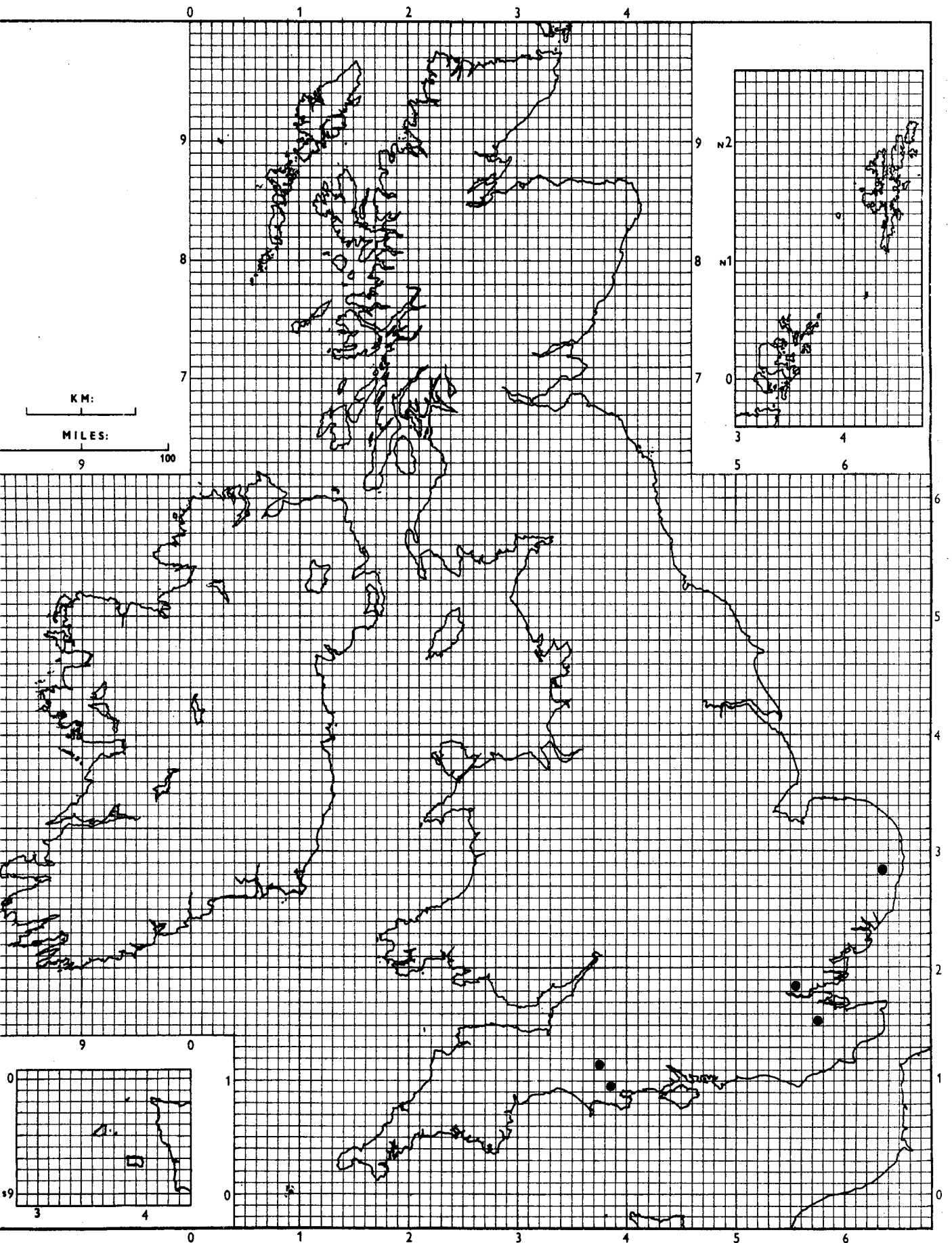


● *Adonido-Iberidetum amarae*

× Related heterogeneous stand from disturbed ground.



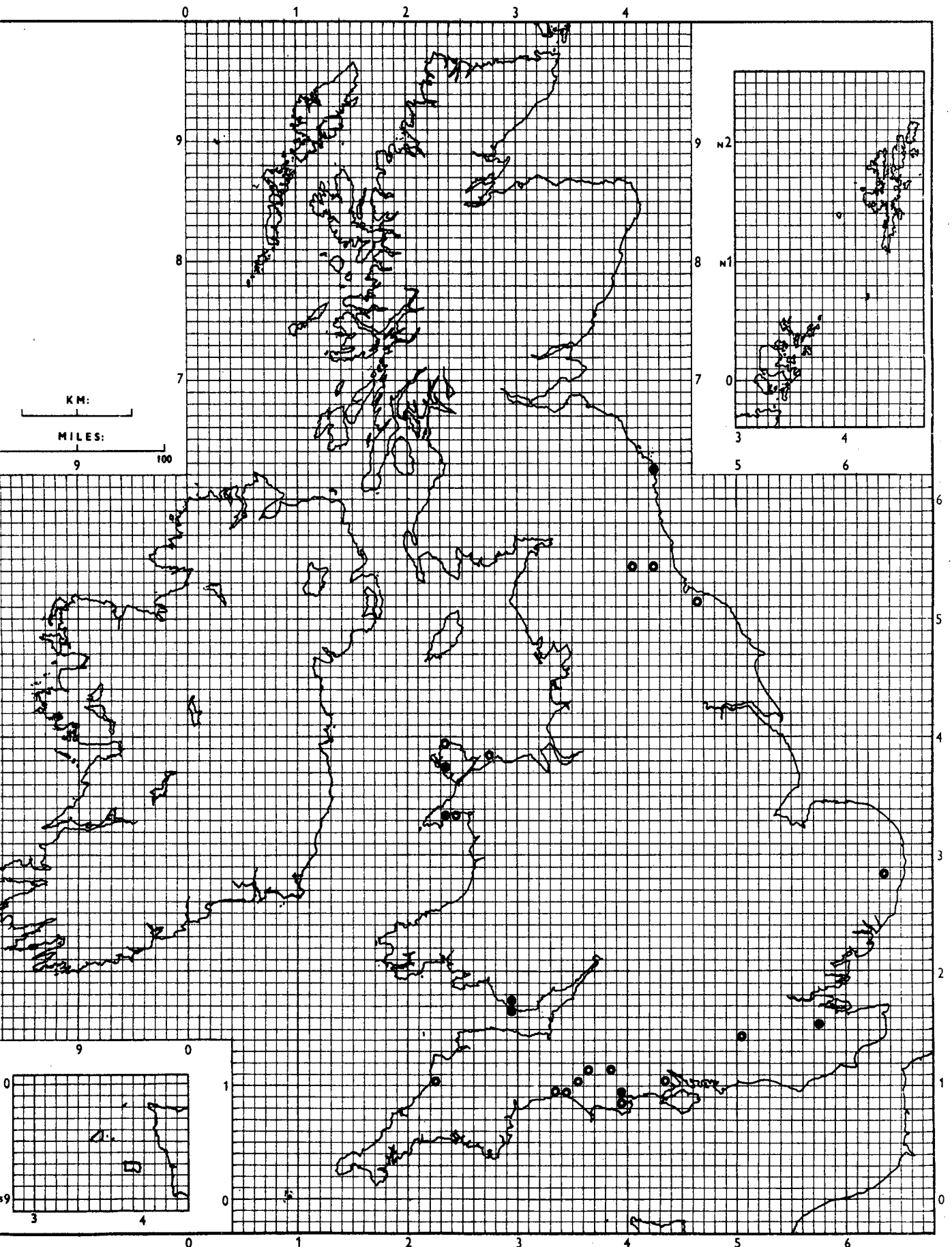
● Convolvulo-Agropyretum - Stellarietea



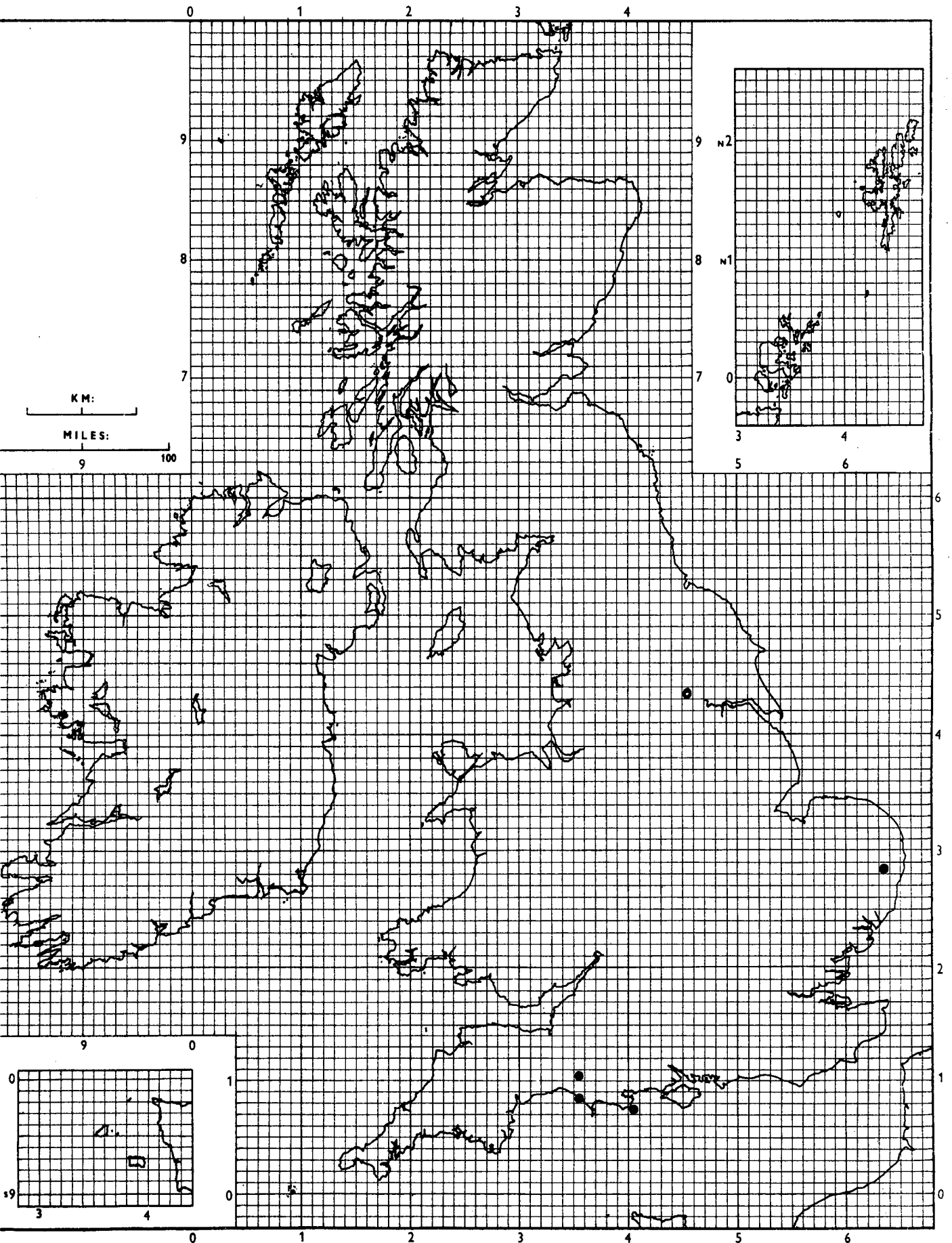
Ranunculetum repentis as an arable community.

● "Pure" association.

○ Transitional forms only.



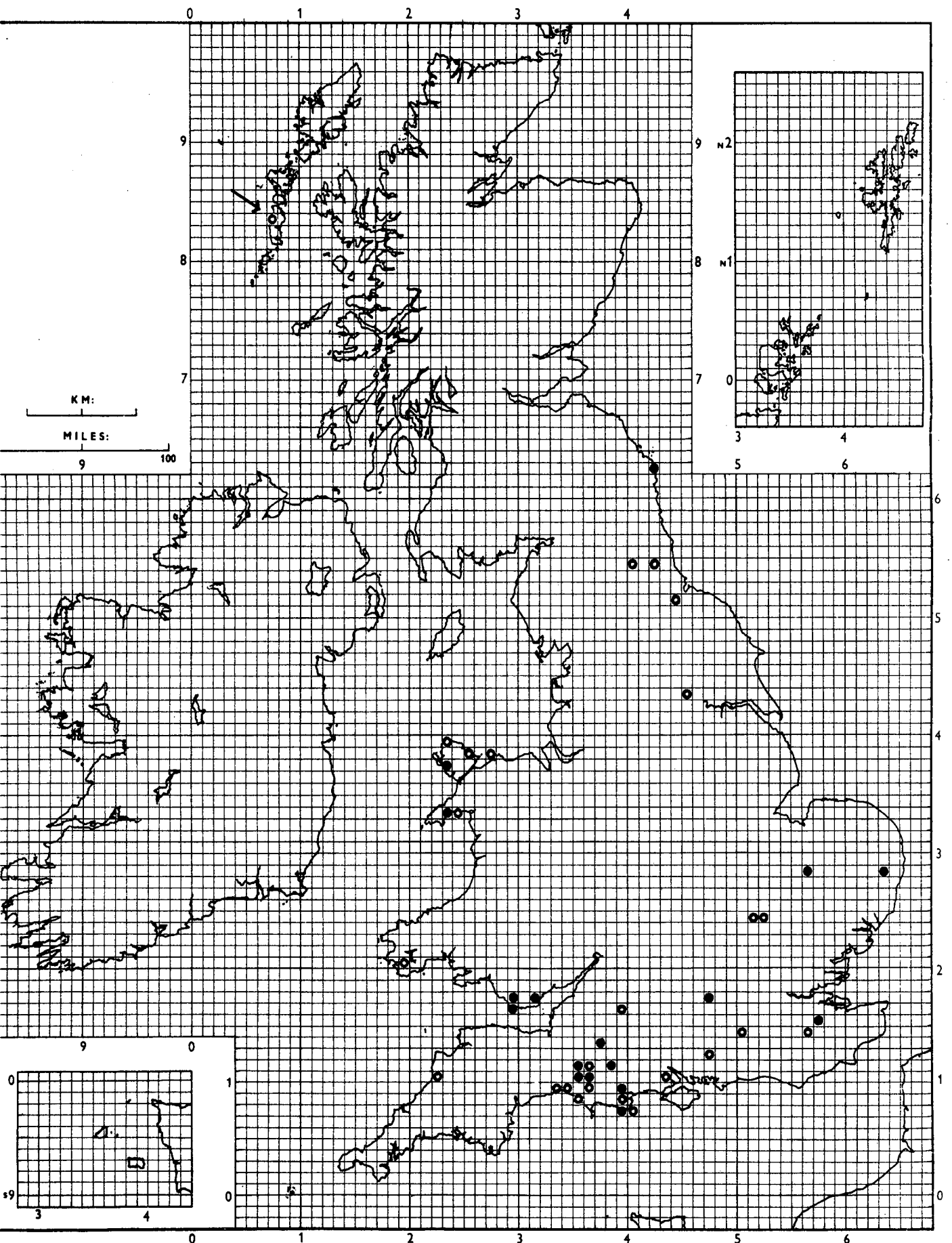
- Potentilletum anserinae as an arable community.
- Rumici-Alopecuretum geniculati as an arable community.



Agrostietalia stoloniferae and contained associations
on arable land.

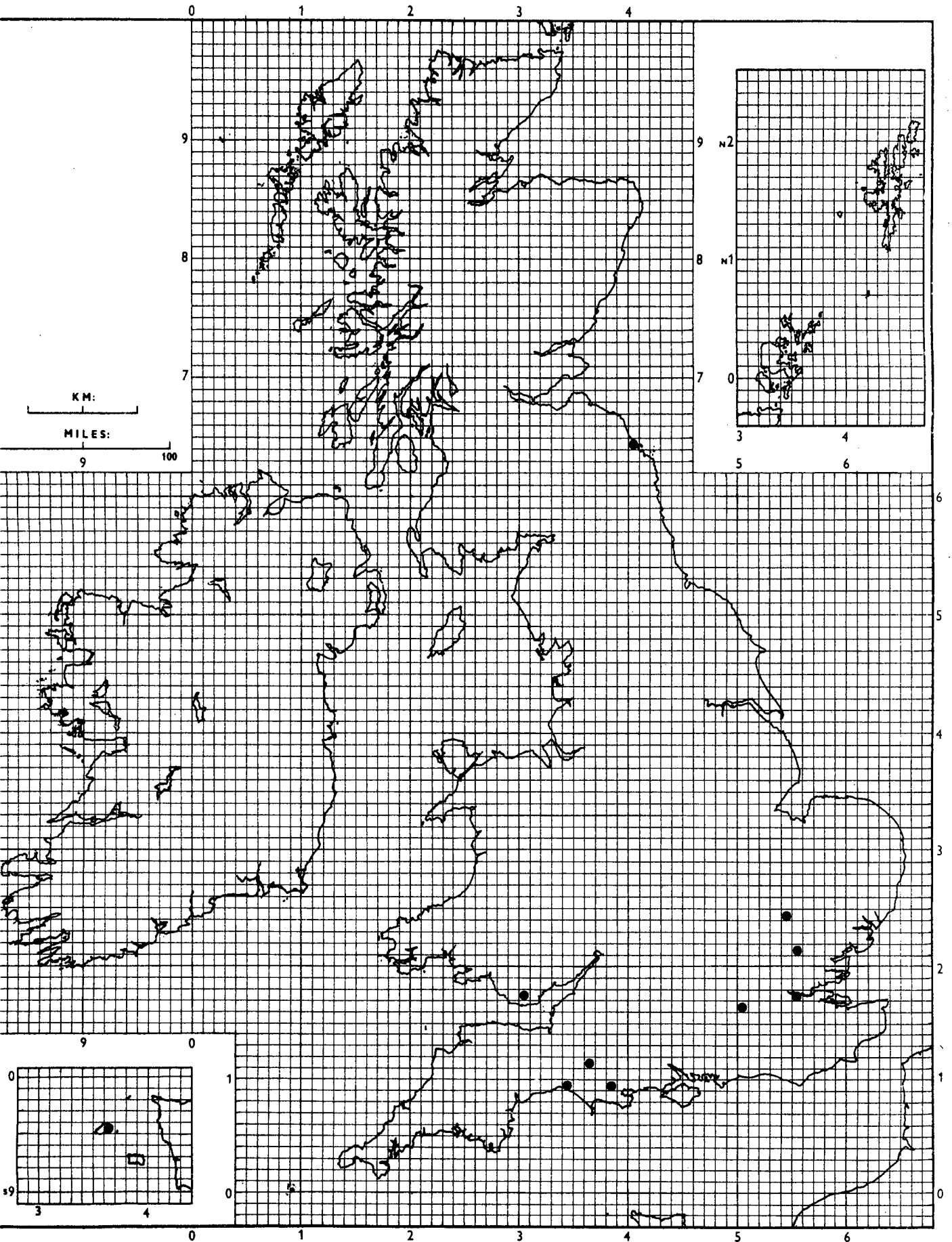
● "Pure" stands.

○ Transitional forms only.

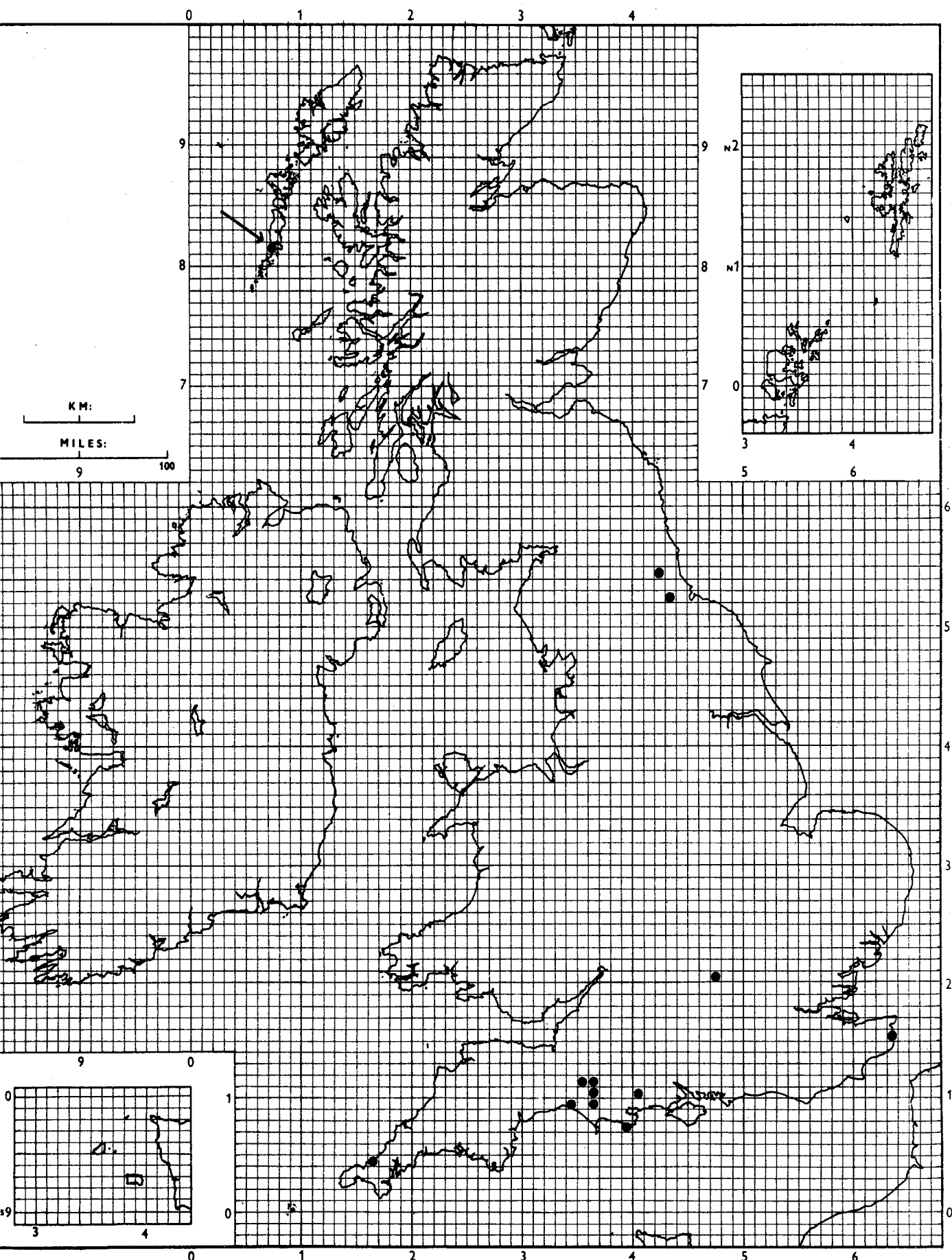


BASED UPON BOTANICAL SOCIETY OF THE BRITISH ISLES DISTRIBUTION MAPS SCHEME

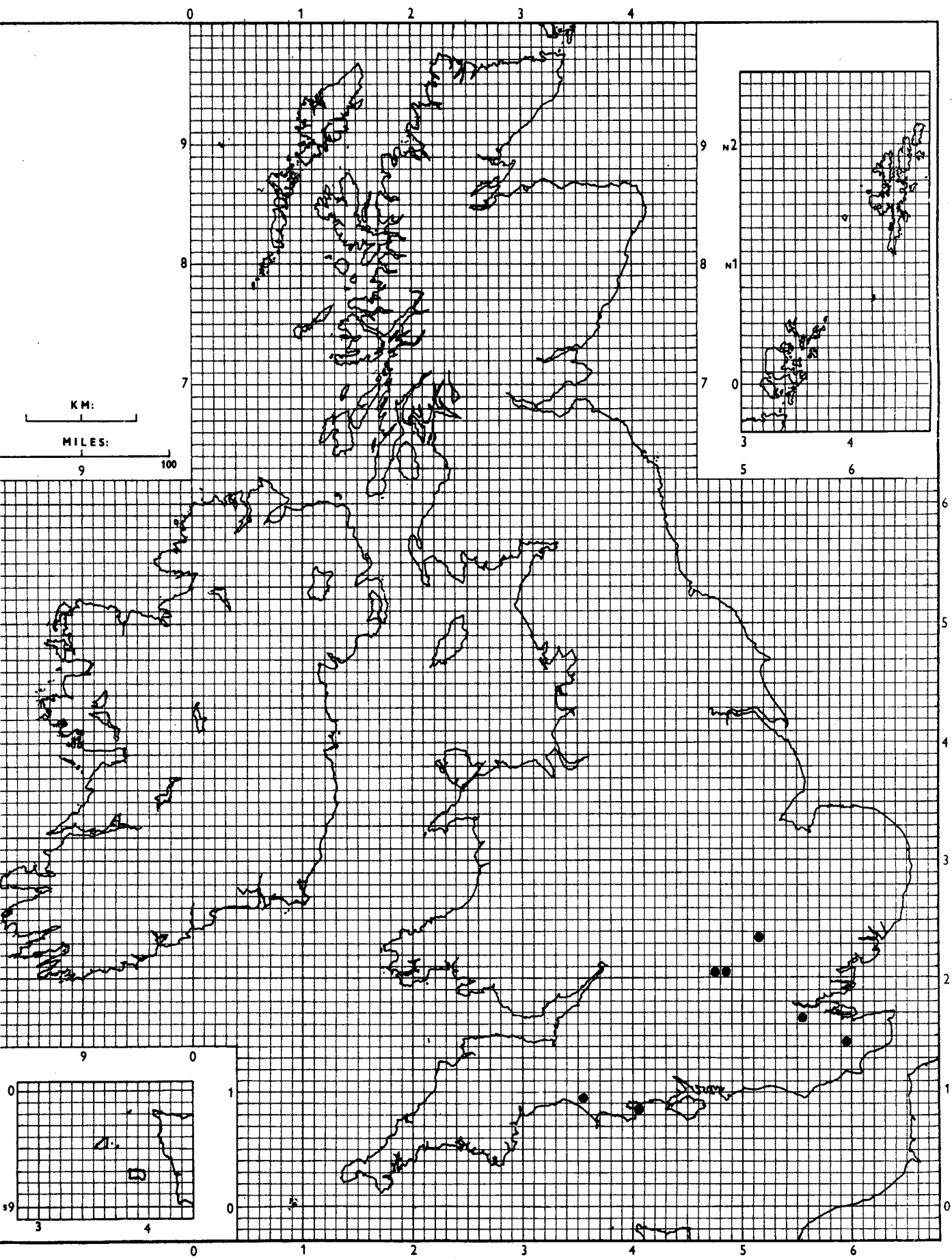
● *Poo-Coronopetum squamati*



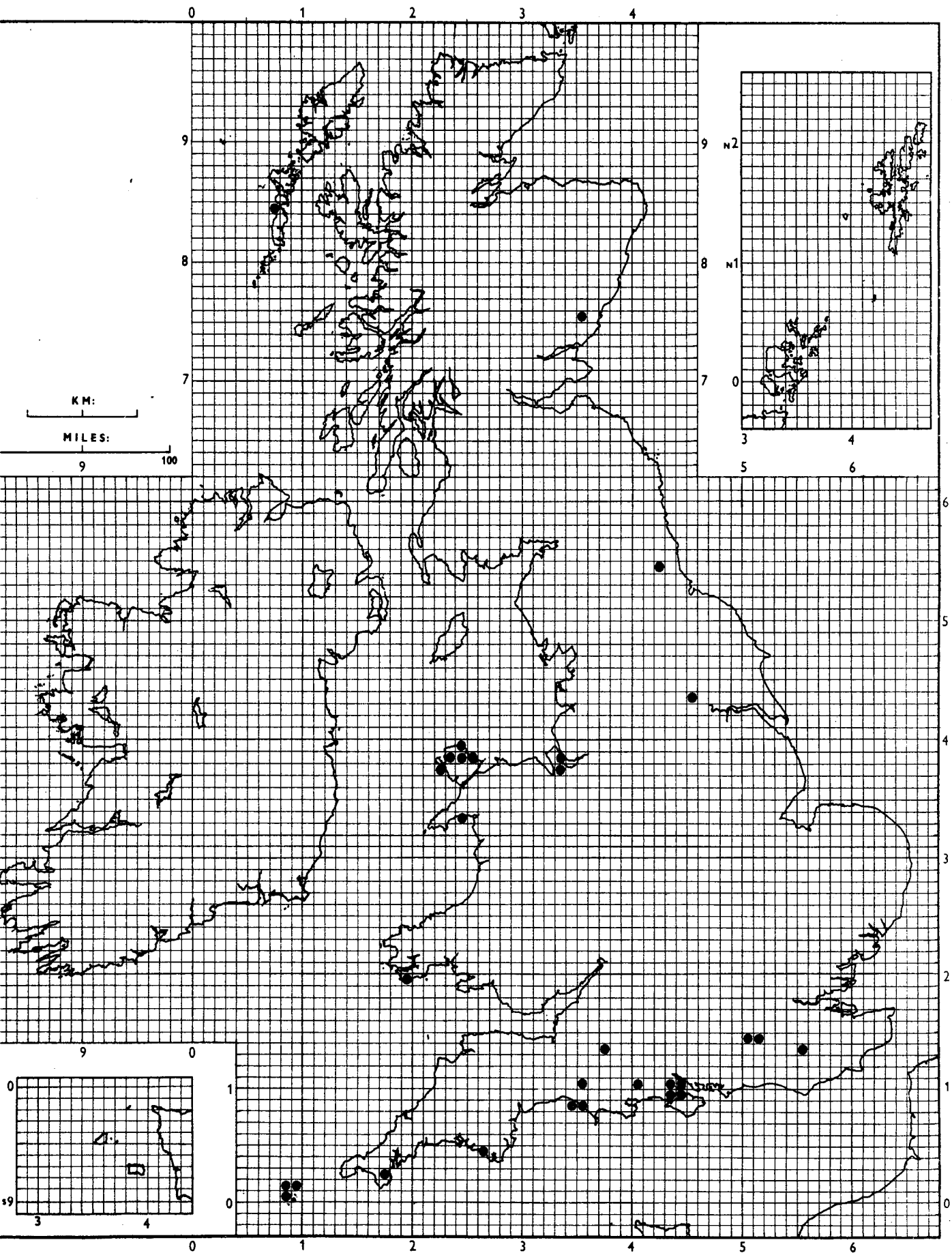
• Molinio-Arrhenatheretea - Stellarietea



● *Pottietum floerkeani*



● *Pottietum truncatae*



Appendix IISoil-analysis Methods and Data

Soil samples were taken from the rooting horizon of most annual weed species, i.e. rarely deeper than 10 cm below the soil surface. The top layer was scraped away before collection of the sample to guard against surface crusts of indigenous minerals or added fertilisers. As soon as possible after collection, samples were dried at 40°C in a ventilated oven and stored in airtight polythene bags prior to analysis.

Soils were extracted with normal ammonium acetate solution by overnight shaking. Schollenberger and Simon (1945) provide the theory of this extraction technique. Bower et al. (1952) showed that shaking is preferable to the leaching method often used.

Exchangeable calcium and potassium were measured using an Eel flame photometer. Calcium is one of the most important environmental variables of apparent relevance to weed vegetation. Potassium is a rather crude cationic indicator of fertiliser levels. The results for selected sandy soils are tabulated below.

Measured exchangeable calcium levels from some Breckland sites may be somewhat inflated by solution by the ammonium acetate of solid calcium carbonate. This may have altered absolute values but is unlikely to have changed the relative calcium levels to any substantial extent. Nevertheless, the double extraction method of Hissink (1923) using sodium chloride solution was tried, all extractions being at room temperature, as recommended by Chapman and Kelley (1930). In theory, the first extraction removed exchangeable calcium plus a proportion of solid calcium carbonate while the second extraction

removed the same proportion of solid calcium carbonate, allowing the exchangeable fraction to be estimated. No useful results were obtained.

Results - all figures in mg /100 g dry soil

1) Bagshot Sands

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>
343	140	2
344	125	2
589	105	2
590	215	3
591	75	4
593	145	1
603	35	2
604	155	6
608	265	1
610	235	1
655	240	12
656	120	1
657	540	8
658	615	15
659	545	3
660	410	10
707	150	29
708	110	68
709	265	5
710	165	7
711	165	5

The local effects of calcareous drainage water from adjacent chalk ridges are obvious in the cases of Aufn. 657 et seq.

2) Lower Greensand

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>
642	590	9
647	385	3
648	450	24
649	390	13
712	195	4
713	220	3
714	150	1
715	685	7
716	470	3
717	85	2
719	570	14
720	200	14
721	325	17
722/		

2) Lower Greensand (Cont.)

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>
722	240	14
723	545	5
739	340	9
740	215	13
741	980	32
742	575	23
743	295	12
744	235	5
745	295	19
746	270	5
747	155	7
748	330	15
749	215	12
765	810	7
808	215	13
825	1035	27
826	215	3
835	220	21

3) Brecklands

<u>Aufnahme</u>	<u>Calcium</u>	<u>Potassium</u>
44	210	1
48	645	1
50	320	1
51	615	4
248	1120	5
250	925	6
264	105	11
265	705	7
752	1075	6
753	1125	8
754	985	5
755	990	4
758	1150	7
759	645	3
760	235	1
761	365	1
762	215	0.5
763	670	1
764	300	10
815	300	3
816	950	9

Appendix III

Dorset is a geologically diverse county, in which Mesozoic formations of the Jurassic and Cretaceous Series outcrop extensively in the west, while Eocene beds form part of the Hampshire Basin in the east. Most of the harder rocks are in some degree calcareous; other formations are mainly clay or sand. Dorset was chosen for this detailed study because of the wide range of solid geology exhibited, and also because the area is unaffected by glacial deposits, which obscure so much further north. Nevertheless, parts of Dorset are covered by local Pleistocene or Recent drift deposits, with marked influences on land use, and these have also been sampled. The account below is based primarily on Chatwin (1960), with additional information from Woodward (1893), Strahan (1898), Arkell (1933, 1947) and Wilson et al. (1958).

Jurassic Stratai) Lower Lias. No aufnahmen

Clays and marls with thin bands of shale and limestone. Outcrops extensively in the Marshwood Vale area, with most land devoted to pasture. Some temporary clover and Lolium leys, but no appreciable amount of arable.

ii) Middle Lias. 3 aufnahmen

Lithologically diverse, with micaceous marls, silts and sands with thicker bands of calcareous sandstone. The overlying Eype Clay consists of micaceous marls and clay with thin layers of limestone. The soils are medium to heavy textured and suitable for arable farming but the steep, hilly nature of the area means that most land is pasture.

iii) Down-Cliff Clay. 1 aufnahme

Only a few small outcrops of sandy clay, devoted primarily to pasture.

iv) Yeovil and Bridport Sands. 3 aufnahmen

Primarily micaceous sands, locally becoming more loamy or passing into micaceous marl. Bands of calcareous sandstone present.

Extensive inland outcrops, but much dissected by steep-sided valleys.

Consequently more land is devoted to pasture than arable farming.

v) Inferior Oolite. 4 aufnahmen

Composed largely of oolitic limestone, but with bands of sand, marl and clay, which are frequently ferruginous, sometimes glauconitic.

Locally, around Sherborne, cereals are grown, but the small outcrops in the south, mainly capping hills, carry little, if any, arable.

vi) Fullers' Earth. 3 aufnahmen

Clays and sandy limestones, supporting arable land near the coast.

vii) Forest Marble. 2 aufnahmen

Composed mainly of oolitic limestone with bands of sandy or micaceous clay and local bands of calcareous sandstone. Some arable land may be seen near the coast, but the area in the north, to the west of Melbury Osmond, seems generally badly drained and is devoted to rather poor pastures.

viii) Cornbrash. 3 aufnahmen

Consists of rubbly yellow limestones, more massive, sometimes sandy limestones, and marls. Produces stony or "brashy" arable soils, hence the name, but now devoted mainly to pasture.

ix) Oxford Clay. 3 aufnahmen

Outcrops extensively in Dorset, but often covered by Head Drift as in the Vale of Blackmoor. Consists of very heavy clays, but the Kellaways Beds towards the base of the formation include hard sandstone and somewhat calcareous clays and shales. The soils are poorly drained and only locally used for poor arable farming.

x) Corallian Beds. 2 aufnahmen

Lithologically variable, with sandy or calcareous clays or oolitic limestones. Most land is devoted to pasture, coastal outcrops are largely built over or occupied by caravan sites or the army.

xi) Kimmeridge Clay. 3 aufnahmen

Composed of clays, with bands of shale and cementstone. Arable farming is important only on the flat, coastal plains around Kimmeridge itself.

xii) Portland Sand. 1 aufnahme

Marls, sands and sandy limestones, not outcropping extensively.

xiii) Portland Stone. 4 aufnahmen

Composed of massive, sandy limestones, forming the more impressive sea-cliffs. Where it is not being quarried, it is locally devoted to arable farming.

xiv) Lower Purbeck. 7 aufnahmen

Outcrops along the coast, consisting of marls, clays and sandy oolitic limestone. The light, friable soils are extensively devoted to arable farming, notably on the Isle of Portland.

xv) Middle Purbeck. 3 aufnahmen

Similar to the Lower Purbeck, supporting some arable land where it outcrops.

xvi) Upper Purbeck. No aufnahmen

Similar to other Purbeck Beds, but much affected by quarrying with areas being left as rough grazing. Some arable land occurs near the coast, but pastures and grass leys are more general.

Cretaceous Strata

i) Wealden. 4 aufnahmen

Composed of rather heavy clays and shales. Outcropping extensively but supporting relatively little arable land. Most land is devoted to pasture.

ii) Lower Greensand. 4 aufnahmen

See description in Section 7.4. The Dorset deposits contain no calcareous strata. In contrast to inland outcrops of other formations, the Lower Greensand is usually devoted to arable farming.

iii) Gault. 3 aufnahmen

Sandy clays, usually exposed on the steep sides of Upper Greensand escarpments and then suitable only for rough pasture.

iv) Upper Greensand. 5 aufnahmen

Composed of base-poor sands, but such arable land as exists is typically limed from adjacent chalk outcrops. In Dorset it mainly caps high hills and is then unsuited to arable farming. Extensively devoted to arable farming just over the county border in Wiltshire.

v) Chalk

Including: Lower Chalk. 2 aufnahmen
Middle Chalk. 1 aufnahme
Upper Chalk. 19 aufnahmen

Composed of the familiar soft limestone. The Lower Chalk is

substantially more marly in character. The Lower and Middle Chalks are exposed mainly on the steep sloping sides of the massive Upper Chalk escarpments and are hence substantially less devoted to arable farming. Most of the Upper Chalk is devoted to barley.

Eocene Strata

i) Reading Beds. 4 aufnahmen

A variable collection of sands, loams, clays with bands of pebbles, gravel and concretionary ironstone. The light clay soils are devoted mainly to pasture, but mixed vegetables and a limited amount of cereals are also grown.

ii) London Clay. 5 aufnahmen

In contrast to the heavy clays of this formation in the London Basin, Dorset deposits are locally very sandy and suitable for arable farming. Most of the area is, however, devoted to pasture.

iii) Bagshot Beds. 13 aufnahmen

See description in Sect. 7.4. Dorset deposits contain substantial amounts of gravel and seams of clay. Much of the area around the Poole Basin is composed of heathland, locally planted with conifers, but with extensive areas of Erica tetralix, Sphagnum or Agrostis setacea. Improved land is mostly pasture, with local, poorly-drained arable land.

Pleistocene Deposits

i) Clay with Flints. 2 aufnahmen

Heterogeneous accumulations of clays with gravels and flints, capping chalk hills. Generally too exposed for arable farming.

ii) Head Drift and other Gravels. 12 aufnahmen

Accumulations of sands, clays and gravels, often suitable for arable farming. Thin layers of Plateau Gravel over Bagshot Sands result in useful cereal-growing land, and such areas form the small areas of cultivated land in the Ringwood Forest area.

Recent Deposits

Alluvium (2 aufnahmen) along inland river-valleys is often devoted to arable land in mixed farming systems.

Appendix IVSite Data for all Aufnahmen

The aufnahmen were recorded before local government reorganisation. Counties thus refer to boundaries current at the dates of the aufnahmen. They have been retained as geographical areas, and as such are generally more informative than the new, larger counties. Wales has been most affected by changes in county boundaries and it is here in particular that interesting areas such as Pembrokeshire are best retained separately from the rest of the new county of Dyfed. Site descriptions are necessarily abbreviated.

0001 TQ 516889 Romford, Essex	29. 6.69 Wasteground
0002 TQ 514890 Romford, Essex	17. 9.69 Wasteground
0003 TQ 514890 Romford, Essex	17. 9.69 Wasteground
0004 TQ 514890 Romford, Essex	17. 9.69 Wasteground
0005 TQ 514891 Romford, Essex	17. 9.69 Wasteground
0006 TQ 513891 Romford, Essex	17. 9.69 Wasteground
0007 NZ 276421 Durham City	3.10.69 Flower bed
0008 NZ 86 06 Sleights, N. Yorks.	4.10.69 Spoil heap
0009 NZ 275410 Durham City	8.10.69 Barley-field
0010 NZ 275410 Durham City	8.10.69 Barley-field
0011 NZ 276423 Durham City	9.10.69 Wasteground
0012 NZ 275426 Durham City	10.10.69 Wasteground
0013 NZ 170410 Durham City	22.10.69 Barley-field
0014 NZ 270410 Durham City	22.10.69 Barley-field
0015 NZ 269410 Durham City	22.10.69 Field gateway
0016 NZ 271412 Durham City	24.10.69 Fallow field
0017 NZ 286621 Felling, Co. Durham	10.11.69 Wasteground
0018 NZ 286621 Felling, Co. Durham	10.11.69 Wasteground
0019 NZ 286621 Felling, Co. Durham	10.11.69 Wasteground
0020 NZ 286621 Felling, Co. Durham	10.11.69 Wasteground
0021 NZ 351621 Boldon Colliery, Co.Durham	10.11.69 Spoil heap
0022 NZ 351621 Boldon Colliery, Co.Durham	10.11.69 Spoil heap
0023 NZ 350622 Boldon Colliery, Co.Durham	10.11.69 Spoil heap
0024 NZ 350622 Boldon Colliery, Co.Durham	10.11.69 Spoil heap
0025 NZ 275403 Durham City	13.11.69 Trackside
0026 SP 384047 Standlake Pits, Oxon.	13. 5.70 Scree
0027 SP 384047 Standlake Pits, Oxon.	13. 5.70 Scree
0028 SP 386046 Standlake Pits, Oxon.	13. 5.70 Scree
0029 SP 412043 Lynch Hill, Oxon.	13. 5.70 Disturbed pasture
0030 TQ 961434 Rippers Cross, Kent	15. 5.70 Hedgebank
0031 TQ 557377 Tunbridge Wells, Sussex	15. 5.70 Flower nursery

0032	TQ	557377	Tunbridge Wells, Sussex	15.	5.70	Flower nursery
0033	TQ	557377	Tunbridge Wells, Sussex	15.	5.70	Flower nursery
0034	TQ	557377	Tunbridge Wells, Sussex	15.	5.70	Flower nursery
0035	TL	805045	Woodham Mortimer, Essex	17.	5.70	Roadside
0036	TL	806046	Woodham Mortimer, Essex	17.	5.70	Roadside
0037	TL	805045	Woodham Mortimer, Essex	17.	5.70	Roadside
0038	TL	831079	Beeleigh, Essex	17.	5.70	Barley-field
0039	TL	831079	Beeleigh, Essex	17.	5.70	Cabbage-field
0040	TQ	062601	Byfleet, Surrey	18.	5.70	Flower nursery
0041	TQ	062601	Byfleet, Surrey	18.	5.70	Flower nursery
0042	TQ	062601	Byfleet, Surrey	18.	5.70	Flower nursery
0043	TL	720824	Lakenheath, Suffolk	20.	5.70	Roadside
0044	TL	724823	Maidcross Hill, Suffolk	20.	5.70	Lucerne-field
0045	TL	725823	Maidcross Hill, Suffolk	20.	5.70	Lucerne-field
0046	TL	725826	Maidcross Hill, Suffolk	20.	5.70	Fallow field
0047	TL	726826	Maidcross Hill, Suffolk	20.	5.70	Celery-field
0048	TL	722716	Tuddenham, Suffolk	20.	5.70	Fallow field
0049	TL	722716	Tuddenham, Suffolk	20.	5.70	Pig-field
0050	TL	723717	Tuddenham, Suffolk	20.	5.70	Fallow field
0051	TL	721718	Tuddenham, Suffolk	20.	5.70	Barley-field
0052	TL	227512	Gamlingay, Cambs.	23.	5.70	Fallow field
0053	TL	227512	Gamlingay, Cambs.	23.	5.70	Fallow field
0054	TL	227512	Gamlingay, Cambs.	23.	5.70	Fallow field
0055	TL	227517	Gamlingay, Cambs.	23.	5.70	Cabbage-field
0056	TL	187492	Sandy, Beds.	23.	5.70	Cauliflower-field
0057	TL	181489	Sandy, Beds.	23.	5.70	Fallow field
0058	TL	169486	Sandy, Beds.	24.	5.70	Allotments
0059	WV	338841	L'Ancrese, Guernsey	30.	5.70	Roadside
0060	WV	303754	Petit Bot, Guernsey	31.	5.70	Potato-field
0061	WV	303754	Petit Bot, Guernsey	31.	5.70	Potato-field
0062	WV	266775	St. Saviour, Guernsey	2.	6.70	Potato-field
0063	WV	268774	St. Saviour, Guernsey	2.	6.70	Barley-field
0064	WV	261773	St. Peter in the Wood, Guernsey	2.	6.70	Fallow field
0065	WV	261773	-do-	2.	6.70	Fallow field
0066	WV	270770	-do-	2.	6.70	Potato-field
0067	WV	336831	L'Ancrese, Guernsey	3.	6.70	Disturbed soil
0068	WV	335826	La Garenne, Guernsey	5.	6.70	Soil heap
0069	WV	338840	L'Ancrese, Guernsey	5.	6.70	Disturbed soil
0070	WV	338840	L'Ancrese, Guernsey	5.	6.70	Disturbed soil
0071	WV	336841	Mont Cuet, Guernsey	5.	6.70	Disturbed soil
0072	WV	336841	Mont Cuet, Guernsey	5.	6.70	Trackway
0073	WV	336841	Mont Cuet, Guernsey	5.	6.70	Compost heap
0074	WV	336842	Mont Cuet, Guernsey	5.	6.70	Wasteground
0075	WV	301767	La Villiaze, Guernsey	6.	6.70	Fallow ground
0076	WV	301762	St. Martin, Guernsey	6.	6.70	Soil heap
0077	WV	301762	St. Martin, Guernsey	6.	6.70	Trackway
0078	WV	334788	St. Peter Port, Guernsey	7.	6.70	Flower bed
0079	NZ	253498	Waldrige Fell, Durham	15.	6.70	Slag heap
0080	NZ	253498	Waldrige Fell, Durham	15.	6.70	Slag heap
0081	NZ	520312	Hartlepool, Durham	15.	6.70	Wasteground
0082	NZ	520311	Hartlepool, Durham	15.	6.70	Wasteground
0083	NZ	520310	Hartlepool, Durham	15.	6.70	Wasteground
0084	NZ	519310	Hartlepool, Durham	15.	6.70	Wasteground
0085	NZ	519310	Hartlepool, Durham	15.	6.70	Wasteground
0086	NZ	518311	Hartlepool, Durham	15.	6.70	Wasteground
0087	NZ	519313	Hartlepool, Durham	15.	6.70	Wasteground
0088	NZ	519310	Hartlepool, Durham	15.	6.70	Wasteground

0089	NZ	272411	Durham City	26.	6.70	Soil heap
0090	NZ	272411	Durham City	26.	6.70	Soil heap
0091	NZ	278415	Durham City	26.	6.70	Disturbed ground
0092	NZ	065371	Wolsingham, Durham	26.	6.70	Disturbed soil
0093	NZ	065371	Wolsingham, Durham	26.	6.70	Disturbed soil
0094	NZ	065371	Wolsingham, Durham	26.	6.70	Disturbed soil
0095	NZ	065371	Wolsingham, Durham	26.	6.70	Earth bank
0096	NZ	278415	Durham City	24.	7.70	Fallow ground
0097	SM	803043	Kete, Pembroke	27.	7.70	Barley-field
0098	ST	069899	Pontypridd, Glamorgan	25.	7.70	Earth bank
0099	ST	071745	Bonvilston, Glamorgan	25.	7.70	Fallow ground
0100	ST	075740	Bonvilston, Glamorgan	25.	7.70	Oat-field
0101	ST	043661	Pleasantharbour, Glamorgan	25.	7.70	Barley-field
0102	SS	923691	Marcross, Glamorgan	25.	7.70	Wheatfield
0103	SS	910728	Wick, Glamorgan	25.	7.70	Wheatfield
0104	SS	096989	Penally, Pembroke	26.	7.70	Fallow ground
0105	SM	991012	Pembroke (town)	26.	7.70	Wasteground
0106	SM	983003	Pembroke (town)	26.	7.70	Barley-field
0107	SR	975980	St. Petrox, Pembroke	26.	7.70	Potato-field
0108	SR	976981	St. Petrox, Pembroke	26.	7.70	Oat/barley-field
0109	SR	897987	Gupton Burrows, Pembroke	26.	7.70	Roadside
0110	SM	883011	Angle, Pembroke	26.	7.70	Barley-field
0111	SM	903005	Kilpaison Burrows, Pembroke	27.	7.70	Barley(8r)-field
0112	SM	905005	Castlemartin, Pembroke	27.	7.70	Barley-field
0113	SM	817084	South Mullock, Pembroke	27.	7.70	Flower bed
0114	SM	817084	South Mullock, Pembroke	27.	7.70	Flower bed
0115	SM	817084	South Mullock, Pembroke	27.	7.70	Flower bed
0116	SM	816053	Dale, Pembroke	27.	7.70	Barley-field
0117	SM	804038	St. Anne's Head, Pembroke	27.	7.70	Barley-field
0118	SM	804038	St. Ann's Head, Pembroke	27.	7.70	Field Gateway
0119	SM	802043	Kete, Pembroke	27.	7.70	Barley-field
0120	SM	811058	Dale, Pembroke	28.	7.70	Bean-field
0121	SM	857114	Talbenny, Pembroke	28.	7.70	Barley-field/Lolium
0122	SM	861141	Broad Haven, Pembroke	28.	7.70	Oat/barley-field
0123	SM	857201	Nolton Haven, Pembroke	28.	7.70	Oat/barley-field
0124	SM	858201	Nolton Haven, Pembroke	28.	7.70	Barley-field
0125	SM	841236	Newgale, Pembroke	28.	7.70	Oat/barley-field
0126	SM	827241	Solva, Pembroke	28.	7.70	Potato-field
0127	SM	769264	Dowrog Common, Pembroke	28.	7.70	Oat/barley-field
0128	SM	767261	Mynydd du, Pembroke	28.	7.70	Cabbage/potato-field
0129	SM	766262	Mynydd du, Pembroke	28.	7.70	Potato-field
0130	SM	765265	Mynydd du, Pembroke	28.	7.70	Potato-field
0131	SM	732276	St. David's Head, Pembroke	28.	7.70	Oat/barley-field
0132	SM	737250	St. David's Head, Pembroke	29.	7.70	Field gateway
0133	SM	737250	St. David's, Pembroke	29.	7.70	Barley-field
0134	SM	895325	Mathry, Pembroke	29.	7.70	Barley-field
0135	SM	895376	Castell-poeth, Pembroke	29.	7.70	Barley-field
0136	SN	045390	Newport, Pembroke	29.	7.70	Barley/Lolium-field
0137	SN	068423	Newport, Pembroke	29.	7.70	Barley-field
0138	SN	115412	Nevern, Pembroke	29.	7.70	Barley-field
0139	SS	565949	Poundfald, Glamorgan	30.	7.70	Barley-field
0140	SS	557885	Pennard, Glamorgan	30.	7.70	Barley-field
0141	SS	554885	Pennard Burrows, Glamorgan	30.	7.70	Soil heap
0142	SS	550891	Parkmill, Glamorgan	30.	7.70	Disturbed soil
0143	SS	492860	Oxwich Green, Glamorgan	30.	7.70	Wheat-field
0144	SS	483890	Reynoldston, Glamorgan	30.	7.70	Cabbage-field
0145	SS	482890	Reynoldston, Glamorgan	30.	7.70	Oat-field
0146	SS	456915	Burry Green, Glamorgan	30.	7.70	Potato-field
0147	SS	457915	Burry Green, Glamorgan	30.	7.70	Barley-field

0148	SS	751921	Baglan, Glamorgan	31.	7.70	Wasteground
0149	SS	751921	Baglan, Glamorgan	31.	7.70	Wasteground
0150	SO	168168	Cragi y Castell, Brecon	1.	8.70	Roadside
0151	SO	212178	Llangattrock, Brecon	1.	8.70	Wasteground
0152	SO	216189	Crickhowell, Brecon	1.	8.70	Allotments
0153	ST	521773	Avonmouth, Somerset	1.	8.70	Roadside
0154	ST	521773	Avonmouth, Somerset	1.	8.70	Roadside
0155	TQ	563853	Corbets Tey, Essex	4.	8.70	Allotments
0156	TQ	564854	Corbets Tey, Essex	4.	8.70	Lettuce-field
0157	TQ	570856	Cranham, Essex	4.	8.70	Fallow field
0158	TQ	570856	Cranham, Essex	4.	8.70	Fallow field
0159	TQ	563851	Corbets Tey, Essex	4.	8.70	Wasteground
0160	TQ	605820	South Ockendon, Essex	4.	8.70	Barley-field
0161	TQ	609815	South Ockendon, Essex	4.	8.70	Barley-field
0162	TQ	546724	Dartford, Kent	7.	8.70	Wasteground
0163	TQ	545723	Dartford, Kent	7.	8.70	Marrow-field
0164	TQ	552719	Dartford, Kent	7.	8.70	Roadside
0165	TQ	543677	Farningham, Kent	7.	8.70	Lettuce-field
0166	TQ	539664	Eynsford, Kent	7.	8.70	Wheat-field
0167	TQ	529625	Shoreham, Kent	7.	8.70	Barleyfield
0168	TQ	529626	Shoreham, Kent	7.	8.70	Wheatfield
0169	TQ	526620	Shoreham, Kent	7.	8.70	Maize-field
0170	TQ	527618	Shoreham, Kent	7.	8.70	Maize-field
0171	TQ	529575	Sevenoaks, Kent	7.	8.70	Disturbed soil
0172	TQ	529575	Sevenoaks, Kent	7.	8.70	Wasteground
0173	TQ	491555	Chipstead, Kent	7.	8.70	Lettuce-field
0174	TQ	495559	Chipstead, Kent	7.	8.70	Sand-pit
0175	TQ	495560	Chipstead, Kent	7.	8.70	Disturbed soil
0176	TQ	495560	Chipstead, Kent	7.	8.70	Rubbish tip
0177	TQ	596820	South Ockendon, Essex	8.	8.70	Gravel mound
0178	TQ	596820	South Ockendon, Essex	8.	8.70	Clay mound
0179	TQ	595820	South Ockendon, Essex	8.	8.70	Gravel mound
0180	TQ	593818	South Ockendon, Essex	8.	8.70	Disturbed ground
0181	TQ	595821	South Ockendon, Essex	8.	8.70	Gravel-pit
0182	TQ	604819	South Ockendon, Essex	8.	8.70	Gravel-pit
0183	TQ	602819	South Ockendon, Essex	8.	8.70	Disturbed ground
0184	TQ	556782	Purfleet, Essex	8.	8.70	Disturbed ground
0185	TQ	557782	Purfleet, Essex	8.	8.70	Gravel mounds
0186	TQ	555782	Purfleet, Essex	8.	8.70	Chalk bank
0187	TQ	555782	Purfleet, Essex	8.	8.70	Chalk mound
0188	TQ	555781	Purfleet, Essex	8.	8.70	Chalk mound
0189	TQ	556782	Purfleet, Essex	8.	8.70	Disturbed ground
0190	TQ	655783	Chadwell St. Mary, Essex	8.	8.70	Wasteground
0191	TQ	654786	Chadwell St. Mary, Essex	8.	8.70	Barley-field
0192	TQ	634911	Herongate, Essex	8.	8.70	Bean-field
0193	TQ	417897	South Woodford, Essex	14.	8.70	Wasteground
0194	TQ	415896	South Woodford, Essex	14.	8.70	Wasteground
0195	TQ	415896	South Woodford, Essex	14.	8.70	Wasteground
0196	TQ	415895	South Woodford, Essex	14.	8.70	Wasteground
0197	TL	473068	Latton Priory, Essex	14.	8.70	Wheatfield
0198	TL	501152	Sawbridgeworth, Essex	14.	8.70	Bean-field
0199	TL	525148	Hatfield Heath, Essex	14.	8.70	Bean-field
0200	TL	525148	Hatfield Heath, Essex	14.	8.70	Wheatfield
0201	TL	514265	Stansted Mountfitchet, Ess.	14.	8.70	Barleyfield
0202	TL	516296	Quendon, Essex	14.	8.70	Barleyfield
0203	TL	512294	Rickling Green, Essex	14.	8.70	Wheatfield
0204	TL	451359	Langley, Essex	15.	8.70	Bean-field
0205	TL	451359	Langley, Essex	15.	8.70	Barley-field
0206	TL	451358	Langley, Essex	15.	8.70	Silage-heap

0207	TL	448354	Langley Upper Green, Essex	15.	8.70	Barley-field
0208	TL	450352	Langley Upper Green, Essex	15.	8.70	Bean-field
0209	TL	455349	Langley Upper Green, Essex	15.	8.70	Barleyfield
0210	TL	459351	Langley Upper Green, Essex	15.	8.70	Bean-field
0211	TL	452392	Chrishall, Essex	15.	8.70	Cabbage-field
0212	TL	454394	Chrishall, Essex	15.	8.70	Barleyfield
0213	TL	452395	Chrishall, Essex	15.	8.70	Barleyfield
0214	TL	399391	Barley, Herts.	15.	8.70	Soil bank
0215	TL	399391	Barley, Herts.	15.	8.70	Barleyfield
0216	TL	374395	Royston, Herts.	15.	8.70	Wheatfield
0217	TL	374394	Royston, Herts.	15.	8.70	Barleyfield
0218	TL	375393	Royston, Herts.	15.	8.70	Wheatfield
0219	TL	384410	Royston, Herts.	15.	8.70	Bean-field
0220	TL	384411	Royston, Cambs.	15.	8.70	Barleyfield
0221	TL	384411	Royston, Cambs.	15.	8.70	Barleyfield
0222	TL	446454	Thriplow, Cambs.	15.	8.70	Beet-field
0223	TL	446455	Thriplow, Cambs.	15.	8.70	Barleyfield
0224	TL	444466	Thriplow, Cambs.	15.	8.70	Beet-field
0225	TL	491427	Coploe Hill, Cambs.	15.	8.70	Barleyfield
0226	TL	503436	Great Chesterford, Essex	16.	8.70	Oatfield
0227	TL	551487	Hildersham Furze Hills, Cambs.	16.	8.70	Barleyfield
0228	TM	100804	Roydon, Norfolk	16.	8.70	Roadside
0229	TM	163787	Scole, Norfolk	16.	8.70	Barleyfield
0230	TM	162787	Scole, Norfolk	16.	8.70	Barleyfield
0231	TM	163786	Scole, Norfolk	16.	8.70	Barleyfield
0232	TM	194791	Thorpe Abbots, Norfolk	16.	8.70	Roadside
0233	TM	283861	Wortwell, Norfolk	16.	8.70	Barleyfield
0234	TM	329895	Bungay, Norfolk	16.	8.70	Barleyfield
0235	TM	329896	Bungay, Norfolk	16.	8.70	Fallow field
0236	TM	330897	Bungay, Norfolk	16.	8.70	Track
0237	TM	370854	Ilketshall, Suffolk	16.	8.70	Barleyfield
0238	TM	409840	Redisham, Suffolk	16.	8.70	Barleyfield
0239	TM	450815	Stoven, Suffolk	16.	8.70	Barleyfield
0240	TM	468797	Wangford, Suffolk	16.	8.70	Barleyfield
0241	TM	519949	Oulton, Suffolk	16.	8.70	Wheatfield
0242	TM	511966	Blundeston, Suffolk	16.	8.70	Beet-field
0243	TM	511965	Blundeston, Suffolk	16.	8.70	Barleyfield
0244	TM	481977	Herringfleet, Suffolk	16.	8.70	Barleyfield
0245	TL	750763	Eriswell, Suffolk	17.	8.70	Barley/Lucerne field
0246	TL	751763	Eriswell, Suffolk	17.	8.70	Barley/Lucerne field
0247	TL	756764	Eriswell, Suffolk	17.	8.70	Barleyfield
0248	TL	756765	Eriswell, Suffolk	17.	8.70	Barley/Lolium field
0249	TL	741776	Eriswell, Suffolk	17.	8.70	Barleyfield
0250	TL	742781	Eriswell, Suffolk	17.	8.70	Barleyfield
0251	TL	737774	Eriswell, Suffolk	17.	8.70	Fallow field
0252	TL	724799	Eriswell, Suffolk	17.	8.70	Fallow field
0253	TL	725803	Little Eriswell, Suffolk	17.	8.70	Barleyfield
0254	TL	725802	Little Eriswell, Suffolk	17.	8.70	Barleyfield
0255	TL	720823	Lakenheath, Suffolk	17.	8.70	Dumped soil
0256	TL	724827	Lakenheath, Suffolk	17.	8.70	Larch plantation
0257	TL	724829	Lakenheath, Suffolk	17.	8.70	Celery field
0258	TL	724829	Lakenheath, Suffolk	17.	8.70	Wheatfield
0259	TL	750917	Feltwell, Norfolk	17.	8.70	Carrot field
0260	TF	769030	Gooderstone, Norfolk	17.	8.70	Carrot field
0261	TF	803031	Cockley Cley, Norfolk	17.	8.70	Barleyfield
0262	TL	822996	Hilborough, Norfolk	17.	8.70	Carrot field
0263	TL	751759	Eriswell, Suffolk	18.	8.70	Beet-field
0264	TL	751759	Eriswell, Suffolk	18.	8.70	Fallow field-margin
0265	TL	753758	Eriswell, Suffolk	18.	8.70	Beet-field

0266	TL	753752	Eriswell, Suffolk	18.	8.70	Barleyfield
0267	TL	728735	Barton Mills, Suffolk	18.	8.70	Wheatfield
0268	TL	728735	Barton Mills, Suffolk	18.	8.70	Potato field
0269	TL	721721	Tuddenham, Suffolk	18.	8.70	Carrot field
0270	TL	781670	Risby, Suffolk	18.	8.70	Beet-field
0271	TL	766654	Barrow, Suffolk	18.	8.70	Beet-field
0272	TL	817658	Risby, Suffolk	18.	8.70	Fallow field-margin
0273	TL	828731	Wordwell, Suffolk	18.	8.70	Disturbed ground
0274	TL	631845	Shippea Hill, Cambs.	18.	8.70	Fallow ground
0275	TL	614853	Littleport, Cambs.	18.	8.70	Wheatfield
0276	TL	603829	Prickwillow, Cambs.	18.	8.70	Roadside
0277	TL	587823	Prickwillow, Cambs.	18.	8.70	Wheatfield
0278	TL	577819	Prickwillow, Cambs.	18.	8.70	Potato field
0279	TL	577819	Prickwillow, Cambs.	18.	8.70	Potato field
0280	TL	533796	Ely, Cambs.	18.	8.70	Beet-field
0281	TL	530796	Ely, Cambs.	18.	8.70	Oat-field
0282	TL	520791	Ely, Cambs.	18.	8.70	Potato field
0283	TL	487789	Witchford, Cambs.	18.	8.70	Beet-field
0284	TL	486789	Witchford, Cambs.	18.	8.70	Barleyfield
0285	TL	431820	Mepal Fen, Cambs.	18.	8.70	Wheatfield
0286	TL	431820	Mepal Fen, Cambs.	18.	8.70	Potato field
0287	TL	381881	Chatteris, Cambs.	18.	8.70	Wheatfield
0288	TL	381881	Chatteris, Cambs.	18.	8.70	Potato field
0289	TL	421920	Wimblington, Cambs.	18.	8.70	Wheatfield
0290	TL	705691	Herringswell, Suffolk	20.	8.70	Market garden
0291	TL	705691	Herringswell, Suffolk	20.	8.70	Barleyfield
0292	TL	704690	Herringswell, Suffolk	20.	8.70	Market garden
0293	TL	704690	Herringswell, Suffolk	20.	8.70	Market garden
0294	TL	705689	Herringswell, Suffolk	20.	8.70	Carrot field
0295	TL	685687	Chippenham, Cambs.	20.	8.70	Sand-pit
0296	TL	684686	Chippenham, Cambs.	20.	8.70	Wheatfield
0297	TL	654703	Chaippenham, Cambs.	20.	8.70	Barleyfield
0298	TL	651691	Chippenham Fen, Cambs.	20.	8.70	Barleyfield
0299	TL	653690	Chippenham Fen, Cambs.	20.	8.70	Barleyfield
0300	TL	564706	Wicken, Cambs.	20.	8.70	Barleyfield
0301	TL	566707	Wicken, Cambs.	20.	8.70	Beet-field
0302	TL	571706	Wicken, Cambs.	20.	8.70	Beet-field
0303	TL	569699	Wicken, Cambs.	20.	8.70	Celery field
0304	TL	571664	Reach, Cambs.	20.	8.70	Beet-field
0305	TF	697262	West Newton, Norfolk	21.	8.70	Barleyfield
0306	TF	698262	West Newton, Norfolk	21.	8.70	Wheatfield
0307	TF	705251	Hillington, Norfolk	21.	8.70	Beet-field
0308	TF	683352	Snettisham, Norfolk	21.	8.70	Beet-field
0309	TF	683352	Snettisham, Norfolk	21.	8.70	Barleyfield
0310	TF	711379	Sedgeford, Norfolk	21.	8.70	Barleyfield
0311	TF	703413	Ringstead, Norfolk	21.	8.70	Barleyfield
0312	TF	697493	Hunstanton, Norfolk	21.	8.70	Beet-field
0313	TG	117431	Weybourne, Norfolk	21.	8.70	Barleyfield
0314	TQ	557733	Dartford, Kent	26.	8.70	Chalky bank
0315	TQ	557734	Dartford, Kent	26.	8.70	Chalky bank
0316	TQ	557734	Dartford, Kent	26.	8.70	Chalky bank
0317	TQ	704674	Cuxton, Kent	26.	8.70	Wheatfield
0318	TQ	698681	Cuxton, Kent	26.	8.70	Barleyfield
0319	TQ	698681	Cuxton, Kent	26.	8.70	Barleyfield
0320	TQ	699681	Cuxton, Kent	26.	8.70	Barleyfield
0321	TQ	627579	Wrotham Heath, Kent	27.	8.70	Barleyfield
0322	TQ	639568	Wrotham Heath, Kent	27.	8.70	Strawberry field

0323	TQ	715543	East Barming, Kent	27.	8.70	Barleyfield
0324	TQ	719544	East Barming, Kent	27.	8.70	Wheatfield
0325	TQ	719542	East Barming, Kent	27.	8.70	Strawberry field
0326	TQ	611437	Pembury, Kent	27.	8.70	Barleyfield
0327	TQ	566367	Tunbridge Wells, Sussex	27.	8.70	Oat-field
0328	SP	815035	Princes Risborough, Bucks.	28.	8.70	Wheatfield
0329	SU	857888	Little Marlow, Bucks.	28.	8.70	Tobacco-patch
0330	SU	857887	Little Marlow, Bucks.	28.	8.70	Cabbage-field
0331	SU	854891	Burroughs Grove, Bucks.	28.	8.70	Fallow field
0332	SP	775018	Bledlow, Bucks.	29.	8.70	Wheatfield
0333	SP	777018	Bledlow, Bucks.	29.	8.70	Wheatfield
0334	SP	786005	Bledlow, Bucks.	29.	8.70	Barleyfield
0335	SU	795998	Bledlow, Bucks.	29.	8.70	Cabbage field
0336	SU	796999	Bledlow, Bucks.	29.	8.70	Barleyfield
0337	SP	797000	Bledlow, Bucks.	29.	8.70	Barleyfield
0338	SP	796001	Bledlow, Bucks.	29.	8.70	Bean-field
0339	SU	747771	Dunsden, Oxon.	29.	8.70	Chalk-pit
0340	SU	747771	Dunsden, Oxon.	29.	8.70	Wheatfield
0341	SU	747767	Dunsden, Oxon.	29.	8.70	Barleyfield
0342	SU	892561	Frimley Green, Surrey	30.	8.70	Disturbed pasture
0343	SU	984563	Smarts Heath, Surrey	30.	8.70	Fallow ground
0344	SU	985561	Smarts Heath, Surrey	30.	8.70	Fallow ground
0345	SU	984562	Smarts Heath, Surrey	30.	8.70	Conifer nursery
0346	SU	985564	Smarts Heath, Surrey	30.	8.70	Fallow ground
0347	SU	985564	Smarts Heath, Surrey	30.	8.70	Conifer nursery
0348	TQ	026685	Thorpe, Surrey	30.	8.70	Barleyfield
0349	TQ	028684	Thorpe, Surrey	30.	8.70	Barleyfield
0350	TQ	032683	Thorpe, Surrey	30.	8.70	Barleyfield
0351	TQ	025687	Thorpe, Surrey	30.	8.70	Trackside
0352	TQ	043588	Pyrford, Surrey	30.	8.70	Barleyfield
0353	SU	838666	Wokingham, Berks.	31.	8.70	Wheatfield
0354	SU	838667	Wokingham, Berks.	31.	8.70	Potato field
0355	SU	966628	Chobham, Surrey	31.	8.70	Hedgebank
0356	SU	968625	Chobham, Surrey	31.	8.70	Fallow ground
0357	TQ	064575	Ockham, Surrey	31.	8.70	Dumped soil
0358	TQ	064574	Ockham, Surrey	31.	8.70	Dumped soil
0359	TQ	063574	Ockham, Surrey	31.	8.70	Cabbage field
0360	TQ	064576	Ockham, Surrey	31.	8.70	Fallow field
0361	TQ	066576	Ockham, Surrey	31.	8.70	Fallow ground
0362	TQ	065574	Ockham, Surrey	31.	8.70	Dumped soil
0363	TQ	269574	Chipstead Bottom, Surrey	31.	8.70	Barleyfield
0364	TQ	265573	Chipstead, Surrey	31.	8.70	Abandoned field
0365	TQ	167562	Leatherhead, Surrey	1.	9.70	Flower bed
0366	TQ	167562	Leatherhead, Surrey	1.	9.70	Wasteground
0367	TQ	166563	Leatherhead, Surrey	1.	9.70	Flower bed
0368	TQ	117487	White Downs, Surrey	1.	9.70	Barleyfield
0369	TQ	116488	White Downs, Surrey	1.	9.70	Barleyfield
0370	SU	784363	Bordon, Hants.	1.	9.70	Wasteground
0371	SU	788366	Bordon, Hants.	1.	9.70	Wasteground
0372	SU	599596	Tadley, N. Hants.	2.	9.70	Barleyfield
0373	SU	598598	Tadley, N. Hants.	2.	9.70	Barleyfield
0374	SO	556183	Whitchurch, Herefordshire	15.	9.70	Beet-field
0375	SO	554180	Whitchurch, Herefordshire	15.	9.70	Fallow ground
0376	ST	840480	Chapmanslade, Wilts.	16.	9.70	Beet-field
0377	ST	840480	Chapmanslade, Wilts.	16.	9.70	Bean-field
0378	SU	154275	Odstock, Wilts.	16.	9.70	Wheatfield
0379	SZ	363959	Lymington, Hants.	16.	9.70	Wheatfield
0380	SZ	365953	Lymington, Hants.	16.	9.70	Wheatfield
0381	SZ	369955	Lymington, Hants.	16.	9.70	Wheatfield
0382	SZ	402978	Lymington, Hants.	16.	9.70	Wheatfield

0383	SZ	268934	Downton, Hants.	16. 9.70	Cabbage field
0384	SN	606880	Borth, Cardiganshire	18. 9.70	Oat-field
0385	SN	681949	Ysgubor-y-coed, Cards.	18. 9.70	Turnip field
0386	SH	596049	Llanegryn, Merioneth	18. 9.70	Turnip field
0387	SH	339704	Aberffraw, Anglesey	19. 9.70	Barleyfield
0388	SH	356747	Llanfaelog, Anglesey	19. 9.70	Turnip field
0389	SH	271758	Rhoscolyn, Holy Is. (Anglesey)	19. 9.70	Oat-field
0390	SH	222806	Gors-goch, -do-	19.9. 70	Oat-field
0391	SH	316845	Llanfachraeth, Anglesey	19. 9.70	Oat-field
0392	SH	380936	Cemaes, Anglesey	19. 9.70	Barley/Lolium-field
0393	SH	430935	Amlwch, Anglesey	19. 9.70	Oat-field
0394	SH	431935	Amlwch, Anglesey	19. 9.70	Cabbage field
0395	SH	471876	City Dulas, Anglesey	19. 9.70	Barley (6r)-field
0396	SH	521807	Benllech, Anglesey	19. 9.70	Barley/Lolium-field
0397	SH	551686	Bangor, Caernarvonshire	20. 9.70	Fallow ground
0398	SH	551685	Bangor, Caernarvonshire	20. 9.70	Turnip field
0399	SH	315414	Pistyll, Caernarvonshire	20. 9.70	Cabbage field
0400	SH	229359	Tudweiliog, Caernarvonshire	20. 9.70	Turnip field
0401	SH	231362	Tudweiliog, Caernarvonshire	20. 9.70	Earth mound
0402	SH	189305	Rhydlios, Caernarvonshire	20. 9.70	Oat-field
0403	SH	318298	Abersoch, Carnarvonshire	20. 9.70	Earth mound
0404	SH	391376	Four Crosses, Caernarvons.	20. 9.70	Barleyfield
0405	SH	454379	Chwillog, Caernarvonshire	20. 9.70	Oat-field
0406	SH	474543	Penygroes, Caernarvonshire	20. 9.70	Turnip field
0407	SH	794808	Llandudno, Caernarvonshire	21. 9.70	Barley/Lolium-field
0408	SJ	368713	Gt. Saughall, Cheshire	21. 9.70	Turnip field
0409	SJ	252838	Thurstaston, Cheshire	21. 9.70	Fallow ground
0410	SJ	252838	Thurstaston, Cheshire	21. 9.70	Barleyfield
0411	SJ	311828	Brimstage, Cheshire	21. 9.70	Barleyfield
0412	SU	745392	Selborne, Hants.	3.10.70	Fallow ground (shoddy)
0413	SU	745392	Selborne, Hants.	3.10.70	Hop-plot (shoddy)
0414	SU	778336	Blackmoor, Hants.	3.10.70	Shoddy-heap
0415	SU	777336	Blackmoor, Hants.	3.10.70	Fruit nursery (shoddy)
0416	SU	777338	Blackmoor, Hants.	3.10.70	Fruit nursery (shoddy)
0417	SU	777339	Blackmoor, Hants.	3.10.70	Shoddy-heap
0418	TL	364049	Cheshunt, Herts.	4.10.70	Disturbed earth
0419	TL	364050	Cheshunt, Herts.	4.10.70	Disturbed earth
0420	TL	359087	Hoddesdon, Herts.	4.10.70	Rubbish-tip
0421	TL	360087	Hoddesdon, Herts.	4.10.70	Rubbish-tip
0422	TL	359087	Hoddesdon, Herts.	4.10.70	Rubbish-tip
0423	NZ	336413	Shadforth, Durham	8.10.70	Potato field
0424	NZ	336414	Shadforth, Durham	8.10.70	Turnip field
0425	NZ	336414	Shadforth, Durham	8.10.70	Turnip field
0426	SN	580816	Aberystwyth, Cards.	17. 4.71	Flower bed
0427	SP	039435	Evesham, Worcs.	18. 4.71	Flower bed
0428	SP	040436	Evesham, Worcs.	18. 4.71	Flower bed
0429	SP	039436	Evesham, Worcs.	18. 4.71	Flower bed
0430	ST	562160	Yeovil, Somerset	18. 5.71	Plant-tub
0431	SW	704229	Garras, Cornwall	19. 5.71	Shrub nursery
0432	SW	704229	Garras, Cornwall	19. 5.71	Shrub nursery
0433	SW	705230	Garras, Cornwall	19. 5.71	Wasteground
0434	SW	793219	Trenance, Cornwall	19. 5.71	Potato field
0435	SW	793219	Trenance, Cornwall	19. 5.71	Bulb-field
0436	SW	794219	Trenance, Cornwall	19. 5.71	Bulb-field
0437	SW	796220	Trenance, Cornwall	19. 5.71	Potato field
0438	SW	803220	Porthoustock, W. Cornwall	19. 5.71	Kale-field
0439	SW	718264	Gweek, Cornwall	19. 5.71	Bulb-field
0440	SW	720263	Gweek, Cornwall	19. 5.71	Fallow bulb-field

0441 SW 720263	Gweek, Cornwall	19. 5.71	Bulb-field
0441 SW 720264	Gweek, Cornwall	19. 5.71	Cabbage field
0443 SW 702118	Lizard Point, Cornwall	19. 5.71	Potato field
0444 SW 697117	Lizard Point, Cornwall	19. 5.71	Potato field
0445 SW 701116	Lizard Point, Cornwall	19. 5.71	Flower bed
0446 SW 534306	Goldsithney, Cornwall	20. 5.71	Cauliflower field
0447 SW 486318	Gulval, Cornwall	20. 5.71	Cauliflower field
0448 SW 487317	Gulval, Cornwall	20. 5.71	Cabbage field
0449 SW 487317	Gulval, Cornwall	20. 5.71	Cauliflower field
0450 SW 487317	Gulval, Cornwall	20. 5.71	Cauliflower field
0451 SW 487317	Gulval, Cornwall	20. 5.71	Potato field
0452 SW 443306	Penzance, Cornwall	20. 5.71	Cabbage field
0453 SW 376335	Carnyorth, W. Cornwall	20. 5.71	Potato field
0454 SW 366263	Sennon, W. Cornwall	20. 5.71	Bulb-field
0455 SW 367265	Sennon, W. Cornwall	20. 5.71	Bulb-field
0456 SW 363261	Sennon, W. Cornwall	20. 5.71	Wasteground
0457 SW 416238	Trevedron, W. Cornwall	20. 5.71	Cauliflower field
0458 SW 563294	Rosudgeon, Cornwall	20. 5.71	Cauliflower field
0459 SW 757398	Frogpool, Cornwall	21. 5.71	Cauliflower field
0460 SW 756401	Frogpool, Cornwall	21. 5.71	Red Cabbage field
0461 SW 760544	Perranporth, Cornwall	21. 5.71	Wasteground
0462 SW 760544	Perranporth, Cornwall	21. 5.71	Disturbed soil
0463 SW 760544	Perranporth, Cornwall	21. 5.71	Wasteground
0464 SW 690445	Redruth, Cornwall	21. 5.71	Cabbage field
0465 SV 909108	Hugh Town, St. Mary's	23. 5.71	Daffs/Potato field
0466 SV 909108	Hugh Town, St. Mary's	23. 5.71	Bulbs
0467 SV 909108	Hugh Town, St. Mary's	23. 5.71	Fallow field
0468 SV 911108	Hugh Town, St. Mary's	23. 5.71	Fallow field
0469 SV 911109	Hugh Town, St. Mary's	23. 5.71	Bulbs
0470 SV 911110	Rocky Hill, St. Mary's	23. 5.71	Daffodils
0471 SV 908116	Porthloo, St. Mary's	23. 5.71	Bulbs
0472 SV 910117	Porthloo, St. Mary's	23. 5.71	Bulbs
0473 SV 911117	Porthloo, St. Mary's	23. 5.71	Daffodils
0474 SV 912117	Content, St. Mary's	23. 5.71	Bulbs
0475 SV 913118	Content, St. Mary's	23. 5.71	Bulbs
0476 SV 913118	Content, St. Mary's	23. 5.71	Fallow
0477 SV 912121	Content, St. Mary's	23. 5.71	Daffodils
0478 SV 914125	Halangy, St. Mary's	23. 5.71	Bulbs
0479 SV 914126	Halangy, St. Mary's	23. 5.71	Daffodils
0480 SV 915126	Halangy, St. Mary's	23. 5.71	Leocojum pulchellum
0481 SV 917123	Trenoweth, St. Mary's	23. 5.71	1-2 yr. fallow
0482 SV 919121	Trenoweth, St. Mary's	23. 5.71	Daffodils
0483 SV 920119	Holy Vale, St. Mary's	23. 5.71	Bulbs
0484 SV 920117	Holy Vale, St. Mary's	23. 5.71	Bulbs
0485 SV 915161	Lower Town, St. Martin's	24. 5.71	Bulbs
0486 SV 915161	Lower Town, St. Martin's	24. 5.71	Fallow
0487 SV 917163	Lower Town, St. Martin's	24. 5.71	Daffodils
0488 SV 917163	Lower Town, St. Martin's	24. 5.71	Fallow
0489 SV 919161	Lower Town, St. Martin's	24. 5.71	Cabbage
0490 SV 920162	Middle Town, St. Martin's	24. 5.71	Bulbs
0491 SV 920162	Middle Town, St. Martin's	24. 5.71	Daffodils
0492 SV 920161	Middle Town, St. Martin's	24. 5.71	Daffs/Glad. byz.
0493 SV 921159	Middle Town, St. Martin's	24. 5.71	Fallow + relic Btrt.
0494 SV 922159	Middle Town, St. Martin's	24. 5.71	Bulbs
0495 SV 927158	Higher Town, St. Martin's	24. 5.71	Leocojum
0496 SV 927158	Higher Town, St. Martin's	24. 5.71	Bulbs
0497 SV 909102	Buzza Hill, St. Mary's	24. 5.71	Bulbs
0498 SV 889142	Appletree Point, Tresco	25. 5.71	Daffodils

0499	SV	889148	Appletree Point, Tresco	25.	5.71	Daffodils
0500	SV	891154	Dolphin Town, Tresco	25.	5.71	Bulbs/Potatoes
0501	SV	891154	Dolphin Town, Tresco, Scilly	25.	5.71	Bulbs
0502	SV	889154	Towns Hill, Tresco	25.	5.71	Bulbs/Potatoes
0503	SV	890155	Dolphin Town, Tresco	25.	5.71	Bulbs
0504	SV	890155	Dolphin Town, Tresco	25.	5.71	Bulbs
0505	SV	892156	Green, Tresco	25.	5.71	Fallow (2nd yr?)
0506	SV	892156	Green, Tresco	25.	5.71	Bulbs
0507	SV	893156	Green, Tresco	25.	5.71	Bulbs
0508	SV	885084	The Bar, St. Agnes	26.	5.71	Fallow
0509	SV	885084	The Bar, St. Agnes	26.	5.71	Bulbs
0510	SV	885084	The Bar, St. Agnes	26.	5.71	Bulbs
0511	SV	884083	Higher Town, St. Agnes	26.	5.71	Bulbs
0512	SV	883080	Higher Town, St. Agnes	26.	5.71	Bulbs
0513	SV	882081	Higher Town, St. Agnes	26.	5.71	Fallow
0514	SV	880085	Porth Killier, St. Agnes	26.	5.71	Bulbs
0515	SV	880084	Middle Town, St. Agnes	26.	5.71	Fallow
0516	SV	910103	Hugh Town, St. Mary's	26.	5.71	Bulbs
0517	SV	911102	Old Town, St. Mary's	26.	5.71	Fallow
0518	SV	911102	Old Town, St. Mary's	26.	5.71	Daffodils
0519	SW	928157	Higher Town, St. Martin's	27.	5.71	Fallow
0520	SV	928157	Higher Town, St. Martin's	27.	5.71	Fallow
0521	SV	929157	Higher Town, St. Martin's	27.	5.71	Fallow
0522	SV	927153	Higher Town, St. Martin's	27.	5.71	Bulbs
0523	SV	915104	Old Town, St. Mary's	27.	5.71	Potatoes
0524	SV	915106	Old Town, St. Mary's	27.	5.71	Bulbs
0525	SV	916107	Parting Carn, St. Mary's	27.	5.71	Fallow
0526	SV	910102	Old Town, St. Mary's	28.	5.71	Bulbs/Potatoes
0527	SV	919108	Tremelethen, St. Mary's	28.	5.71	Fallow
0528	SV	927108	Porth Hellick Down, St. Mary's	28.	5.71	Disturbed ground
0529	SV	928111	Carn Friars, St. Mary's	28.	5.71	Bulbs
0530	SV	928112	Carn Friars, St. Mary's	28.	5.71	Daffodils
0531	SV	926114	Pelistry, St. Mary's	28.	5.71	Bulbs
0532	SV	927117	Pelistry, St. Mary's	28.	5.71	Daffodils
0533	ST	473014	Beaminster, Dorset	29.	5.71	Lettuces (garden)
0534	ST	473014	Beaminster, Dorset	29.	5.71	Strawberries (garden)
0535	SU	350064	Beaulieu Road, Hants.	30.	5.71	Gravel track
0536	TQ	246507	Reigate, Surrey	30.	5.71	Vegetable garden
0537	TQ	246507	Reigate, Surrey	30.	5.71	Flower garden
0538	SU	9950	Guildford, Surrey	26.	6.71	Strawberries (garden)
0539	TQ	519892	Romford, Essex	3.	7.71	Shrubbery - Forsythia
0540	TQ	519891	Romford, Essex	3.	7.71	Rose bed
0541	TQ	975485	Westwell, Kent	4.	7.71	Barley (2r)
0542	TR	262655	Sarre, Kent	4.	7.71	Peas
0543	TR	260653	Sarre, Kent	4.	7.71	Onions
0544	TR	348577	Sandwich, Kent	4.	7.71	Wheat
0545	TR	339549	Worth, Kent	4.	7.71	Wheat
0546	TR	365494	Ringwould, Kent	4.	7.71	Barley (2r)
0547	SU	633526	Basingstoke, Hants.	6.	7.71	Disturbed ground
0548	SU	633526	Basingstoke, Hants.	6.	7.71	Wasteground
0549	SU	520445	Micheldever Stn., Hants.	6.	7.71	Chalk spoil heap
0550	SU	520446	Micheldever Stn., Hants.	6.	7.71	Chalk Spoil heap
0551	SU	521445	Micheldever Stn., Hants.	6.	7.71	Wheat
0552	SU	496390	Weston Colley, Hants.	6.	7.71	2r Barley
0553	SU	438432	Barton Stacy, Hants.	6.	7.71	2r Barley
0554	SU	438431	Barton Stacy, Hants.	6.	7.71	Fallow area/cartway
0555	SU	438429	Barton Stacy, Hants.	6.	7.71	Disturbed soil
0556	SU	150272	Odstock Hospital, Wilts.	7.	7.71	2r Barley

0557	SU	149271	Odstock Hospital, Wilts.	7.	7.71	Field entrance
0558	SU	153271	Odstock Hospital, Wilts.	7.	7.71	2r Barley
0559	ST	914789	Kington Langley, Wilts.	7.	7.71	Disturbed soil
0560	SS	463351	Braunton Burrows, Devon	8.	7.71	Oats
0561	SS	466358	Braunton, Devon	8.	7.71	Narcissi
0562	SS	467358	Braunton, Devon	8.	7.71	2 yr fallow
0563	SS	467357	Braunton, Devon	8.	7.71	2 yr fallow
0564	SS	426408	Baggy Point, Devon	8.	7.71	2r Barley
0565	SS	477354	Braunton Marshes, Devon	9.	7.71	Cabbages
0566	SS	465359	Braunton, Devon	9.	7.71	2 yr fallow
0567	SS	512325	Fremington, Devon	9.	7.71	Onions (garden)
0568	SS	468287	Westleigh, Devon	9.	7.71	Fallow
0569	SS	305236	Clovelly, Devon	9.	7.71	2r Barley
0570	SS	293239	Hartland, Devon	9.	7.71	2r Barley
0571	SS	259164	Eastcott, Cornwall	9.	7.71	2r Barley
0572	SS	222055	Bude, Cornwall	9.	7.71	2r Barley
0573	SX	272834	Piper's Pool, Cornwall	9.	7.71	Roadside
0574	SX	329849	Launceston, Cornwall	10.	7.71	Shrubbery
0575	SX	329849	Launceston, Cornwall	11.	7.71	Wasteground
0576	SX	4952	Plymouth, Devon	12.	7.71	Shrubbery
0577	SX	4952	Plymouth, Devon	12.	7.71	Wasteground
0578	SX	691483	Aveton Gifford, Devon	12.	7.71	2r Barley
0579	SX	690484	Aveton Gifford, Devon	12.	7.71	2r Barley
0580	SX	824421	Torcross, Devon	12.	7.71	Flower garden
0581	SX	824505	Blackawton, Devon	12.	7.71	Oats/Red Clover
0582	SX	783532	Halwell, Devon	13.	7.71	2r Barley
0583	SX	772641	Staverton, Devon	13.	7.71	2r Barley
0584	SX	780717	Ashburton, Devon	13.	7.71	2r Barley
0585	SX	780717	Ashburton, Devon	13.	7.71	Cabbages
0586	SU	029089	Horton, Dorset	13.	7.71	2r Barley
0587	SU	028088	Horton, Dorset	13.	7.71	2r Barley
0588	NZ	374271	Sedgefield, Co. Durham	19.	7.71	Wheat
0589	SU	093076	Verwood, Dorset	26.	7.71	2r Barley
0590	SU	093075	Verwood, Dorset	26.	7.71	2r Barley
0591	SU	067062	Horton Common, Dorset	26.	7.71	2r Barley
0592	SU	067062	Horton Common, Dorset	26.	7.71	Abndnd conifer plntn.
0593	SU	068062	Horton Common, Dorset	26.	7.71	2r Barley
0594	SU	053067	Horton, Dorset	26.	7.71	Wheat
0595	SU	050067	Horton, Dorset	26.	7.71	Wheat
0596	SU	043073	Horton, Dorset	26.	7.71	Wheat
0597	SU	038079	Horton, Dorset	26.	7.71	Carrots
0598	SU	038079	Horton, Dorset	26.	7.71	Lettuces
0599	SU	046090	Woodlands, Dorset	26.	7.71	Wheat
0600	SU	047115	Edmondsham, Dorset	26.	7.71	2r Barley
0601	SU	047118	Edmondsham, Dorset	26.	7.71	Oats
0602	SU	082124	Cranborne, Dorset	26.	7.71	2r Barley
0603	SY	915932	Sherford, Dorset	27.	7.71	Wheat
0604	SY	917928	Sherford, Dorset	27.	7.71	Wheat
0605	SY	913871	Wareham, Dorset	27.	7.71	Dumped Soil
0606	SY	914871	Wareham, Dorset	27.	7.71	Potatoes
0607	SY	913871	Wareham, Dorset	27.	7.71	2r Barley
0608	SY	926863	Wareham, Dorset	27.	7.71	2r Barley
0609	SY	940867	Ridge, Dorset	27.	7.71	Cart-track
0610	SY	957839	Middlebere Heath, Dorset	27.	7.71	Cabbages
0611	SY	988814	Harman's Cross, Dorset	27.	7.71	2r Barley
0612	SY	981781	Worth Matravers, Dorset	27.	7.71	Cabbages
0613	SY	974780	Worth Matravers, Dorset	27.	7.71	Cabbages
0614	SY	974781	Worth Matravers, Dorset	27.	7.71	Oats

0615	SY	682691	Portland Bill, Dorset	28.	7.71	2r Barley
0616	SY	683692	Portland Bill, Dorset	28.	7.71	Potatoes/Wheat
0617	SY	683693	Portland Bill, Dorset	28.	7.71	2r Barley
0618	SY	684693	Portland Bill, Dorset	28.	7.71	Potatoes
0619	SY	684694	Portland Bill, Dorset	28.	7.71	2r Barley
0620	SY	680712	Weston, Is. of Portland, D.	28.	7.71	2r Barley
0621	SY	714819	Redcliff Point, Dorset	28.	7.71	2r Barley
0622	SY	837952	Bere Regis, Dorset	29.	7.71	2r Barley
0623	SY	836953	Bere Regis, Dorset	29.	7.71	Cabbages
0624	SY	832952	Bere Regis, Dorset	29.	7.71	Wheat
0625	SY	747942	Puddletown, Dorset	29.	7.71	Wheat
0626	SY	709932	Charminster, Dorset	29.	7.71	Wheat
0627	SY	716944	Piddlehinton, Dorset	29.	7.71	2r Barley
0628	SY	716944	Piddlehinton, Dorset	29.	7.71	Oats
0629	ST	703016	Piddletrenthide, Dorset	29.	7.71	2r Barley
0630	ST	646174	Sherborne, Dorset	29.	7.71	Earth mound
0631	ST	646175	Sherborne, Dorset	29.	7.71	Wheat
0632	ST	646175	Sherborne, Dorset	29.	7.71	Wheat
0633	ST	623177	Sherborne, Dorset	29.	7.71	Wheat
0634	ST	613189	Trent, Dorset	29.	7.71	6r Barley
0635	ST	765287	Bourton, Dorset	30.	7.71	Wheat
0636	ST	792327	Zeals, Wilts.	30.	7.71	2r Barley
0637	ST	786331	Stourton, Wilts.	30.	7.71	2r Barley
0638	ST	773355	Kilminster, Wilts.	30.	7.71	2r Barley
0639	ST	822284	Gillingham, Dorset	30.	7.71	Wheat
0640	ST	839131	Child Okeford, Dorset	30.	7.71	Fallow
0641	ST	841139	Child Okeford, Dorset	30.	7.71	2r Barley
0642	ST	839140	Child Okeford, Dorset	30.	7.71	Wheat
0643	ST	971021	Badbury, Dorset	31.	7.71	2r Barley
0644	ST	947036	Tarrant Keyneston, Dorset	31.	7.71	2r Barley
0645	ST	948036	Tarrant Keyneston, Dorset	31.	7.71	Wheat
0646	ST	920058	Buzbury Rings, Dorset	31.	7.71	2r Barley
0647	ST	838142	Farrington, Dorset	31.	7.71	Wheat
0648	ST	838146	Farrington, Dorset	31.	7.71	2r Barley
0649	ST	847159	Farrington, Dorset	31.	7.71	2r Barley
0650	ST	850161	Sutton Waldron, Dorset	31.	7.71	Wheat
0651	ST	868199	West Melbury, Dorset	31.	7.71	2r Barley
0652	ST	864161	Sutton Waldron, Dorset	31.	7.71	2r Barley
0653	ST	853151	Sutton Waldron, Dorset	31.	7.71	Oats
0654	ST	861153	Sutton Waldron, Dorset	31.	7.71	2r Barley
0655	SY	961929	Lytchett Minster, Dorset	1.	8.71	Wheat
0656	SY	964929	Lytchett Minster, Dorset	1.	8.71	2r Barley
0657	SY	958927	Lytchett Minster, Dorset	1.	8.71	Wheat
0658	SY	957927	Lytchett Minster, Dorset	1.	8.71	Wheat
0659	SY	976827	Bushey, Dorset	1.	8.71	Wheat/Red Clover
0660	SY	976826	Bushey, Dorset	1.	8.71	2r Barley
0661	SZ	029817	Ballard Down, Dorset	2.	8.71	2r Barley
0662	SZ	021814	Ballard Down, Dorset	2.	8.71	2r Barley
0663	SZ	022814	Ballard Down, Dorset	2.	8.71	2r Barley
0664	SZ	036813	Ballard Down, Dorset	2.	8.71	2r Barley
0665	SZ	034813	Ballard Down, Dorset	2.	8.71	2r Barley
0666	SZ	017790	Swanage, Dorset	2.	8.71	2r Barley
0667	SZ	017791	Swanage, Dorset	2.	8.71	2r Barley
0668	SY	956789	Kingston, Dorset	2.	8.71	Wheat
0669	SY	955786	Kingston, Dorset	2.	8.71	2r Barley/White Clover
0670	SY	954772	Chapman's Pool, Dorset	2.	8.71	Wheat
0671	SY	952773	Chapman's Pool, Dorset	2.	8.71	Wheat
0672	SY	954775	Chapman's Pool, Dorset	2.	8.71	Wheat

0673	SY	950795	Kingston, Dorset	2.	8.71	Wheat
0674	SY	933787	Swyre Head, Dorset	2.	8.71	Oats
0675	SY	940789	Kingston, Dorset	2.	8.71	2r Barley
0676	SY	936818	Church Knowle, Dorset	2.	8.71	2r Barley
0677	SY	916812	Steeple, Dorset	2.	8.71	Fallow
0678	SY	915811	Steeple, Dorset	2.	8.71	6r Barley
0679	SY	390949	Whitchurch Canonicorum, Dst.	3.	8.71	2r Barley
0680	SY	448930	Eype, Dorset	3.	8.71	2r Barley
0681	SY	450931	Bridport, Dorset	3.	8.71	Wheat
0682	SY	477947	Bradpole, Dorset	3.	8.71	2r Barley
0683	SY	482961	Mangerton, Dorset	3.	8.71	Wheat
0684	SY	484988	Melplash, Dorset	3.	8.71	2r Bly/R.Clov/Lol hy.
0685	SY	485988	Melplash, Dorset	2.	8.71	2r Barley
0686	SY	639947	Frampton, Dorset	4.	8.71	Dumped gravel
0687	SY	639947	Frampton, Dorset	4.	8.71	Dumped gravel
0688	SY	630957	Frampton, Dorset	4.	8.71	2r Barley
0689	SY	623967	Maiden Newton, Dorset	4.	8.71	2r Barley
0690	ST	610016	Cattistock, Dorset	4.	8.71	2r Barley
0691	ST	611017	Up Sydling, Dorset	4.	8.71	2r Bly/W.Clv/Lol per.
0692	ST	578088	Melbury Osmond, Dorset	4.	8.71	Wheat
0693	ST	578088	Melbury Osmond, Dorset	4.	8.71	Broad beans
0694	ST	568110	Ryme Intrinseca, Dorset	4.	8.71	Oats/Lol. hyb.
0695	ST	584108	Ryme Intrinseca, Dorset	4.	8.71	Wheat
0696	ST	619100	Yetminster, Dorset	4.	8.71	Wheat
0697	ST	643128	Longburton, Dorset	4.	8.71	2r Barley
0698	ST	655049	Minterne Magna, Dorset	4.	8.71	Wheat
0699	ST	662022	Up Cerne, Dorset	4.	8.71	2r Barley
0700	SY	667986	Nether Cerne, Dorset	4.	8.71	Wheat
0701	SY	667979	Nether Cerne, Dorset	4.	8.71	Wheat
0702	TL	527518	Babraham, Cambs.	6.	8.71	Beet
0703	TL	579649	Swaffham Prior, Cambs.	6.	8.71	2r Barley
0704	TL	579648	Swaffham Prior, Cambs.	6.	8.71	Mustard
0705	NZ	285104	Oxen-le-Fields, Co. Durham	22.	8.71	Wheat
0706	NZ	328104	Neasham, Co. Durham	22.	8.71	Building site
0707	TQ	043581	Pyrford, Surrey	29.	8.71	Lettuces
0708	TQ	044580	Pyrford, Surrey	29.	8.71	Carrots
0709	TQ	039586	Pyrford, Surrey	29.	8.71	Turnips
0710	TQ	042588	Pyrford, Surrey	29.	8.71	2r Barley
0711	TQ	043588	Pyrford, Surrey	29.	8.71	2r Barley
0712	TQ	086464	Burrows Cross, Surrey	30.	8.71	2r Barley
0713	TQ	091463	Burrows Cross, Surrey	30.	8.71	Oats
0714	TQ	092463	Burrows Cross, Surrey	30.	8.71	Oats
0715	TQ	088455	Peaslake, Surrey	30.	8.71	Fallow cold-frame
0716	TQ	129459	Abinger, Surrey	30.	8.71	2r Barley
0717	TQ	011406	Hascombe, Surrey	30.	8.71	Wheat
0718	SU	971439	Godalming, Surrey	30.	8.71	Flower bed
0719	SU	940430	Milford, Surrey	30.	8.71	2r Barley
0720	SU	940430	Milford, Surrey	30.	8.71	Lettuces
0721	SU	939431	Milford, Surrey	30.	8.71	Cabbages
0722	SU	938429	Milford, Surrey	30.	8.71	Potatoes
0723	SU	930431	Milford, Surrey	30.	8.71	Disturbed roadside
0724	SY	548918	Litton Cheney, Dorset	31.	8.71	Wheat
0725	SY	531887	Puncknowle, Dorset	31.	8.71	2r Barley
0726	SY	512898	Burton Bradstock, Dorset	31.	8.71	Wheat
0727	SY	492892	Burton Bradstock, Dorset	31.	8.71	2r Barley
0728	SY	502887	Burton Bradstock, Dorset	31.	8.71	2r Barley
0729	SU	374038	Beaulieu, Hants.	1.	9.71	Wheat
0730	SU	451002	Langley, Hants.	1.	9.71	2r Barley

0731	SU	464005	Stanswood, Hants.	1.	9.71	Turnips
0732	SU	465005	Stanswood, Hants.	1.	9.71	Turnips
0733	SU	480014	Calshot, Hants.	1.	9.71	Wasteground
0734	SU	469020	Calshot, Hants.	1.	9.71	Wheat
0735	SU	531031	Meon, Hants.	1.	9.71	Kale
0736	SU	531031	Meon, Hants.	1.	9.71	Potatoes
0737	SY	759873	Warmwell, Dorset	2.	9.71	Refuse tip
0738	SY	625824	Langton Herring, Dorset	2.	9.71	Wheat
0739	ST	969670	Sandy Lane, Wilts.	2.	9.71	2r Barley
0740	ST	969670	Sandy Lane, Wilts.	2.	9.71	French beans
0741	ST	971599	Poulshot, Wilts.	2.	9.71	Fallow
0742	SU	247873	Shrivenham, Berks.	2.	9.71	2r Barley
0743	TL	233486	Potton, Beds.	4.	9.71	Runner beans
0744	TL	233486	Potton, Beds.	4.	9.71	Carrots
0745	TL	210491	Potton, Beds.	4.	9.71	2r Barley
0746	TL	194486	Sandy Heath, Beds.	4.	9.71	Wheat
0747	TL	193487	Sandy Heath, Beds.	4.	9.71	2r Barley
0748	TL	197505	Everton, Beds.	4.	9.71	Marrows
0749	TL	198505	Everton, Beds.	4.	9.71	Beetroots
0750	NZ	667145	Stanghow Moor, Yorks. N.R.	8.	9.71	2r Barley
0751	NZ	739127	Scaling, Yorks. N.R.	8.	9.71	2r Bly/Alsike Clov.
0752	TL	757962	Northwold, Norfolk	9.	9.71	Maize
0753	TL	785945	Cranwich, Norfolk	9.	9.71	Beet
0754	TL	785945	Cranwich, Norfolk	9.	9.71	2r Barley
0755	TL	741771	Portway Heave, Eriswell	9.	9.71	Beet
0756	TM	395560	Iken, Suffolk	9.	9.71	Potatoes
0757	TM	408541	Sudbourne, Suffolk	9.	9.71	2r Barley
0758	TL	752763	Eriswell, Suffolk	10.	9.71	Dactylis/Lucerne
0759	TL	726826	Lakenheath, Suffolk	10.	9.71	Fallow
0760	TL	954881	Roudham, Norfolk	10.	9.71	2r Bly/Lucerne
0761	TL	973903	Knights Fen, Norfolk	10.	9.71	Beet
0762	TL	941922	Great Hockham, Norfolk	10.	9.71	2r Barley
0763	TL	877894	Croxton, Norfolk	10.	9.71	Carrots
0764	TL	858679	Fornham St. Martin, Suffolk	10.	9.71	2r Barley
0765	TL	495691	Chittering, Cambs.	10.	9.71	Potatoes
0766	NO	508347	Monifieth, Angus	14.	9.71	Carrots
0767	NO	509347	Monifieth, Angus	14.	9.71	Potatoes
0768	NO	573349	Carnoustie, Angus	14.	9.71	Relic carrots
0769	NO	581353	Panbride, Angus	14.	9.71	Turnips
0770	NO	638411	Arbroath, Angus	14.	9.71	Wasteground
0771	NO	681443	Auchmithie, Angus	14.	9.71	Potatoes
0772	NO	514510	Rescobie, Angus	14.	9.71	2r Barley
0773	NO	478509	Forfar, Angus	14.	9.71	2r Barley
0774	NO	479509	Forfar, Angus	14.	9.71	2r Barley
0775	NO	689561	Montrose, Angus	14.	9.71	Beet
0776	NO	871804	Catterline, Kincardine	14.	9.71	Swedes
0777	NJ	201708	Lossiemouth, Moray	15.	9.71	Cabbages
0778	NJ	197707	Lossiemouth, Moray	15.	9.71	2r Barley
0779	NJ	172697	Duffus, Moray	15.	9.71	Carrots
0780	NG	394633	Uig, Skye	16.	9.71	Turnips
0781	NF	753152	Kilbride, South Uist	17.	9.71	Turnips
0782	NF	753151	Kilbride, South Uist	17.	9.71	Oats
0783	NF	753151	Kilbride, South Uist	17.	9.71	Potatoes
0784	NF	743153	Smerclett, S. Uist	17.	9.71	Rye
0785	NF	743152	Smerclett, S. Uist	17.	9.71	Rye
0786	NF	744152	Smerclett, S. Uist	17.	9.71	Potatoes
0787	NF	724276	Trollaskeir, S. Uist	17.	9.71	Rye
0788	NF	724278	Trollaskeir, S. Uist	17.	9.71	Rye

0789	NF	726274	Trollaskeir, S. Uist	17.	9.71	Rye
0790	NF	865756	Machair Robach, N. Uist	18.	9.71	Rye
0791	NF	864756	Machair Robach, N. Uist	18.	9.71	Fallow
0792	NF	737335	Stoneybridge, S. Uist	19.	9.71	Black oats
0793	NF	735334	Cnoca Breac, S. Uist	19.	9.71	Rye
0794	NF	736335	Cnoca Breac, S. Uist	19.	9.71	Fallow
0795	NF	736344	Cnoca Breac, S. Uist	19.	9.71	Rye/Black oats
0796	NF	752359	Howbeg, S. Uist	19.	9.71	Potatoes
0797	NF	752359	Howbeg, S. Uist	19.	9.71	Rye
0798	NF	783470	Carnon Lochdar, S. Uist	19.	9.71	Rye/Black oats
0799	NF	776501	Borve, Benbecula	19.	9.71	Potatoes
0800	NF	776501	Borve, Benbecula	19.	9.71	Rye/Black oats
0801	NF	738671	Balmore, N. Uist	20.	9.71	Rye
0802	NF	738676	Balmore, N. Uist	20.	9.71	Black oats
0803	NF	831471	Grimsay, Benbecula	22.	9.71	Potatoes
0804	TQ	501817	Dagenham, Essex	25.	9.71	Ash tip
0805	TQ	501819	Dagenham, Essex	25.	9.71	Ash tip
0806	TQ	627735	Northfleet, Kent	25.	9.71	Refuse tip
0807	NZ	066394	Tunstall Reservoir, Durham	31.10.71		Turnips
0808	SU	769241	Petersfield, Hants.	9.11.71		2r Barley
0809	TQ	064585	R.H.S. Gdns., Wisley, Surrey	5.	4.72	Abandoned flower bed
0810	TQ	064585	R.H.S. Gdns., Wisley, Surrey	5.	4.72	Abandoned flower bed
0811	TQ	064585	R.H.S. Gdns., Wisley, Surrey	5.	4.72	Abandoned flower bed
0812	TQ	066586	R.H.S. Gdns., Wisley, Surrey	5.	4.72	Conifers
0813	TQ	066586	R.H.S. Gdns., Wisley, Surrey	5.	4.72	Fallow ground
0814	SU	985562	Smart's Heath, Mayford, Surr.	27.	5.72	Conifers
0815	TL	722716	Tuddenham, Suffolk	28.	5.72	Fallow, 3rd yr
0816	TL	751763	Eriswell, Suffolk	28.	5.72	Fallow, 2nd yr
0817	TQ	50 88	Romford, Essex	8.	8.72	Flowers (Erica)
0818	TQ	50 88	Romford, Essex	8.	8.72	Flowers (Erica)
0819	TQ	117487	Effingham, Surrey	11.	8.72	2r Barley
0820	TQ	116488	Effingham, Surrey	11.	8.72	2r Barley
0821	SE	586316	Thorpe Willoughby, Yorks.	30.	8.72	2r Barley
0822	SE	586316	Thorpe Willoughby, Yorks.	30.	8.72	Wheat
0823	SE	689451	Wheldrake, Yorks.	30.	8.72	Potatoes
0824	TA	039121	Elsham, Lincs.	30.	8.72	2r Barley
0825	TA	044128	Elsham, Lincs.	31.	8.72	Beet
0826	TF	091981	Holton le Moor, Lincs.	31.	8.72	2r Barley
0827	TF	088983	Holton le Moor, Lincs.	31.	8.72	Wheat
0828	TF	109879	Market Rasen, Lincs.	31.	8.72	Cabbages
0829	TF	189643	Woodhall Spa, Lincs.	31.	8.72	Beet
0830	SK	894684	Eagle, Lincs.	31.	8.72	Kale
0831	SK	894684	Eagle, Lincs.	31.	8.72	Beet
0832	SK	830687	Spalford Warren, Notts.	31.	8.72	Rye
0833	SK	82 72	North Clifton, Notts.	31.	8.72	Cabbages
0834	TL	100304	Barton Hills, Herts.	5.	9.72	2r Barley
0835	TL	063362	Flitton, Beds.	5.	9.72	Cabbages
0836	NU	2413	Lesbury, Northumberland	10.	9.72	2r Barley
0837	NU	2221	Embleton, Northumberland	10.	9.72	2r Barley
0838	NU	2232	Seahouses, Northumberland	10.	9.72	Ploughed track
0839	NU	1635	Budle, Northumberland	10.	9.72	2r Barley
0840	NU	059427	Beal, Northumberland	10.	9.72	Potatoes
0841	NT	954608	Burnmouth, Berwicks.	10.	9.72	Turnips
0842	NT	819694	Head Chester, Berwicks.	10.	9.72	Potatoes
0843	NT	625745	Stenton, E. Lothian	10.	9.72	Turnips
0844	NT	572705	Garvald, E. Lothian	10.	9.72	2r Barley
0845	NZ	522275	Seaton Carew, Co. Durham	30.10.69		Wasteground
0846	NZ	52 22	Seal Sands, Co. Durham	30.10.69		Wasteground

0847	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0848	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0849	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0850	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0851	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0852	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0853	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0854	NZ	52 22	Seal Sands, Co. Durham	30.10.69	Wasteground
0855	NZ	292415	Shincliffe, Co. Durham	1.11.69	Fallow
0856	NZ	292415	Shincliffe, Co. Durham	1.11.69	Fallow
0857	NZ	292415	Shincliffe, Co. Durham	1.11.69	Fallow
0858	TQ	555881	Hornchurch, Essex	20. 7.70	2r Barley
0859	TQ	06 58	R.H.S. Gdns, Wisley, Surrey	4. 9.72	Gravel mound
0860	TL	766850	Brandon, Suffolk	18. 6.73	2r Barley
0861	TL	758840	Wangford Warren, Suffolk	19. 6.73	Fallow
0862	TQ	005484	Guildford, Surrey	July, 73	2r Barley
0863			Cuxton, Kent	July, 73	Potatoes
0864			Cuxton, Kent	July, 73	2r Barley
0865-N			Horgheim, W. Norway	July, 73	Turnips
0866-N			Horgheim, W. Norway	July, 73	Turnips
0867-N			Sunndalsora, W. Norway	July, 73	Potatoes
0868-N			Valle, W. Norway	July, 73	Potatoes
0869	NZ	249649	Newcastle-upon-Tyne	1. 5.73	Flower bed
0870	NS	185877	Ardentinny, Argyllshire	1. 5.74	Flower bed
0871	NO	062627	Kindrogan, Perthshire	14. 5.73	Nursery
0872	NS	494639	Paisley, Renfrewshire	6. 8.74	Flower bed
0873	NS	365736	Langbank, Renfrewshire	19. 6.75	Gravel Path

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