The vegetation and management of hay meadows in upland Britain.

Joanna Hughes

THE VEGETATION AND MANAGEMENT OF HAY MEADOWS

IN UPLAND BRITAIN

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to the University of Durham.

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'It is . . . the tragedy of science that she must perforce lag sadly behind practice - she is only able and fully qualified to teach when to a large degree it is already too late:'

R.G. Stapledon - 'The hill lands of
Britain - development or decay?'

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DECLARATION

I declare that this thesis is entirely my own work and has on no previous occasion been submitted in consideration for any degree. The work of which it is a record was carried out by myself and where others assisted, they worked under my direction and their assistance has been acknowledged. To the best of my knowledge, all quotations have been distinguished and all reference sources acknowledged.

J.C. HUGHES

ABSTRACT

Hay meadows throughout much of Upland Britain were studied. 430 2m x 2m relevés were taken, recording the presence of 236 species on the Domin scale of cover/abundance. 18 vegetation types were recognised, with the aid of TWINSPAN and DECORANA analyses, ranging from semi-natural, herb-rich Festuca rubra grasslands to species-poor Lolium perenne swards. The problems in relating these vegetation types to published communities, particularly those from the Continent, are discussed. The environmental factors and agricultural management associated with the samples were assessed and explored, using CANOCO. The variables which were shown in the analyses to vary with the patterns in vegetation included: altitude, slope, amount of artificial fertiliser applied, age of the sward, date of cutting and length of shut-up period. Published work on the effects of fertilisation and other management factors on the botanical composition of meadow vegetation is briefly reviewed. Meadows are of vital importance within the upland farming system. As agricultural grasslands, their management has changed with changing farming practices and a brief discussion of the history of hay meadow management in Britain precedes a more detailed discussion on the changes in grassland management seen over the last 40 to 50 years. An understanding of the consequences of these changes on the botanical composition of the fields - to which this work makes a contribution - is of relevance to the nature conservation of these rich, and rapidly declining, communities.

INTRODUCTION

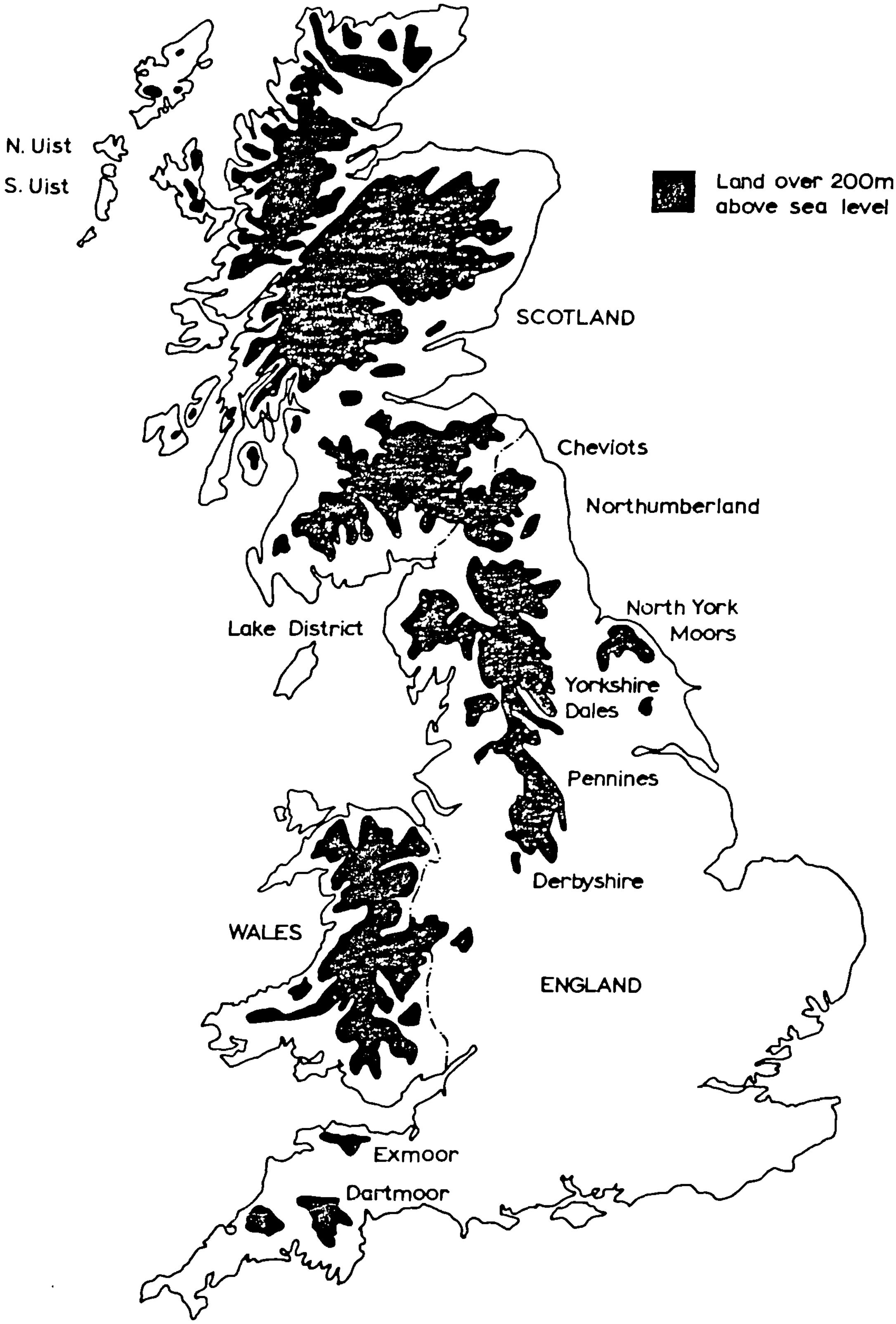
This study has been carried out within the area of Great Britain known as the Uplands. The Uplands lie to the north and west of Britain, where much of the land is over 240m (800 feet) above sea level (see figure 1). 9% England and 39% Wales is above 240m a.s.l. (Countryside Commission, 1984). The high altitudes of this region result in low temperatures, both in summer and in winter, and there are several months in which frosts are likely. The growing season is rarely above 220 days in the Uplands (Peel and Matkin, 1982). The prevailing winds, from the south-west, are moisture-laden from their crossing of the Atlantic Ocean and so precipitation levels in these western hills are characteristically high. Peel and Matkin (1982) described the Uplands as having fewer than five days per annum in which grass growth is impeded by lack of readily-available soil moisture and as experiencing more than 850mm precipitation per annum. During the winter months, much of this precipitation falls as snow.

One cannot, however, define the extent of the Uplands of Britain by altitude alone. Not all the land within the area accepted as the Uplands lies above 240m. Many of the valleys in the upland area are at lower levels and as one moves north within Britain, the increasing latitude results in similar climatic conditions being experienced at lower and lower altitudes. In the far north of Britain, the Western and Northern Isles of Scotland are generally considered to fall within the Uplands although much of the land of these islands lies close to sea level. One can relate the Uplands of Britain to the so-called less favoured areas of the European Economic Community, defined under E.E.C. directive 75/268. For a full discussion of the area of Britain considered to be within the Uplands, see Allaby (1983).

The Uplands can additionally be considered to be characterised by difficult soils and topography. Except in the more sheltered valleys with deeper, richer soils, commercial arable farming is rarely feasible under the harsh climatic and poor edaphic conditions of the Uplands; in general, upland farming is entirely stock-based. As one moves up the altitudinal gradient, the farming emphasis shifts from dairy to beef cattle and, on the highest hill farms, sheep alone are kept. Most of the farms sampled in this study rely mainly on sheep, with a small number of store cattle, housed indoors for much of the winter, supplementing income.

Within the Uplands, low temperatures prevent grass growth during the winter months. The stock must be fed during this period. Winter fodder is cut during the late summer from areas of enclosed grassland; these fields are known as meadows. The meadows may be grazed during the spring and autumn, but during the summer months the animals

FIGURE 1 Map of the British Isles showing land over 200m a.s.l.



are excluded and a grass crop allowed to develop. Within a traditional upland farming system, the meadows are those fields closest to the farm buildings; they usually lie on the better soils. Together with the enclosed pasture (grazing) land, they form the so-called in-bye land of the farm (the out-bye is the unenclosed, rough hill grazing land).

Meadows are important from two major standpoints: agriculturally and botanically. The provision of winter feeding for the stock is of vital importance within the farming enterprise. There has traditionally been a close relationship between the meadows and the stock: the amount of winter fodder that could be produced on the farm defined the number of animals that could be supported and thus the income of the farmer.

Traditionally-managed meadows support a species-rich flora. The release of grazing pressure during the summer months allows the flowering and setting of mature seed by most of the meadow plants. Within pastures, in contrast, where more-or-less continual grazing is experienced, flowering is rarely achieved and most pasture plants are those which rely, to a large extent, on vegetative reproduction for their continued survival. The existence of this period of 'shut up' provides one reason for the high species diversity of these meadows. A second reason is related to the nutrient status of the fields. Upland soils are rarely nutrient-rich. Removal of a fodder crop from the meadow results in a depletion from the system of nutrients, which are replaced only through the faeces and urine of the grazing stock. Thus, a reasonably low and stable nutrient status is maintained by traditional meadow management. Such a nutrient balance characteristically supports a highly species-diverse plant community. Where higher nutrient levels are found or created, a limited number of more highly nutrient-responsive species tend to come to dominate the community, out-competing those species which respond less rapidly to increased nutrient levels.

The traditional management of the meadows on an upland farm can be briefly outlined as follows: during the winter, the cattle are housed indoors; the sheep are brought down from the hills and are fed on the in-bye fields, usually concentrated on the pasture land in order to prevent poaching damage on the more valuable meadow land. The farmyard manure from the cattle sheds is spread on the meadows during periods of frost when the hard ground minimises trampling and tractor damage. When the warmer, lighter days of spring encourage grass growth, the ewes and lambs are released onto the meadows to graze the early grass. In mid-May, the animals are removed from the fields and led up onto the hill grazing, where the rough grassland and moorland are now free from the risk of heavy snow. The meadow grass can now grow until, usually during August, a period of favourable weather conditions is chosen and the hay crop is cut. The grass is tossed on the fields for three to five days, until it has dried sufficiently to be removed and stored.

In some areas, particularly in Scotland, the grass is traditionally dried over hurdles or fences. After a few weeks' late season growth, the aftermath provides a 'late bite' for the sheep and cattle, until the damp, cold weather of late autumn and early winter makes the removal of the stock from the meadows necessary. Most grass species have two periods of strong growth within the year, with an intervening summer 'lull' (e.g. Rappe, 1963; Thomas and Morris, 1973). The autumn growth may be upto 30% of the total annual dry matter production and so is a valuable feed-source (Anslow and Green, 1967; Parker, 1985).

During this century, Man's ability to change the environment in which he lives has increased enormously. Around 80% of Britain's land surface is farmed (Nature Conservancy Council, 1977) and so it is through changes in agriculture that Man has had much of his impact on the landscape in Britain.

Most changes in agricultural practice have occurred since the 1940's. The modernisation and mechanisation of farming that have taken place over the last 40 years or so will have been evident to all. Farming in the Uplands has been, to date, subject perhaps to fewer changes than the more blatantly economic enterprises of the lowlands. In addition to the physical constraints imposed by the harsh conditions suffered by much of the Uplands, the isolated, 'family farm' farming communities of these areas are in general more conservative and more resistant to change. Nonetheless, there have been changes in methods of farming in the Uplands during the last 40 years, some of which have affected the 'heart of the farm', the meadow.

During the Second World War, many meadows were ploughed and root and cereal crops planted, in order to 'dig for victory'. After the War, commercial seeds mixes were used to put the fields back down to meadow grass. This in itself had a major impact on the meadow vegetation but the concomitant change in attitude which this disturbance of the ancient meadow sward caused is perhaps of equal importance in the history of meadow management. On most farms, the supreme importance of the meadow in providing the crucial winter fodder had, over the centuries, endowed the hay fields with an almost mystic value. The need to maximise home food production during the Second World War not only stimulated research into increased grass production and thus encouraged reseeding of the sward but it also provoked this, in many cases, first breaking of the old meadow which would otherwise probably have remained unploughed due to its well-nigh sacrosanct nature.

These early seeding mixes contained species poorly-suited to the harsh climatic conditions and poor soils of much of the Uplands. It is likely that where meadows adjacent to these reseeded fields were unploughed, species-dispersal from the old meadows helped to establish a sward, over the years, more akin to the original sward of the fields. Where farms have changed hands, it may now be impossible to easily identify fields ploughed during the War and floristic differences between adjacent fields which have been managed in an identical fashion over the intervening years may be attributable to the War-time disturbance of only one or two of the several contiguous meadows.

In other areas, particularly on more nutrient-rich soils and in areas where widespread ploughing of meadows occurred, it is likely that the failure of the sown grass/clover varieties resulted in arable weed encroachment and this encouraged reploughing of the fields, with subsequent reseeding. Thus was set a pattern, particularly noticeable during the 1960's and early 1970's, of periodic reseeding of the grass fodder fields. Here, grass is grown as a crop and even where it is termed 'permanent pasture', the sward is rarely more than 15 years old. It is worth noting at this stage that in some areas of the Uplands, particularly in Scotland, hay has traditionally been produced as part of a rotation of crops and so the tradition of ancient hay meadows is rare. Today, this rotation is now lost in most areas and the fodder crop is produced from frequently- reseeded swards, which are usually used as meadows and pastures in different years.

At the same time as reseeding of the meadow sward has been prevalent, application of artificial fertilisers to increase nutrient levels and to boost grass growth and thus cropping density has become almost ubiquitous. The species of grass and herb found 'naturally' in meadows in the Uplands are rarely highly responsive to nutrients - fertile areas are relatively rare in nature and so few organisms are adapted to such environments - and so to fully exploit the inorganic nutrients applied, reseeding with two or three highly nutrient-responsive grass varieties has been advised (e.g. Heddle and Herriott, 1968). Thus, one has a situation where it was only after reseeding (with more nutrient-responsive species) came to be common that fertilisation become economically viable and where, once fertilisation became frequent, reseeding became more likely.

Some farmers, particularly those with meadows which had, perhaps due to the farmer's persistence, escaped ploughing in the 1939-1945 war, were and are loath to destroy the meadow vegetation. The sward has developed, perhaps over centuries, in balance with the particular conditions of the upland site. It has served the farmer and his forebears well in the past and he is not keen to break the well-known and well-respected sward. Few farmers, however, can justifiably resist the lure, indeed the evidence, of increased fodder crops as a result of artificial fertilisation.

The third, and last, major change in meadow management that has occurred has been a move towards fermentation rather than drying as a method of grass preservation in the process of winter fodder production. Silage-making does not require the eagerly-awaited and rare three to five days of fine weather required for high-quality hay production and collection. The grass is removed from the field within hours of cutting.

Most varieties of grass have a maximum digestibility and feeding value early in the season, often before flowering. At this stage, the grass has too high a tissue water content to easily dry to hay. There is no such problem with silage production; indeed, with the heavy inorganic fertilisation often associated with silage grass, an early cut is advised, since the lush, forced growth may otherwise lodge later in the season, making collection difficult and increasing losses. In some areas, the shorter growing season required by heavily-managed silage grass may allow multiple silage cuts within one season. This is rare on 'natural' upland swards.

One does not need to emphasise the fact that these more modern agricultural techniques have had a range of major effects on the vegetation of the meadows. Over most of Britain, meadows are given heavy dosages of inorganic fertilisers and reseeding has, at least in the recent past, been the norm rather than the exception. As a result of these changes, the valuable species-rich, herb-rich hay meadow has become a rarity. Such meadows have been replaced, at the extreme, by uniform and bright green silage fields; where management changes have not been so overwhelming, where reseeding has not taken place for example, then degradation of the 'natural' meadow sward is seen.

Thus, within the Uplands, one might expect a suite of meadow vegetation types, reflecting not only the varying environmental conditions within the Uplands, but also the subtly different management regimes adopted by farmers, running from the more artificial, heavily-managed silage fields through to the traditionally-managed, low-input:low-output hay meadows where little has changed in terms of management since the early years of this century and beyond. It is this range of anthropogenic, semi-natural, fodder-producing grasslands that have been the subject of this study.

The aims of the research were threefold:

a) to assess the status and distribution of the more traditionally-managed (and thus, in terms of nature conservation, more valuable) fields.

b) to describe the vegetation of these semi-natural grasslands, under a range of management regimes and over a wide environmental range.

c) to relate the vegetation types defined to not only the environmental conditions under which they are found but also to the management practices associated with them, in order to be able to assess the impact of the variousfarming methods on the meadow vegetation.

Work on hay meadow vegetation in the Uplands has tended to be small-scale. The Nature Conservancy Council has carried out surveys of hay meadows in many areas of upland Britain (e.g. Nature Conservancy Council 1980a, 1980b, 1981, 1982; Mackintosh, 1984; Mackintosh and Urquhart, 1984) and some county conservation trusts have also conducted surveys, few of which are published (e.g. Herefordshire and Radnor, unpub.; Northumberland, Loring, 1983). National Park Authorities have also shown interest in assessing the meadow resources within their jurisdiction, e.g. Dartmoor (unpub.), Northumberland (Haffey, 1979). Many of these surveys concentrated on assessing the individual fields in order to locate those requiring conservation and/or protection. Even where some attempts have been made to analyse vegetation data and thus to recognise vegetation types, the results may be very local and difficult to relate between the regions.

On a broader scale, Smith (1983, 1985) drew together work from Northumberland, the Yorkshire Dales, Cumbria and mid-Wales in his study of northern upland hay meadows. Jones (1983) similarly looked at meadows throughout northern England.

Thus, there has been no attempt to look at hay meadow vegetation throughout Britain. Studies of neutral grasslands (e.g. Page, 1980; National Vegetation Classification, in prep.) have included hay meadows but have not worked exclusively with meadow vegetation.

Smith (1983, 1985) and Jones (1983) give details of the effects of environmental and management factors on hay meadow vegetation but, as stated above, on a localised geographical scale. Agricultural work has tended to concentrate on the effects of the various factors on yield, rather than on botanical composition (e.g. Chestnutt, Young and Rippey, 1962; Alcock, 1976; Hopkins, Dibb and Forbes, 1980). Hopkins (1982) looked at the impact of various environmental and management factors on agricultural grasslands in southern England from an agricultural viewpoint and McAdam (1983b), although giving little botanical detail, carried out a similar study in Northern Ireland.

Given the rapid rate of loss of valuable meadow vegetation and the resulting conservation interest in hay meadows, there is an urgent need for a 'census' of meadows and for an understanding of the factors that contribute both to the richness of meadow swards and to their deterioration. One needs to understand the factors that have operated in the past

(Schwaar, 1972). Thus, the requirement for a study of meadows throughout upland Britain and an attempt to relate the pattern in meadow vegetation to both the environmental and management factors associated with the meadows is both timely and pertinent.

METHODS OF VEGETATION STUDY

All areas within England, Wales and Scotland with land predominantly over 240m were surveyed. In addition, regions in north-west Scotland at lower altitudes, for example some of the Outer Hebridean islands, were also visited. Due to constraints of time and money, only a sample of the Western Isles was studied and the Northern Isles were not surveyed. Northern Ireland and Eire were similarly excluded from the study.

Thus, the regions covered include Bodmin Moor, Dartmoor and Exmoor in south-west England, the Cambrian mountains of Wales, and the Pennine Ridge from Derbyshire in the south, up into the Cheviots and Southern Uplands of the north. The Lake District to the west and the North York Moors to the east of the Pennines were surveyed and most of western and northern Scotland was also covered.

In many areas of upland Britain, hay meadows have been lost and instead silage grass is grown as a crop. The first year's survey indicated that study of these short-term fodder fields was unprofitable; the vegetation of these heavily-managed fields reflects the composition of the seeds mixtures used to produce the swards and is rarely influenced by environmental or other management features. A limited number of fields reseeded 15 to 30 years ago was sampled, in order to provide some information on the changes in reseeded fields over the years, but for the bulk of the samples, fields which had not been reseeded during the last 35 to 40 years were chosen. It is in the vegetation of these older fields that a range of vegetation types can be distinguished, which it is possible to relate to the environmental and management factors associated with the samples.

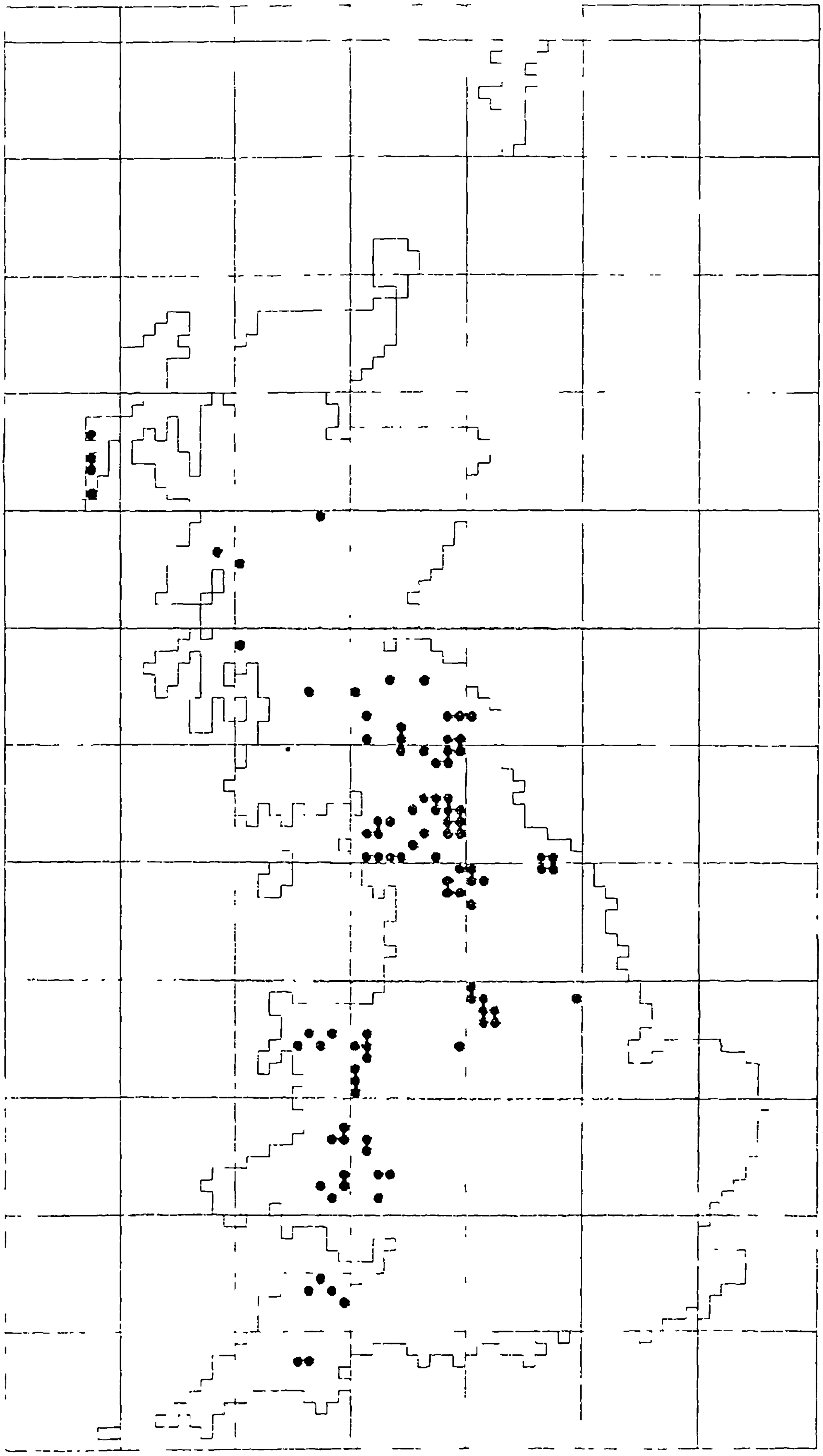
In a very limited number of areas, such fields were frequent and so it was possible to follow a reasonably systematic sampling strategy. Within a valley, two or three evenly-spaced villages or concentrations of farms were chosen from a 1:50,000 or 1:250,000 map. The site was located and the first farm with fields visually assessed to be suitable was visited and the farmer questioned as to the age of his hay and silage fields. In the late spring and summer it is to some extent possible to separate recently-reseeded fields from the older fields sought in the survey, based on colour and textural differences in the sward due to the varying species compositions. Thus, it was possible to avoid wasting the time of the surveyor, and of the farmer, visiting farms with no suitable fields.

Within regions where almost all fodder fields are ploughed and reseeded regularly, finding a field eligible for sampling was a lengthy process. In general, one can see an altitudinal gradation, with frequently-reseeded fields on the lower, more level land, less improved enclosed grassland on the lower valley sides, moving up into the rougher out-bye grazings. The older, more traditionally-managed fodder fields are likely, if any remain, to lie on the upper limits of the enclosed land. In different regions, the altitude at which such land is found will vary but once it is detected on visiting the area, farms with land within this altitudinal range are worthy of the bulk of the surveying time. It is often the most isolated and least accessible farms that retain old meadows. Where such farms are still occupied, the farmer tends to be elderly (few young farmers of the 1980's want to live such an isolated and unprofitable life) and resistant to change; it is, in addition, unlikely that he will have the desire to spend any capital that he may have (and it is likely to be very limited) on 'improving' his fields when he is nearing the end of his working life and when, as is usually the case, the farm will not remain in the family. Where these inaccessible farms have already lost their elderly occupants and now form part of a larger farm or estate based elsewhere, their very inaccessibility saves them from the new farmer's improving zeal, which, with a large area of farming land, can be concentrated on more visible and profitable sites.

In many areas, all those meadows which can be ploughed are now part of a reseeding programme and those meadows which, for reasons of slope or whatever, are unsuitable for ploughing and/or reseeding have been turned to pasture. In order to provide during the survey as complete as possible a cover of semi-natural grassland vegetation, where suitable meadows were not found, pastures with a previous history of hay meadow management were sampled. In many areas, no suitable fields (meadows or 'ex-meadows') were found. Thus, absence of a 'dot' on the map of 10km squares sampled (figure 2) does not indicate that the area was unsurveyed but rather that no suitable meadows were found. (Similarly, presence of a dot on the map may indicate more than one sample within that particular 10km grid square.)

In the first field season, a double system of visits was operated. During March and April, all those areas to be later surveyed were visited, suitable fields located through discussions with farmers and management details obtained; later in the year, these same fields were revisited and the vegetation surveyed. The aim of this system was to maximise the amount of the short growing season surveying the vegetation. Following the first season, this system was discontinued, since it proved to be prohibitively expensive to travel twice around the large areas of the Uplands. In addition, locating suitable meadows proved to be difficult during the spring; the fields suggested by farmers later proved to be unsuitable and meadows were more easily located, by eye, later in the season. The problems of locating old grassland, in order to enable the best use of the short summer season when this grassland can be surveyed, have been discussed by Forbes (1978).

FIGURE 2 10 km. grid squares containing meadows sampled



Once a farm was located which was identified through discussion with the farmer as having one or more fields suitable for study (that is, fields which have a tradition of cutting and which are not thought to have been reseeded during the last 40 years), the fields were surveyed. Where the vegetation was assessed to be similar in all the meadows on the farm and the management identical for all the fields, then only one meadow was sampled, in order to maximise the time for sampling other meadows on other farms with different vegetation and/or management. Elsewhere, where, as is commonly the case, different meadows have markedly different vegetation, two or three fields were sampled. On some farms, there may be both hay and silage fields, which are managed differently; on others, there may be the opportunity to compare fields ploughed and reseeded during the War with those which were not. Where more than one farm is now managed as one unit, study of the meadows on all the individual farms will usually reveal differences in vegetation, related to different past management regimes and/or varying environmental conditions between the sites.

Within each field, the range of visually-assessed vegetation types was sampled. When the entire meadow consisted of one more-or-less uniform plant community, two randomly-placed quadrats were sampled. Where two or more distinct communities could be distinguished in the field, both were randomly sampled. The edges of the field, near walls, fences, gates and trees were avoided.

2m x 2m quadrats were studied. This is the habitual method of sampling grassland vegetation within Britain. Following this custom allows the comparison of these data with those of other surveys, notably the National Vegetation Classification (in prep.). Although the concept of a 'minimum area' for a surface-area sample is today losing widespread application, studies both on degraded and on more traditionally-managed, species-rich sites indicated that a $4m^2$ sample was justifiable in terms of time expended and proportion of species found within the sampled community which were recorded by the sample (see Appendix 1). Studies on other methods of sampling (see Appendix 2) suggested that use of any other method rather than the square quadrat used in this survey could not be justified.

Within the 2m x 2m quadrats, all species of higher plant and bryophyte were recorded with their value on the Domin scale of cover/abundance in common usage amongst British vegetation scientists (see Bannister, 1966, for justification):

1)		(1 or 2 individuals
2)	< 4% cover	(a few individuals
3)		(many individuals

4 4 - 10% cover
5 10 - 25% cover
6 25 - 33% cover
7 33 - 50% cover
8 50 - 75% cover
9 75 - 90% cover
10 90 - 100% cover

Nomenclature of the plant species recorded follows Clapham, Tutin and Warburg (1962) for Angiosperms and Pteridiophytes; Smith (1978) for mosses; and Watson (1981) for liverworts.

Back in the office, the overwhelming wealth of information in this set of relevés (samples) can be reduced to a more manageable and more easily-interpreted form by amalgamating those samples with similar species compositions together, into groups. This technique, known as classification, is continued until the groupings seem to represent more-or-less justifiable vegetation types (or noda, sensu Poore, 1955). These vegetation types can then be defined and described.

Advances in computer science have not failed to exploit the potential of computers to operate classification algorithms. The program most commonly used, certainly within Britain, for classification of plant community data is Two-Way Indicator Species Analysis (TWINSPAN; Hill, 1979b). TWINSPAN provides a polythetic, divisive classification of the vegetation data. It groups and orders the samples, ultimately amalgamating samples with similar species compositions, and then uses this classification to similarly group the species, according to their distribution amongst the samples. Thus, a two-way ordered table of species versus samples is produced, which approximates to the results of a traditional Braun-Blanquet tabular rearrangement (Braun-Blanquet, 1932). This table can be studied, the groupings assessed by eye, and the skill and experience of the investigator applied to determine the vegetation types to be defined.

Although the theoretical arguments that once raged about whether vegetation should be perceived as a continuum or as a sequence of more-or-less discrete communities are now rarely heard (see Westhoff, 1970), the two commonest techniques of multivariate data analysis could be said to reflect these two approaches (see, for example, Lambert and Dale, 1964; Anderson, 1965). Classification aims to recognise distinct vegetation types and ordination, as its name suggests, purely to order the individuals through a continuum of variation. The representation of particularly the samples but also the species on a two-dimensional plot along the extracted ordination axes of maximum variation is an attractive method of presentation and can be a powerful aid in assessing the relationships between the individuals and also between the individuals and those variables which may be reflecting factors controlling the vegetation. The method of ordination used here was Detrended Correspondence Analysis (DECORANA; Hill, 1979a).

METHODS OF MANAGEMENT/ENVIRONMENT STUDY

In order to relate the vegetation to the environmental conditions experienced by, and management practised on, the fields, a suite of physical and agricultural data was collected.

Environmental data

* Grid reference - four-figure northing and easting references were read from 1:25,000 and 1:50,000 Ordnance Survey maps.

* Height above sea level in metres was, similarly, taken from large-scale O.S. maps.

* Slope was assessed visually, in degrees.

* Aspect was recorded, in degrees, using a compass.

* Soil pH was measured, in distilled water, using a pH meter and glass electrode.

Management data

From discussions with the farmer, the following were elucidated:

* whether the crop taken is hay or silage.

* grazing practice - when the animals are on the meadows and whether both sheep and cattle graze the fields.

* the date at which the stock leave the field in late spring/early summer (date of shut up).

* the date at which the crop is taken (cutting date).

* treatments - whether manure is applied
  - whether lime is applied (and how frequently).

* inorganic fertilisation - the type and amount of inorganic fertiliser applied.

* the date of last ploughing and reseeding of the sward.

Data collection

Any data collected from people have a measure of unreliability due to the vagaries of people's memories and their responses to the questions asked. The hill and upland farming communities of Britain often have a long history of isolation. Nowadays, most will have a television but some have never travelled beyond the local market town. The surveyor cannot rush in, clutching an official-looking pro-forma survey sheet, fire off a barrage of questions phrased in academic syntax and expect to obtain the required information. Many of these independent countrymen have a strong distrust and dislike of bureaucrats and may resent being questioned. More considered discussion, usually held out in the fields, about farming in the hills, gently leading the conversation through the points of interest and only recording the results on paper once out of the farmer's eye-shot, is more likely to yield results.

Most farmers have an even more strongly negative attitude towards nature conservationists, who seek to interfere in the farmers' management of their own land and so the farmers are suspicious of vegetation surveys lest the surveys subsequently result in orders of restraint being placed on areas of their farms. Thus, simply to be allowed to put one's questions can be a difficult task.

To obtain answers to the questions posed is a further source of problems. In some cases, the farmer, however willing to help, may be unable to provide answers to some of the questions. A farmer who has occupied the land for 10 years is unlikely to know when the meadows on his farm were last ploughed. Since vegetation is undoubtedly influenced by events far in the past, where the present management regime was of recent origin, information on past management practices was also sought. Many upland farms are, however, still family farms and most of the farmers are middle-aged or older, so it is usually possible to obtain fairly precise long-term management details.

However, even where long continuity of occupancy is seen, there may still be problems in obtaining accurate data on management. Where one has farmed the same land in practically the same way for 50 years or more, one is unlikely to be able to distinguish one year from any other sufficiently well to give a precise date for, say, reseeding.

Once one has answers, one then has the problem of assessing the precision and general validity of these responses. Very few people deliberately lie but some remember incorrectly, or, failing to remember and wishing to be helpful, guess. A national survey of grassland by the Permanent Pasture Group noted that farmers described 93% grassland as permanent and only 7% as temporary, whereas in fact only 55% was more than 20 years old and 30% was less than 8 years old (Forbes et al, 1980). Similarly, Morrison and Idle (1972) found that few of the farmers they questioned could give reliable details of their management practices. A few give the answers which they assume the questioner is seeking, and there are those who, aware of current, or past, Ministry of Agriculture, Fisheries and Food advice on fodder field management, profess to carry out these practices to the letter, whatever they might, in practice, do. In some cases it is possible to detect indecision, and the evidence of the sward may suggest that the management data were unreliable (although it is a dangerous practice at this stage to judge management data on sward characteristics, when one aim of the study is to do the reverse). In these cases, the samples can be omitted from any subsequent analyses involving management data.

During the first weeks of the survey, it soon became apparent that it was unrealistic to expect to obtain accurate answers to some questions of management practice (e.g. a measure of grazing density; some measure of the amount of farmyard manure applied) and so, in order to minimise disturbance to the farmer and to concentrate attention on those questions which could more easily be answered, these 'difficult' questions were omitted. Several more potential questions were dropped, since they provided information of little value to the study, e.g. details of drainage. These observations lead one into the general problem of potentially valuable data being unavailable. This is perhaps particularly pertinent for soil nutrient levels. Not only are nutrient levels one of the primary factors controlling the vegetation, but many farming activities are related to altering the nutrient levels of the grassland system. It soon became apparent that given the widespread nature of the survey, detailed soil ion analyses were not practical. Given the overwhelming influence of artificial fertiliser input on the nutrient levels of the soil of these fields, detailed nutrient analyses of the soil taken at one particular time may well in fact have yielded little additional and reliable data. The levels of artificial fertiliser applications probably give a good indication of soil nutrient levels. The artificial fertiliser values were not calculated in terms of units of nitrogen, phosphate and potassium applied, as would be the theoretical ideal. Upland farmers tend to apply different fertilisers in different years and some are unable to say what they have applied; most can, however, say how many bags they have applied. Thus, where fertilisation dosages are given in this thesis, they are recorded in the form in which almost all farmers gave them, in cwt/ac. This imprecise and anachronistic measure should only be taken as an approximation of dosage - it provides little real information on nutrient input to the fields but serves its purpose within the requirements of this study as an indicator of relative artificial fertiliser inputs.

Data analysis

Given the management and environmental data, the analysis of the relationships between these data and the vegetation data can be considered. By carrying out an ordination on the vegetation data, the axes along which the samples (and species) are most dispersed in the multidimensional space in which they lie, defined by their species compositions, can be extracted. These so-called axes of maximum variation reflect the major directions of variation in the vegetation data. By studying the dispersal of the species along such an axis, one can attempt to relate one or more environmental variables to the direction of the axis and thus elucidate some of the possible environmental factors contributing to the variation in the vegetation. For example, one may have a scatter of species associated with damp conditions at one end of the axis and species of dry environments at the opposite end, leading one to suggest the importance of soil moisture content in determining the pattern in the vegetation. Where one has obtained data on environmental conditions, it is possible to relate the axes and environmental variables more directly. Following an ordination, each sample has a co-ordinate on each axis, determined by its species composition. Where each sample also has a value for a suite of environmental variables, one can carry out a regression or other statistical technique, relating the ordination score on any given axis for each and every sample with the corresponding environmental variable value for each sample. The Michigan Interactive Data Analysis System implemented on the University of Durham's mainframe computer was used to run some statistical tests on the data to explore the relationships between the vegetation and the environmental and management data. The values of the environmental and management factors for each sample were compared with that sample's score on the four ordination axes extracted by the DECORANA of the data. 36 samples were omitted from the analysis since they had some management variables which could not easily be accommodated in the analysis (e.g. more than one hay cut per annum). pH was omitted from the analysis due to the large number of missing cases. There are three types of environmental/management variables: continuous, categorical and yes/no. Three different analyses were therefore carried out. With the nine continuous variables, regressions were carried out. With the categorical variables, an analysis of variance was run and with the yes/no data, a student t-test was required. A stepwise multiple regression was attempted but since this method uses only those samples for which there are no missing variable values, only a small proportion of the sample data set was being used, given the nature of the data set with many samples having one or two missing values. This drew into question the validity of these multiple regression results and they are therefore not recorded here. These statistical techniques are examples of indirect gradient analyses and were not developed further but rather a technique of direct gradient analysis was adopted.

Canonical correspondence analysis (CANOCO; ter Braak, 1986) combines regression and ordination. The ordination is based on the algorithm used in DECORANA (Hill, 1979a) but the axes are constrained to be linear combinations of environmental variables. The problem of missing values remains with this method. Where a large proportion of any one variable's values were missing, the variable was excluded from the analysis. Elsewhere, where a smaller number of values were missing, then the mean of the values recorded or their mode (with categorical variables) was inserted. As in the earlier analyses, 36 samples were omitted and the values for pH were omitted from the main analysis. A CANOCO run on a sub-set of the data, including only those samples for which pH values were present, indicated little correlation of pH with the first ordination axis. For all the environmental variables and most of the management variables, the data collected were ordinal (that is, a direct quantitative value). For some of the environmental variables, however, the data were categorical (or nominal). Within CANOCO, categorical variables can be treated in two ways: either as pseudo-quantitative values or dummy variables can be created. Thus, with lime application where one has:

1 = no lime applied
2 = lime applied, infrequently
3 = lime applied, frequently,

one can regard this as a quantitative sequence. With grazing, however, dummy variables must be created. Thus, from

1 = sheep
2 = sheep + cattle
3 = cattle,

one has sheep (from 1 and 2) and cattle (from 2 and 3) as two separate variables with values of 1 (yes) or 0 (no). In this example, some fields were not grazed, creating an implicit third dummy variable. When a nominal variable has n+1 classes, only n dummy variables should be used in the analysis - otherwise collinearity between the variables will be introduced. Even where one option is excluded, collinearity or high negative correlations may be present. The dummy variable hay was excluded from the analysis on these grounds, since few fields were cut for either hay and silage or neither, resulting in a close correlation between the two variables hay and silage. Aspect had been recorded in degrees. It was now transformed and its 'northness' and 'eastness' recorded using the cosine and sine of the angle, respectively.

Initial runs of CANOCO indicated that the spatial dispersal of the sites within Britain was exerting an overwhelming effect, obscuring any more subtle effects of the other environmental and management factors included in the analysis. The most recent version of CANOCO allows one to define covariance in the data and so to carry out a partial ordination, leading to an ordination of the residual variation in the data that remains after fitting the effects of those variables which one defines as covariables. The environmental variables are regressed on the covariables and the residuals of these multiple regressions take the place of the original environmental variables in the subsequent analysis, thus, the effect of the environmental variables on the species is corrected for the effect that the covariables have on the species. (For more details, see ter Braak, 1986.) Thus, in this case, the two grid reference figures were defined as covariables in the analysis.

DESCRIPTION OF VEGETATION TYPES

Eighteen vegetation types were recognised, following consideration of the TWINSPAN and DECORANA analyses of the 430 samples and 236 species included in the data analysis. The species distributions which distinguish the vegetation types at each level of splitting are indicated on the dendrogram representation of the vegetation types (figure 3).

The major division in the analysis splits the first nine noda from the remaining nine (figure 3 and table 1). Noda 1 to 9 contain Festuca rubra, Plantago lanceolata, Rhinanthus minor, Trifolium pratense, Brachythecium rutabulum and Eurhynchium praelongum at higher constancy than the remaining nine noda. In addition, they contain Luzula campestris/multiflora, Centaurea nigra, Euphrasia officinalis agg., Hypochoeris radicata, Lotus corniculatus, Prunella vulgaris, Vicia cracca and a range of other species (see table 1) and consistently higher cover values for, amongst others, Anthoxanthum odoratum and Cynosurus cristatus.

Within this group of noda 1 to 9, the first four noda can be separated from the remaining five groups. Thus, for example, Euphrasia officinalis agg., Hypochoeris radicata and Succisa pratensis are found at high constancy in noda 1 to 4 and Alopecurus pratensis, Bromus mollis, Lolium perenne and Bellis perennis are, amongst the first nine noda, characteristic of noda 5 to 9.

The first four noda, characterised by low levels of Lolium perenne, also lack Dactylis glomerata, with the exception of nodum 3. Noda 2 to 4 have Luzula campestris/multiflora at high constancy and noda 1 to 3 contain Cynosurus cristatus, Rhinanthus minor and Trifolium pratense. Noda 1 and 2 are characterised by Agrostis stolonifera at high constancy, whereas Agrostis tenuis characterises noda 3 and 4.

The tables giving the vegetation data are enclosed in a flap at the back of the thesis.

Nodum 1 - Agrostis stolonifera-Carex nigra-Potentilla anserina nodum.

Constants: Agrostis stolonifera, Cynosurus cristatus, Holcus lanatus, Carex nigra, Cerastium holosteoides, Lychnis flos-cuculi, Potentilla anserina, Ranunculus acris, Trifolium repens, Equisetum fluviatile.

KEY TO FIGURE 3

The numbers circled on the figure refer to the following species; (c) refers to a species being found at higher constancy and (n) refers to a species being found with greater average cover in that nodum's releves, where n is the pseudospecies number corresponding to a particular range of Domin values (as used in TWINSPAN).

1 Festuca rubra (c), Anthoxanthum odoratum (2), Cynosurus cristatus (2), Trifolium pratense (c), Rhinanthus minor (c), Plantago lanceolata (c), Luzula c/m, Lotus corniculatus, Euphrasia officinalis agg., Hypochoeris radicata, Vicia cracca, Prunella vulgaris, Centaurea nigra.

2 Euphrasia officinalis agg., Hypochoeris radicata, Succisa pratensis.

3 Alopecurus pratensis, Lolium perenne, Bromus mollis, Bellis perennis.

4 Alopecurus pratensis, Poa trivialis (2).

5 Phleum pratense, Poa annua (c).

6 Agrostis stolonifera, Juncus acutiflorus, Carex nigra, Lychnis flos-cuculi.

7 Dactylis glomerata, Agrostis tenuis, Heracleum sphondylium, Conopodium majus, Centaurea nigra.

8 Lolium perenne, Cynosurus cristatus, Anthoxanthum odoratum, Trifolium pratense, Rhinanthus minor, Trifolium repens.

9 Juncus articulatus (2), Filipendula ulmaria (2), Geranium sylvaticum (3).

10 Bromus mollis (2), Ranunculus bulbosus, Taraxacum officinale agg.

11 Ranunculus repens.

12 Poa trivialis, Ranunculus repens, Cerastium holosteoides, Vicia cracca, Potentilla anserina, Caltha palustris, Dactylorchis fuchsii, Equisetum fluviatile.

13 Luzula campestris/multiflora, Succisa pratensis (c), Pedicularis sylvatica, Rhytidiadelphus squarrosus.

14 Cynosurus cristatus (2), Trifolium repens (2), Euphrasia officinalis agg. (2), Trifolium pratense (2), Leontodon autumnalis (c).

15 Bromus mollis, Plantago lanceolata (2), Ranunculus bulbosus.

16 Geranium sylvaticum.

17 Alopecurus pratensis (2), Poa trivialis, Anthriscus sylvestris, Trifolium pratense.

18 Poa pratensis, Plantago lanceolata, Ranunculus ficaria, Cardamine pratensis, Achillea millefolium.

19 Caltha palustris.

20 Agrostis tenuis, Lolium perenne (2), Trifolium repens (2).

21 Dactylis glomerata, Conopodium majus, Alchemilla xanthochlora.

22 Ranunculus repens (2).

23 Bromus mollis (3), Anthriscus sylvestris (3).

24 Cynosurus cristatus, Anthoxanthum odoratum, Holcus lanatus, Cerastium holosteoides, Trifolium repens, T. pratense.

25 Trifolium repens, Heracleum sphondylium, Cardamine flexuosa.

26 Achillea millefolium, Ranunculus bulbosus.

27 Alopecurus pratensis, Anthoxanthum odoratum, Trifolium repens (2), Agrostis tenuis (c).

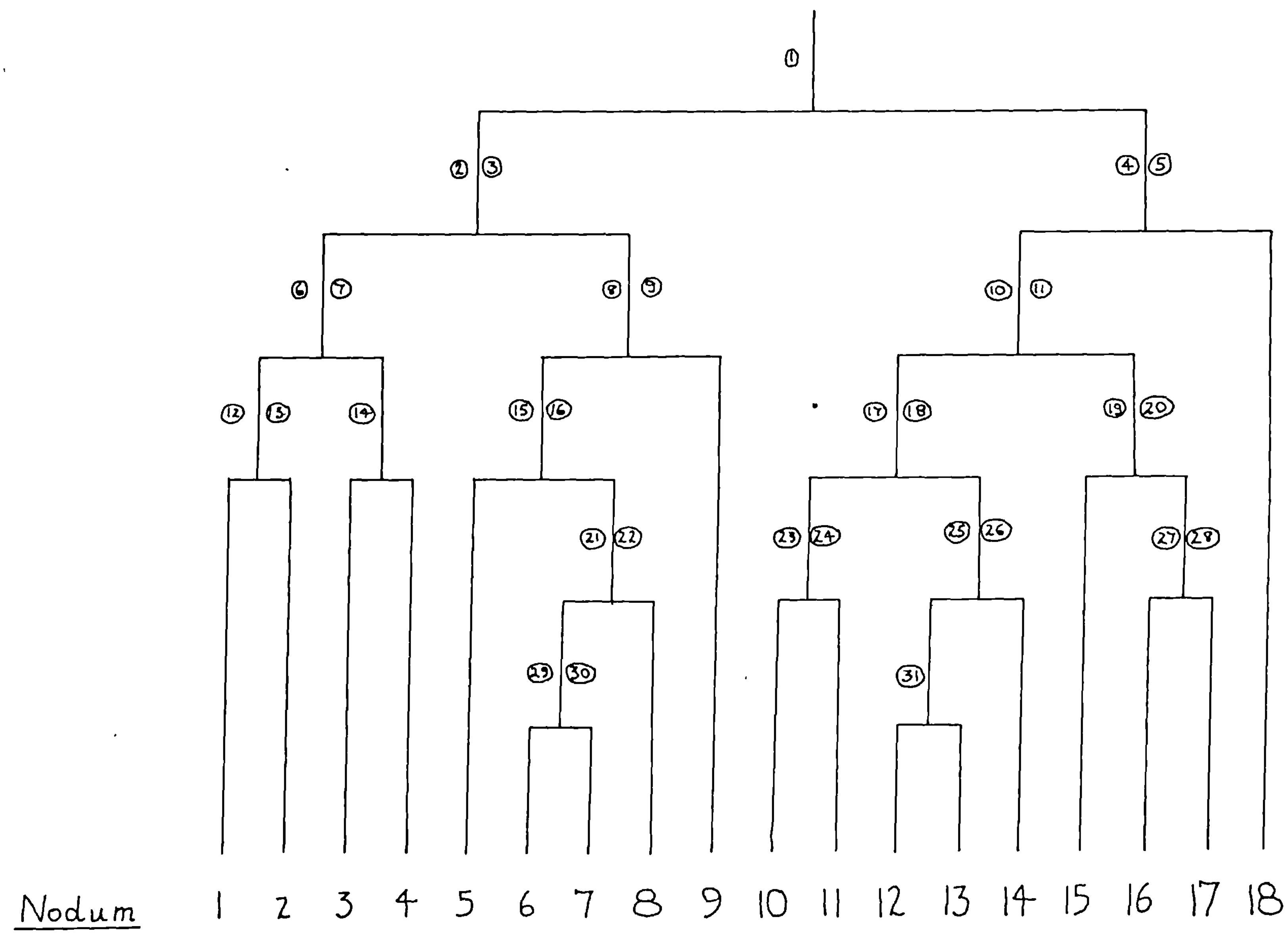
28 Bromus mollis, Stellaria media, Dactylis glomerata, Alchemilla glabra.

29 Bromus mollis, Rhinanthus minor, Plantago lanceolata, Bellis perennis, Trifolium pratense, Taraxacum officinale agg.

30 Ranunculus repens (2), Rhytidiadelphus squarrosus.

31 Poa trivialis, Cynosurus cristatus.

FIGURE 3 -- Dendrogram of vegetation types defined.



The eleven relevés in this nodum were all taken from the Uists, Outer Hebrides (figure 4-1). It is not unexpected that these samples should fall together, since the hay meadows on the Hebridean Islands are unusual in many respects. Firstly, they lie at low altitude (mean of 7.3m above sea level). They were the only fields recorded in the survey which received seaweed as a form of organic fertilisation. In addition, the cultivated land on the islands forms a fringe along the west coasts and lies on calcareous shell sands which grade into peats as one travels inland. The mean soil pH for these samples is pH 6.6. A long shut up period is characteristic of these fields; the harsh, cool conditions experienced on these exposed islands render plant growth slow. The hay on the small crofts of the islands is traditionally taken from fields in rotation, with oats and root crops being grown on the same land. The hay vegetation traditionally develops 'naturally', following a period of fallow, and species-rich, herb-rich meadow vegetation can be seen in fields which were ploughed and used for corn only three or four years before.

More recently, agricultural grant aid, in various forms, has come to the islands and there will probably soon be a change towards the more widespread form of cultivation seen on the mainland of Britain, with fodder crops being grown in the same fields for many years consecutively, artificial fertilisers being used and commercial seeds mixes being applied.

The fields which were sampled on the Islands were, to some extent, atypical of the traditional crofting methods. Since in the rest of Britain the more traditional method of hay cultivation involves the retention of old swards, in order to make any samples taken from the Hebrides comparable with the rest of the samples, older hay fields were sought. Thus the fields which were studied were those few on each island which the local crofters identified as having been down to hay grass for the longest period of time. Most of those sampled had swards of 10 to 15 years' standing.

A suite of damp fen-meadow species were found in these fields, including Iris pseudacorus, Potentilla palustris, Polygonum amphibium, Oenanthe lachenalii and Eleocharis palustris. Some of the species were those of marine habitats, for example, Plantago maritima and Triglochin maritima. The fields were characterised by Potentilla anserina and also by Vicia cracca, Juncus acutiflorus, Dactylorchis fuchsii, Polygonum amphibium and Equisetum fluviatile. As well as these species and the constants listed above, Anthoxanthum odoratum, Poa trivialis, Ranunculus repens, Trifolium pratense, Rhinanthus minor and Caltha palustris were also common. Such high constancy for Caltha palustris and Ranunculus repens is distinctive within this data set. Some of the samples contained Molinia caerulea and Succisa pratensis. Noda 1 and 2 share Agrostis

Vegetation types from Upland Meadow Study, 1985-87 - J C Hughes

Nodum code nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ranunculus acris	V	V	IV	IV	IV	V	IV	V	IV	III	V	V	IV	V	III	II	V	II
Rumex acetosa	II	IV	IV	V	V	V	V	V	V	III	V	V	IV	V	IV	III	V	IV
Holcus lanatus	V	V	V	V	V	V	V	V	V		IV	V	IV	III	V	V	V	II
Trifolium repens	V	IV	V	IV	V	V	V	V		II	IV	V	V	III	III	V	V	IV
Poa trivialis	IV		III	II	IV	III	IV	V	III	V	V	V		II	V	V	III	III
Anthoxanthum odoratum	IV	V	V	V	V	V	V	V	II		IV	V	IV	V	III	V		III
Ranunculus repens	IV		I	I	II	II	IV	IV	III	I	II	IV		II	V	V	V	II
Cerastium holosteoides	V		V	IV	V	V	V	V		I	V	V	V	V	IV	V	V	V
Lolium perenne	I		II	I	V	V	V	V		V	V	V	V	V	V	V	V	V
Dactylis glomerata			IV	II	V	V	V	I	IV	V	IV	V	V	IV	II		V	IV
Poa annua	II		I	I	I	I	II	I		I	I	III	IV	II	II	I		IV
Poa pratensis	III		I	I	II	III	II	II		I	I	III	V	V			III	III
Agrostis tenuis	I		IV	V	III	II	V	II	II		I	I	II			V	III	II
Taraxacum officinale agg		II	II		III	IV	I	III	II	V	V	IV	IV	IV			III	IV
Bellis perennis	I		II		IV	V	I	IV		III	IV	V	V	III	III			V
Conopodium majus			III	V	III	IV	IV	I	III		II	III	V	IV	II			II
Agrostis stolonifera	V	V	I		I	I	II	I			I	I			II			I
Veronica chamaedrys			II	II	II	III	IV	I	IV		III	I	V	III				II
Ranunculus bulbosus			III	II	III	II	I	I		II	III	II	IV	V				II
Veronica serpyllifolia				I	I	II	I	I			I	IV	II	II		I	III	III
Phleum pratense	II		I		I	II	II	I		II	II	I						IV
Heracleum sphondylium			II	I	II	II	I			I	I	II	IV					I
Alchemilla glabra			I	I	I	I	II	I			I			I			V	I
Myosotis discolor	I		II		II	II		III			I	III			I			II
Alchemilla xanthochlora			I	I	I	IV	II				I	I	V					I
Achillea millefolium			II	III	I	I	II	I				II		V				I
Filipendula ulmaria			I	II	I	II		II	V				II		I			I
Agropyron repens	I		I		I	I		I		II	I							I
Ranunculus ficaria					I	I			II		I	II	V	II				I
Caltha palustris	IV		I			I		II					II		III			I
Cardamine flexuosa			I			I	I				I	III	II					I
Vicia sepium			I		I	I											III	I
Holcus mollis			I		I		III										III	
Lathyrus pratensis	II		II	II	II	II	III	II	IV	I								I
Prunella vulgaris	II	IV	III	I	I	I	I	II					II					I
Luzula campestris/multiflora	II	V	IV	IV	II	II	III	I					II					
Lychnis flos-cuculi	V	V	I	I	I		I	I										I
Succisa pratensis	II	V	I	III	I	I		I	II									
Arrhenatherum elatius	I		I		I	I	II		II		I							I
Achillea ptarmica			I	II	I	I	III	I	III						I			
Hypochoeris radicata	II	IV	IV	III	I	I		II										
Lotus corniculatus	I	IV	III	III	i		I	I										
Equisetum arvense	III	II	I		i	;		I	III									
Juncus effusus	I	II	I		I			I	II									I
Deschampsia cespitosa			I	II	:	I		I	IV						I			
Festuca pratensis			I		I	I	I	II			I				II			
Plagiomnium undulatum	I	I.	I	I	I		II											
Juncus acutiflorus	IV	II	I	I		I		I										
Euphrasia officinalis agg	III		IV	I	I	I		I										
Calliergon cuspidatum	III		I	I	I		I	I										
Potentilla erecta		II	II	IV	I			I	IV									
Carex sp			I	I	I			II	II									I
Ajuga reptans		II	I	I	I	I												
Carex nigra	V	IV	I				I											
Molinia caerulea	II	II		I					III									
Dactylorchis fuchsii	IV		I					I	II									
Cirsium palustre		IV					I	I	II									
Angelica sylvestris			I	I				I	III									
Juncus articulatus			I	I				II	V									
Geum rivale			I			I	I		III									
Festuca rubra	III	IV	V	V	V	V	V	IV	IV		II	I	IV	IV	III	I		I
Plantago lanceolata	II	IV	V	V	V	V	I	II	II		III	II	IV	I				II
Cynosurus cristatus	V	V	V	I	V	IV	II	V			III	V		I	II	IV		II
Brachythecium rutabulum	III	II	IV	II	III	III	II	IV	II		I	I			II			II
Trifolium pratense	IV	IV	V	III	V	IV	I	IV			IV	I		I	I			I
Rhinanthus minor	IV	V	IV	III	III	IV	I	IV		I	II				II			I
Eurhynchium praelongum	I		III	I	III	III	V	I	II		I			I			III	I
Leontodon autumnalis	II		IV	I	II	II	II	II			I		IV					I
Rhytidiadelphus squarrosus	I	V	II	III	I	I	V	I					II					I
Chrysanthemum leucanthemum	I		III	I	I	I					I			I				I
Centaurea nigra			IV	III	II	I		I	IV				II					I
Leontodon hispidus			II	I	I	I		I	II					I				I
Geranium sylvaticum			I		I	III	I	I	IV		I							I
Cardamine sp		IV	I		I	I		I			I			I				
Bromus lepidus			I		I	I		I	IV		I							I
Vicia cracca	IV		I	I	I	I												I
Cardamine pratensis	I	II			I	I	I	III	II		I	V	V	IV	III	I		I
Alopecurus pratensis			I		II	IV	II	III	III	V	V	V	II	V	V	V		I
Rumex obtusifolius			I		I	I		I		I	II	III	II	II	III	I		II
Bromus mollis			II		IV	IV		II		V	IV	V	IV	V	II		V	IV
Anthriscus sylvestris					I	II				IV	III	I			I			I
Stellaria media					I			I		IV	II	III		IV	III	I	V	II
Hydrocotyle vulgaris	III	II																
Potentilla anserina	V		I															
Polygonum amphibium	III		I															
Equisetum fluviatile	V		I			I												
Nardus stricta		IV	I															
Carex panicea		IV	I															
Briza media		IV	I	I														
Pedicularis sylvatica		V		I														
Carum verticillatum		IV						I										
Trollius europaeus			I	I					III									
Crepis paludosa					I				III									
Senecio aquaticus	III																	
Carex echinata		IV																
Cirsium dissectum		IV																
Galium aparine									IV									
Total number of taxa (236)	74	58	142	81	110	97	70	87	47	24	57	40	36	40	33	21	19	89

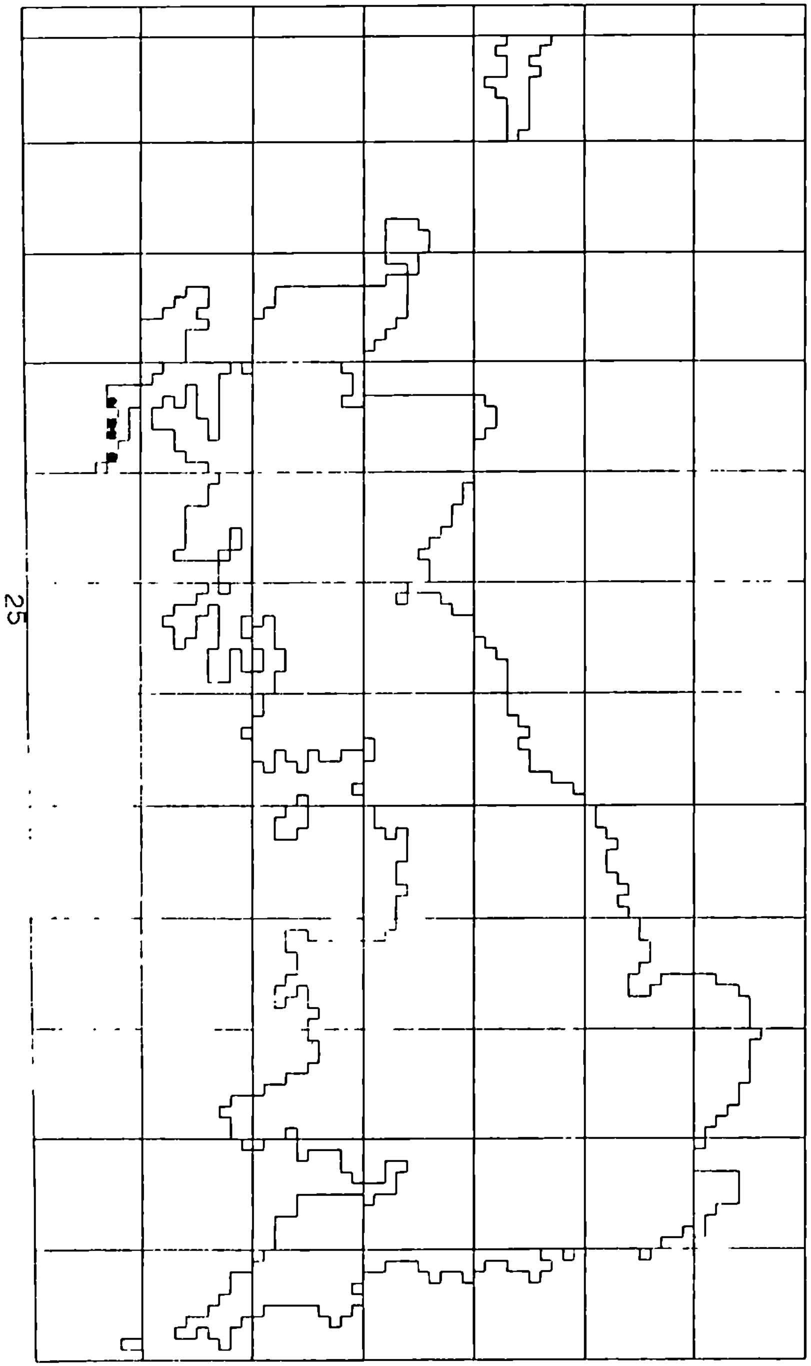


Figure 4-1
NODUM 1

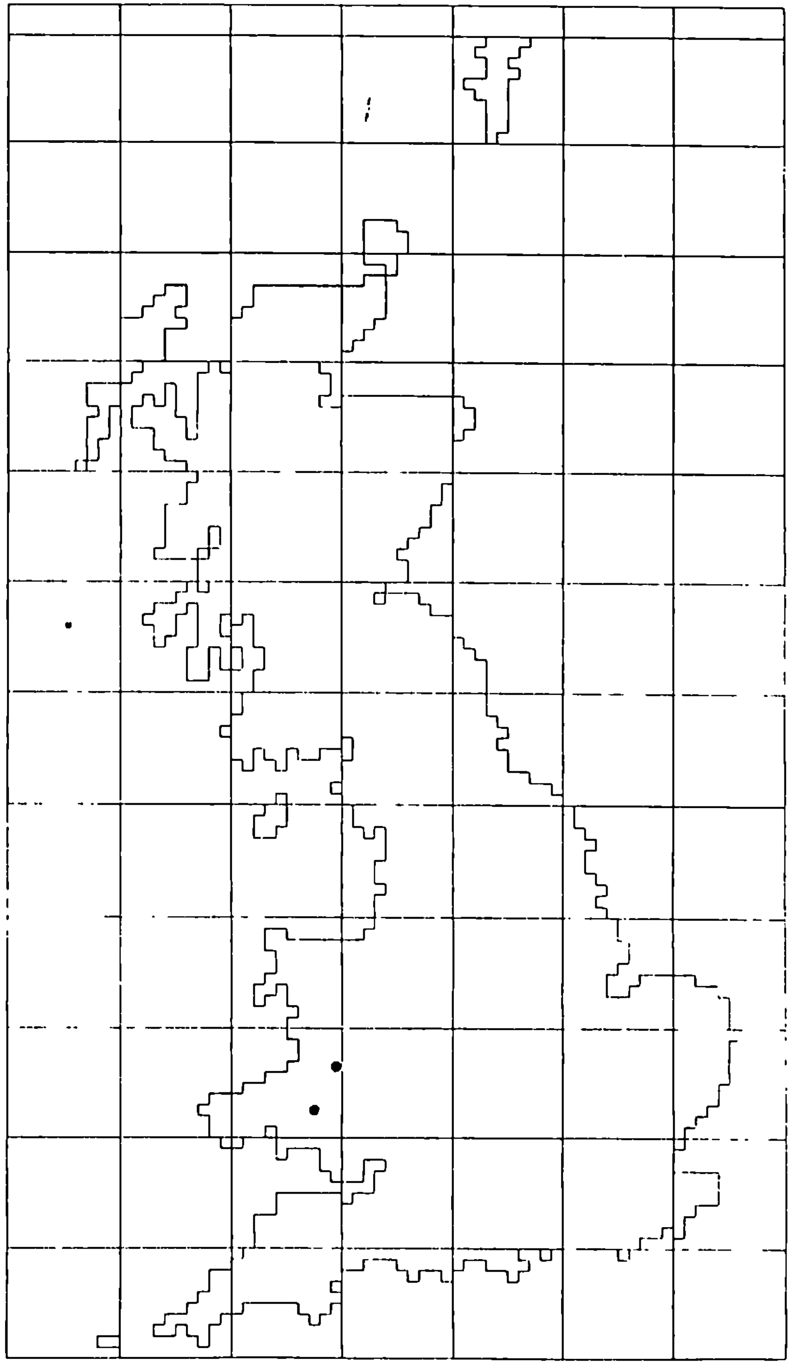


Figure 4-2
NODUM 2

stolonifera, Carex nigra, Hydrocotyle vulgaris and Lychnis flos-cuculi. They can be distinguished by the accompanying species.

Nodum 2 - Agrostis stolonifera-Succisa pratensis-Rhytidiadelphus squarrosus nodum.

Constants: Agrostis stolonifera, Anthoxanthum odoratum, Cynosurus cristatus, Holcus lanatus, Luzula campestris/multiflora, Lychnis flos-cuculi, Pedicularis sylvatica, Ranunculus acris, Rhinanthus minor, Succisa pratensis, Rhytidiadelphus squarrosus.

These three species-rich relevés from central Wales (figure 4-2) are characterised by high levels of Succisa pratensis and a range of sedge-meadow species. The damp fields contain much Rhytidiadelphus squarrosus, with Nardus stricta and Briza media, both rarely found in the survey. Carex nigra, C. echinata and C. panicea were recorded, along with Cirsium palustre and a range of meadowland species, such as Festuca rubra, Rumex acetosa, Trifolium repens, Plantago lanceolata, Trifolium pratense, Lotus corniculatus, Hypochoeris radicata, Prunella vulgaris and Cirsium dissectum. Carum verticillatum, a reasonably common grassland plant in mid- and south Wales is recorded within the nodum. The samples in this nodum are unusual amongst the entire data set for their lack of Poa trivialis and Cerastium holosteoides.

Nodum 3 - Agrostis tenuis-Euphrasia officinalis agg.-Hypochoeris radicata nodum.

Constants: Anthoxanthum odoratum, Cynosurus cristatus, Festuca rubra, Holcus lanatus, Cerastium holosteoides, Plantago lanceolata, Trifolium pratense, T. repens.

The 57 relevés in this nodum come from a range of sites in Britain. Most come from Derbyshire and mid-Wales, but some were taken in Snowdonia, Dartmoor, the Lake District, the Durham Dales and the Uists (figure 4-3).

These meadows contain a range of grass and herb species characteristic of traditional hay meadow management in Britain. In addition to the constants listed above, Agrostis tenuis, Dactylis glomerata, Ranunculus acris, Rumex acetosa, Rhinanthus minor, Leontodon autumnalis, Centaurea nigra, Hypochoeris radicata, Euphrasia officinalis agg., Luzula campestris/multiflora and Brachythecium rutabulum achieve high constancy within the nodum. The presence of Leontodon autumnalis at high constancy and of high levels of Cynosurus cristatus, Trifolium pratense and T. repens distinguishes

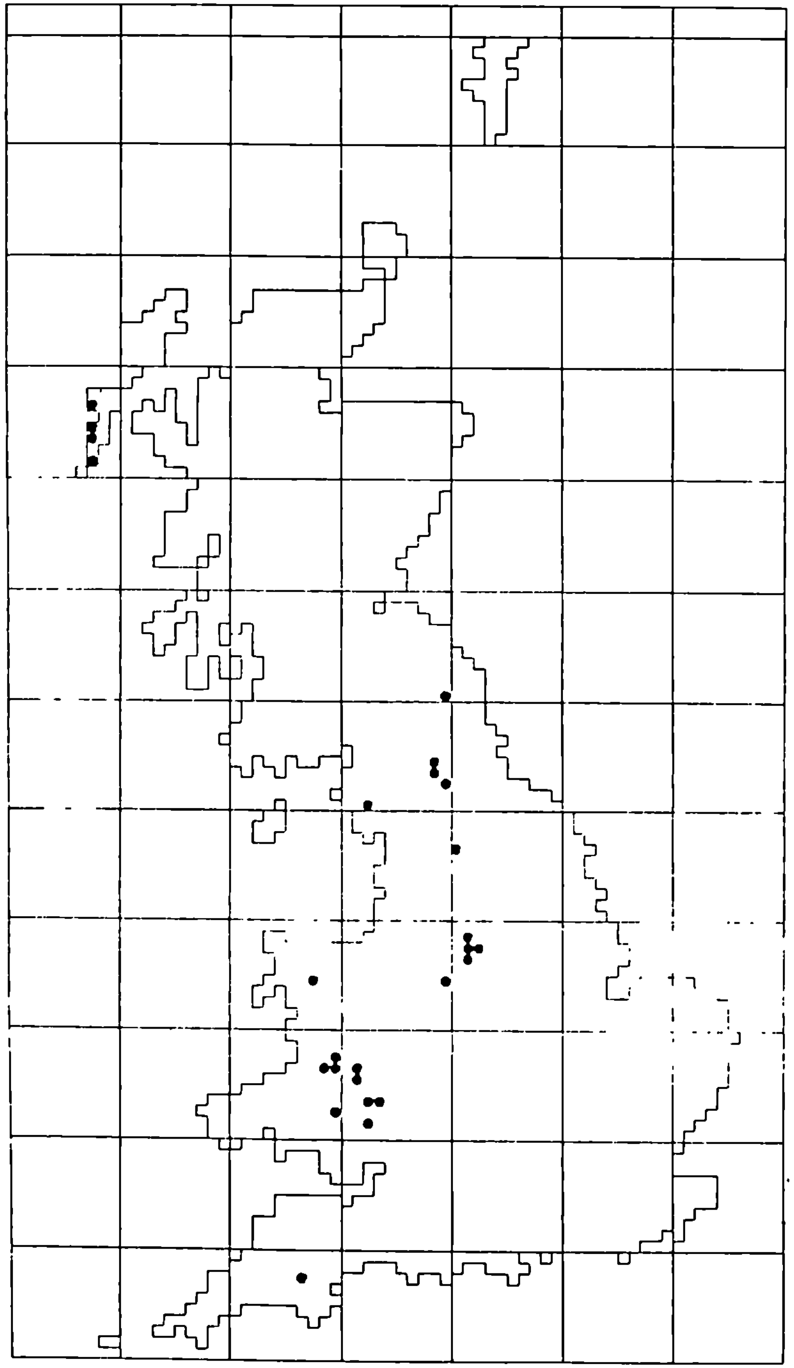


Figure 4-3
NODUM 3

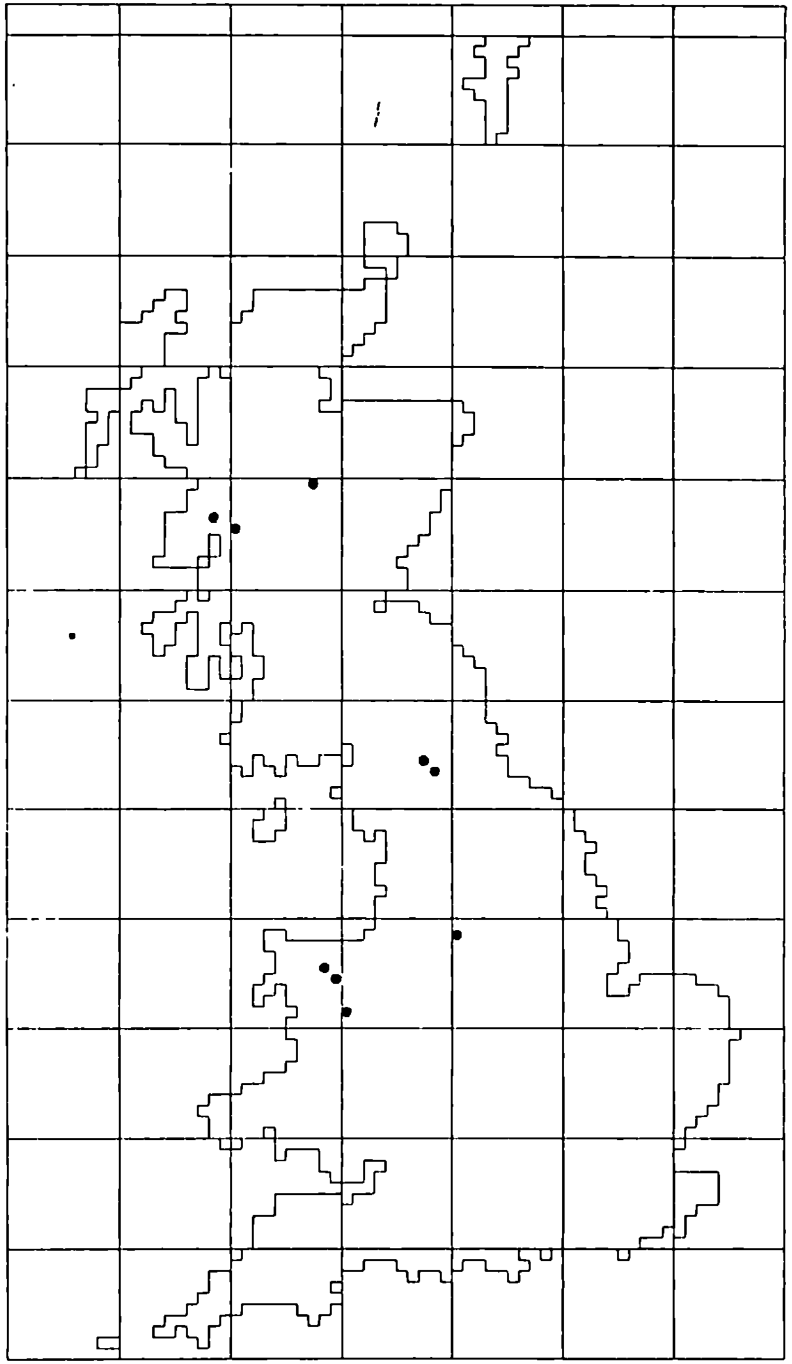


Figure 4-4
NODUM 4

this nodum from the closely related following nodum, nodum 4. The fields from which the relevés were taken receive on average only 0.7 cwt/ac artificial fertilisation. None of the sampled fields for which details were obtained are thought to have been ploughed and reseeded within living memory. Many may have escaped ploughing because of topographical problems - the samples had a mean slope of 7.9°. A late cut-date and long shut-up period are also characteristic of samples in this nodum. Thus, in summary, the fields from which these relevés were taken are managed in a traditional manner.

Nodum 4 - Agrostis tenuis-Conopodium majus-Potentilla erecta nodum.

Constants: Agrostis tenuis, Anthoxanthum odoratum, Festuca rubra, Holcus lanatus, Conopodium majus, Plantago lanceolata, Rumex acetosa.

Once again, the 15 relevés in this nodum are not geographically restricted; the samples came from North and mid-Wales, Derbyshire, the North Pennine Dales and western Scotland (figure 4-4). The meadows sampled are managed in a more or less traditional fashion, with low artificial fertilisation (mean application rate of 0.9 cwt/ac), and where determined, the swards date from before the Second World War and beyond (mean age of sward of 86.4 years). Many of the fields with this vegetation type are steeply sloping, which may be partly responsible for the less intensive agriculture practised upon them. The hay cut is taken late in the year and the shut-up period is long (mean of 87.5 days, as compared with the mean of 70.4 days for the entire data set). It is likely that the soil of these samples is of low pH (the mean for the four relevés for which information was obtained was pH 4.9).

The grasses and herbs found at highest constancy in this nodum are those of old, traditionally-managed hay meadows. In addition to those constants given above, Luzula campestris/multiflora, Ranunculus acris, Cerastium holosteoides, Trifolium repens and Potentilla erecta are found at high constancy.

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Noda 5 to 9 are intermediate in character between the grasslands of noda 10 to 18 and those of noda 1 to 4. They contain some species characteristic of both groups of samples.

Nodum 5 - Lolium perenne-Cynosurus cristatus-Festuca rubra nodum

Constants: Anthoxanthum odoratum, Cynosurus cristatus, Dactylis glomerata, Festuca rubra, Holcus lanatus, Lolium perenne, Cerastium holosteoides, Plantago lanceolata, Rumex acetosa, Trifolium pratense, T. repens.

Samples from Exmoor and Dartmoor, Derbyshire, the Yorkshire Dales, the North Pennine Dales, the Lake District, the North York Moors, the Cheviots, North Wales, mid-Wales, south-west Scotland and the Uists are included amongst the 120 relevés in this nodum (figure 4-5). It is distinguished from the closely related noda 6 and 7 by the presence of Ranunculus bulbosus and by the presence of Bromus mollis and Plantago lanceolata at higher cover values. In addition, it lacks Geranium sylvaticum.

The vegetation of these meadows contains a wide range of grass species, both those associated with more 'natural' grassland and those characteristic of more intensive agricultural management. In addition to the constants listed above, Poa trivialis and Bromus mollis are common. Similarly, there are a range of herbs found in the samples in the nodum. In general, these are found at low constancy amongst the large number of samples, suggesting that one is sampling here a suite of partially degraded vegetation types, with certain species missing from certain samples. Those herbs with highest constancy are the common agricultural grassland species, such as Bellis perennis, Cerastium holosteoides, Ranunculus acris and Trifolium spp. Other herbs which are more distinctive of old meadowland, such as Succisa pratensis, Hypochoeris radicata and Rhinanthus minor, are less consistently found amongst the nodal relevés. The fields from which these samples are taken receive a range of fertilisation dosages, with a mean of 1.3 cwt/ac. The average age of the swards sampled is 83.9 years. The mean slope of the samples is 5.7°; this compares with a mean of 3.9° for the entire data set. This large nodum can be divided into two sub-types, with the first 54 relevés containing Conopodium majus and the remaining 66 containing Leontodon autumnalis. In addition, the first sub-grouping has Ranunculus bulbosus and Poa pratensis at high constancy.

Nodum 6 - Festuca rubra-Alchemilla xanthochlora-Conopodium majus nodum.

Constants: Anthoxanthum odoratum, Dactylis glomerata, Festuca rubra, Holcus lanatus, Lolium perenne, Bellis perennis, Cerastium holosteoides, Plantago lanceolata, Ranunculus acris, Rumex acetosa, Trifolium repens.

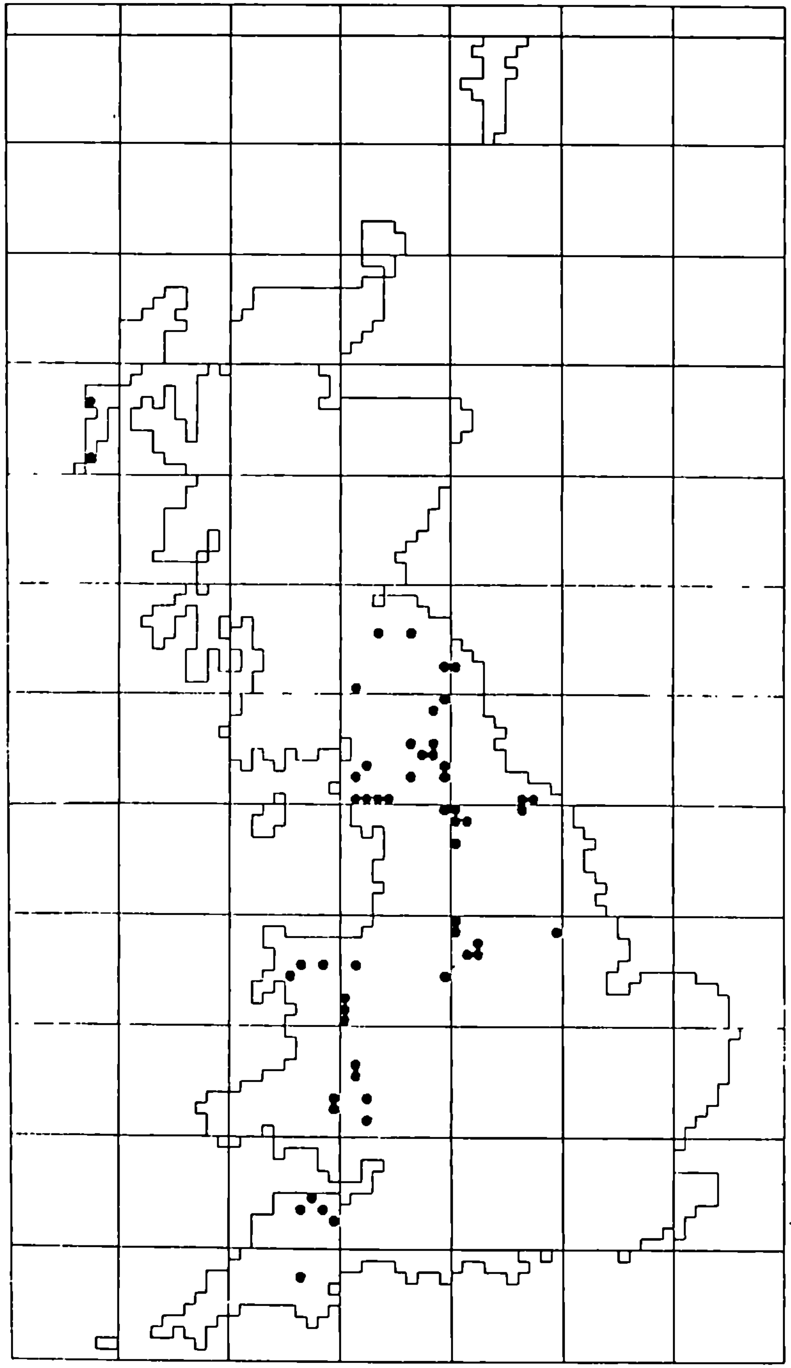


Figure 4-5
NODUM 5

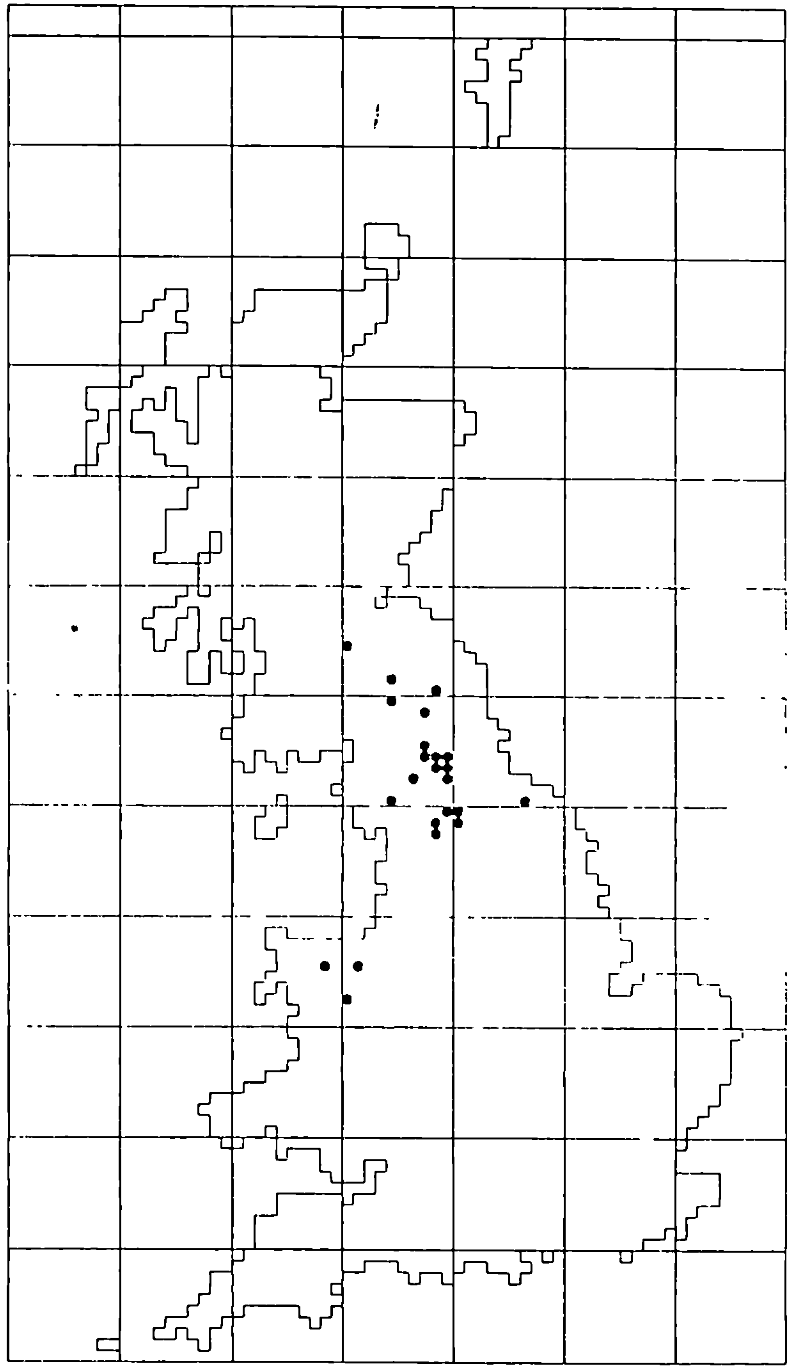


Figure 4-6
NODUM 6

The 49 relevés in this nodum come from the Yorkshire and North Pennine Dales, the North York Moors, the Lake District, North Wales and south-west Scotland (figure 4-6).

As well as the constants given above, Alopecurus pratensis, Bromus mollis, Cynosurus cristatus, Alchemilla xanthochlora, Conopodium majus, Rhinanthus minor, Taraxacum officinale agg. and Trifolium pratense are found in most of the samples in this vegetation type. Thus, as in nodum 5, one has a large number of grass and herb species in the nodum, including both 'old meadowland species' and species associated more with intensive agricultural management. One can thus suggest that the fields from which these samples came are managed in a manner intermediate between the more traditional methods and those most intensive, 'modern' farming techniques. A range of fertilisation dosages are seen amongst the samples in this nodum, with a mean of 1.8 cwt/ac. The average age of the swards sampled is 89.5 years.

Nodum 7 - Agrostis tenuis-Rhytidiadelphus squarrosus-Veronica chamaedrys nodum

Constants: Agrostis tenuis, Anthoxanthum odoratum, Dactylis glomerata, Festuca rubra, Holcus lanatus, Lolium perenne, Cerastium holosteoides, Rumex acetosa, Trifolium repens, Eurhynchium praelongum, Rhytidiadelphus squarrosus.

Although there are only 6 relevés in this nodum, the geographical distribution of the nodum is wide, ranging from North Wales, through Swaledale, the Lake District and South Tyne valley to south-west Scotland (figure 4-7).

One can see in this nodum a number of species which are found in relatively old agricultural grassland which is managed in a reasonably intensive manner, such as Poa trivialis, Ranunculus acris, R. repens, Conopodium majus and Veronica chamaedrys. The mean artificial fertiliser dosage for these samples is 1.6 cwt/ac and the mean age of the swards sampled is 69.5 (with information on age of sward obtained for only 2 out of the 6 relevés). Perhaps surprisingly, with ploughing and reseeding seen within this nodum, the mean slope of the samples was 7.7°.

Figure 4-7
NODUM 7

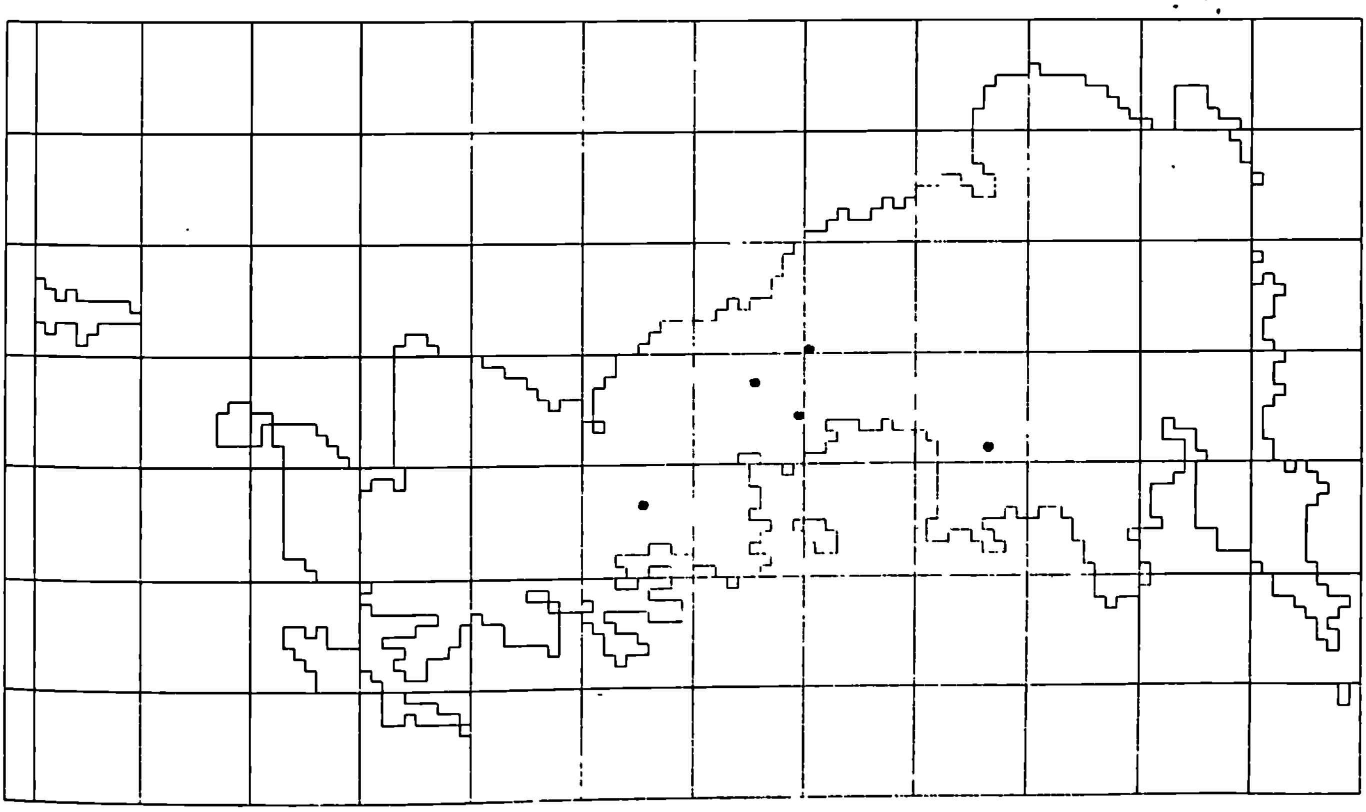
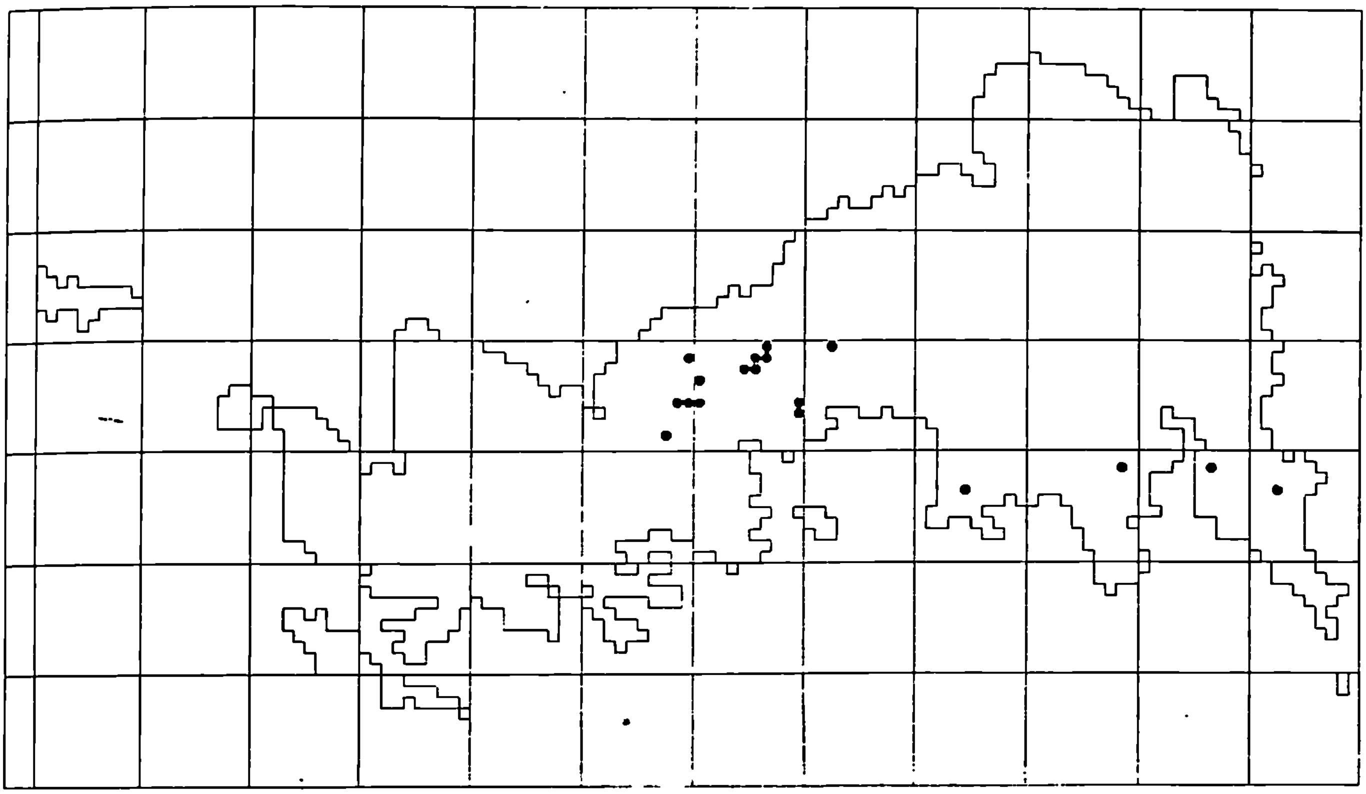


Figure 4-8
NODUM 8



Nodum 8 - Cynosurus cristatus-Rhinanthus minor-Brachythecium rutabulum nodum

Constants: Anthoxanthum odoratum, Cynosurus cristatus, Holcus lanatus, Lolium perenne, Poa trivialis, Cerastium holosteoides, Ranunculus acris, Rumex acetosa, Trifolium repens.

This nodum contains samples from the Lake District, Durham Dales, Yorkshire Dales, Cheviots, North Wales, mid-Wales and Dartmoor (figure 4-8). Samples in this nodum can be distinguished from those in noda 6 and 7 by higher cover values of Ranunculus repens and lower cover values of Dactylis glomerata, Alchemilla xanthochlora and Conopodium majus. As well as Ranunculus repens, this nodum contains Festuca rubra, Bellis perennis, Rhinanthus minor, Trifolium pratense and Brachythecium rutabulum in addition to the constants. A range of ages of sward are seen amongst the samples in this nodum, with a mean age of 84.9 years. The mean fertilisation level is the highest amongst the first nine noda, at 1.8 cwt/ac.

Nodum 9 - Juncus articulatus-Filipendula ulmaria-Geranium sylvaticum nodum

Constants: Holcus lanatus, Juncus articulatus, Filipendula ulmaria, Rumex acetosa.

Three of the four relevés of this nodum come from the Cheviots, with the remaining one coming from western Scotland (figure 4-9). This vegetation type is highly distinct from others in the data set, with many species which achieve high constancy only in this nodum. Thus, Juncus articulatus and Filipendula ulmaria are highly constant only in this nodum and Lathyrus pratensis and Deschampsia cespitosa are found little in samples outside this nodum. In addition to these species and to the constants, Dactylis glomerata, Bromus lepidus (c.f. B. mollis), Festuca rubra, Ranunculus acris, Veronica chamaedrys, Potentilla erecta, Centaurea nigra and Galium aparine are also common in the nodum. The nodum is found on damp, poor soils. Unfortunately, there is no information available on fertilisation levels amongst these samples. The shut-up period for this nodum is very short, with a mean of only 35 days, and the mean altitude of the samples is low, at 153.8 m a.s.l. (c.f. mean of 234.9m a.s.l. for the entire data set).

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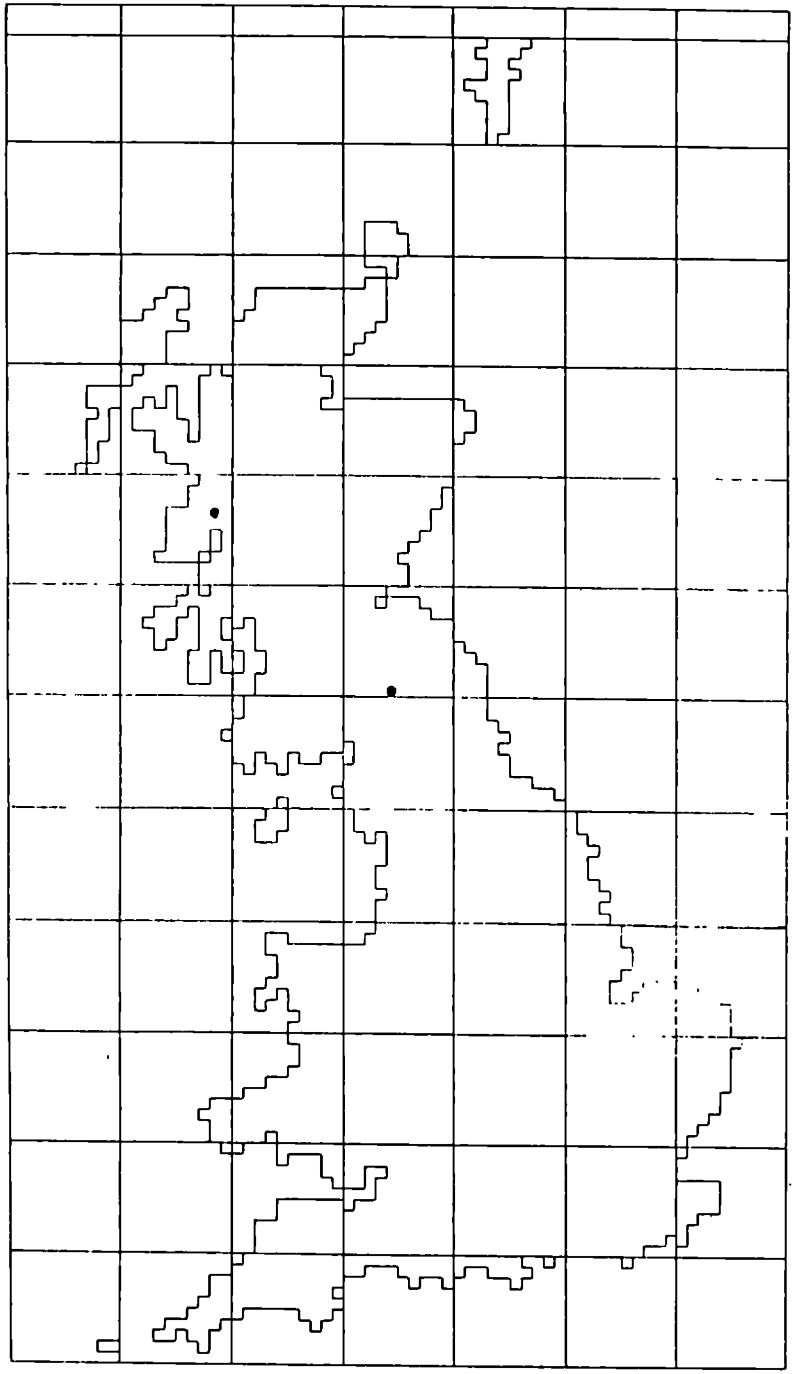


Figure 4-9
NODUM 9

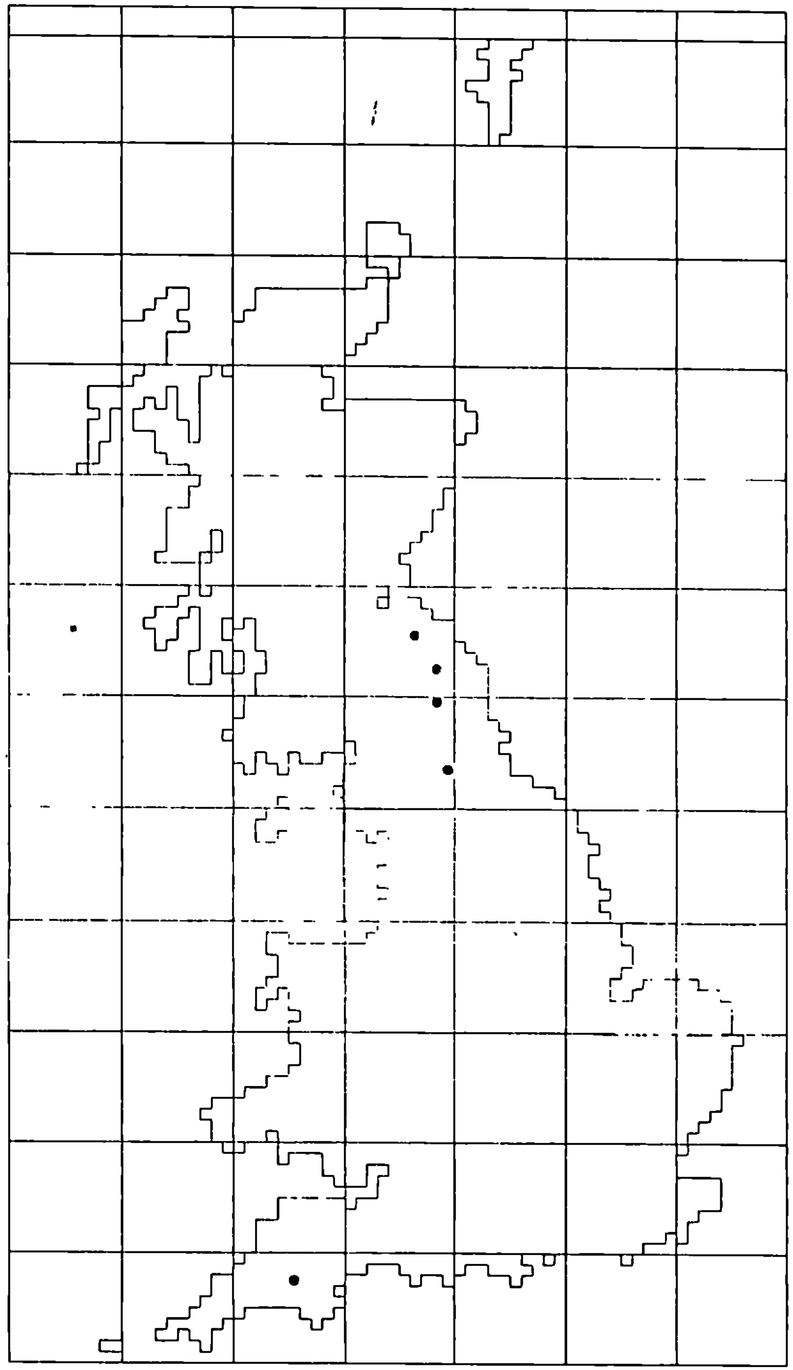


Figure 4-10
NODUM 10

Noda 10 to 18 lack the range of old grassland species, particularly herbs, found in the first nine noda.

Nodum 10 - Bromus mollis-Anthriscus sylvestris-Stellaria media nodum

Constants: Alopecurus pratensis, Bromus mollis, Dactylis glomerata, Lolium perenne, Poa trivialis, Taraxacum officinale agg.

Like nodum 9, this nodum, although small - containing only 5 relevés, comes from a wide geographical range, encompassing Dartmoor, Weardale and Northumberland (figure 4-10).

This vegetation type contains species indicative of heavy agricultural management. The grasses present - Bromus mollis, Lolium perenne, Poa trivialis, Dactylis glomerata, Alopecurus pratensis, Agropyron repens and Phleum pratense - are either those associated with reseeding or those which develop under high nutrient regimes, particularly when overgrazing and/or unbalanced fertilisation has created bare patches in the sward. Taraxacum officinale agg., Stellaria media and Anthriscus sylvestris are also associated with high nutrient levels and a broken sward cover; Bellis perennis is more resistant to heavy grazing than many meadow species. Unusual amongst the meadow vegetation sampled in this study, the samples in this nodum lack Holcus lanatus and Anthoxanthum odoratum and contain little Trifolium repens and Cerastium holosteoides. The vegetation is relatively species-poor; the mean number of species per relevé is only 12.8. High nitrogen levels and good general soil fertility are indicated. A mean value of 2.6 cwt/ac was obtained for artificial fertilisation for this nodum. Reseeding has taken place within some of the swards sampled; the average age of sward is 66.3 years.

Nodum 11 - Alopecurus pratensis-Poa trivialis-Trifolium pratense nodum

Constants: Alopecurus pratensis, Lolium perenne, Poa trivialis, Cerastium holosteoides, Ranunculus acris, Rumex acetosa, Taraxacum officinale agg.

The 26 relevés in this nodum come exclusively from England, from Dartmoor and Exmoor, Derbyshire, Yorkshire Dales, North Pennine Dales, Northumberland and the North York Moors (figure 4-11).

The presence of Cynosurus cristatus, Holcus lanatus, Anthoxanthum odoratum, Cerastium holosteoides, Trifolium pratense and T. repens distinguishes this nodum from the closely related nodum 10, as well as the lower cover values for Bromus mollis and Anthriscus sylvestris. Dactylis glomerata and Bellis perennis are also found at high constancy in this vegetation type. Lower nitrogen levels in the soils of the fields from which the samples in this nodum came are likely, given the higher levels of legumes and of grass species which are poor competitors under high fertility conditions. The current mean fertiliser application rate, of 2.5 cwt/ac, is almost identical to that of 2.6 cwt/ac obtained for nodum 10. It may be that heavy fertilisation dosages have been introduced more recently to the fields sampled here, than those sampled within nodum 10. In addition, the swards sampled in nodum 11 would appear to be older than those in nodum 10, with a mean age of 81.0 years c.f. 66.3 years for nodum 10.

Nodum 12 - Cynosurus cristatus-Lolium perenne-Veronica serpyllifolia nodum

Constants: Alopecurus pratensis, Anthoxanthum odoratum, Bromus mollis, Cynosurus cristatus, Dactylis glomerata, Holcus lanatus, Lolium perenne, Poa trivialis, Bellis perennis, Cardamine pratensis, Cerastium holosteoides, Ranunculus acris, Rumex acetosa, Trifolium repens.

The six relevés in this nodum come from Wensleydale, Dentdale (Cumbria) and North Wales (figure 4-12). This nodum is distinguished from the closely related nodum 13 by the presence of Cynosurus cristatus and Poa trivialis; it is distinct amongst the entire sequence of noda due to the high frequency of Veronica serpyllifolia, although this is a species which is commonly found at low constancy amongst samples in other noda and so cannot be considered to be faithful to the nodum. As well as a wide range of grass species, the samples in this nodum contain a number of herb species characteristic of agricultural grasslands, such as Ranunculus repens and Taraxacum officinale agg. in addition to the constants listed above. The range of species present in this nodum suggests that some at least of the sampled swards are old. Indeed, the mean age is 84.2 years. Thus, the agricultural grassland character of this nodum has probably resulted more from intensive farming methods with high artificial fertiliser application, than from frequent reseeding. The mean fertilisation application is 3.7 cwt/ac, making this one of the most heavily fertilised noda in this study.

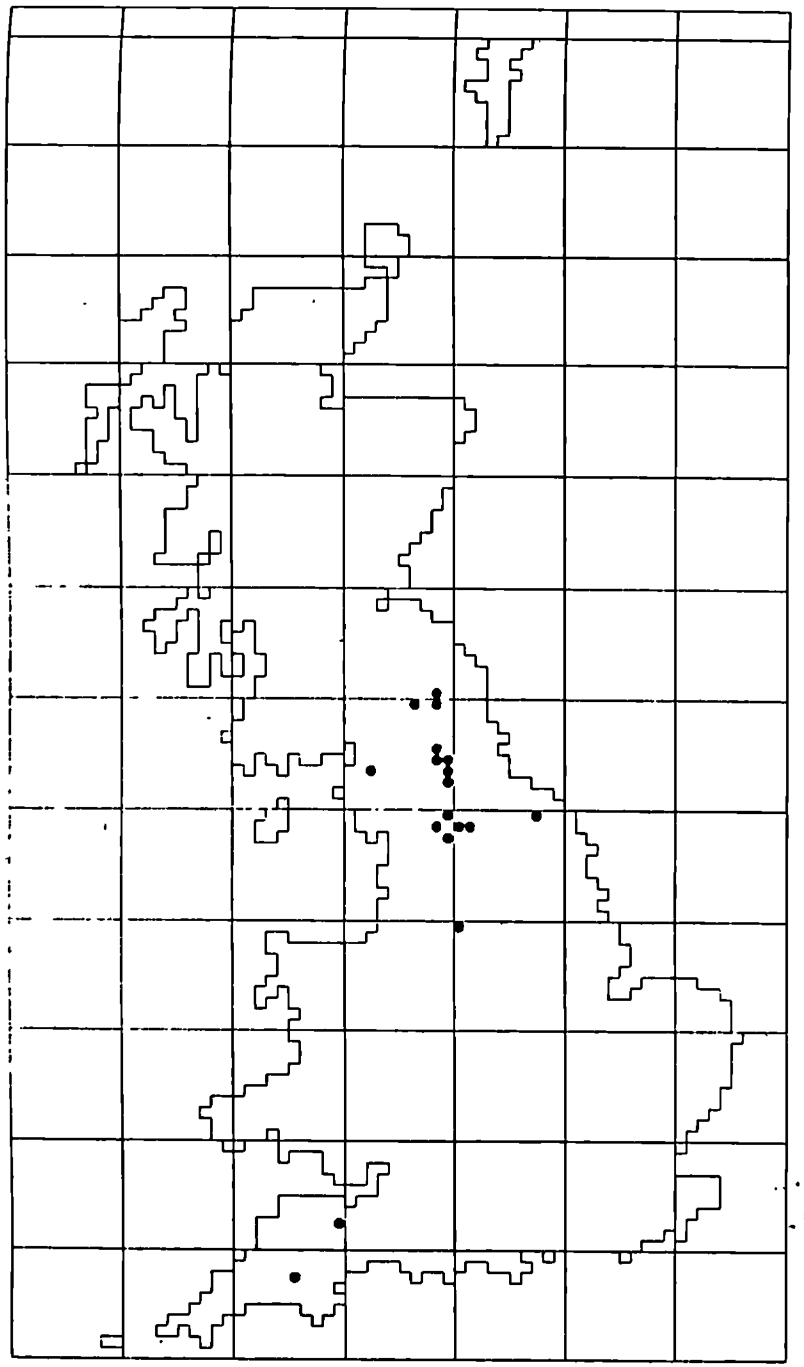


Figure 4-11
NODUM 11

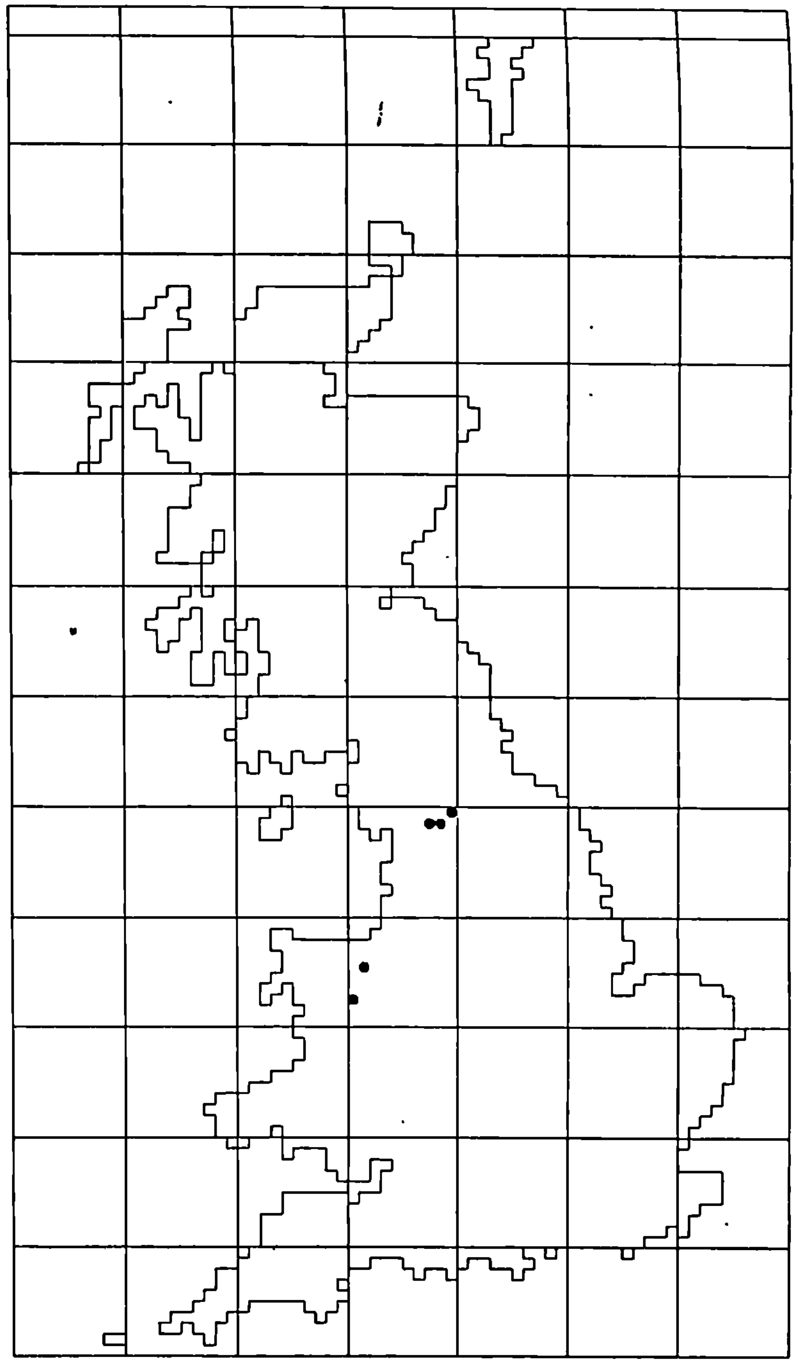


Figure 4-12
NODUM 12

Nodum 13 - Lolium perenne-Conopodium majus-Heracleum sphondylium nodum

Constants: Dactylis glomerata, Lolium perenne, Poa pratensis, Alchemilla xanthochlora, Bellis perennis, Cardamine pratensis, Cerastium holosteoides, Conopodium majus, Ranunculus ficaria, Trifolium repens, Veronica chamaedrys.

There are only three relevés in this nodum, from Swaledale and eastern Cumbria (figure 4-13). The nodum has a low mean altitude of 160m a.s.l. and is characterised by the high constancy values for Heracleum sphondylium and Ranunculus ficaria. Noda 13 and 14 both contain Poa pratensis at high constancy. Whilst Poa pratensis and P. trivialis are easily distinguished later in the season, the very earliest season growths, with only one or two leaves, may be confused and so it is probably unwise to place too much emphasis on differences between noda based on the presence of one of these species in one nodum and the presence of the other in a second nodum. Further problems can occur in using Ranunculus ficaria as a characteristic species, since it will not be apparent in fields surveyed later in the year; it was not recorded at the study farm in Swaledale after mid-June. Heracleum sphondylium is considered, like many members of the Umbelliferae, to be a competitive species in high fertility soils, being favoured in particular by nitrogen fertilisation. The associated presence of Ranunculus ficaria in these samples with Heracleum sphondylium supports the hypothesis that species with bulbs and corms are frequently more resistant to increased nitrogen fertilisation than other herbs. Not only does the presence of the perennating organ ensure continued survival under less advantageous conditions but it also allows early season growth and consequent exploitation of those resources which are later subject to more intense competition. These relevés contain a number of species associated with old grassland, such as Holcus lanatus, Anthoxanthum odoratum, Festuca rubra, Ranunculus acris, Rumex acetosa, Plantago lanceolata, Ranunculus bulbosus and Leontodon autumnalis. Thus it is likely that one is seeing here samples of heavily-fertilised old meadow swards, and indeed none of the fields from which these samples came from are known to have been reseeded in living memory. The mean artificial fertilisation application rate is high, 3.5 cwt/ac, and the fields from which these samples were taken were well-limed.

Nodum 14 - Bromus mollis-Achillea millefolium-Ranunculus bulbosus nodum

Constants: Alopecurus pratensis, Anthoxanthum odoratum, Bromus mollis, Lolium perenne, Poa pratensis, Achillea millefolium, Cerastium holosteoides, Ranunculus acris, R. bulbosus, Rumex acetosa.

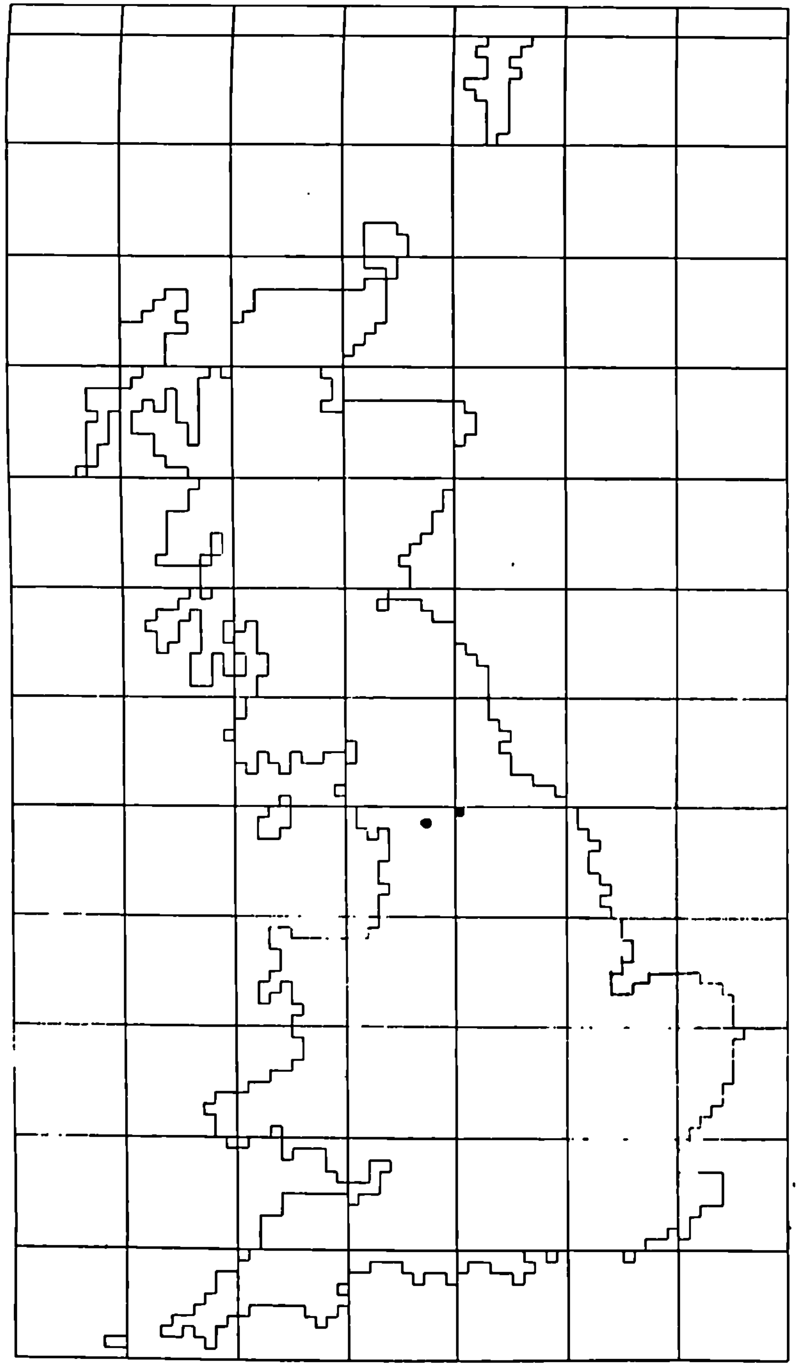


Figure 4-13
NODUM 13

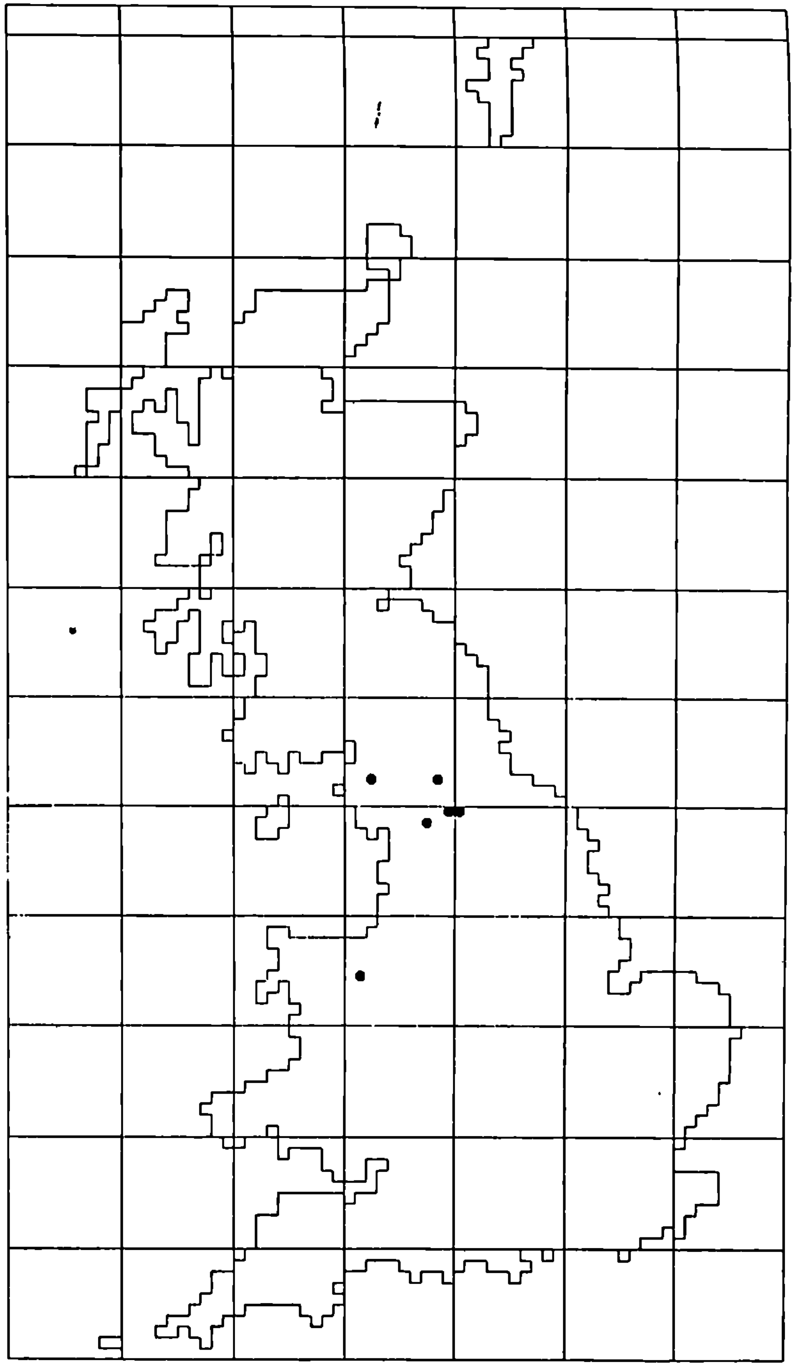


Figure 4-14
NODUM 14

The 8 relevés in this nodum, from a range of sites in North Wales, the Pennine Dales and Cumbria (figure 4-14), are characterised by the high constancy of Achillea millefolium. Like nodum 13, many samples in this nodum would appear to come from fields which have not been recently ploughed but which have been subjected to reasonably intensive farming practices, particularly artificial fertiliser applications. The mean age of sward for the nodum is 88.3 years and the mean artificial fertiliser dosage is 2.7 cwt/ac. In addition to the constants, Festuca rubra, Dactylis glomerata, Taraxacum officinale agg., Stellaria media, Conopodium majus and Cardamine pratensis also achieve high constancy levels.

Nodum 15 - Alopecurus pratensis-Ranunculus repens-Caltha palustris nodum

Constants: Alopecurus pratensis, Holcus lanatus, Lolium perenne, Poa trivialis, Ranunculus repens.

The seven relevés in this nodum come from northern England - the Durham Dales and Northumberland, with one sample from the Cheviots (figure 4-15). The mean altitude of the samples within this nodum is high, at 340.7m a.s.l.

The presence of Caltha palustris distinguishes this nodum amongst this group of vegetation types. Apart from the constants listed above, only Rumex acetosa and Cerastium holosteoides are found in any number of the samples in this nodum. The low levels of Dactylis glomerata found in these samples are noteworthy. The relevés are relatively species-poor, with from 10 to 19 taxa recorded in the samples. Where details were obtained, the fields from which the relevés in this nodum were taken were said not to have been ploughed and reseeded within living memory, although several of the species found within the nodum are those commonly associated with reseeded swards, either as constituents of the seeding mix or as incursive weeds. It is likely that the fields sampled have been managed in such a way as to create those agricultural swards which are often compared with sown swards in quality and general character by both agriculturalists and botanists. The fields receive an average of 2.5 cwt/ac of artificial fertiliser and have a late cut-date and a long shut-up period. Caltha palustris is similarly common in nodum 1 with its late cut-date and long shut-up period.

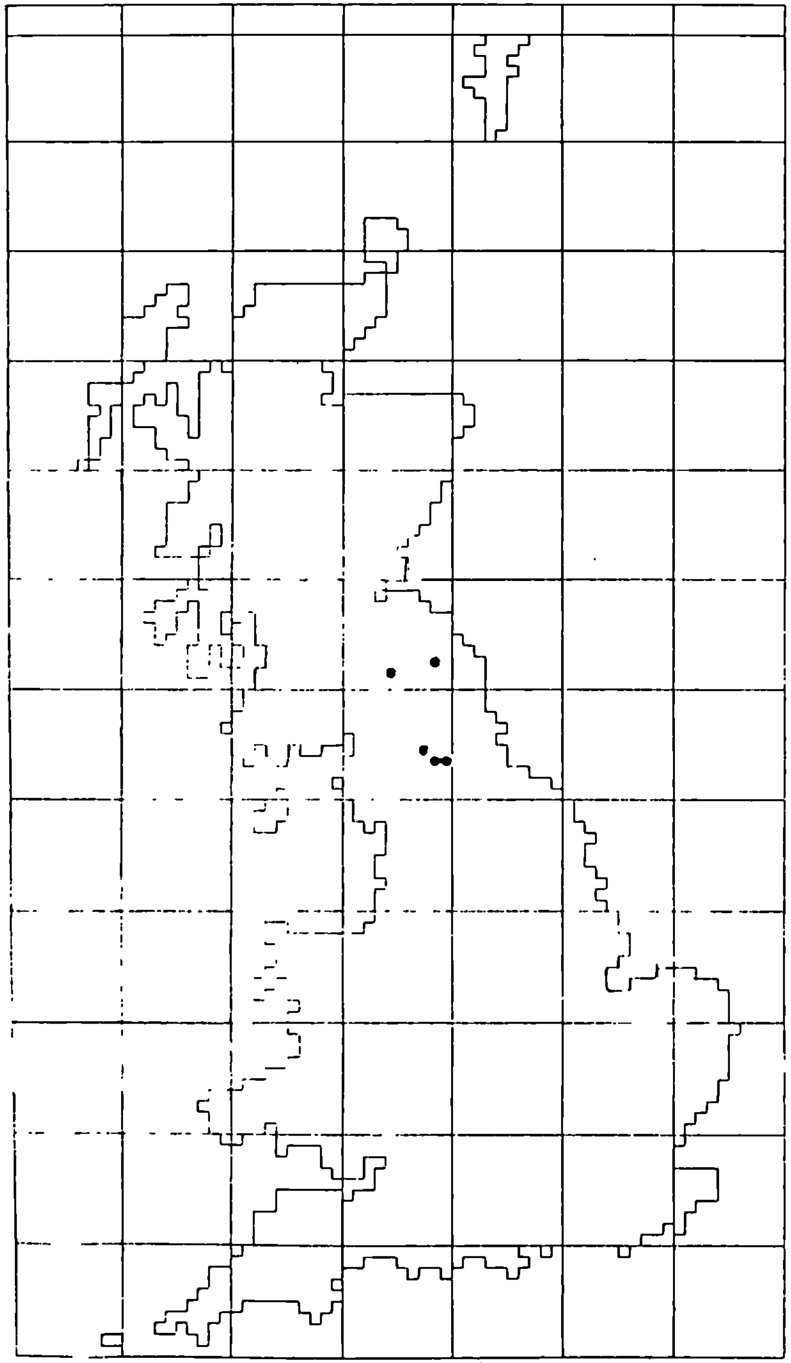


Figure 4-15
NODUM 15

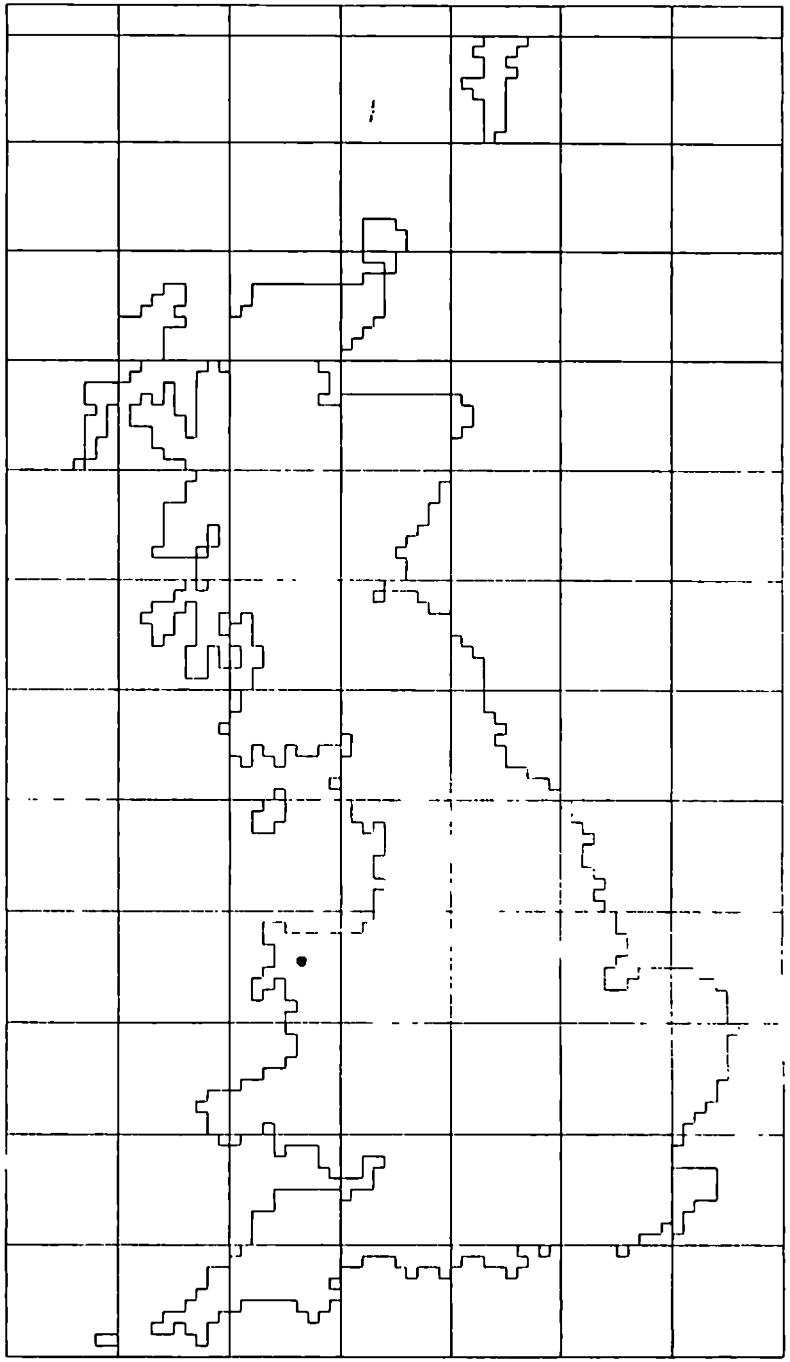


Figure 4-1[6]
NODUM 16

Nodum 16 - Agrostis tenuis-Alopecurus pratensis-Lolium perenne nodum

Constants: Agrostis tenuis, Alopecurus pratensis, Anthoxanthum odoratum, Holcus lanatus, Lolium perenne, Poa trivialis, Cerastium holosteoides, Ranunculus repens, Trifolium repens.

This nodum was described by six relevés all from Capel Curig in North Wales (figure 4-16). The presence of Alopecurus pratensis and Anthoxanthum odoratum distinguishes nodum 16 from the closely related nodum 17. The samples in this nodum lack Dactylis glomerata, have low levels of Ranunculus acris and contain Cynosurus cristatus. The fields sampled here were reseeded during the Second World War, lie on poor hill land and have been managed intensively for many years, with high artificial fertiliser applications (mean dosage of 3.0 cwt/ac). The samples are species-poor, with a mean of only 12.2 species per relevé for the nodum. Although the seeds mix used for reseeding is not known, it seems unlikely that some of the species now found in the fields were deliberately introduced into the sward and so one can recognise the invasion into the reseeded sward of several grassland species, which are common in the rough grassland surrounding the small enclave of meadows which were sampled, e.g. Agrostis tenuis, Anthoxanthum odoratum and Holcus lanatus. The harsh climatic conditions at this site demand the late cut-date and long shut-up seen. These fields are grazed by sheep only.

Nodum 17 - Lolium perenne-Alchemilla glabra-Ranunculus repens nodum

Constants: Bromus mollis, Dactylis glomerata, Holcus lanatus, Lolium perenne, Alchemilla glabra, Cerastium holosteoides, Ranunculus acris, R. repens, Rumex acetosa, Stellaria media, Trifolium repens.

These two relevés from a low altitude site in western Scotland (figure 4-17) are distinguished by the high levels of Alchemilla glabra. The presence of this species, Stellaria media, Bromus mollis and Dactylis glomerata separates these two samples from the closely related ones in nodum 16, which, in contrast, have Alopecurus pratensis, Anthoxanthum odoratum, Agrostis tenuis and high cover values of Trifolium repens. The field from which the two samples were taken was reseeded 25 years ago but the relatively low-input agricultural management which has been practised since that date (e.g. mean artificial fertiliser application rate of 1.0 cwt/ac) has allowed the development of a fairly species-rich sward (mean species number of 15.0) as species immigration has occurred. Hay is no longer taken from the field sampled in this nodum.

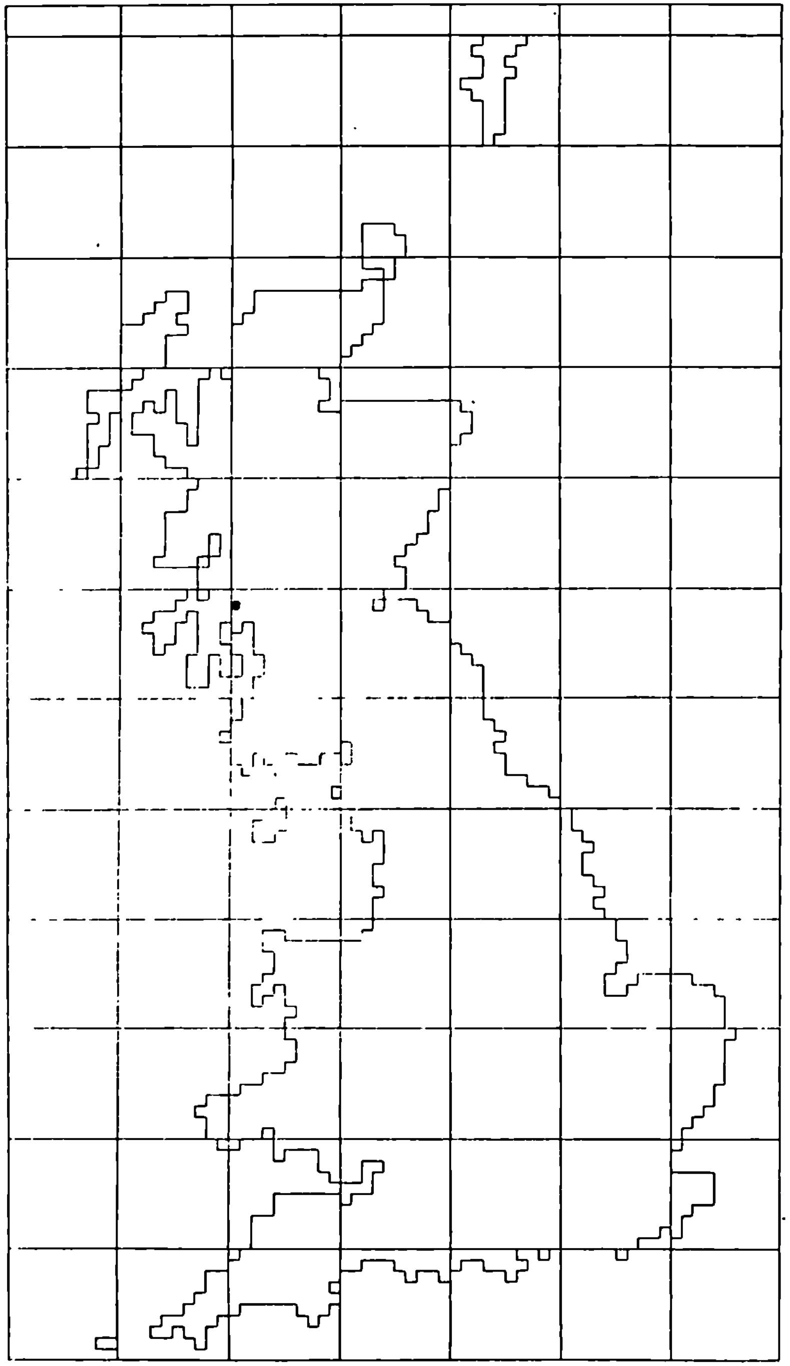


Figure 4-17
NODUM 17

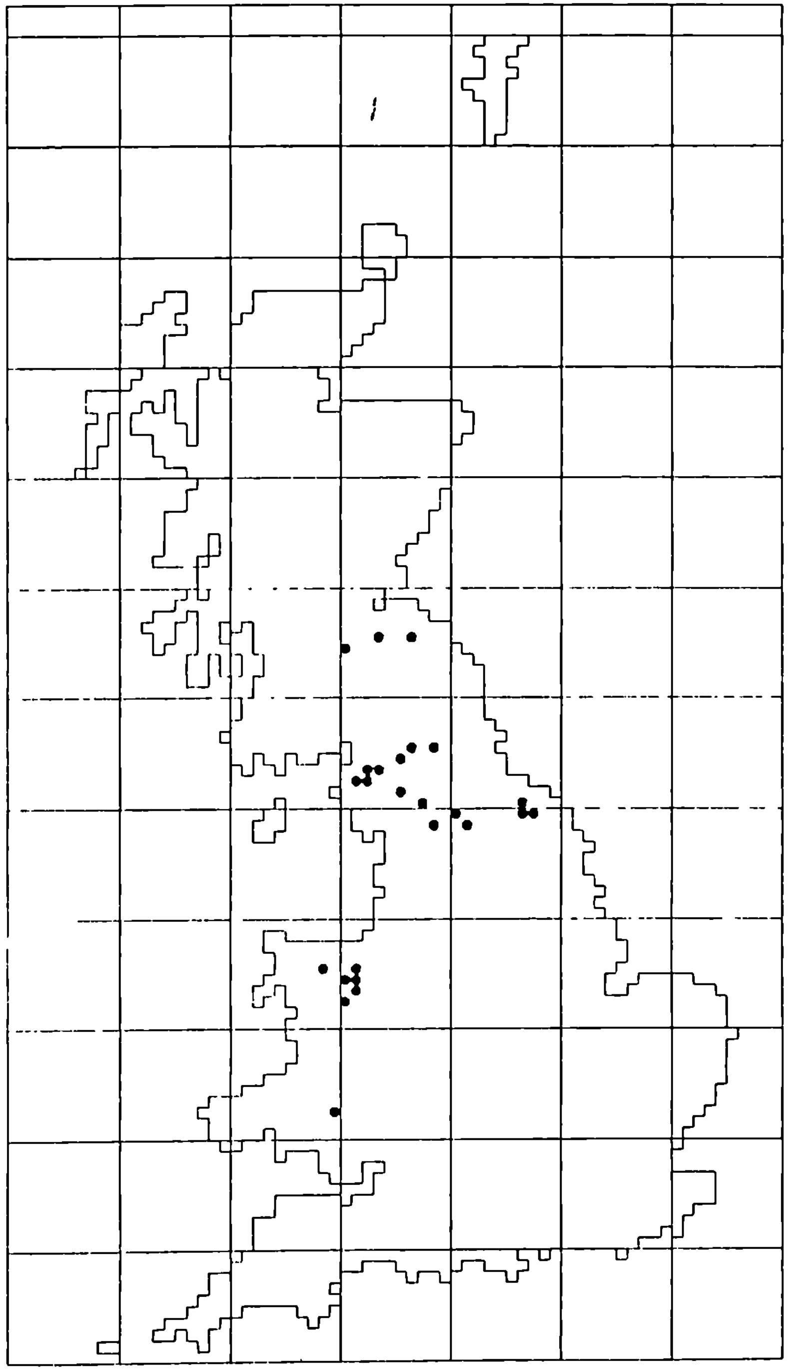


Figure 4-18
NODUM 18

Nodum 18 - Phleum pratense-Poa annua-Lolium perenne nodum

Constants: Lolium perenne, Bellis perennis, Cerastium holosteoides.

The 74 relevés in this nodum come from mid- and North Wales, Cumbria, North York Moors, Yorkshire and Durham Dales, Northumberland and south-west Scotland (figure 4-18). The samples in this nodum are characterised by the presence of Phleum pratense, a grass used commonly in reseeding mixes. Many of the fields sampled within this nodum have been ploughed and reseeded; the mean age of sward is 51 years (from the 44 samples with information on age of sward). Some of the fields, nonetheless, are thought not to have been reseeded this century, if at all. This is reflected in the scattered presence throughout this large nodum of species more usually associated with old grassland. Such species do not reach high constancy values within the nodum. Where swards have not been reseeded, the predominance of various grasses associated with seeds mixes and of accompanying herbs of a 'weedy' nature seen in the nodum indicates intensive farming methods. Indeed, the mean fertiliser application rate for samples in this nodum is 2.4 cwt/ac.

Associated with the intensive agricultural management of the fields samples from which fall within this nodum, a low species-diversity was found, with a mean of only 18 species per relevé. In addition to the constants and Phleum pratense, Bromus mollis, Dactylis glomerata, Poa annua, Rumex acetosa, Taraxacum officinale agg. and Trifolium repens were common.

AFFINITIES OF THE VEGETATION

Most meadow vegetation falls within the class Molinio-Arrhenatheretea Tx. 1937, which has the following character species in Britain (O'Sullivan, 1965 and Shimwell, 1968, in Page, 1980): Holcus lanatus, Festuca rubra, Poa trivialis, P. Pratensis, Alopecurus pratensis, Festuca pratensis, Helictotrichon pubescens, Vicia cracca, Cerastium holosteoides, Rumex acetosa, Ranunculus acris, Cardamine pratensis, Rhinanthus minor, Lathyrus pratensis and Ophioglossum vulgatum. None of the vegetation types described correspond closely to the typical meadow vegetation type, the Arrhenatherion elatioris (Br.-Bl. 1925) Koch 1926 described on the continent. Of the character species of the Arrhenatherion and Arrhenatheretum elatioris (and here the widest range of character species, described by many different authors on the continent, have been taken) only Arrhenatherum elatius, Bromus mollis, Cynosurus cristatus, Trisetum flavescens, Dactylis glomerata, Tragopogon pratensis, Anthriscus sylvestris and Heracleum sphondylium are found - and never with the high constancies seen in the 'true' examples described from continental Europe (for example, Schreiber, 1962; Stuchlikowa, 1967; Balatova-Tulackova, 1969; Tumidajowicz, 1971; Trinajstic, 1975; Dierschke and Vogel, 1981). Page (1980) comments that the different management characteristics between the continental Arrhenatherum elatius meadows and the hay meadows of Britain, notably the habit of grazing the meadows during the winter in Britain, is responsible for the lack of true Arrhenatheretum elatioris in Britain. Arrhenatherum elatius is known as a hay meadow species which is intolerant of grazing pressure. Wells (1985, pers. comm.) has said that grazing during the winter months is uncommon on southern English meadows but Hundt (1974), looking at southern English grassland, noted the depauperate nature of the Arrhenatheretum elatioris seen in southern England when compared with central Europe. The missing continental and thermophilous species are replaced by atlantic species, for example, Holcus lanatus and Centaurea nigra. Where it does occur, Arrhenatheretum elatioris tends to be a roadside community within Britain (Page, 1980; Grubb, 1982).

The more general problem of fitting British vegetation into the continental syntaxonomy is explored in Shimwell (1968) and Jones (1983) amongst others. Jones (1983) created a hierarchical classification of meadows in northern England which is very different from the classical continental syntaxonomy; the details of this classification are not given here.

This discussion of meadow vegetation types owes much to the classification of neutral grasslands in Britain of Page (1980), to which extensive reference has been made and is gratefully acknowledged.

Order **Arrhenatheretalia** Pawl. 1928

Many of the vegetation types defined from Britain do fall within the order Arrhenatheretalia Pawl. 1928 but within the alliances Cynosurion cristati Tx. 1947 and Polygono-Trisetion Br.-Bl. 1925 rather than the Arrhenatherion (see table 2). Many of the character species of the Arrhenatheretalia are familiar in this data set: Dactylis glomerata, Trisetum flavescens, Bromus mollis, Veronica chamaedrys, Daucus carota, Trifolium dubium, Taraxacum officinale agg., Bellis perennis, Chrysanthemum leucanthemum, Knautia arvensis (O'Sullivan, 1965); Trisetum flavescens, Bellis perennis, Chrysanthemum leucanthemum, Achillea millefolium, Carum carvi, Heracleum sphondylium, Tragopogon pratensis, Saxifraga granulata, Anthriscus sylvestris, Crepis capillaris, Stellaria graminea, Ornithogalum umbellatum, Tragopogon orientalis (Ellenberg, 1978).

Alliance **Cynosurion cristati** Tx. 1947

Within the Cynosurion cristati (character species: Cynosurus cristatus, Phleum pratense, Hordeum secalinum, Lolium perenne, Phleum bertolonii, Leontodon autumnalis, Odontites rubra, Veronica filiformis, V. serpyllifolia, Trifolium repens), various associations, communities and noda have been recognised. Three widely-known associations will be considered here in some detail: Lolio-Cynosuretum Tx. 1937, Centaureo-Cynosuretum Br.-Bl. et Tx. 1952 and Alchemillo-Cynosuretum Oberd. 1950 emend. Müll. apud Oberd. und Mitarb. 1967.

Lolio-Cynosuretum Tx. 1937

Character species: Cynosurus cristatus, Phleum pratense, Trifolium repens (Tüxen, 1947, in Page, 1980).

Differential species: Lolium perenne, Hordeum secalinum (Tüxen, 1947, in Page, 1980). Shimwell (1968) added Achillea millefolium and Cirsium arvense.

Constants: Lolium perenne, Cynosurus cristatus, Holcus lanatus, Trifolium repens (Page, 1980).

Noda from this study: 8, 12, (14), 16.

TABLE 2 - Meadow vegetation syntaxonomy (based on Tüxen, 1970 and Page, 1980)

Class Molinio-Arrhenatheretea Tx. 1937

Order Arrhenatheretalia Pawl. 1928

Alliance Arrhenatherion elatioris (Br.-Bl. 1925) Koch 1936

Association Arrhenatheretum elatioralis

Association Festuco-Phleetum pratensis

Alliance Cynosurion cristati Tx. 1947

Association Lolio-Cynosuretum

Association Centaureo-Cynosuretum

Association Alchemillo-Cynosuretum

Association Anthoxantho-Festucetum (rubrae)

Alliance Polygono-Trisetion Br.-Bl. 1925

Association Trisetetum flavèscentis

Order Plantaginetalia majoris Tx. 1947

Alliance Lolio-Plantaginion Sissingh 1969

Lolium perenne-*Poa trivialis* nodum

Lolium perenne-*Plantago lanceolata* nodum

Lolium perenne-*Alopecurus pratensis* nodum

Association Poo-Lolietum

Alliance Agropyro-Rumicion Nordh. 1940

Community *Potentilla anserina*-*Carex nigra*

Order Molinietalia Koch 1926

Alliance Juncion acutiflori Br.-Bl. 1947

Alliance Calthion palustris Tx. 1937

This association includes much of the improved grassland seen on mesotrophic soils. It is considered by many (e.g. Page, 1980) to be derived from grasslands of the Centaureo-Cynosuretum following more intensive agricultural management. Within the range of intensity of agricultural grassland management, a series of sub-associations and variants of this association can be recognised. Three such sub-groupings are commonly recognised within Britain and are represented within this data set. Within the typical sub-association, the National Vegetation Classification (in prep.) and Page (1980) noted the common presence of Alopecurus pratensis under a mowing regime. It may sometimes have been sown in the hay seeds mix. Ranunculus acris is also preferential for this variant. Nodum 12 is related to this Alopecurus pratensis variant.

The National Vegetation Classification also noted an Anthoxanthum odoratum variant, with Anthoxanthum odoratum, Rumex acetosa, Hypochoeris radicata and Luzula campestris. Page (1980) raised this sub-type to the level of a sub-association, the Anthoxanthetosum odorati Page 1980. He suggested that this sub-association is intermediate between the Lolio-Cynosuretum and the Centaureo-Cynosuretum and derives from the Centaureo-Cynosuretum following artificial fertilisation. Centaurea nigra and Chrysanthemum leucanthemum are retained but Lotus corniculatus and Lathyrus pratensis are lost, compared with the Centaureo-Cynosuretum. Nodum 8 contains Anthoxanthum odoratum and Rumex acetosa.

Birse (1980) noted two sub-associations: typical with Phleum pratense, Poa annua, Ranunculus repens, Veronica serpyllifolia, Rumex obtusifolius; and Luzula campestris sub-association with Luzula campestris, Lotus corniculatus and Rhytidiadelphus squarrosus. The latter he considered to be less improved than the former, which typically has higher nutrient levels. Lebrun et al (1949) similarly noted a sub-association à Luzula campestris (with Luzula campestris, Lotus corniculatus, Hypochoeris radicata, Achillea millefolium and Agrostis tenuis) of his association à Lolium perenne et Cynosurus cristatus which he placed within the alliance Arrhenatherion elatioris Pawl. 1928. Lebrun associated this sub-association with dry soils, poor in calcium. These sub-associations cannot be so clearly distinguished within this data set. Nodum 12 falls within Birse's more improved sub-association, with Ranunculus repens, Rumex obtusifolius, Veronica serpyllifolia and Poa annua. Noda 8 and 16 also have high levels of Ranunculus repens. However, nodum 16 has much Agrostis tenuis, and nodum 14, Achillea millefolium; both species which Lebrun considers to be more characteristic of a Luzula campestris sub-association.

Nodum 14 is a poor variant of this association. It contains Achillea millefolium as a constant. This is described by Shimwell (1968) as a differential species for this association.

Centaureo-Cynosuretum Br.-Bl. et Tx. 1952

Character species: Cynosurus cristatus, Phleum pratense, Trifolium repens, Senecio jacobaea (Braun-Blanquet and Tüxen, 1952, in Page, 1980).

Differential species (from Lolio-Cynosuretum): Centaurea nigra, Leontodon taraxacoides. Page (1980), noting the inadequacy of these species when studying the community outside Ireland, suggested: Briza media, Carex flacca, Lotus corniculatus, Lathyrus pratensis, Centaurea nigra, Chrysanthemum leucanthemum, Leontodon hispidus, Rhinanthus minor, Primula veris. This is similar to the list of species suggested by Shimwell (1968): Briza media, Carex flacca, Luzula campestris, Rhinanthus minor, Lotus corniculatus, Senecio jacobaea, Crepis capillaris, Lathyrus pratensis, Vicia cracca, Trifolium dubium, Rhytidiadelphus squarrosus and Pseudoscleropodium purum. O'Sullivan (1965, in Page, 1980) listed the following locally differential species for Ireland: Luzula campestris, Hypochoeris radicata, Senecio jacobaea, Rhytidiadelphus squarrosus.

Constants: Anthoxanthum odoratum, Festuca rubra, Cynosurus cristatus, Agrostis tenuis, Trifolium repens, Lotus corniculatus, Plantago lanceolata, Centaurea nigra (Page, 1980).

Noda from this study: 3, (4).

Nodum 3 falls within this association and is closely related to the examples of this association given by many authors, for example, Ivimey-Cook and Proctor (1966), Birks (1973), Birse (1980), the National Vegetation Classification (in prep.), Page (1980) and the Nature Conservancy Council survey of the Peak District and Lake District (as Community Type B - unimproved neutral meadow grassland) (Nature Conservancy Council, 1980a and 1980b).

Nodum 4 is closely related to the Community Type D of this same Nature Conservancy Council survey - unimproved acidic meadow grassland, which received farmyard manure but no artificial fertiliser (Nature Conservancy Council, 1980a and 1980b). This report referred this vegetation type to the Centaureo-Cynosuretum. It would seem however to be closely related to the Anthoxantho-Festucetum (rubrae) association of Page (1980) (see below).

Alchemillo-Cynosuretum Oberd. 1950 emend. Müll. apud Oberd. und Mitarb. 1967

Character species: Cynosurus cristatus, Trifolium repens (Page, 1980).

Differential species: Alchemilla glabra, A. xanthochlora, A. monticola, A. acutiloba, A. subcrenata, A. wichurae, Geranium sylvaticum, Cochlearia officinalis ssp. alpina (Page, 1980).

Constants: Cynosurus cristatus, Dactylis glomerata, Anthoxanthum odoratum, Alchemilla glabra, A. xanthochlora, Ranunculus acris, R. bulbosus, Plantago lanceolata, Cerastium holosteoides, Rumex acetosa, Bellis perennis, Conopodium majus, Trifolium repens (Page, 1980).

Noda from this study: (5).

Nodum 5 is the nodum in this study in which the Teesdale meadows which contain the 'rare' Alchemilla microspecies fall (see Bradshaw, 1962) but it is in many respects different to the published examples from the Alchemillo-Cynosuretum (e.g. Page, 1980), not least in its low constancy values for three of the constants and differentials of this association, Alchemilla glabra, A. xanthochlora and Geranium sylvaticum.

Anthoxantho-Festucetum (rubrae) Page 1980

Character species: Anthoxanthum odoratum, Festuca rubra, Agrostis tenuis (Page, 1980).

Differential species: (from Cynosurion), Galium saxatile, Hieracium pilosella, Campanula rotundifolia; (from Nardo-Galion), Lolium perenne, Poa pratensis, Trifolium repens (Page, 1980).

Constants: Anthoxanthum odoratum, Festuca rubra, Agrostis tenuis, Holcus lanatus, Plantago lanceolata (Page, 1980).

Noda from this study: 4.

Page (1980) describes this association as being derived from the Nardo-Galion through grazing and mild manuring. It replaces the Centaureo-Cynosuretum on poor, sandy soils. It is related to the broad Agrosto-Festucetum of, for example, McVean and Ratcliffe (1962). Nodum 4 is best attributed to this association.

Alliance **Polygono-Trisetion** Br.-Bl. 1925

This second alliance of the order Arrhenatheretalia Pawl. 1928 is described in detail in Page (1980). It replaces the Arrhenatherion at higher altitudes in the mountainous areas of Europe. In Britain, the impoverished montane flora renders many of the character and differential species given by continental authors for this alliance absent; of the above, only Geranium sylvaticum and Silene dioica are common. Page (1980) suggests the use of Alchemilla vulgaris agg. and Geranium sylvaticum as character species. Shimwell (1968) called in the alliance Ranunculo-Anthoxanthion Gjaerevoll 1956 emend. to replace the Polygono-Trisetion in Britain. Page (1980) felt, however, that this was not required. It is difficult to distinguish between this alliance and the Cynosurion in Britain as the boundaries between the two alliances appear to be indistinct in this country (Page, 1980).

Trisetetum flavescentis Beger 1922

Character species: Trisetum flavescens, Alchemilla vulgaris agg., Geranium sylvaticum, Meum athamanticum, Phyteuma nigra, Sanguisorba officinalis, Lathyrus montanus, Anthriscus sylvestris (Lebrun et al, 1949).

Constants: Poa trivialis, Festuca rubra, Dactylis glomerata, Geranium sylvaticum, Plantago lanceolata, Alchemilla glabra (Page, 1980).

Noda from this study: (6).

Page (1980) places the 'traditional Dales meadows' in this association. Thus, most of the 'northern meadows' of Ratcliffe et al (1979) fall, within the scheme of Page (1980), either into the Trisetetum flavescentis or the Alchemillo-Cynosuretum. Both of these vegetation types are thought to have derived from the tall-herb ground layer (Lactucion alpinae) of sub-alpine birch woods (Betulo-Adenostyletea) (Page, 1980). The Trisetetum flavescentis can be distinguished from the Alchemillo-Cynosuretum by the presence of Sanguisorba officinalis and the absence of Cynosurus cristatus, Bromus mollis and Alchemilla vestita.

Nodum 6 would appear to be most closely related to this association, although it contains some species more characteristic of the Cynosurion, for example, Bromus mollis, Cynosurus cristatus and Lolium perenne. There would appear to be few published vegetation types which correspond clearly to nodum 6. Two surveys of meadows with a more restricted geographical range described similar vegetation types: the Geranium sylvaticum/Rumex acetosa meadows found in Northumberland are a less-improved and less heavily-grazed relation of nodum 6 (Vegetation Type III; Haffey, 1979) and the Geranium sylvaticum/Dactylis glomerata traditional cranesbill/pignut/buttercup meadows, found on alluvial soils in the Yorkshire Dales by Smith (1983 and 1985), are similar.

Order **Plantaginetalia majoris** Tx. 1947

Character species: Blysmus compressus, Juncus tenuis, Matricaria matricarioides, Sagina procumbens, Coronopus squamatus, Lepidium ruderale, Malva pusilla, Sclerochloa dura (Ellenberg, 1978, in Page, 1980).

Alliance **Lolio-Plantaginion** Sissingh 1969

Character species: Plantago major, Malva pulsilla, Cynodon dactylon, Lolium perenne (from Page, 1980).

Noda from this study: 7, 10, 11, 13, 14, 15, 17.

Into this alliance fall the Lolium perenne leys and related grasslands described, amongst other authors, by the National Vegetation Classification. These are the most heavily-managed agricultural grasslands which derive, mainly, from the Lolio-Cynosuretum, either by heavy fertilisation and/or grazing, or by ploughing and reseeding. The species found in the swards are either those which were introduced in seeding mixes, incursive weed species or species which are resistant to high intensity management, including high artificial fertility levels. Noda 10, 11 and 17 do not fall clearly into any of the published associations and noda of the Lolio-Plantaginion but are most likely to represent degraded examples of the Lolio-Cynosuretum and thus probably should lie within this alliance, the Lolio-Plantaginion.

Lolium perenne-Poa trivialis nodum Page 1980

Constants: Lolium perenne, Poa trivialis, Trifolium repens (Page, 1980).

Noda from this study: 7.

Lolium perenne-Plantago lanceolata nodum Page 1980

Constants: Lolium perenne, Plantago lanceolata, Dactylis glomerata (Page, 1980).

Noda from this study: 13.

Lolium perenne-Alopecurus pratensis nodum Page 1980

Constants: Lolium perenne, Alopecurus pratensis, Dactylis glomerata (Page, 1980).

Noda from this study: 15.

Poo-Lolietum De Vries and Westhoff apud Bakker 1965

Character species: combination of Lolium perenne, Poa pratensis, P. trivialis, Trifolium repens, Ranunculus repens, Taraxacum officinale agg., Plantago major (Westhoff and Den Held 1969, in Page, 1980).

Constants: Lolium perenne, Poa pratensis (Page, 1980).

Noda from this study: 13, 14.

This association is found where grazing pressure is heavy and so trampling damage can result and species sensitive to trampling are lost. Species with folded (conduplicate) leaves (such as Poa spp., Dactylis glomerata and Lolium perenne), which are common in this vegetation type, are thought to be more resistant to trampling (Page, 1980). It probably derives from the Lolio-Cynosuretum by degradation and species loss due to trampling (Page, 1980).

Alliance **Agropyro-Rumicion** Nordh. 1940

Community **Potentilla anserina-Carex nigra** Birse 1980

Noda from this study: 1.

Nodum 1 is related to this vegetation type which Birse described from calcareous dune-slacks in the Orkneys (Birse, 1980). It also shares Agrostis stolonifera and Potentilla anserina with Oberdorfer's Agrostis stolonifera-Potentilla anserina association (Oberdorfer, 1983).

Order **Molinietalia** Koch 1926

Character species: Equisetum palustre, Orchis latifolia, Lychnis flos-cuculi, Lathyrus palustris, Stachys officinalis, Cirsium palustre, Deschampsia cespitosa, Juncus effusus, Achillea ptarmica, Selinum carvifolia, Colchicium autumnale, Trollius europaeus, Filipendula ulmaria, Sanguisorba officinalis, Angelica sylvestris, Galium uliginosum, Carex panicea, Juncus conglomeratus, Lotus pedunculatus, Taraxacum sect. palustria (Williams, 1968).

Ellenberg (1978) listed some of the above, with Lysimachia vulgaris, Silaum silaus, Valeriana dioica, Platanthera chlorantha and Thalictrum flavum in addition (in Page, 1980).

The Molinietalia has been sub-divided and reordered several times by different authors. Ivimey-Cook and Proctor (1966), for example, created a new alliance, the Filipendulo, to replace the two given here. Page (1980) emphasises the Senecioni-Brometum racemosi Tx. and Preising 1951, which he sees, in an impoverished form, in many damp meadow vegetation types. He lists the following as character species for Britain: Carex disticha, Caltha palustris, Senecio aquaticus, Cynosurus cristatus, Trifolium pratense and Anthoxanthum odoratum.

Alliance **Juncion acutiflori** Br.-Bl. 1947

Noda from this study: 2.

Nodum 2 can be compared, for example, with the association Potentillo-Juncetum acutiflori Birse et Roberton 1976 emend. Birse sub-association with Epilobium palustre typical variant of western and south-western Scotland. Birse (1980) noted that this association tends towards the Lolio-Cynosuretum with grazing.

Alliance **Calthion palustris** Tx. 1937

Noda from this study: 9.

Nodum 9 is not closely related to any published vegetation types. It is most similar to two continental descriptions: the association à Valeriana officinalis et Filipendula ulmaria sub-association à Holcus lanatus of Lebrun et al (1949), a drained Calthion palustris type, and the dry meadow form of Filipenduleto-Cirsietum oleraceae Géhu 1961. It also resembles the Trollium europaeus-Crepis paludosa nodum described by Page, 1980.

Festuco-Phleetum pratensis Birse 1984

Noda from this study: 18.

Nodum 18 shares some species with this meadow type of Birse. It is otherwise difficult to relate to published vegetation work. Birse placed this association within the alliance Arrhenatherion (Birse, 1984).

Discussion

The relationships between the noda defined within this study and published vegetation types are shown in Table 3. Within an intensive study of hay meadow vegetation, it is likely that the vegetation types defined will be, in some cases, facies and variants of published vegetation types and so it will prove difficult to relate the noda described to recognised associations. Indeed, in such a study, some noda may contain relevés from

TABLE 3 - Affinities to vegetation types defined with published vegetation types

NODUM	AFFINITIES TO VEGETATION TYPES DEFINED
1	Potentilla anserina- Carex nigra Birse 1980
2	Juncion acutiflori Br.-Bl. 1947
3	Centaureo-Cynosuretum Br.-Bl. et Tx. 1952
4	Anthoxantho-Festucetum (rubrae) Page 1980
5	(Alchemillo-Cynosuretum Oberd. 1950 emend. Müll. apud Oberd. u. Mitarb. 1967)
6	(Trisetetum flavescentis Beger 1922)
7	Lolio-Plantaginion Sissingh 1969
8	Lolio-Cynosuretum Tx. 1937
9	Calthion palustris Tx. 1937
10	Lolio-Plantaginion Sissingh 1969
11	Lolio-Plantaginion Sissingh 1969
12	Lolio-Cynosuretum Tx. 1937
13	Lolio-Plantaginion Sissingh 1969
14	(Lolio-Cynosuretum Tx. 1937) Lolio-Plantaginion Sissingh 1969
15	Lolio-Plantaginion Sissingh 1969
16	Lolio-Cynosuretum Tx. 1937
17	Lolio-Plantaginion Sissingh 1969
18	Festuco-Phleetum pratensis Birse 1984

more than one recognised association. Where clearly defined associations are not apparent throughout a data set, it is impractical to redesignate relevés from such noda, which may therefore appear 'confused' to those familiar with a classical (hierarchical) syntaxonomic treatment. Such is the case in this study. It should be borne in mind that the aim of this study was not so much to classify hay meadow vegetation from the Uplands of Britain in a fashion comparable to the syntaxonomic treatments of a wider range of grasslands but rather to form vegetation types which could be related to the management regimes which were practised on them.

HISTORY OF HAY MEADOW MANAGEMENT IN BRITAIN

The need for a fodder crop which can be kept throughout the winter and gradually used as feed in order to keep alive some animals into the spring is a fundamental requirement of stock-raising in areas with inhospitable winter climates and so hay-making is likely to have developed soon after the domestication of livestock. Evidence for the beginnings of hay-making is difficult to find. Franklin (1953) related the increase in grass pollen found in the pollen records of around 500 B.C. to the beginnings of hay cropping. It has been suggested that at this time a deterioration in climate resulted in cattle being housed and fed during the winter (Franklin, 1953). Hay-making scythes date from 750 B.C. (Franklin, 1953). Other workers have tried to relate the pollen assemblages found to hay meadow communities of today, in order to have evidence of hay-making. Given the often subtle differences between hay meadow vegetation and other types of grassland and the crudity of the taxonomic levels to which the identification of the pollen of some herbaceous taxa is possible, it is perhaps not surprising that such procedures have rarely been attempted. Sometimes deposits containing seeds are found and these, if taken as barn stores, can be more enlightening. Knörzer (1979) found evidence of a community similar to that of present-day continental hay meadow vegetation, the Arrhenatherion, at a Roman site in Dormagen, West Germany. Greig (1983) has carried out similar studies in Britain.

Franklin (1953) gives a history of hay meadows in Britain from which the following brief description is taken. Between 600 and 900 A.D., Anglo-Saxons cleared forests in lowland valleys to produce the rich meadowland of, for example, the Midlands. The use of -ham as an ending for placenames derives from the Anglo-Saxon term for hay meadow. Further north, Norsemen cleared valley forests for meadows. Around 900 to 1200 A.D. began a greater increase in grass at the expense of forests, which lasted until about 1500. Meadows were highly prized in the early agrarian communities. The richness of the medieval manor depended on the amount of ploughing that could be carried out, that is, the strength of the oxen during the winter ploughing period. Thus, the provision of adequate hay to feed the oxen was of vital importance. In the Domesday Book, it appears that 1 acre of meadow had four times the value of 1 acre of arable land (Franklin, 1953). During the 15th and 16th centuries, sheep-farming flourished and grassland expanded, at the expense of arable land (Fussell, 1964).

In the desire to increase yields, ploughing and reseeding of the meadow sward were practised from early times. The first records of leys are in the books of the monks of Coupar Abbey, Scotland; in 1463, ley-farming was described as 'that ancient custom' (Franklin, 1953). Following the dissolution of the monastries in the 16th century, the practice of reseeding appears to have been forgotten until the introduction of new grasses and legumes from the continent in the late 17th century stimulated it once more. A refugee from the Civil War, Sir Richard Weston, is traditionally given the credit for introducing red clover into Britain on his return from exile in the Netherlands (Moore, 1966). In fact, the Port Books of the Public Records Office for 1620 show the import of red clover and ryegrass seeds (Franklin, 1953). Already, by 1653, the great interest in the yield-promoting effects of clovers (known to the monks, who included native white clovers in their ley mixtures) was recorded in print, in Andrew Tarranton's 'The great improvement of lands by clover' (Moore, 1966). The first record of ryegrass leys in Britain is given in a history of Oxfordshire by Plot, published in 1677 (Beddows, 1967). Seeds of Phleum pratense and Dactylis glomerata were introduced from America in 1763 and those fields which were formed following parliamentary enclosure in the late 18th century frequently retain high levels of these two species and of Alopecurus pratensis, another species in common use during that period (Anderson and Shimwell, 1981).

Although the use of introduced species was limited by shortage of seed, indigenous species were largely neglected despite Benjamin Stillingfleet listing 95 suitable for cultivation in 1759. Stillingfleet's ideas were endorsed by William Curtis in 1790 and in the four following editions of his book which came out before 1815 (Fream, 1888), but concentration still focussed on introduced species. In their two books, Curtis and Stillingfleet gave the common names to most of our native grass species (Harvey, 1951 and Fussell, 1964). Curtis recommended the following species for meadows: Anthoxanthum odoratum, Alopecurus pratensis, Poa trivialis, P. pratensis, Festuca pratensis, Cynosurus cristatus, Trifolium pratense and T. repens (Harvey, 1951). Curtis, with great prescience, wrote (Curtis, 1790; from Harvey, 1951):

> 'for I have no doubt but, at some future time, it will be as common to sow a meadow with a composition somewhat like this as it is now to sow a field of wheat or barley'.

Although cultivated species of grass, such as wheat and barley, are recognised as introduced, it is more difficult to imagine, as Scholz (1975) has suggested, that since meadows and pastures are semi-cultivated, then their species can be regarded as semi-domesticated. Poa pratensis, for example, is thought to be a cross between Poa trivialis and another, unknown species (Scholz, 1975). Dactylis glomerata and Anthoxanthum odoratum are both frequently tetraploids; polyploidy is often a feature of cultivated species (Scholz, 1975). Scholz (1975) further noted that Arrhenatherum elatius, Phleum pratense and Alopecurus pratensis are all of mediterranean origin, indeed few of our 'agricultural' grasses are native to Britain (Scholz, 1975).

George Sinclair's work of 1816 based at Woburn Abbey emphasised the use of complex seeds mixtures. Such mixtures guaranteed some success, since whatever the conditions, some species would survive. Ryegrass continued to be the major species used, although by the mid-19th century, a protracted debate on the relative merits of ryegrass and other species had begun. Seeds of native species were not commercially available until the mid-19th century, when Lawson of Edinburgh is credited with first providing a reliable source of seeds (Harvey, 1951). At about the same time, the opening up of the New World and the import of cheap grain led to an agricultural depression in this country. Between 1874 and 1914, around 4 million acres of arable land reverted to grassland (Duffey et al, 1974), much of it 'tumbling down' rather than being reseeded. Animal products were, due to the problems of perishability, more resistant to competition from abroad than cereals.

In the early 20th century, Gilchrist's work at Cockle Park produced a simplification of seeds mixtures. The Cockle Park Mixture of Lolium perenne, Dactylis glomerata, Phleum pratense, Trifolium pratense, T. repens and Medicago lupulina has been extremely influential. This trend to simplify seeds mixtures was firmly established once work on species and varieties enabled the production of mixes containing groups of plants well-suited to the environment into which they were to be introduced (Jones, 1933). The early work in this field was carried out at the Welsh Plant Breeding Station, Aberystwyth, founded in 1919 to organise the reseeding of the 1.5 million hectares of grassland ploughed up during World War I (Lazenby, 1981). George Stapledon, the first director of the W.P.B.S., was the driving force behind the 20th century grassland reseeding programmes. In 1937, partly as a result of Stapledon's convictions, the Council of the Royal Agricultural Society of England recommended to the government annulments of all covenants forbidding the ploughing up of ancient grassland (Duffey et al, 1974). Many of these covenants had been in existence since the early Middle Ages. In 1939, the covenants were annulled by parliament and, in addition, a grant of £2 per acre was allowed to farmers who ploughed up grasslands more than 7 years old and more than 2 acres in extent (Duffey et al, 1974).

At the beginning of the Second World War in 1939, Stapledon sent a memorandum to the Ministry of Agriculture recommending the earliest possible ploughing of grassland throughout Britain, to increase the area of arable and high-yielding leys. Stapledon has been credited with saving the country from starvation (Lazenby, 1981). In 1939, 83% grassland in England and Wales showed no evidence of having been ploughed and reseeded (Idle, 1975, using the data of Davies, 1942). Between 1939 and 1947, 6 million acres of old grassland were ploughed (Idle, 1975). Financial support from the government for ploughing of grassland continued after the War and between 1947 and

1959 a further 2 1/4 million acres were ploughed (Idle, 1975, using the data of Baker, 1962). Thus, between 1939 and 1959, only 5 million out of an original 13.4 million acres of old grassland were undisturbed. Since old grassland was judged as that which gave no evidence of having been reseeded, it is possible that this figure of 5 million is in fact an overestimate (Idle, 1975).

Although the need to be self-sufficient in food was widely recognised, not everyone supported the wholescale way in which the war-time ploughing programmme developed. In 1943, G.F.H. Smith, Chairman of the Wild Plant Conservation Board and Honorary Secretary of the Society for the Promotion of Nature Reserves, wrote to the Ministry of Agriculture:

> 'where land has never been cultivated or at least not since the critical days of the Napoleonic Wars it may be the habitat of rare British plants, and if it be ploughed up such plants may be exterminated to the grave detriment of botanical science.'
>
> (in Duffey et al, 1974)

In response, the Ministry of Agriculture instructed the County War Agricultural Executive Committees to notify botanists of areas of grassland to be destroyed. For many areas, this was too late and too little.

The potential of increasing yield through a programme of improvement including ploughing and reseeding has encouraged ploughing of grassland through to the present day. In 1938-40, only about 4% swards contained more than 40% 'preferred' (i.e. sown) species; by 1970-72, this had risen to 45% of swards (Green, 1982, using data from Davies, 1942). Turning to the proportion of Lolium perenne in the sward, another measure of the 'improved nature' of the grassland, in 1939, less than 10% grassland had more than 30% Lolium perenne; by 1980, this had risen to 40% grassland. Shortages of seed led to a simplification of seeds mixtures during the War (Davies, 1952) and the current mixtures often consist of only two or three species (Harper, 1971), although each may include many different varieties. Lolium perenne is by far the most popular species sown today (Hopkins, 1979) and many varieties of it are available to farmers (National Institute of Agricultural Botany, 1985). Most species of grass have been used in mixtures at some point over the last few centuries, including Alopecurus pratensis, Cynosurus cristatus and even Anthoxanthum odoratum. During the 1950's and 1960's, Dactylis glomerata and Festuca pratensis were popular (Hopkins and Down, 1981). Trifolium pratense has lost favour, in part due to its susceptibility to diseases and pests and to its high cost (Hopkins, 1979), and currently, Phleum pratense is fashionable (Frame, Harkess and Hunt, 1973). In recent decades, work has been carried out to find or breed species and varieties specifically adapted to use in the Uplands (e.g. Munro and Hughes, 1968; Morris and Thomas, 1972; Kneale, 1979).

Within the last ten years or so, the emphasis has shifted and farmers have been encouraged not to reseed so frequently, but rather to create and maintain a 'good' agricultural sward through management (grazing, fertilisation etc.). The Uplands suffer particular problems and as a result, native species, particularly in a low-N regime, may yield better than sown species (e.g. Chestnutt, Young and Rippey, 1962; Thomas and Morris, 1973; Haggar, 1976; Robinson and Rorison, 1983; Peel and Green, 1984). Many reseeded swards have deteriorated to the extent that reseeding is the only answer and so, despite the high costs involved, reseeding will undoubtedly continue to be common in many areas. The decline in sown species seen in the years following reseeding has been monitored by many workers (e.g. Morrison and Idle, 1972; Forbes et al, 1980; Green, 1982; Hopkins et al, 1985; Peel et al, 1985). This decline is particularly rapid in conditions of impeded drainage (Oswald and Haggar, 1976; Hopkins and Green, 1979; Forbes et al, 1980; Green, 1983) and of low fertilisation (Green, 1983; Hopkins et al, 1985). The effect that such a change in species composition has on yield has been much-debated. The factors affecting grassland yield are explored in Halliday and Sylvester (1950). A correlation between the proportion of 'preferred' species in a sward and its yield has been noted by many authors (e.g. Peel, 1979; Dibbs and Haggar, 1979; Hopkins, 1979; Forbes et al, 1980; Hopkins, 1982). Garstang (1979), however, felt that the ingress of 'weed' species into sown swards did not necessarily reduce the yield, except where these incursive species were predominantly Poa species. The relationship between 'preferred' species and yield may in fact not be a direct, causal relationship - it may be that a high proportion of 'preferred' species and a high yield both result from good management (Peel, 1979; Dibbs and Haggar, 1979; Hopkins, 1979; Forbes et al, 1980; Hopkins, 1982).

Another aspect of meadow management, with a shorter history, is mineral fertilisation. Removal of a fodder crop takes nutrients out of the system and so yields will decline over the years unless some nutrient input is made. The use of organic manures to maintain the fertility of the soil has probably been in existence for as long as fodder has been cut. Fussell (1962) gives a history of early fertilisation. Marl was spread over meadows in some parts of Britain in the Middle Ages but at the end of the 18th century, use of horn and bone waste from the Sheffield knife handle factories began the habit of applying ground or treated bone to the ground (Fussell, 1962 and 1964). Other industrial waste was also used in some areas (see Fussell, 1962). In the 19th century, guano from Peru and then nitrates from Chile were used on grassland (Fussell, 1964). By 1850, Chilean nitrates, superphosphate (replacing bone) and ammonium sulphate (as a waste product of the expanding gas-light industry) were all available to farmers (Fussell, 1962). When the Thomas process of steel-making was introduced in the 1880's, slag became available (Duffey et al, 1974), as a rich basic source of phosphorus and trace elements (Copeman, 1978).

In the 20th century, the use of nitrates developed. The so-called artificial fertilisers became important products of the petro-chemical industry, deriving from oil. Very little artificial fertiliser was applied pre-1939. As late as the 1950's, many farmers believed that these fertilisers 'poisoned' the soil (Davies, 1976, in Lazenby, 1981). Archer (1986) gives a history of artificial fertiliser use in Britain. In 1947, less than 5 kg/ha N was applied to grassland on average (Yates and Boyd, 1949). In 1951, a grant was given to farmers to help them to purchase P fertiliser and in the following year, this grant was both increased and extended to other fertilisers (Bowers and Cheshire, 1983). Recently, the amount of fertilisers applied to grassland has risen dramatically. Between 1969 and 1976, the amount of N applied to grassland rose by 50%, although the amount of P fell by about 30% and the amount of K remained about the same (Down and Lazenby, 1981). Now, more than 50% of the N, 33% of the P and of the K used in England and Wales are applied to grassland.

In 1985, the following mean amounts, in kg/ha, of the major plant nutrients were applied to meadows in England and Wales (Chalmers and Leech, 1986):

	Silage	Hay
N	197	94
P	33	23
K	64	25

Ministry of Agriculture, Fisheries and Food guidelines recommend 60 kg/ha N on hay crops in the Uplands; this is equivalent to about 2.5 cwt/acre 20:10:10 (a commonly used compound fertiliser mix). For silage fields, 120 kg/ha of N is recommended, with supplements of 100 kg/ha for any further cuts (Ministry of Agriculture, Fisheries and Food, 1983b).

Excessive rates of fertiliser application are wasteful and can cause pollution problems. The response of yield to increasing dosages of nitrogen gradually levels out (Reid, 1961). It has been ascertained that nitrogen application does not extend the growing season directly but rather only increases the growth during the season (Spedding, 1971; Ollerenshaw et al, 1976).

Upland conditions present particular difficulties for fertilisation. There are usually very high organic (unavailable) N levels in upland soils (Batey, 1982) but low mineralisation as a result of the low microbial activity, constrained by low soil pHs and low temperatures (Dowdell, 1986). Nitrogen applied to upland soils can be lost through leaching, denitrification and immobilisation into organic forms (Dowdell, 1986). Ploughing can release this nitrogen, resulting in nitrate pollution of upland water courses. In addition, heavy N applications can increase the likelihood of winter frost damage to swards (e.g. Copeman, 1978). The problems and principles of fertilisation are well-elaborated by Salette (1975).

Fertilisation, by forcing grass growth, can allow earlier cutting, which encourages silage taking. In 1882, Vicomte de Chezelles introduced to Britain the idea of fermenting fodder in pits, at the Royal Show, Reading (Moore, 1966). This did not prove to be successful in Britain and was little developed. At the turn of the century, the tower silo was introduced from North America (Moore, 1966). The expense of the tower delayed its spread in this country but from the 2nd World War onwards, silage making became more popular. In 1940, about 250,000 tons of silage were made in the U.K.; by 1957, this had increased to 3,860,000 tons (Moore, 1966). In 1966, however, only 17% conserved fodder was silage (Lazenby, 1981). Technical problems were gradually eliminated during the late 1960's and by the late 1970's, the amount of silage made in this country exceeded the amount of hay.

The relative benefits of hay and silage are given in Economic Development Committee for Agriculture (1974). Some farmers feel that animals prefer hay and there is some evidence that this is so (e.g. Strickland, Wickens and Hopkins, 1966; Strickland and Jackson, 1969; Strickland and Bastimann, 1978). Another important factor for farmers is the relative ease of handling and transporting hay.

A final feature of meadow management that is difficult to measure but that has undoubtedly altered over the centuries is the intensity of grazing on the fields. Between 1961 and 1978, there was an increase in stocking rates of about 98% (Mair, 1981). In this same period the number of hill ewes in Great Britain increased from 4.8 million to 7.4 million and the number of hill cows increased from 351,000 to 827,000 (Mair, 1981).

Over the centuries, all of these features of changing farming practice have left their mark on the meadows of Britain.

RELATIONSHIPS BETWEEN THE VEGETATION AND THE ENVIRONMENTAL AND MANAGEMENT VARIABLES.

The relationships between the environmental and management variables recorded and the vegetation were explored using two techniques. The Michigan Interactive Data Analysis System (MIDAS) was used to carry out various statistical tests on the data, using the DECORANA ordination scores of the sites as a measure of the vegetation. Secondly, the more directly visual CANOCO was run on the data. The MIDAS analysis included hay (since it was analysed separately from silage, unlike during the CANOCO analysis, where the almost perfect negative correlation between these two variables forced the removal of hay from the analysis; see below). In addition, the two grid reference components, which were used as covariables in the CANOCO analysis, were included as variables in the MIDAS analysis. The sets of results from the two methods are comparable, although the ordinations are subtly different, since in CANOCO the axes are constrained to be linear combinations of the environmental variables and there is no advantage to be gained from using a detrended ordination algorithm. The dispersion of the sites (and species) in the two ordinations (CANOCO and DECORANA) are still, however, very close. The 1st and 2nd ordination axes are reversed in the CANOCO results, relative to the DECORANA results, and so where the DECORANA axes are referred to, the scores have been reversed, in order to make comparison with the CANOCO results clearer.

The relationships between the vegetation (as ordination scores) and the environmental/management variables revealed by the two methods utilised to explore them are similar. The correlations between the 3rd and 4th axes and the variables are more varied but this might perhaps be expected, since these latter axes explain less of the variation in the vegetation data and so might be considered to have less clear-cut relationships with the environmental/management data. The MIDAS statistical results are given in table 4. The first axis scores show a significant relationship with the amount of artificial fertiliser added, the two grid reference components, altitude, slope, cutting date, age of sward, the crop taken and length of the shut-up period. Following the first season's work, there was a significant relationship between the date of sampling and the scores on the first ordination axis. In order to attempt to explain this relationship, a study was made of the change in species composition recorded at a number of sites during the season (see Appendix 3). The cutting date, slope, altitude, the two grid reference components, amount of artificial fertiliser applied and grazing with sheep vary in a direction related to that of the second ordination axis. These relationships, and those with the third and fourth axes, will not be elaborated here, since they are mirrored by the CANOCO results which are discussed fully below.

TABLE 4 - Significant relationships between environmental and management variables and the vegetation of the samples (as DECORANA values) using MIDAS statistical analyses

VARIABLE	Axis 1	Axis 2	Axis 3	Axis 4
Fertiliser	++	+	++	+
Manure	++		+	
Lime			+	-
Cut-date	--	++		
Shut-up period	-		--	
Age	--			--
Hay	--			
Silage	++			
G.R. N-S	++	++	++	
G.R. E-W	++	-	++	--
Altitude	++	--	++	--
Slope	--	--	--	
Sheep		++	-	++

A single character shows significance at the 0.05 level and a double one, significance at the 0.01 level. See text for details of the various statistical tests carried out in this analysis.

\+ shows a positive relationship and -, a negative one.

(In order to facilitate comparison with the CANOCO results, the 1st and 2nd axis loadings have been reversed; see text for explanation.)

The CANOCO results are shown in table 5. The differences between the relationships indicated by the two methods will not be discussed for axes 2, 3 and 4 in any detail. The 1st axis explains much of the variation in the vegetation data and so the environmental/management relationships along this axis are worthy of more attention. Only in three cases do the two methods differ. Both note a significant relationship between manuring and the first axis but CANOCO sees a negative relationship and the MIDAS student t-test, a positive one. This is difficult to explain. In addition, CANOCO indicates a negative relationship between cattle and/or sheep grazing and the first axis; whereas no significant pattern is recorded by a MIDAS student t-test. This is probably related to the fact that CANOCO is performing a regression test on variables which have only two cases (present and absent).

The CANOCO results provide statistically-rigorous and easily-visualised details of the relationships between the species/samples and the environmental and management factors recorded. From the eigenvalues associated with the derived axes (1st axis: 0.154; 2nd axis: 0.073; 3rd axis: 0.049; 4th axis: 0.047), one can see that the major proportion of the variation in the data explained in the analysis is associated with the 1st axis. Therefore, any attempts to explain the pattern of variation in the vegetation by relating them to any corresponding patterns of change in the environmental and management factors recorded should concentrate on the patterns revealed along this 1st ordination axis. The variables significantly associated with all four of the ordination axes derived are shown in table 5. Various of the environmental and management variables involved in the analysis show significant variation in the direction of this axis, suggesting that these variables, in some combination, may play an important role in defining the plant communities recorded. It should not be forgotten that correlation does not necessarily indicate causal relationships. High fertilisation levels and high altitudes are associated with high scores on the 1st axis and manuring, a long period since last reseeding, a late cutting date and a long shut-up period, steeper slopes, sheep grazing, cattle grazing and a slope to the east are all associated with low scores on the axis (see table 5).

Before continuing with an assessment of the variables associated with these axes, a comment on correlation between the environmental/management variables should be made. CANOCO assesses inter-variable correlations and one is able thus to recognise redundancy in the data and delete variables which are more or less perfectly correlated, either directly or inversely, with other variable(s) considered. Thus, 'hay' was removed from the analysis since so few fields were cut for either both hay and silage or neither that a perfect negative correlation between hay and silage was found. However, there may still be partial correlations between variables indicating relationships between them which may result in misunderstanding the correlations between the variables and the

TABLE 5 - Significant relationships between environmental and management variables and the vegetation of the samples (as ordination values) from CANOCO analyses

VARIABLE	Axis 1	Axis 2	Axis 3	Axis 4
Fertiliser	+	+		+
Manure	-	+	-	-
Lime				-
Cut-date	-	+	+	
Shut-up period	-	+	-	+
Age	-	-	+	-
Altitude	+	-	-	
Slope	-	-		+
Slope east	-		-	+
Sheep	-	+	-	
Cattle	-	+	-	

+ shows a positive relationship and -, a negative one. A t-value is considered to be significant when it reaches an absolute value of >2 (see ter Braak, 1986).

There were no significant relationships between the values on the axes and the taking of silage, nor between the values on the axes and aspect in the north-south orientation.

vegetation that they control, unless these inter-variable correlations are recognised and taken into account. The partial correlations between the variables considered in this CANOCO analysis are shown in table 6; only those correlations over 0.1 or less than -0.1 are shown.

The correlations revealed include the following: there is a positive correlation between slope and altitude, indicating that that steeper slopes are found at the higher altitudes, as might indeed be intuitively expected. There is a strong positive correlation between cutting date and the length of the period of shut-up; this renders it difficult to isolate these two factors when attempting to explain the vegetation. However, it is likely that the effects of these two factors (late cut-date and long shut-up period) on the vegetation are very similar and are related to the flowering and seed set of later-flowering species in the meadow. There is also a positive correlation between cutting date and the age of the field, that is, the number of years since the sward was last ploughed and reseeded. This could be explained by the fact that a late cutting date and the retention of old meadowland are both characteristic of a more traditional method of farming. Alternatively, it may be that the older swards grow more slowly and so hay cutting is carried out later in the season in order to maximise production. There is certainly no danger of lodging forcing an early cut with old meadow swards. Negative correlations are recorded between cutting date, and both fertiliser levels and silage cutting. With higher fertiliser dosages, grass growth is rapid enough to allow, or even demand, early cuts. Earlier cuts are also associated with silage cropping (which is itself associated with higher fertilisation levels). Longer shut-up periods are also negatively correlated with fertilisation levels, for the same reason. There is, however, no correlation between the shut-up period, and age or silage. This suggests that the later cutting date associated with the older fields is not related to the potentially slower growth rate of the old swards, as was hypothesised above. The older fields are evidently grazed later into the late spring than the younger fields. The dense sward, with a strong mat of roots and probably a moss layer, renders older swards more resistant to trampling damage than younger, more open swards. The lack of correlation between the shut-up period and the taking of silage indicates a lack of full exploitation of the silage system by some of the farmers concerned. The effects of insolation are indicated in the positive correlation between the length of shut-up period and the degree of slope to the north shown by the sample. In general, there are few significant relationships shown between aspect and other factors, possibly because the aspect of the sample need not necessary reflect the aspect of the field in general and thus may have little effect on the management and vegetation of the meadow as a whole. There is no correlation, either positive or negative, between manure and fertilisation but there is a positive correlation between lime and fertiliser application and a negative

TABLE 6 - Correlations between environmental/management variables

Altitude	slope	0.1883
	age	0.1096
Slope	altitude	0.1883
	manure	0.1759
	age	0.1620
	slope N	0.1047
	fertiliser	-0.2074
Cut-date	shut up	0.4537
	age	0.1307
	silage	-0.1149
	lime	-0.1985
	fertiliser	-0.2575
Shut up	cut-date	0.4537
	slope N	0.1183
	lime	-0.1497
	fertiliser	-0.3042
	sheep	-0.4096
Age	slope	0.1620
	cut-date	0.1307
	altitude	0.1096
	manure	0.1083
	slope E	-0.1739
	silage	-0.1757
Fertiliser	silage	0.2623
	lime	0.2310
	sheep	0.1745
	slope	-0.2074
	cut-date	-0.2575
	shut up	-0.3042
Manure	slope	0.1759
	age	0.1083
	silage	0.1001
	slope E	-0.1105
	lime	-0.1632
	cattle	-0.2043
Lime	fertiliser	0.2310
	shut up	-0.1497
	manure	-0.1632
	cut-date	-0.1985
Sheep	fertiliser	0.1745
	cattle	-0.1172
	slope N	-0.1227
	shut up	-0.4096

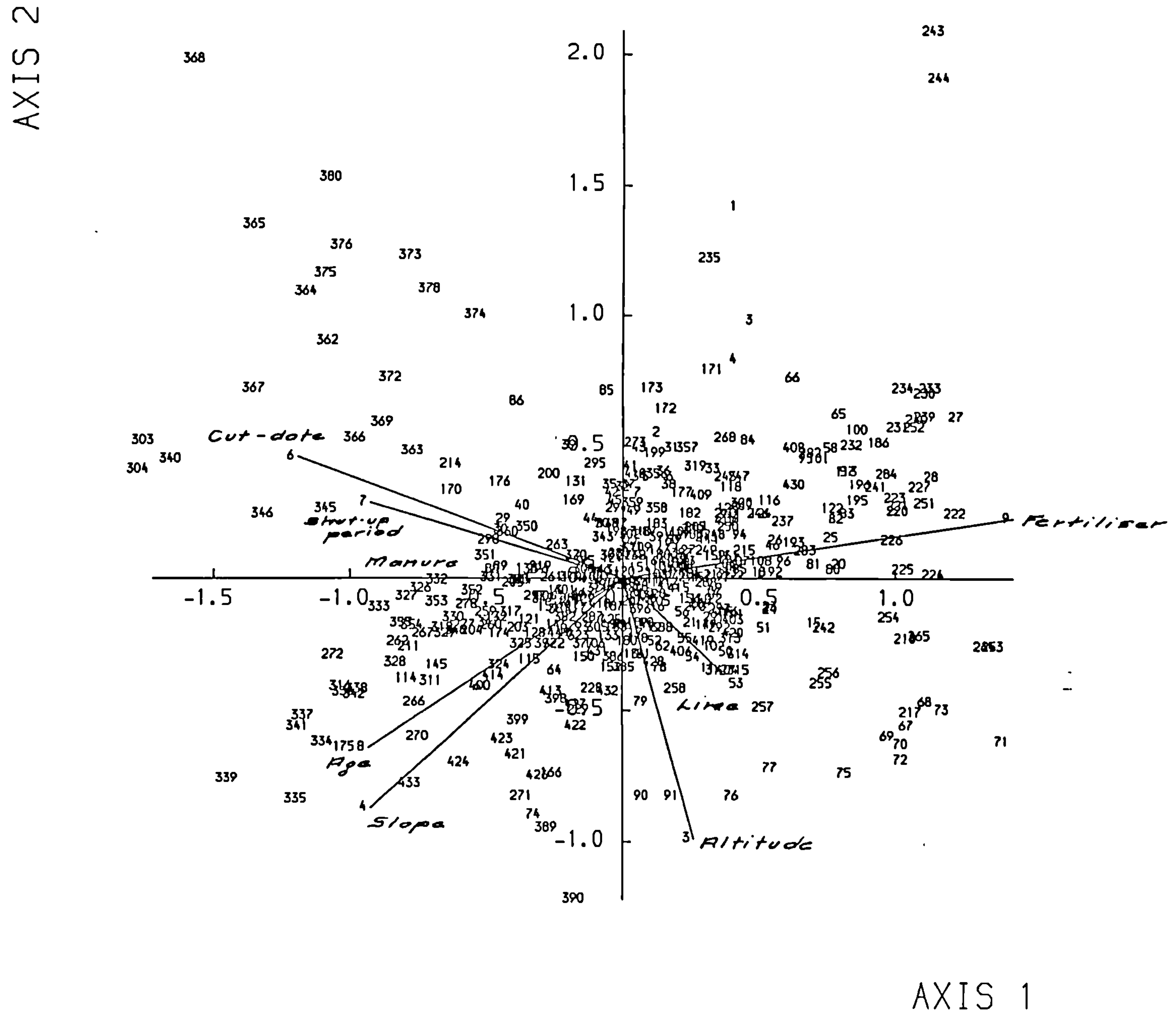
correlation between lime and manure correlation. This is possibly related to the general efficiency of the farming practised. Since grant aid was removed from lime application in 1960, fewer upland farmers feel that it is worth-while expending their meagre financial resources on lime; those who do not apply expensive artificial fertilisers are even less likely to apply lime, which has less immediate effect on yield.

With the possible existence of these complicating inter-variable correlations in mind, the variables associated with the 1st axis can be studied further. The 1st axis represents a gradient from the more traditional hay meadow management to more intensive management. Old swards with a long shut-up period, late cutting date and low artificial fertilisation input fall to the negative end of the axis (see figure 5). A long period of shut-up allows the full development of the hay meadow vegetation; even the more slowly growing species have sufficient time to become mature and set seed. Lengthy, heavy and late spring grazing is damaging to the sward and is well-known, amongst farmers, to damage the hay-cropping potential of the field (see, e.g., Smith, 1927). A late cutting date allows the seed set and dispersal of the later-flowering, traditional hay meadow herbs. Species such as Cirsium dissectum, Rhinanthus minor and Succisa pratensis are associated, here, with the late cut-date and long shut-up period.

Sites on steeper slopes (possibly coincidentally mainly to the east) also lie at this end of the axis. There is an element of correlation with other variables involved here: it is unlikely that the steep slopes themselves define the vegetation on them but rather that the slopes have prevented and continue to prevent intensive agricultural use (for example, ploughing, heavy artificial fertilisation) which would otherwise have destroyed the vegetation of these sites. A negative correlation between slope and level of artificial fertilisation was, indeed, recorded.

Sheep and cattle grazing are both more commonly seen amongst sites that fall to the negative end of the axis. Since most sites are grazed by sheep (350 out of 394 with details) this is unlikely to be an important distinguishing factor. 273 sites are grazed by cattle and so the association of sites grazed by cattle is perhaps more likely to be meaningful. Having said that, it is in fact difficult to explain this pattern. The cattle on the upland and hill farms studied were predominantly store cattle - small beef herds. The presence of cattle on the farm provides farmyard manure for treatment of the meadows (and indeed those fields receiving manure, 244 out of 374 with details, also fall to this end of the axis). However, farmyard manure application and the presence of cattle on the fields are not strongly positively correlated in this data set. One might intuitively have felt that cattle grazing of the fields was likely to result in poaching of the meadows, allowing the ingress of those weed species associated with a degradation of the sward.

FIGURE 5 CANOCO SCORES OF SAMPLES



However, this is plainly not the case in these data. The fact that a student t-test revealed no significant correlation between cattle and/or sheep grazing and position on the first axis should be remembered. It seems likely that the patterns revealed by the CANOCO analysis are not significant. Other workers have found that the intensity of grazing is directly proportional to the percentage of 'preferred' species in the sward and to the persist nce of sown species (e.g. Jones, 1967).

From observing the different ways in which cattle and sheep graze, one might expect there to be differences in the botanical composition of swards grazed by cattle or sheep at comparable rates and under similar managements. However, although grazing by sheep alone can lead to degradation of swards, there is little good evidence of differential effects of sheep and cattle grazing (Hodgson and Grant, 1981). Treading can lead to a reduction in the yield of some species; there is a reduction in yield of the following species, in increasing order: Lolium perenne, Poa pratensis, P. trivialis, Trifolium repens, Phleum pratense, Dactylis glomerata, Trifolium pratense, Holcus lanatus (Edmond, 1964, in Charles, 1979). Forbes et al (1980) found a significant correlation between the proportion of 'preferred species' in the sward and the stocking rate. Poaching damage often has a more important effect than defoliation (grazing effects) on the botanical composition of the grazed sward (Lockhart et al, 1969).

Application of FYM to meadows is usually associated in one's mind with low input, low intensity (i.e. more traditional) farming methods. Attempts during this study to quantify manure dosages failed, and so it is not possible to indicate the range of manuring levels which must exist. Treatment of the hay meadows with low levels of FYM is necessary in the absence of any other nutrient inputs in order to replace the soil nutrients depleted by removal of the hay crop and prevent the development of an impoverished soil and associated poor sward. High levels of FYM are however likely to have a deleterious effect on the botanical interest of the meadow. FYM provides a range of major and minor plant nutrients in a slow-releasing organic form - less than 25% total dung nitrogen becomes available to plants in the year of deposition (Wotton, 1979), in contrast to most artificial fertilisers, but a major increase in (artificial) soil fertility is still possible using organic manures, given sufficiently high dosages. FYM is said to be an important source of copper (Thomas, Holmes and Clapperton, 1955) and calcium (Duffey et al, 1974) amongst other minor plant nutrients. Uneven and heavy application of manure to fields can result in the 'suffocation' of the vegetation under concentrations of manure; the resulting bare ground is then available for weed invasion and establishment. Heavy manuring can also encourage the growth of coarse, tufty grasses, which also result in the development of bare patches in the sward and thus weed ingress. However, since those sites receiving manure centre around the opposite end of the axis to those receiving high levels of artificial fertiliser, it is evident that FYM levels are rarely damagingly high on the farms studied, in the same way that heavy dosages of artificial fertilisers are damaging to the swards.

Increasing altitude is associated with a rise in scores along this axis. The range of altitudes at which meadows were sampled tends to follow a geographical pattern, with lower altitude sites falling to the north-west of Scotland; this range mirrors the decrease in altitude at which the harsh climatic (and frequently soil) conditions associated with the Uplands of Britain are found. Early analyses revealed an overwhelming effect of geographical position on the data and encouraged the development of a version of CANOCO to cope with the phenomenon of covariance. (The regressions of the DECORANA 1st ordination axis scores for the sample sites against their two grid reference components also revealed strong correlations with both elements.) It is probable that this apparent effect of altitude on the vegetation is not purely one of altitude (as might be seen in a altitudinal transect study in any one area of the British Isles) but rather a more general reflection of changing environmental and management factors seen as one moves from one area to another within upland Britain.

The overwhelming trend along the 1st axis is from low to high levels of artificial fertilisation. One can thus state that the level of fertilisation applied to the meadow is a major factor determining the vegetation of that field. It is therefore worth studying in some detail the effects of artificial fertiliser application on meadow vegetation.

Only in the 1940's did artificial fertilisation of grassland become a recognised practice and it was not until the 1960's that it became widespread. Today, fertilisation of meadowland is practically ubiquitous and unquestioned. Thus, most of the research on the impact of fertilisation upon sward composition occurred between the 1950's and early 1970's, much of it being ancillary to the more applied study of yield with respect to fertilisation levels. Many of the systems studied were highly controlled and artificial, far removed from the situation on the farm. Input:output research requires a careful account of production and so both pastures and meadows were often subjected to a regime of frequent clipping. Thus, the distinction between pasture and meadow systems is often blurred although some workers who attempted to compare the two management types have noted different transformations of the sward as a result of fertilisation (e.g. Liiv, 1966, Davies, 1970 and Elberse, van den Bergh and Dirven, 1983). Given the different vegetation that is found under haying regimes when compared with continuous grazing, one might indeed suspect a different response pattern. Various workers have compared the vegetation of meadows with that of pastures (e.g. Tamm, 1956; Wells, 1971; Spedding, 1983; Jones, 1983; Madgwick, 1984). In this brief review, therefore, wherever possible, only natural haying or experimental cutting systems have been included. Williams (1985) provides a recent example of work on the effects of artificial fertilisation on the botanical composition of pastures.

Even with this constraint, it is only with care that different sets of results can be compared. The vegetation at a site is influenced by many factors, including altitude, climate and substrate conditions - the moisture and mineral contents and structure of the soil etc. Water is required for nitrogen uptake (Garwood, Salette and Lemaire, 1980). Other workers have found that the availability of water can dominate the response obtained to fertiliser nitrogen and have concluded that only where irrigation is available can reliable predictions of reponse to nitrogen be made (Baker, 1986). Responses to any one management feature at any one site can be affected by, for example, temporary weather conditions (see Sonneveld, Kruijne and de Vries, 1959); some workers have thus found a bewildering inconsistency in response to a particular treatment (for example, Tomka, Liham and Habovstiak, 1970). Daget-Bertoletti and Daget (1974) contrasted meadows in two different areas of France and found different species responses to fertilisation under the two different sets of conditions. Reports of fertilisation experiments unfortunately, and surprisingly, rarely present information on the character of the soil at the beginning of the study. The fertility, organic content and pH of the soil at this stage and the history of fertilisation practice at the site are obviously all of great importance. The influence of pH on the effect of increased nitrogen on yields has been noted by Tomka et al (1974) and Prins, den Boer and van Burg (1986) amongst others. When one of the three major nutrients (N, P, K) is in short supply in the soil, the response of the vegetation on treatment with the nutrients will be controlled by this deficiency, and other responses may be hidden. In many of the experimental sites, soil potassium concentration was at a low level. Thus, heavy nitrogen fertilisation soon depleted K reserves leading to an imbalance in the vegetation and to changes in sward composition related more to K deficiency than to high N levels directly; P levels may similarly be affected (Chisci, 1968). Given the frequency of K deficiency (e.g. Swift et al, 1981), a considerable amount of work on K uptake has been carried out. Blaser and Brady (1950) suggested that 'weeds' were more efficient at K uptake than grasses and so, at low levels of K gained/regained a competitive advantage. However, Drake, Vengris and Colby (1951) found that grasses take up K more efficiently than legumes and the observation of Holmes and MacLusky (1954) that Agrostis tenuis, Holcus lanatus and Festuca rubra seemed to be tolerant of lower soil potassium concentrations supported their findings. It is certainly the case that in the presence of high N levels but the absence of K, grasses are usually able to outcompete the dicotyledonous plants, often to the point of eradication. In eastern Scotland, 40% permanent grassland soils had very low P values

(Swift et al, 1982). With increasing altitude, P deficiency becomes more common (see, for example, Burnham et al, 1970). It is worth commenting at this juncture that deficiency of a major nutrient may not produce the opposite effects on the vegetation to its superabundance, a fact often ignored.

Moving back to the problems encountered in a comparison of fertilisation trials, the amount of fertiliser applied varies greatly. The composition of the treatment and its level of application can vary enormously. The date of treatment application may vary (as indeed it should, given different conditions) and the treatment may be given in more than one dose. Changes in the botanical composition of the sward on treatment are highly dependent upon the nature of the initial vegetation and this may vary greatly between sites. With long-term trials, natural 'ageing' effects of a successional character may be seen and misinterpreted; conversely, short-term trials may miss important, less rapid changes and highlight transient changes of minor ultimate importance.

Some workers have studied the effects of fertilisation on new leys, whilst others have looked at the effects on old meadow land. The criteria by which the results are judged (and indeed the aim of the management carried out on the sward) are different for these two cases: with leys, the emphasis is on controlling invasion and encouraging the retention of the few sown species and with old meadow land, the effects can usually be considered in terms of slow eradication of many species and a change in the sward towards a new composition. Since the fields studied in this research project include a range of meadow types, from leys through to old meadow land, the consideration of the widest selection of these published works is valid.

As well as the problems elaborated above, with respect to the different types of experimental and observational work carried out to study the effects of fertiliser application on swards, further areas of constraint can be recognised. Much of the early work on the factors controlling the vegetation of grasslands and on the impact of agricultural techniques were carried out by Dutch workers; more recent work has been concentrated in Eastern Europe (and is thus largely inaccessible to workers in the West). Although it is possible to suggest that heavily-managed agricultural grasslands are similar throughout much of temperate Europe in terms of their communities, which are simplified and constrained by the management, it is not the case with more natural grassland communities, and within this latter grouping would come the more traditionally-managed hay meadows, where they are found. Not only will different communities consist of different species and so show a different response to nutrient application but they may also, more confusingly, contain the same species but with different competitive structures or even with different ecological potential. Rabotnov

(1977) commented that the response of a species to an exogenous nutrient depends in part on the amount of that species present. Species also become adapted gradually to the environments in which they grow and so ecologically-distinct sub-taxa can result. Those species which are found through a range of habitats and environmental conditions may not as individuals be tolerant of a wide range of conditions but may, rather, have developed a large number of ecotypes suited to each of the habitats. The work carried out on the Park Grass plots at Rothamsted on Anthoxanthum odoratum shows how ecotypic variation can occur under different management regimes (Snaydon, 1976). Thus, the responses to nutrient application of any individual species may be contradictory, if a range of ecotypes have been studied.

One should not forget, in addition, that the application of a fertiliser containing given nutrients does not result only in the input into the receiving ecosystem of those given nutrients. Rather, additional microelements will probably be present. The increased growth of responsive species following such fertilisation creates a different phytoclimate for the members of the plant community and the structure of the vegetation changes; Rabotnov (1977) comments that the vertical structure of the vegetation is made more uniform. Fertilisation results in an increased proportion of shallow-rooted plants, since the nutrients applied lie predominantly in the top few centimetres of the soil (Rabotnov, 1977). (This is in contrast to the greater depths to which fertilisers have been found to penetrate at Rothamsted; Thurston, pers. comm.) This will have an impact on the drought-resistance capabilities of the swards. A predominance of older individuals and thus of longer-lived species is also noted, following the change from seed-based regeneration to vegetative processes seen as a result of shading of the soil surface by the lusher vegetation growth following prolonged fertilisation (Rabotnov, 1977). Not only the plants respond to the nutrient application - the other biocomponents of the ecosystem may also be affected and this will almost undoubtedly have a further impact on the plant community. Thus, the 'natural' nutrient cycling of the ecosystem will be affected, as the decomposing fungi and bacteria levels are disturbed (see below). The further effects of pH changes resulting from unwise fertilisation on the microflora were mentioned above (and see Standen, 1984). Any change in the botanical composition of the ecosystem will also affect the decomposition; Rabotnov (1977) comments that the increase in the grass component of the sward following N fertilisation results in an increased organic content in the soil, since in general grasses are broken down more slowly than herbs. There is probably a large number of effects on the organic contents of soil treated with heavy dosages of artificial fertilisers which remain undescribed (Traczyk, Traczyk and Pasternak-Kusmierska, 1984b). Most meadow species have endomycorrhizae, which are lost following NPK application (Rabotnov, 1977). When active agricultural systems are studied, fertilisation may be accompanied by other changes in management which may themselves have an impact on the sward, thus confusing the assessment of the effects of fertilisation. Increased grass growth, for example, would permit heavier grazing. Within this survey, each of the swards sampled was in agricultural use and so it is particularly important to recall that increased fertilisation will almost undoubtedly result in other management changes.

Nitrogen is usually the primary factor limiting temperate grassland production and as such might be expected to have a major impact on the relatively fragile competitive relationships that determine the composition of the sward (see Rhodes, 1970). The effects of N application are thus an area of fertilisation impact work which has attracted much attention. It is noticeable that there is fair agreement between workers on the impact of N application, despite the range of doses used and the differences in sward types studied.

The application of N favours those N-responsive species which, taking advantage of the earlier and greater growth potential created by the additional N, are able to outcompete other, less N-responsive species for light, other nutrients and perhaps soil moisture. Earlier growing species are able to get an even greater advantage than usual over later season developers; thus, grasses tend to be favoured over, say, legumes. In addition, herbs generally use N less effectively than grasses (Rabotnov, 1977). N application always results in a rise in the contribution of grasses to the sward (e.g. Rodriguez et al, 1981). Within the grasses, some species respond more rapidly and to a greater extent to N; these, of course, are the preferred cultivated species. Many of these latter, however, occur naturally in British meadows; hence the phenomenon of 'improving' grassland to a composition very similar to a reseeded ley purely by management (and without reseeding). The capacity for varied response to a nutrient is poorly understood. Cowling and Lockyer (1967) noted that Dactylis glomerata and Phleum pratense recovered N from the soil with higher efficiency than did Agrostis spp. Cowling (1966) suggested that the response of Agrostis to N is less than that of both Dactylis glomerata and Festuca pratensis, not only because of its poorer recovery of N but also because of its lower dry-matter:N ratio. Species from sites with low nitrate levels have a high potential to reduce nitrates (the first process in nitrate utilisation by plants) but correlations between nitrate reduction and plant growth were found not to be significant by Osborne and Whittington (1981), suggesting that the efficiency of the incorporation of the reduced nitrogen into the plant structure is a more important stage in the production of dry matter. Traczyk and Kotowska (1976) summarised the degree of response to N that common grasses show. Nitrophilous species include Arrhenatherum elatius, Dactylis glomerata, Agropyron repens, Bromus inermis, Festuca pratensis and Poa trivialis; those species favoured by moderate N fertilisation include Poa pratensis, Holcus lanatus, Phleum pratense, Bromus mollis, Deschampsia cespitosa and Lolium perenne; species negatively affected within the community by high N levels include Festuca rubra, Agrostis tenuis, Anthoxanthum odoratum and Agrostis stolonifera. It is worth emphasising at this point that, as a general rule, all grass species, in monoculture, will show increased growth on N application (c.f. Bradshaw et al, 1964; Frame, 1983). Only within communities will competition result in reduced production by some species.

From very poor land, a scale of 'improvement' can be seen; thus, on some sites, a transformation from N-unresponsive species to moderately responsive species is seen, whereas on better soils, the change may be from the moderately responsive species to the highly responsive ones. The capacity of the species to invade a sward is also of relevance here. Many of the changes which are seen on fertilisation are only of the nature of a shift from one group of species present in the vegetation before the commencement of the trial to another group also present initially. However, species not found in the plots before the experiment often invade following fertilisation; the Poa species are common examples of this phenomenon.

McAdam (1983a), Frankena (1937), de Vries (1949) and Jackson and Williams (1979) all noted an otherwise undefined 'increase in preferred grass species' on inorganic N appliation. Davies and Munro (1974), working on poor soils, noticed a shift from Festuca ovina and Nardus stricta to Poa pratensis and Agrostis tenuis on brown earth soils and from Molinia caerulea to Holcus lanatus, Festuca ovina and Poa trivialis on peaty gley soils following N application. Chestnutt (1971) and Harris and Brougham (1968) both found that N application favoured Poa spp. over Agrostis spp. Castle and Holmes (1960) saw a decline in Holcus lanatus and Agrostis tenuis. Heddle (1967) similarly found that N application curbed the spread of Holcus lanatus; Lolium perenne and Dactylis glomerata were favoured instead. Elliott et al (1974), however, observed an increase in Holcus lanatus and no change in Lolium perenne levels; Agrostis spp. declined and Poa trivialis levels rose dramatically. Williams (1969) saw a rise in Lolium perenne levels. Minderhoud et al (1975) noted a favouring of Arrhenatherum elatius and Alopecurus pratensis following heavy N fertilisation of their sward. Rabotnov (1966) listed the following as N-responsive species: Alopecurus pratensis, Agropyron repens, Festuca pratensis, Poa pratensis, P. trivialis and Phleum pratense. Alopecurus pratensis requires high P and K levels, in addition to high N levels, for maximal growth (Rabotnov, 1966; Klesnil and Turek, 1974). Daget-Bertoletti and Daget (1974) listed Dactylis glomerata, Holcus lanatus, Poa trivialis, P. pratensis and Lolium perenne as N-responsive species, with Anthoxanthum odoratum, Cynosurus cristatus and Agrostis tenuis as species out-competed at high N levels. De Vries and Kruijne (1943), in experimental fields trials, found Phleum pratense, Poa trivialis, Alopecurus pratensis, Holcus lanatus, Bromus mollis, Alopecurus geniculatus and Poa pratensis to be favoured and Agrostis tenuis, Cynosurus cristatus and Anthoxanthum odoratum to be reduced, following treatment with high N dosages.

The relative responses of Lolium perenne, Phleum pratense, Festuca pratensis and Dactylis glomerata, all N-responsive and commonly cultivated species, occupy much of the remaining work on the effects of N fertilisation. The varying treatments, environmental conditions and cultivars used have resulted in a range of conclusions. Mulder (1949) saw an increase in Lolium perenne on N application. On peat, however, and with very high levels of N treatment, Lolium gave way to Poa pratensis. Pearson Hughes and Evans (1951) saw a rise in Phleum pratense relative to Lolium perenne. Holmes and MacLusky (1955) noted a fall in Agrostis tenuis and suggested the following order of increasing response to N: Festuca pratensis, Phleum pratense and Lolium perenne, Dactylis glomerata. Bradshaw et al (1964), working on experimental monocultures, saw an increasing response from Festuca ovina, Agrostis canina, A. tenuis/Cynosurus cristatus, to Lolium perenne/A. stolonifera; Nardus stricta alone showed a negative response to nitrogen. Wheeler (1958) noticed that at very high N levels, Poa spp. were unsuccessful invaders of a Lolium perenne sward. Neither Poa annua nor P. trivialis are aggressive species (Haggar, 1971; Wells and Haggar, 1984). Indeed, Poa trivialis is inefficient in its N utilisation at high N levels (Haggar, 1971). Widdowson, Penny and Williams (1963), on experimental plots found that Dactylis glomerata and Phleum pratense were more responsive to N than were either Lolium perenne or Festuca pratensis. They related this to their ability to recover N from the soil. Similarly, Dactylis glomerata increased relative to Lolium perenne in the work of Reith et al (1964). Cowling and Lockyer (1965) observed a shift from Agrostis tenuis to Festuca pratensis and then to Lolium perenne, Dactylis glomerata and Phleum pratense on N application. Regal (1966) listed Alopecurus pratensis, Dactylis glomerata, Festuca pratensis and Agropyron repens as favoured by N treatment and Trisetum flavescens as a nitrophobe. In contrast, Calleja et al (1981) saw a rise in Trisetum flavescens levels on N application, along with Dactylis glomerata, Holcus lanatus and Poa trivialis in their Spanish montane grasslands. Wolton et al (1968) found by experimentation that Dactylis glomerata showed a stronger response to N than did either Lolium perenne or Festuca pratensis. Liiv (1970) noted rises in Dactylis glomerata, Phleum pratense, Poa pratensis and P. trivialis on N application.

Several workers have shown that heavy N fertilisation, leading to an increase in tall, tussock-forming grasses e.g. Dactylis glomerata (see e.g. Pasternak and Kotowska, 1976), can result in bare ground being created, allowing the invasion of ruderal species and often also of Agropyron repens. Thus, Pasternak-Kusmierska (1984) noted that the increase in Dactylis glomerata on N treatment provided bare ground that was exploited by Bromus inermis and Agropyron repens. Both Holmes (1951) and Traczyk and Kotowska (1976) also refer to this phenomenon. In North America, Magdoff, Amadon and Wood (1980) found an increase in Agropyron repens, following a decline of Phleum pratense and Poa pratensis under heavy N application. Murphy (1961) noticed a decline in Festuca rubra levels on N treatment that might indeed be expected, given the poorly N-responsive character of this grass. However, some workers have experienced a remarkable rise in Festuca rubra cover after high and prolonged N application (e.g. Castle and Holmes, 1960; Heddle, 1967). This fall in the proportion of herbs in the sward can have an impact on the feeding value of the fodder, since herbs tend to have higher mineral contents than grass species (Brünner, 1966; Solberg, 1968; Lambert, Denudt and Toussaint, 1974). Smith, Elston and Bunting (1971) commented on how stable and resistant to invasion and further modification by fertilisation this Festuca turf can be. It is probably that this Festuca dominance results from imbalances in other nutrients in the soil, following heavy N application.

A fall in legume levels in N-fertilised plots is a well-known and well-recorded fact. When the use of artificial fertilisers became more common in the 1940's, the contrasting practices in the Netherlands, where N was supplied by heavy artificial fertiliser application, and in New Zealand, where clovers were used to provide available N were frequently discussed. Walker et al (1952) suggested that legumes decline under heavy N fertilisation because they are shaded out by the more N-responsive grass species. Many workers noted a diminution in legume (often Trifolium repens) levels on N application (Frankena, 1937; de Vries, 1949; Mulder, 1949; Blaser and Brady, 1950; Holmes, 1951; Pearson Hughes and Evans, 1951; Walker et al, 1952; Holmes and MacLusky, 1955; Wheeler, 1958; NAAS (Wales), 1959; van Burg, 1960; Castle and Holmes, 1960; Green and Cowling, 1961; Murphy, 1961; Wilcox, 1962; Armitage and Templeman, 1964; Reith et al, 1964; Regal, 1966; Shaw, Brockman and Wolton, 1966; Williams, 1969; Speidel and Weiss, 1971; Davies, 1972; Elliott et al, 1974; Magdoff, Amadon and Wood, 1980; Calleja et al, 1981; Garstang, 1981 and Hopkins, 1986). Legumes which concentrate on vegetative means of reproduction (e.g. Lathyrus pratensis, Vicia spp., Trifolium repens) are more resistant to N than those with seed-based regeneration (e.g. Trifolium pratense) (Rabotnov, 1977).

The lush, early growth of grasses resulting from N application reduces the light intensity incipient not only on the legumes but also on the later-growing herbs, particularly the low-growing rosette plants, which are soon lost under regimes of heavy N application. Those woodland plants found in hay meadows, and of ontological interest, are thus eradicated by N treatment. A decline in broad-leaved dicotyledonous species, or alternatively, a reduction in their success in invading the sward has been widely reported (e.g. Davies, 1970; Davies, 1972; Holmes and MacLusky, 1955; Heddle, 1967; Elliott et al, 1974 and Garstang, 1981). Smith, Elston and Bunting (1971), working on chalk grassland, found a decline in Carex spp., Leontodon hispidus, Plantago lanceolata and various chalkland herbs on N application. More unusually, Holmes (1951) saw a fall in Bellis perennis and Ranunculus repens on fertilisation and Regal (1966) noted that at very high N levels on 'good' soils, Ranunculus acris levels fell. There are nonetheless some moderately nitrophilous herbs, such as Geranium pratense, Heracleum sphondylium and Anthriscus sylvestris (Regal, 1966). Liiv (1970) similarly saw a rise in Anthriscus sylvestris on N application, accompanied by Taraxacum officinale agg. and Filipendula ulmaria. It is a well-recognised fact that many Umbellifers respond well to high N levels (e.g. Coupland, 1979).

The form in which N is applied can be important. Early experiments often used ammonium sulphate, prolonged application of which results in acidification of the plot and corresponding changes in both the vegetation and the soil fauna and microflora. Thurston (1969) noted a fall in legume levels, an increase in Agrostis tenuis, accompanied by some Festuca rubra, Rumex acetosa and Potentilla reptans on repeated ammonium sulphate treatment. Brenchley (1958) commented that ammonium sulphate application led to an increase in Holcus lanatus, whereas nitrate application resulted in Arrhenatherum elatius, Dactylis glomerata and Alopecurus pratensis predominance (see also Williams, 1978). Ammonium sulphate application also favours Agrostis tenuis and Festuca rubra; Poa pratensis declines and Poa trivialis, Bromus mollis and Lolium perenne levels all fall markedly. Later work on the same plots (Thurston, Williams and Johnston, 1976) distinguished a rise in Agrostis tenuis, Anthoxanthum odoratum or Holcus lanatus in the plots with ammonium sulphate, compared with a rise in Arrhenatherum elatius and Alopecurus pratensis on nitrate application. A predominantly grass sward results from long-term ammonium sulphate application.

Most farmers 'hedge their bets' by applying NPK compound fertilisers to their grassland. Work on NPK treatment has tended to produce much the same results as N treatments, suggesting that N levels in the treatments were sufficiently high to 'dampen out' any response to K and P. Thus, McNair and Fowler (1942) concluded that addition of NPK with/without farmyard manure resulted in a fall in legumes and other herbs, a less dramatic fall in 'second-rate' grasses and a rise in 'valuable' grasses. This has frequently been reinforced (e.g. Henderson, Edwards and Hammerton, 1962; Brauer, 1966, in Davies, 1970; Liiv, 1966; Vidrih, 1974; Traczyk and Kotowska, 1976; Traczyk, Traczyk and Pasternak, 1976; van den Bergh, 1979; Petal, 1983; Traczyk, Traczyk and boreale, Filipendula vulgaris and Hypericum maculatum; legumes declined on N application. The work of Smith, Elston and Bunting (1971) on chalk soils showed an increase in Tragopogon pratensis (a recognised nitrophile) on NPK treatment; Festuca rubra, Cirsium vulgare, Senecio jacobaea, Taraxacum officinale agg. and Filipendula vulgaris were also favoured.

Thurston (1969) distinguished between ammonium sulphate and sodium nitrate N-sources; with the former in combination with P and K, Holcus lanatus came to predominate; with sodium nitrate, P and K, Alopecurus pratensis, Dactylis glomerata and Arrhenatherum elatius were favoured. Working on the same plots, Brenchley (1958) had seen a rise in Holcus lanatus and Agrostis tenuis levels and a lesser increase in Anthoxanthum odoratum and Arrhenatherum elatius. When ammonium sulphate-NPK was applied at higher levels, Holcus came to predominate, with Dactylis glomerata, Lolium perenne, Poa pratensis and P. trivialis, and even Agrostis tenuis. Alopecurus pratensis and Festuca rubra levels fell with more ammonium sulphate and legumes were lost. Zürn (1966), working on fertile soils, made the observation that fertilisation with a treatment leading to acidification of the soil led to a fall in the levels of herbs and a rise in the cover of N-responsive grasses.

In some cases, the N:P:K ratios obviously became unbalanced in the soils, leading to the kinds of sward deterioration mentioned above. Thus, Linehan and Lowe (1956), working on very nutrient-deficient swards, saw no increase in the 'better' grasses after five years of NPK application. Indeed, the levels of Alopecurus pratensis, Lolium perenne, Phleum pratense and Anthoxanthum odoratum remained more or less stable. Holcus lanatus and Poa trivialis levels fell and Festuca rubra, Cynosurus cristatus and Festuca pratensis increased. Johnson and Meadowcroft (1968) saw a fall in Poa levels and no change in Lolium perenne levels. Festuca spp. increased their contribution to the sward, as did Alopecurus pratensis and Agrostis spp.

Several workers refer loosely to the impact of 'fertilisation' on the botanical composition of the sward, which one can interpret, perhaps, best under a discussion of the effects of NPK treatment. Holmes (1980) comments on the eradication of Rhinanthus minor, Euphrasia officinalis agg. and Pedicularis sylvatica after fertilisation and Holmes and MacLusky (1954) noted the frequently-seen increase in Phleum pratense and Agropyron repens, and also of Poa trivialis at very high fertility. Schwendimann (1968) saw an increase in Festuca rubra and Dactylis glomerata and also in Taraxacum officinale agg. and Geranium sylvaticum, both fairly nitrophilous herbs. Liiv (1966, 1970) recorded a decline in Nardus stricta, Molinia caerulea, Festuca ovina, Sesleria albicans, Sieglingia decumbens, Carex spp., rosette plants (e.g. Plantago lanceolata), Potentilla erecta, Orchis

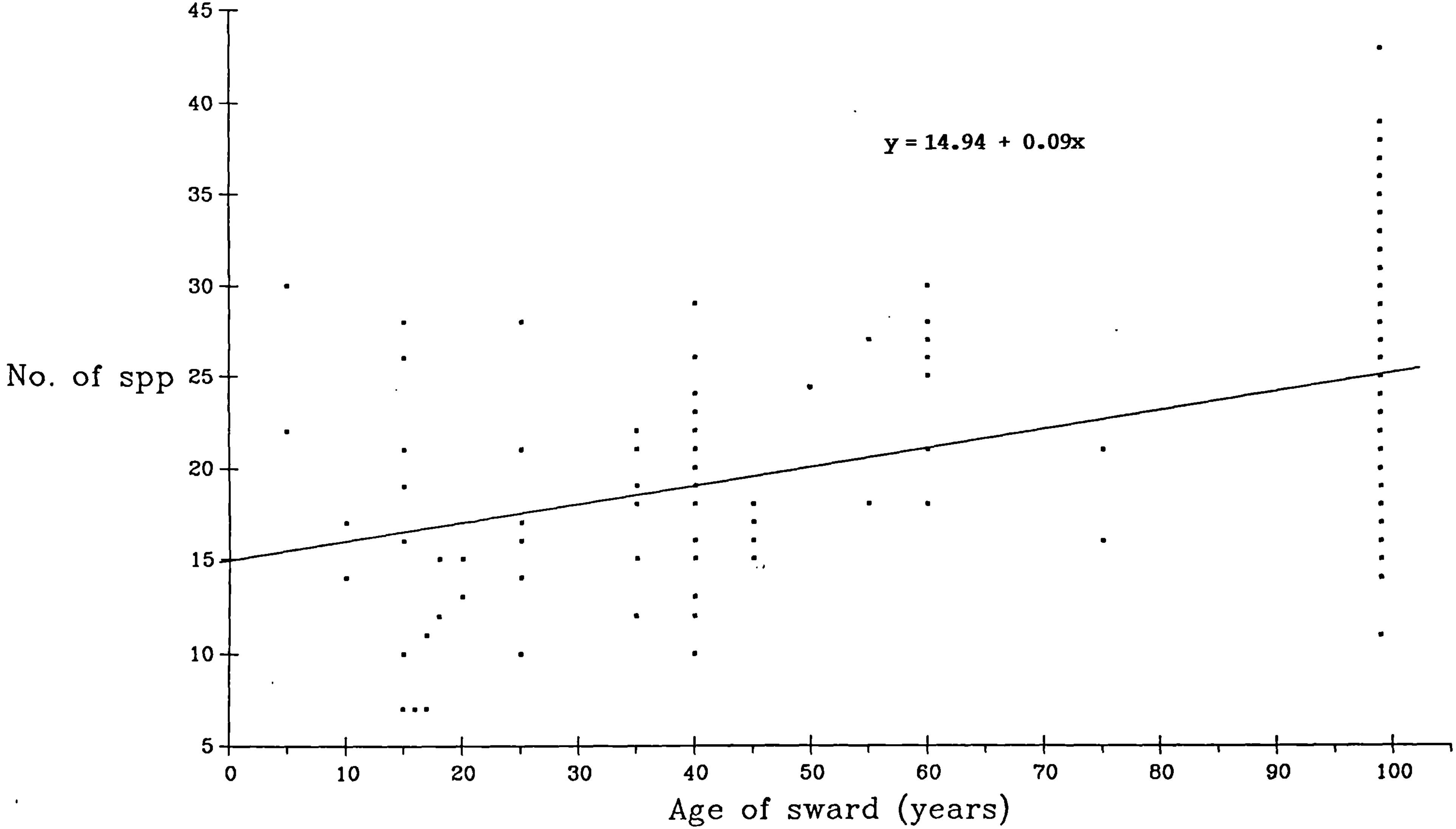
Pasternak-Kusmierska, 1984a). A change from hill species to more lowland species following fertilisation has often been noted (e.g. Milton, 1940; Rabotnov, 1977). On a more detailed level, Milton (1947) working on a hayed Molinia caerulea sward, saw a fall in Molinia and Nardus stricta and a rise in fine-leaved Festuca spp. following NPK addition; with a similar treatment of an Agrostis/Festuca sward, it was Agrostis spp. levels which fell and, unusually, Trifolium repens levels rose. Milton was, however, working on low-fertility swards which would rarely be cut for hay, although he practised a cutting regime on them for experimental purposes. Habovstiak and Tomka (1972) saw high NPK leading to Trisetum flavescens predominance and van den Bergh (1979) noted an increase in Lolium perenne and Alopecurus pratensis over Agrostis spp., but also a succession amongst the taller grasses: Poa pratensis - Dactylis glomerata - Arrhenatherum elatius, although with Anthriscus sylvestris sometimes entering instead of the latter grass. Bastiman and Mudd (1971) similarly saw a rise in Lolium perenne and Alopecurus pratensis levels, a smaller rise in Holcus lanatus, Dactylis glomerata more or less constant, a small fall in Agrostis stolonifera and a greater fall in Poa spp. and Festuca spp. levels after four years of treatment. Elberse, van den Bergh and Dirven (1983) distinguished between meadow and pasture management (and incidentally revealed the confusion inherent in much of the other work on the subject). NPK application resulted in a fall in herbs and legumes in both grassland types but the grass species' responses were distinctly different: Alopecurus pratensis and to a lesser extent Dactylis glomerata levels rose in the meadow, whereas Lolium perenne and Poa trivialis were favoured in the pasture. Traczyk, Traczyk and Pasternak (1976) noted an increase in Dactylis glomerata, Arrhenatherum elatius and Cirsium arvense and a decline in Festuca rubra, Rumex acetosa, Achillea millefolium, Plantago lanceolata, Taraxacum officinale agg. and Leontodon autumnalis. Traczyk and Kotowska (1976) also saw an increase in Cirsium arvense at high levels of NPK application. At lower NPK levels, Rumex acetosa and R. crispus were incursive. In all cases, Achillea millefolium, Plantago lanceolata, Cerastium holosteoides and the legumes declined under treatment. Rabotnov (1966) noted a rise in grasses, a fall in legumes, particularly Vicia cracca, Lathyrus pratensis and Trifolium pratense, and a small rise in herbs, although Taraxacum officinale agg. and Rhinanthus minor levels declined. Petal (1983) saw an increase in Dactylis glomerata, Arrhenatherum elatius and Poa pratensis. Traczyk, Traczyk and Pasternak-Kusmierska (1984a) also noted an initial increase in Arrhenatherum elatius and Poa pratensis but later Dactylis glomerata, Bromus inermis and Agropyron repens replaced these. At all levels, legumes, dicotyledons and Festuca rubra fell. Hopkins (1986) noted the association of Festuca rubra with low NPK levels. Liiv (1966) observed the continued presence of some herbs tolerant of more fertile soils, for example, Chrysanthemum leucanthemum, Geum rivale, Taraxacum officinale agg., Galium mollugo, G.

mascula, forest species (e.g. Anemone nemorosa), Linum catharticum, Succisa pratensis and Veronica officinalis. Kneale and Johnson (1972) noted a rise in Alopecurus pratensis, Agrostis spp. and Festuca spp. and a fall in Poa spp. and a reduction in the number of grass species. Williams (1984) saw a fall in Agrostis tenuis, Festuca rubra, Luzula campestris, Leontodon spp., Cerastium fontanum and Trifolium repens and a rise in Holcus lanatus, Alopecurus pratensis and Rumex acetosa. In meadows near Warsaw, fertilisation saw an increase in grasses and a fall in moss cover (Mickiewicz, 1976). Of the mosses, Brachythecium albicans and Eurhynchium swartzii were affected the least.

Extended reference has been made here to specific changes in botanical composition on fertilisation but, on a more general level, one major observation is the fact that increased fertility usually leads to fewer species in the sward: a few, highly nutrient-responsive species (almost inevitably grass species) are able to gain an inexorable advantage of high competitive position whereas without fertilisation a diversity of less competitive species is maintained under the conditions of low levels of the primary nutrients (van der Maarel, 1971). Thus, Traczyk, Traczyk and Pasternak (1976) saw 35 species reduced to 22 after 2 years' fertilisation and Liiv (1970) recorded a reduction to about half the initial number of species after 10 years of treatment. Traczyk and Kotowska (1976), after 3 years of N application, noted a range of species diversity - without N, there were 83 species (18 grasses), with 280 kg/ha NPK, 65 species (17 grasses) and with 680 kg/ha NPK, only 38 species (16 grasses). Traczyk, Traczyk and Pasternak-Kusmierska (1984a) showed that after only one year's treatment with 280 kg/ha NPK the number of species in their field declined from 35 to 28 and after 7 years, it was down to only 16 species. Pasternak-Kusmierska (1984) recorded an even more dramatic decline in species diversity on NPK treatment: after 5 years' NPK application at 280 kg/ha the number of species declined from 37 to 11 (the number of dicotyledons declined from 20 to 3); after 5 years' treatment at 680 kg/ha, the corresponding numbers were 37 to 8 and 20 to 2. Elberse, van den Bergh and Dirven (1983), working on a meadow on heavy clay soil near Wageningen, found that only P maintained the original species-diverse sward after over 20 years of experimental treatment; NPK treatment lead to a decline from 38 species in 1958 to 9 in 1978.

The species-diversity of the swards studied, as represented by the number of species recorded from the 4m quadrats, showed a significant relationship with three environmental/management variables: age, cutting date (but not shut-up period) and fertilisation dosage. These relationships, with their regression lines, are shown in figures 6a-c. The trend for a rise in species number with increasing age and later cutting date and the fall seen with heavier fertilisation are to be expected, for the various reasons given above. In addition, following 'improvement' of the sward by whatever means,

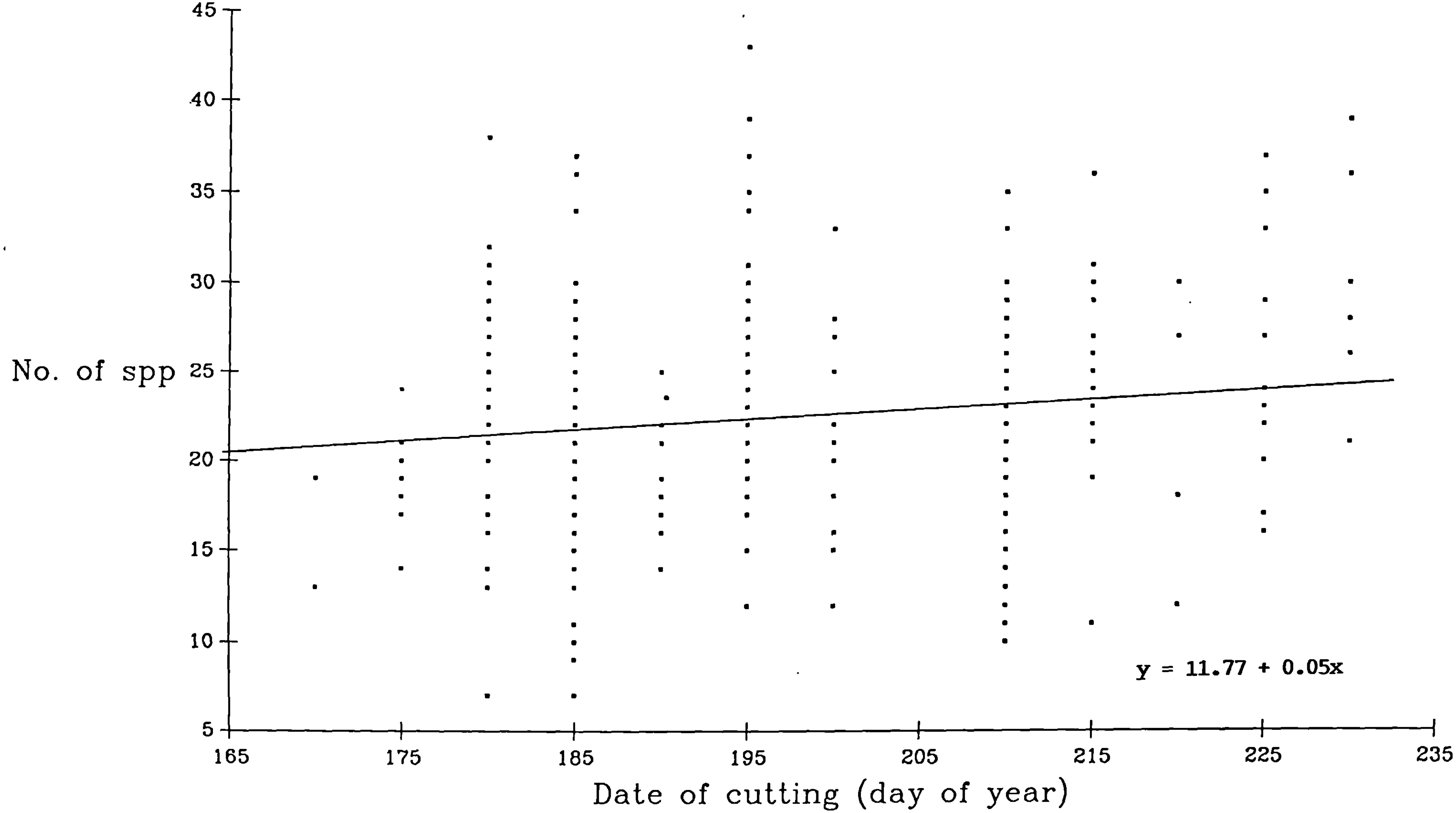
Figure 6a -- Scatter plot of no. of spp vs age of sward



F = 71.47 with 271 d.f.

P < 0.0001

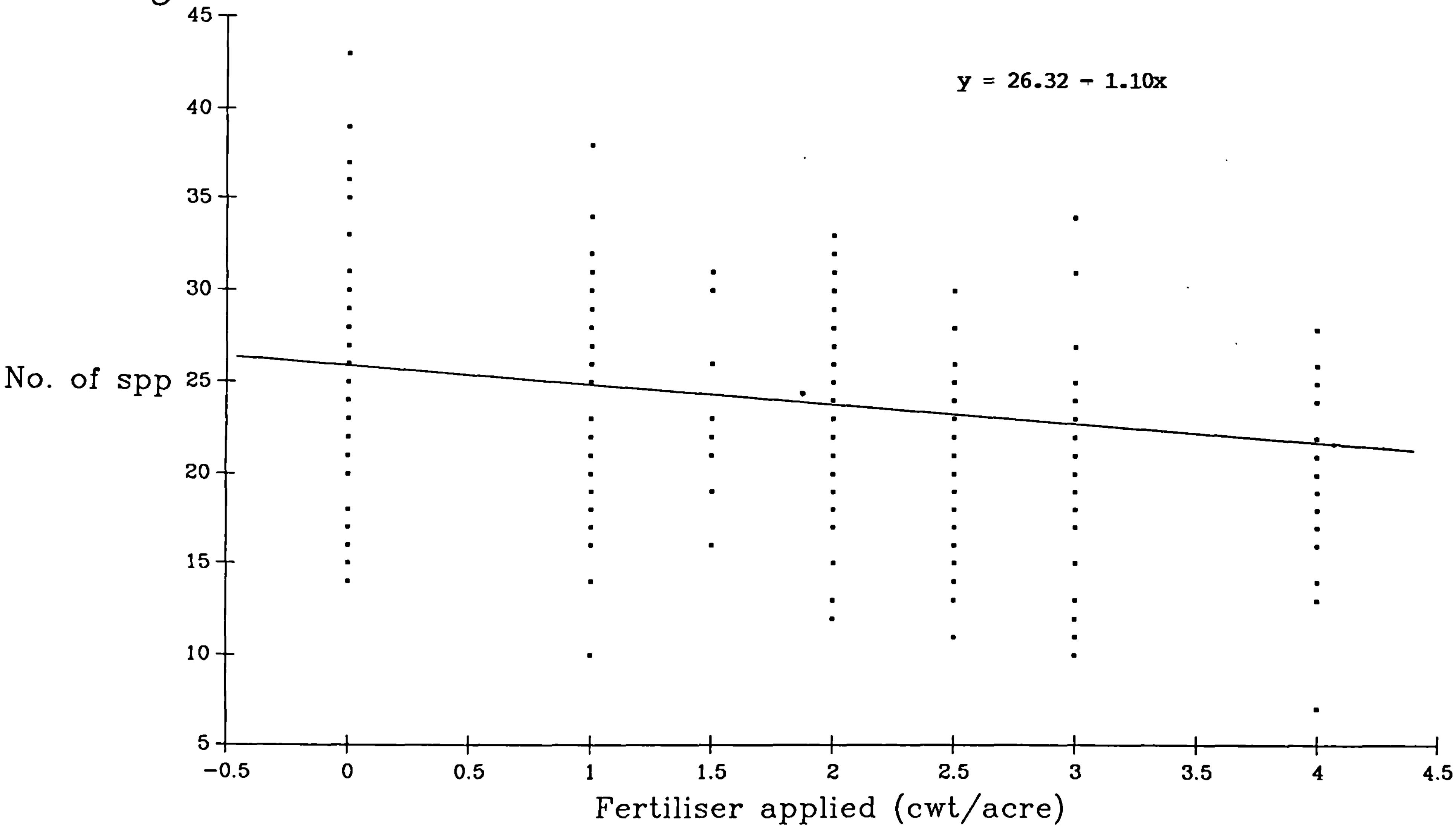
Figure 6 b --Scatter plot of no.of spp vs date of cutting



F = 6.79 with 376 d.f.

P < 0.01

Figure 6c --- Scatter plot of no. of spp vs fertiliser



F = 56.10 with 291 d.f.

P < 0.0001

there is the loss of heterogeneity of microhabitats associated with ancient swards, which support a wide range of species (Rorison, 1971; Madgwick, 1984).

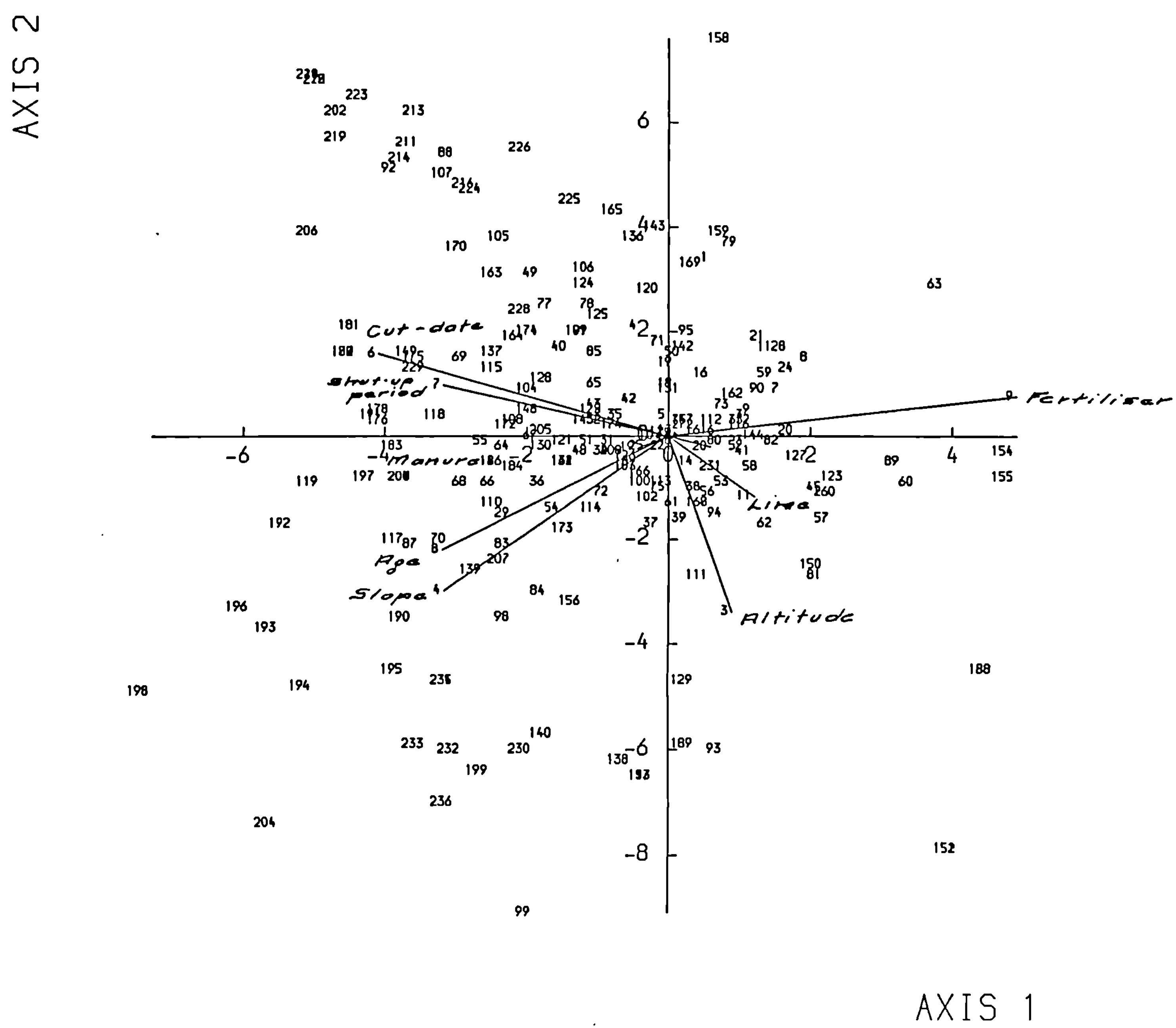
The supposition that the major factor associated with the dispersal of the sites and species along the 1st ordination axis is the level of artificial fertiliser applied is supported by study of the species distribution along this axis. Whilst the other factors showing significant relationships with this axis may be playing a role, the overwhelming influence of fertilisation is evident from the similarity between many of the species distributions and the effects of fertilisation application on species composition recorded by other workers and reviewed briefly above.

Species found at the positive end of the 1st ordination axis include Veronica officinalis, V. serpyllifolia, Cerastium glomeratum, Cardamine pratensis, Rumex obtusifolius, R. crispus, Stellaria media, Cirsium arvense, Anthriscus sylvestris, Montia fontana, Taraxacum officinale agg., Bellis perennis, Achillea millefolium, Vicia sativa, V. sepium and Ranunculus repens (see figure 7). Species associated with the negative end of the axis include Serratula tinctoria, Primula veris, Vicia orobus, Cirsium dissectum, Carex nigra, Potentilla anserina, P. erecta, Pedicularis sylvestris, Carum verticillatum, Betonica officinalis, Succisa pratensis, Lotus corniculatus, Endymion non-scriptus, Leontodon hispidus, Prunella vulgaris, Euphrasia officinalis agg., Vicia cracca, Ajuga reptans, Sanguisorba officinalis, Luzula campestris/multiflora and Lychnis flos-cuculi. One can see here a trend from more nitrogen-responsive species to the more nitrophobic typical 'meadow plants'. This pattern is even more clearly seen if one takes one of the groups of plants which shows distinct nitrogen reponses.

The order of grass species moving from high scores on the axis to low scores is as follows: Poa annua, Phleum pratense, Poa pratensis, Arrhenatherum elatius, Lolium perenne, Bromus mollis, Alopecurus pratensis, Festuca pratensis, Dactylis glomerata, Agropyron repens, Poa trivialis, Holcus lanatus, Anthoxanthum odoratum, Deschampsia cespitosa, Alopecurus geniculatus, Cynosurus cristatus, Agrostis stolonifera, Festuca rubra, Agrostis tenuis, Holcus mollis, Trisetum flavescens, Molinia caerulea, Briza media, Helictotrichon pubescens, Sieglingia decumbens and Nardus stricta. One can see here a clear progression from more N-responsive species through to species associated with low nutrient levels.

The following order of legumes is seen: Vicia sepium, V. sativa, Medicago lupulina, Trifolium repens, Lathyrus montanus, Trifolium dubium, T. medium, T. pratense, Lathyrus pratensis, Vicia cracca, Lotus pedunculatus, L. corniculatus and V. orobus. One has in this sequence, a progression from those species with vegetative reproduction

FIGURE 7 CANOCO SCORES OF SPECIES



to those more reliant on seed production. Thus, Lathyrus montanus, for example, is rhizomatous. Lotus pedunculatus, in contrast with L. corniculatus, is stoloniferous. Lotus corniculatus is outcompeted by other legumes on fertilisation (Fenton, 1931). Trifolium dubium and Medicago lupulina are likely to be annuals in the Uplands and the former is most likely to have been an incursive weed in heavily poached areas of intensively-farmed fields. Within the legumes, Trifolium repens, T. pratense and, to a lesser extent in meadows, T. dubium are all cultivated and so their presence in fields may be indicative of reseeding but they do not persist well in swards which receive heavy dressings of nitrogenous fertilisers.

It is noticeable that few bryophytes are found in heavily improved fields and it has been suggested that bryophytes could, therefore, provide some kind of measure by which the level of improvement of hay meadows could be assessed. Evidently more work is required on the bryophyte floras of grassland before such a assessment would be possible. It is certainly the case within this study that most of the bryophytes recorded came from sites which fall at the negative end of the 1st ordination axis, that is, those fields which received less fertiliser. The order of species, from high scores to low, is as follows: Amblystegium serpens, Brachythecium rivulare, Plagiomnium ellipticum, P. rostratum, Hypnum cupressiforme, Eurhynchium swartzii, Brachythecium rutabulum, Eurhynchium praelongum, Plagiomnium affine, Rhytidiadelphus squarrosus, Hylocomium splendens, Rhizomnium punctatum, Pleuridium sp., Thiudium tamariscinum, Plagiomnium cuspidatum, Calliergon cuspidatum, Pseudoscleropodium purum, Thiudium delicatulum, Barbula sp., Lophocolea bidentata, Mnium hornum, Plagiomnium undulatum, Cirriphyllum piliferum, Brachythecium albicans, Bryum sp., Bryum pseudotriquetrum, Pellia sp. and Pohlia sp. It is probable that bryophytes are favoured by the late cut and long shut-up period associated with the lower fertility fields, with the associated development of shade and high humidity microenvironments. The manuring more commonly associated with these fields which receive lower dosages of artificial fertilisers may also favour mosses and liverworts. In addition, it is likely that the age of the sward is important. Most of the bryophyte species are associated with the older swards.

From their position on the ordination axes and the environmental and management variables associated with the axes, one can make some tentative comments about the environmental preferences of the species found in the meadows. For a limited number of the species commonly associated with traditionally-managed hay meadows, the following remarks can be made: Trollius europaeus, Ranunculus ficaria, Achillea ptarmica, Geum rivale, Centaurea nigra and Leontodon hispidus are associated with old swards. In addition, Ranunculus ficaria is not sensitive to high levels of fertilisation.

This is probably because it produces its leaves and is able to flower before the fertiliser-induced early summer growth of grasses which later are able to shade out many other herbs. In addition, Ranunculus ficaria has corms and so is likely to be tenacious under conditions where species reliant on seed set and dispersal are lost. Amongst the visually-similar species, Leontodon hispidus, L. autumnalis and Hypochoeris radicata, Leontodon hispidus and Hypochoeris radicata are more clearly related to older swards than is L. autumnalis. Hypochoeris radicata is less common under higher fertility regimes than the other two species, though none is able to survive under very high fertilisation treatment. L. autumnalis is, perhaps not surprisingly, more closely associated with a late cutting date and long shut-up period than the other two species. Many other species are associated with later cutting dates and longer shut-up periods, for example, Rhinanthus minor, Campanula rotundifolia, Anemone nemorosa, Euphrasia officinalis agg., Lotus corniculatus, Succisa pratensis and Carum verticillatum. Some of these relationships seem rather difficult to explain; it may be that they hide correlations with other undistinguished factors. Lotus corniculatus, for example, is sensitive to heavy grazing (Fenton, 1931). Several species are not found at sites with high fertilisation levels, for example, Primula veris, Cirsium heterophyllum, Succisa pratensis, Carum verticillatum and Cirsium dissectum. Succisa pratensis, in addition to being favoured by low fertiliser levels and a late hay cut, is found predominantly in old swards and in fields receiving manure. Carum verticillatum mirrors the requirements of Succisa pratensis. Cirsium dissectum and C. heterophyllum are both associated with old swards. Conopodium majus, Plantago lanceolata and Caltha palustris show some correlation with older swards. Geranium sylvaticum would seem to be favoured by lime application and is indicative of older swards. It is however reasonably tolerant of fertilisation. The following species are most commonly found in fields receiving manure: Chrysanthemum leucanthemum, Sanguisorba officinalis, Prunella vulgaris, Lotus corniculatus, Potentilla erecta, Succisa pratensis and Carum verticillatum. Potentilla erecta, Endymion non-scriptus and Primula veris are all found on steeper slopes and are all associated with older swards, as is Prunella vulgaris.

Amongst the Alchemilla vulgaris agg., the individual microspecies were not recorded sufficiently commonly or widely to be able to make confident conclusions about their environmental preferences. Alchemilla vestita was found at a site receiving high levels of artificial fertiliser, A. xanthochlora and A. glabra were widespread, A. monticola, A. acutiloba and A. subcrenata were found only in Teesdale, in some of the high altitude, reasonably traditionally-managed meadows found in that valley. Amongst Ranunculus repens, R. acris and R. bulbosus, the latter was associated with older swards and the former with more intensive management but there were, perhaps surprisingly, few clear differences between the three species in this analysis. One has a sequence of reduced dampness and increased palatability running from Ranunculus repens, through to R. acris and R. bulbosus (Harper and Sagar, 1953). Ranunculus bulbosus is almost always associated with well-drained soils (Barling, 1955).

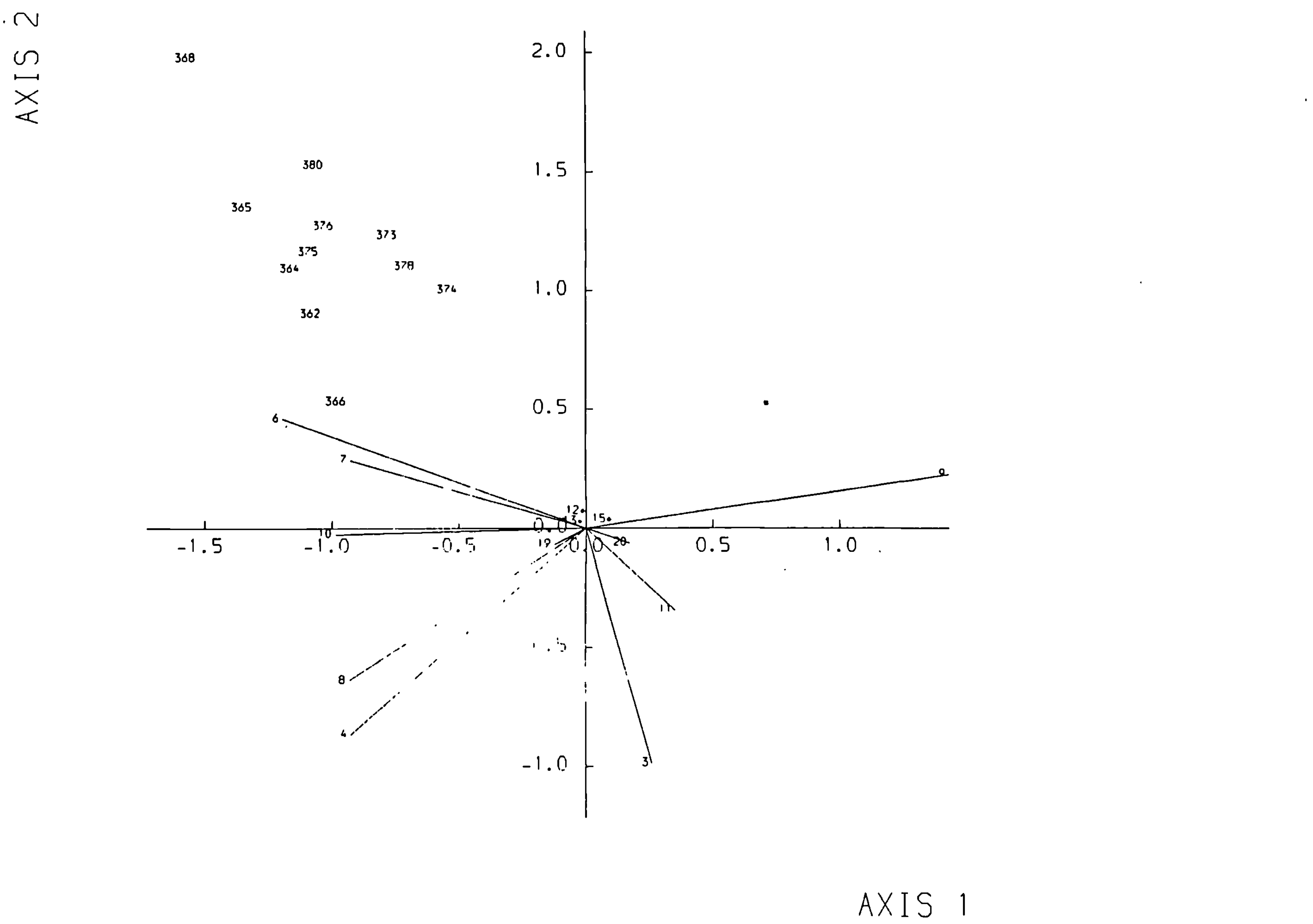
Amongst the species determined to be indicative of old, traditionally-managed meadowland from Nature Conservancy Council England Field Unit surveys (e.g. Nature Conservancy Council, 1982a), some, although possibly indicative of old swards, are seen here to be reasonably tolerant of high fertilisation levels and as such may not in fact be good indicators of traditional management. Alchemilla vestita, Geum rivale, Saxifraga granulata, Alchemilla xanthochlora, Trollius europaeus, Caltha palustris, Geranium sylvaticum and Filipendula ulmaria are such species. It is possible that some of these species tend to be found in areas where fertilisation, although heavy on the rest of the field, is lighter - Geum rivale, Caltha palustris and Filipendula ulmaria, for example, are often restricted to damper areas in fields, where the tractor may not pass closely. Saxifraga granulata may, like Ranunculus ficaria, complete its major growth of the season before the N-responsive species have begun their growth (Anderson, pers. comm.).

Agricultural work on the change in species composition with age has tended to concentrate on the degeneration of reseeding swards. Poa species are common invaders of such swards; Oswald and Haggar (1976) noted the progression from Poa annua to P. trivialis and Morrison and Idle (1972) found an association between Poa trivialis and swards of 9 to 20 years standing. Lolium perenne levels are inversely associated with age of sward; Bromus mollis and Cynosurus cristatus are associated with swards 15 to 50 years old; Anthoxanthum odoratum and Holcus lanatus with older swards; and Agrostis tenuis and Festuca rubra with the oldest, according to the study of Madgwick (1984). These findings are all substantiated in this work.

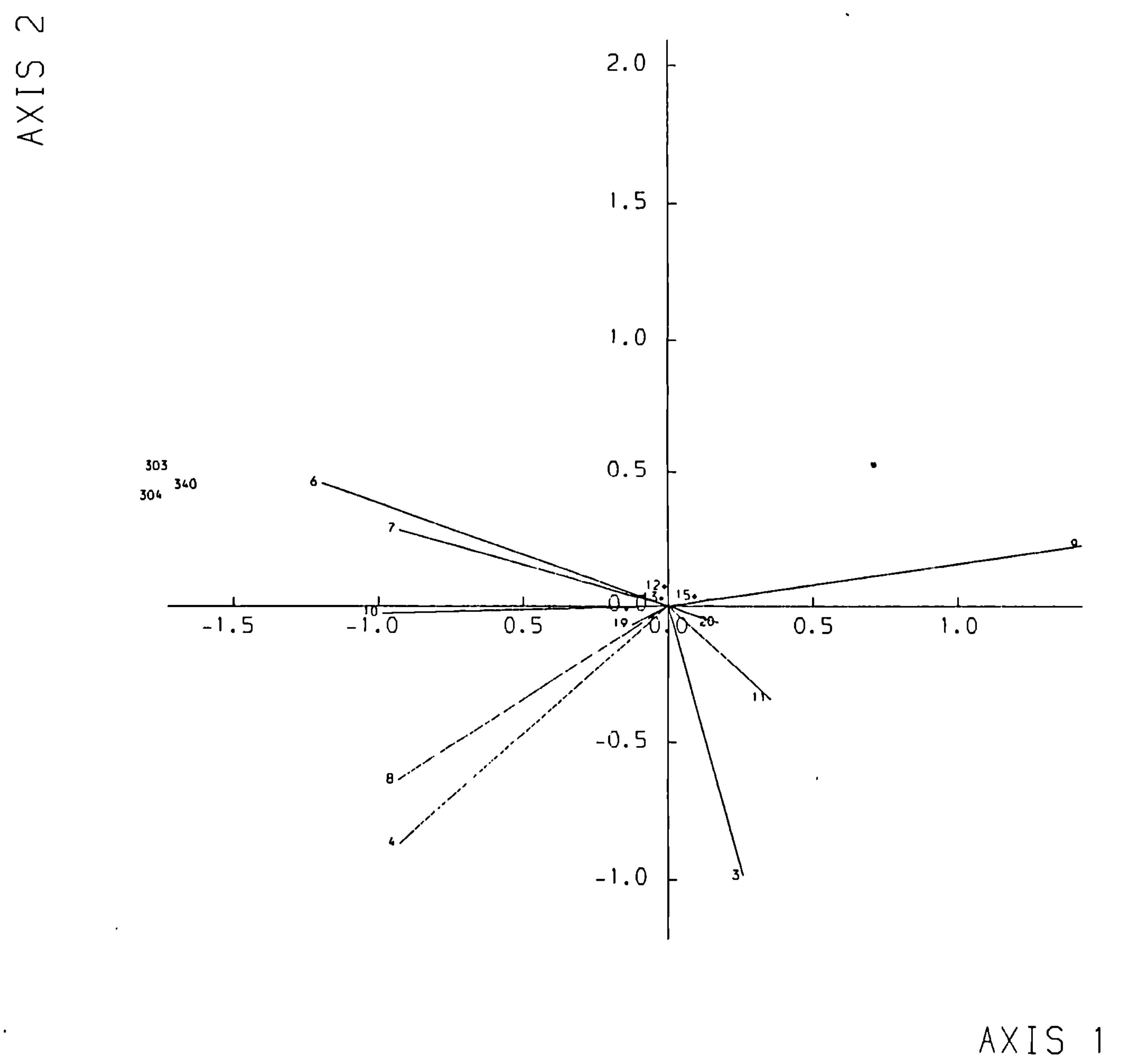
The relationships between the vegetation types and the environmental and management variables are often well-defined (see figures 8-1 to 8-18 and table 7).

In figures 8-1 to 8-18 one can see, from nodum 1 through to nodum 18, a progression along the first CANOCO axis, associated with increasingly intensive cultivation methods. Thus, the samples in nodum 1 cluster in the top left-hand corner of the CANOCO plot of axis 1 versus axis 2, associated with young, level swards at low altitudes, which receive no artificial fertilisation and have a late cut-date and long shut-up period. Nodum 2 is similarly located on the plot. Again, no artificial fertiliser is applied to the sampled fields. In comparison with nodum 1, this nodum contains older swards,

BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 1) FIGURE 8-1.

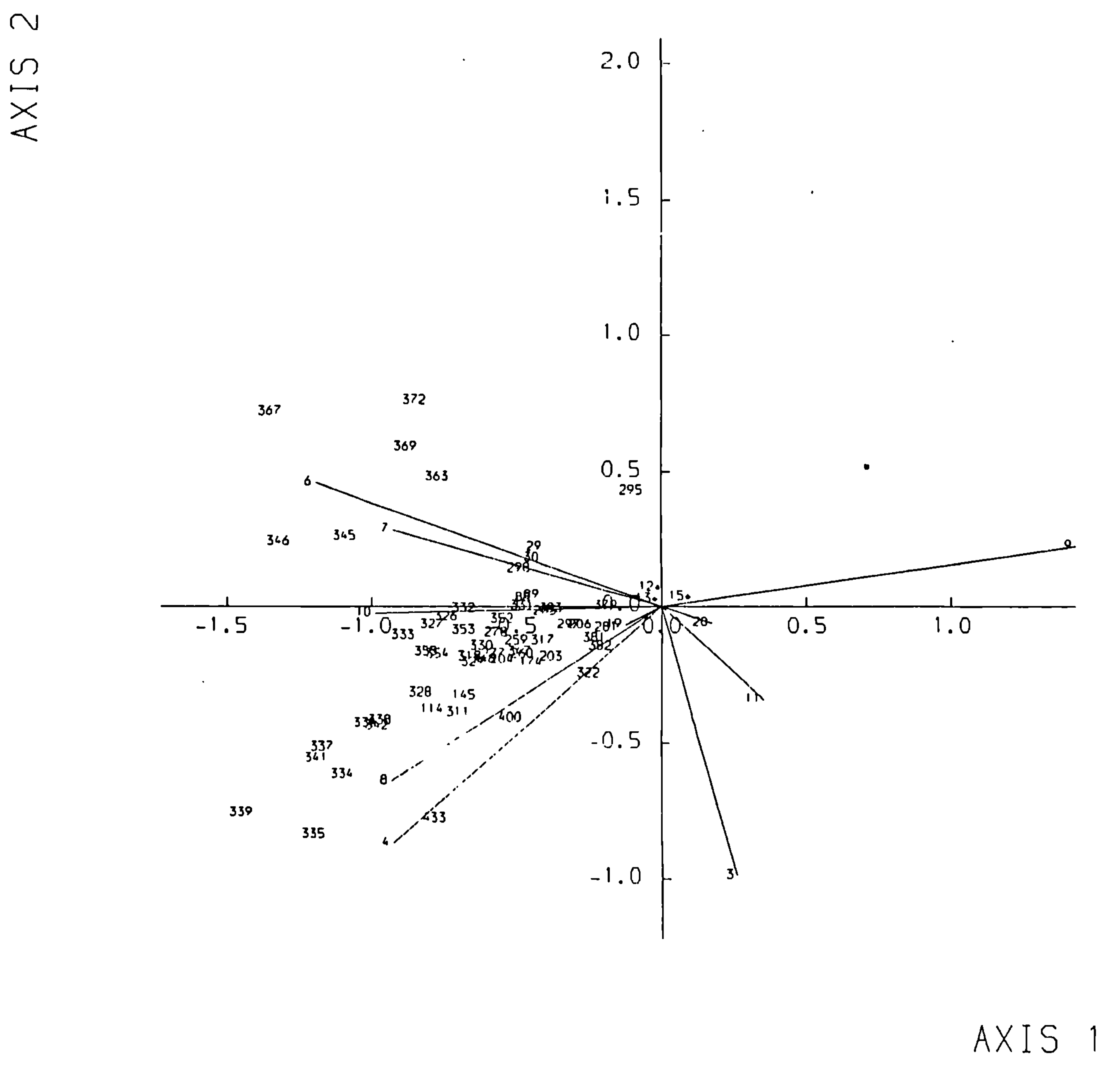


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 2) *FIGURE 8-2.*



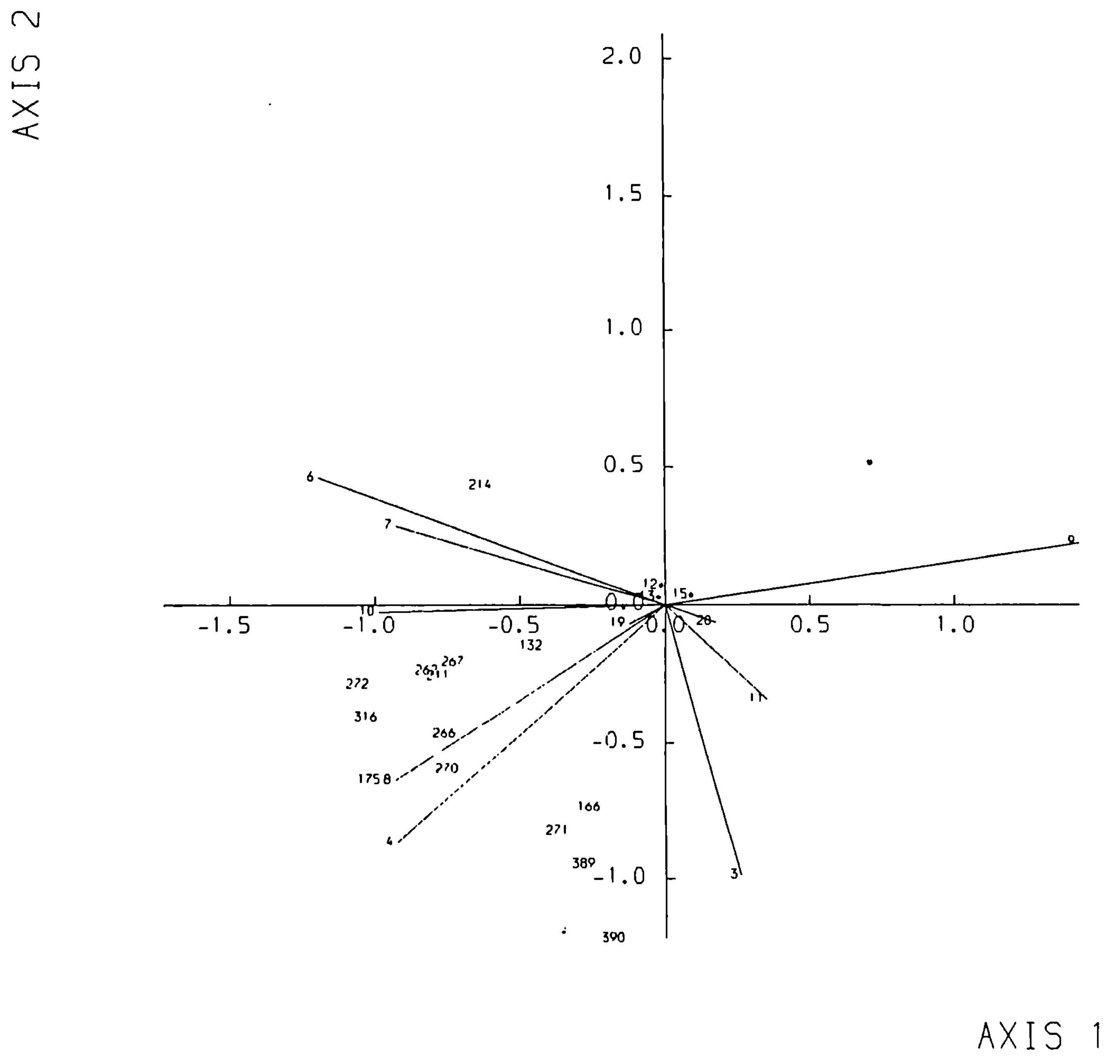
BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 3)

FIGURE 8-3.



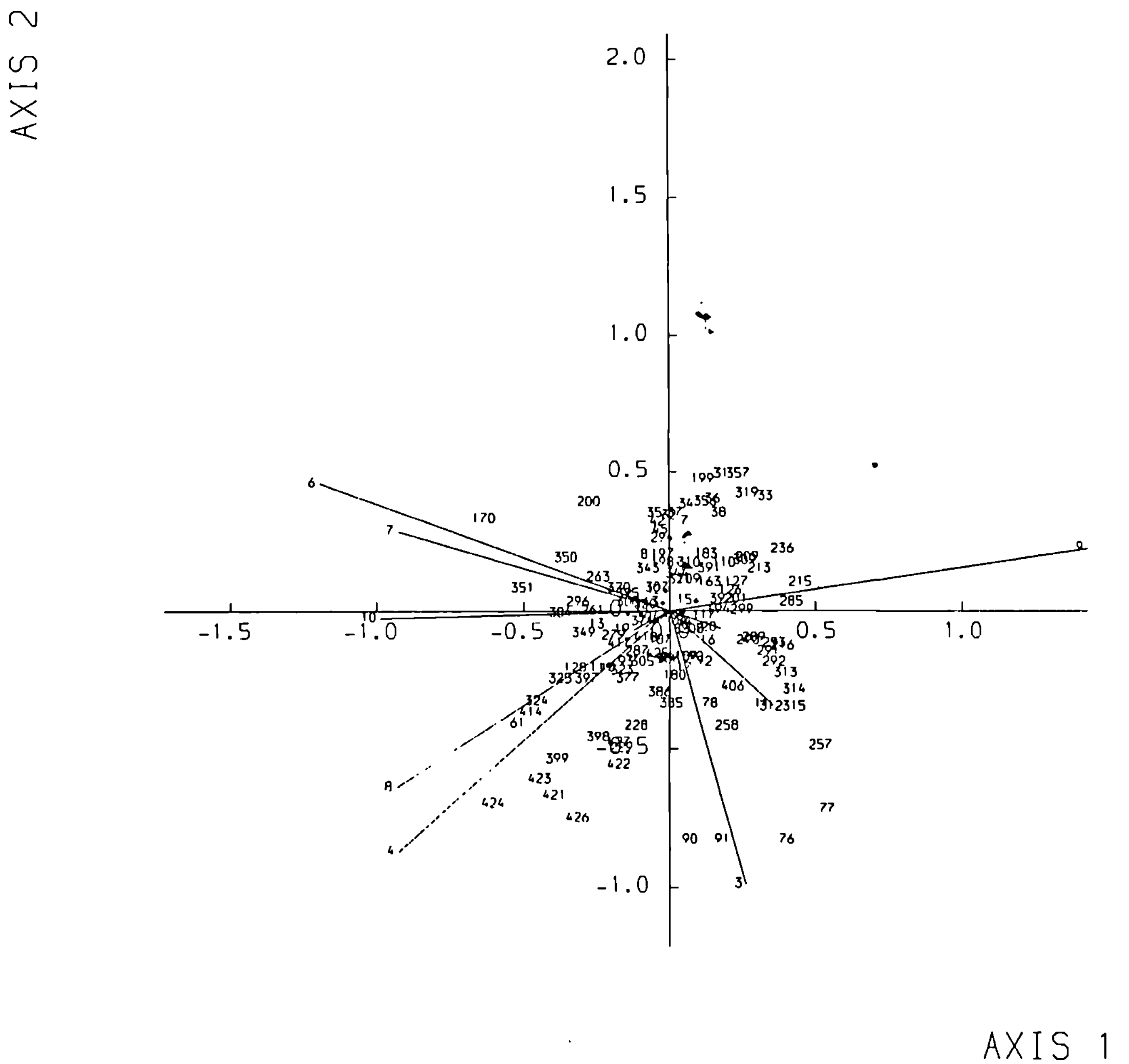
BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 4)

FIGURE 8-4.

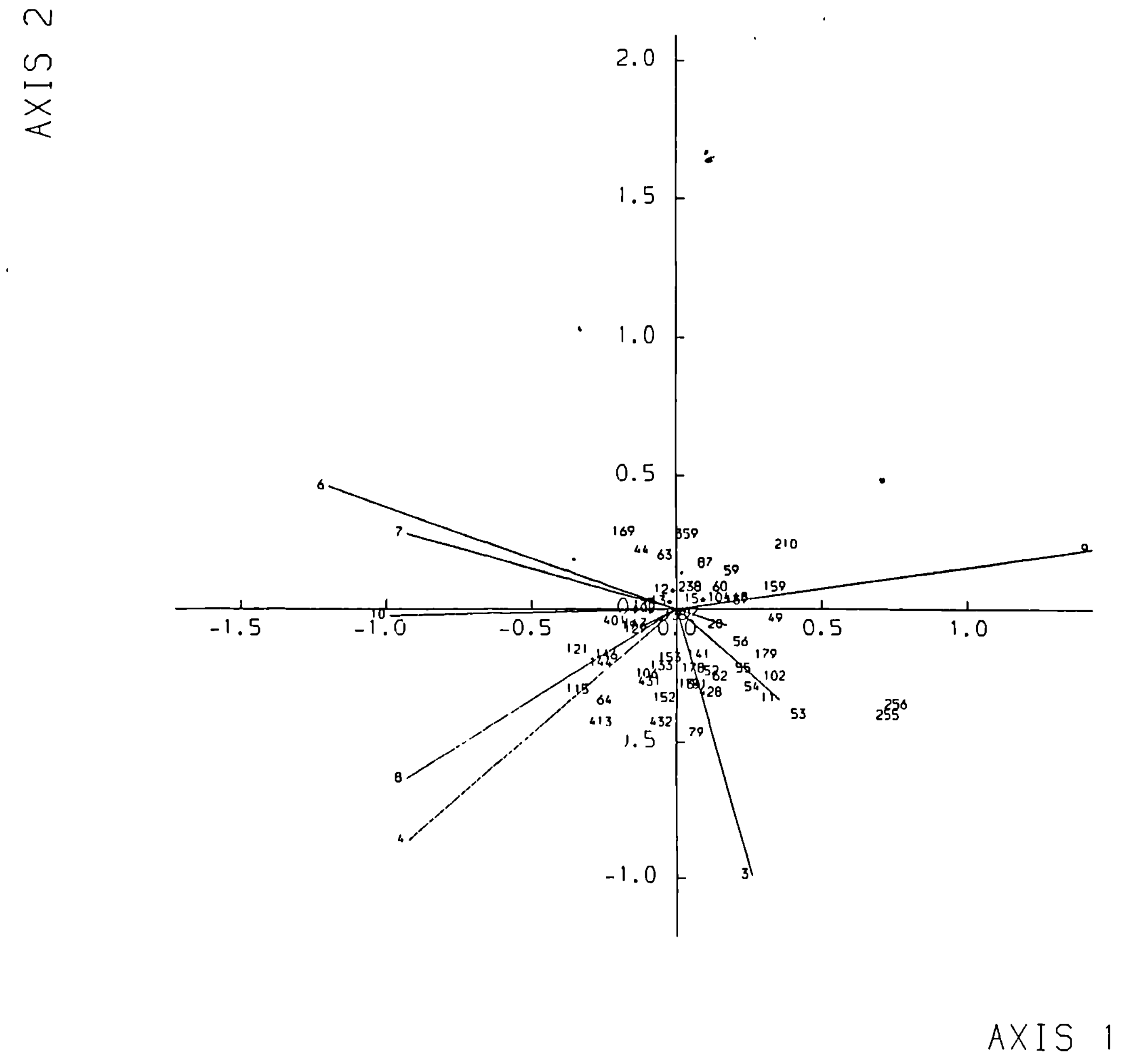


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 5)

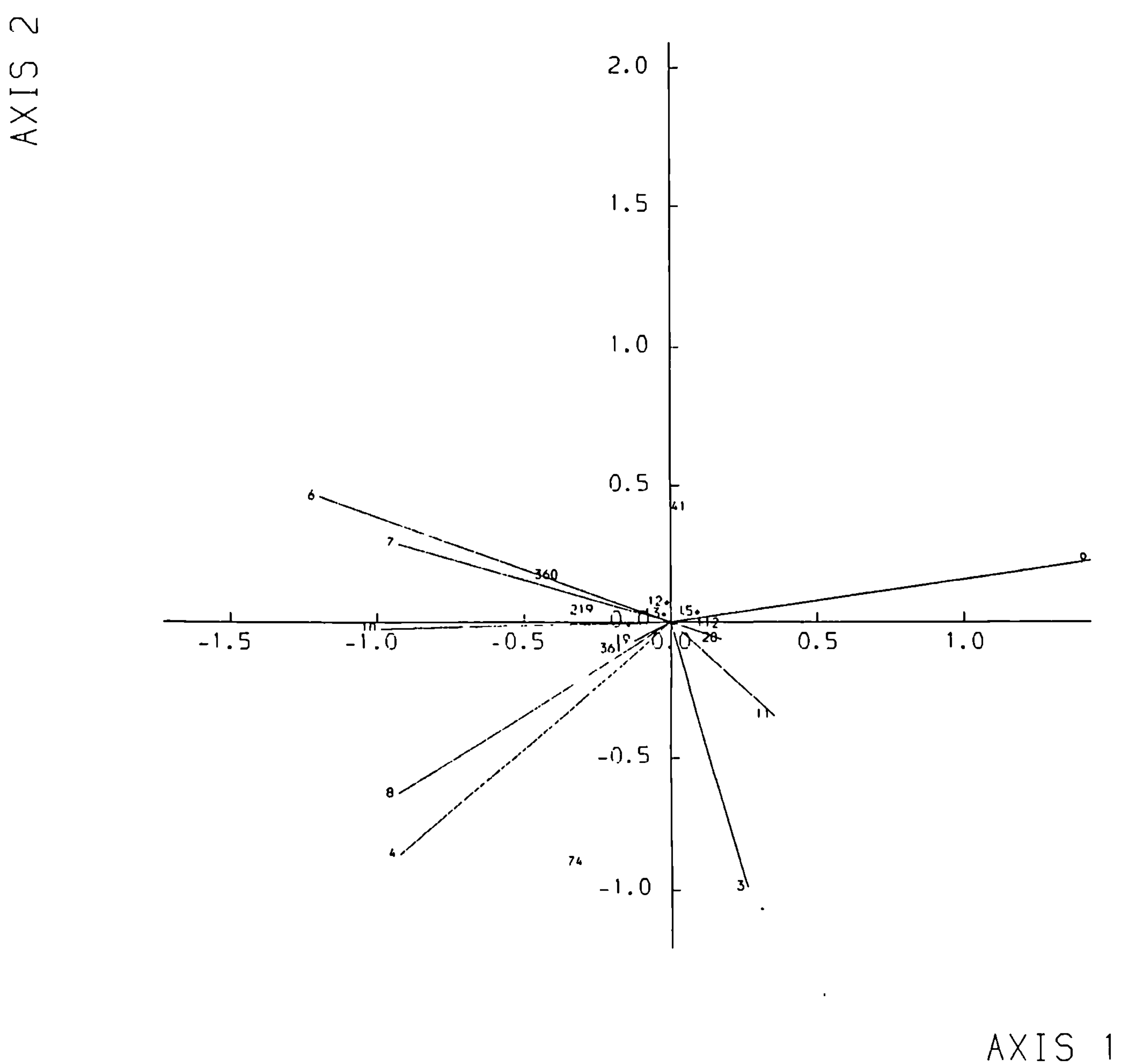
FIGURE 8-5.



BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 6) *FIGURE 8-6.*

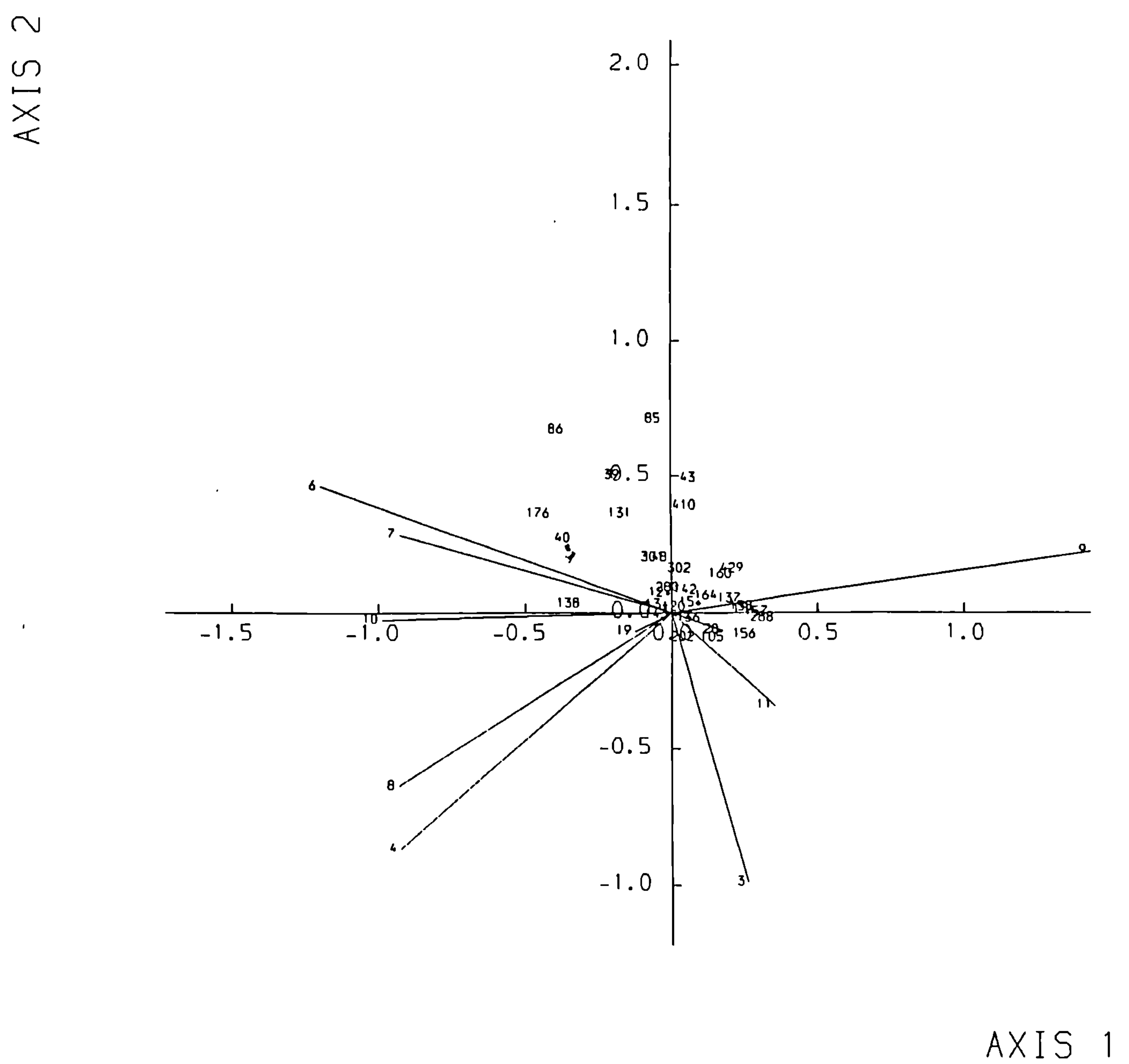


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 7) *FIGURE 8-7.*

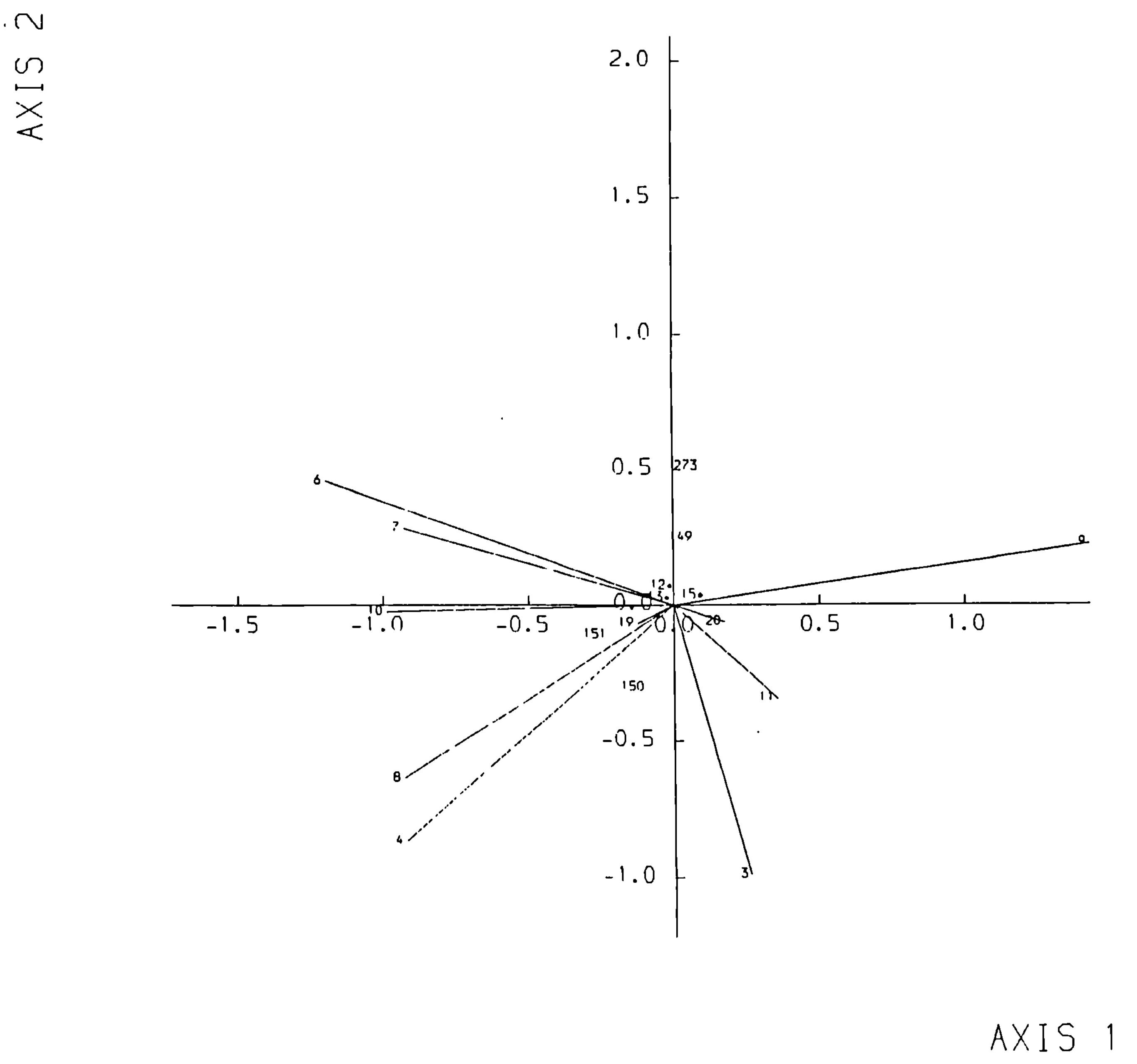


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 8)

FIGURE 8-8.

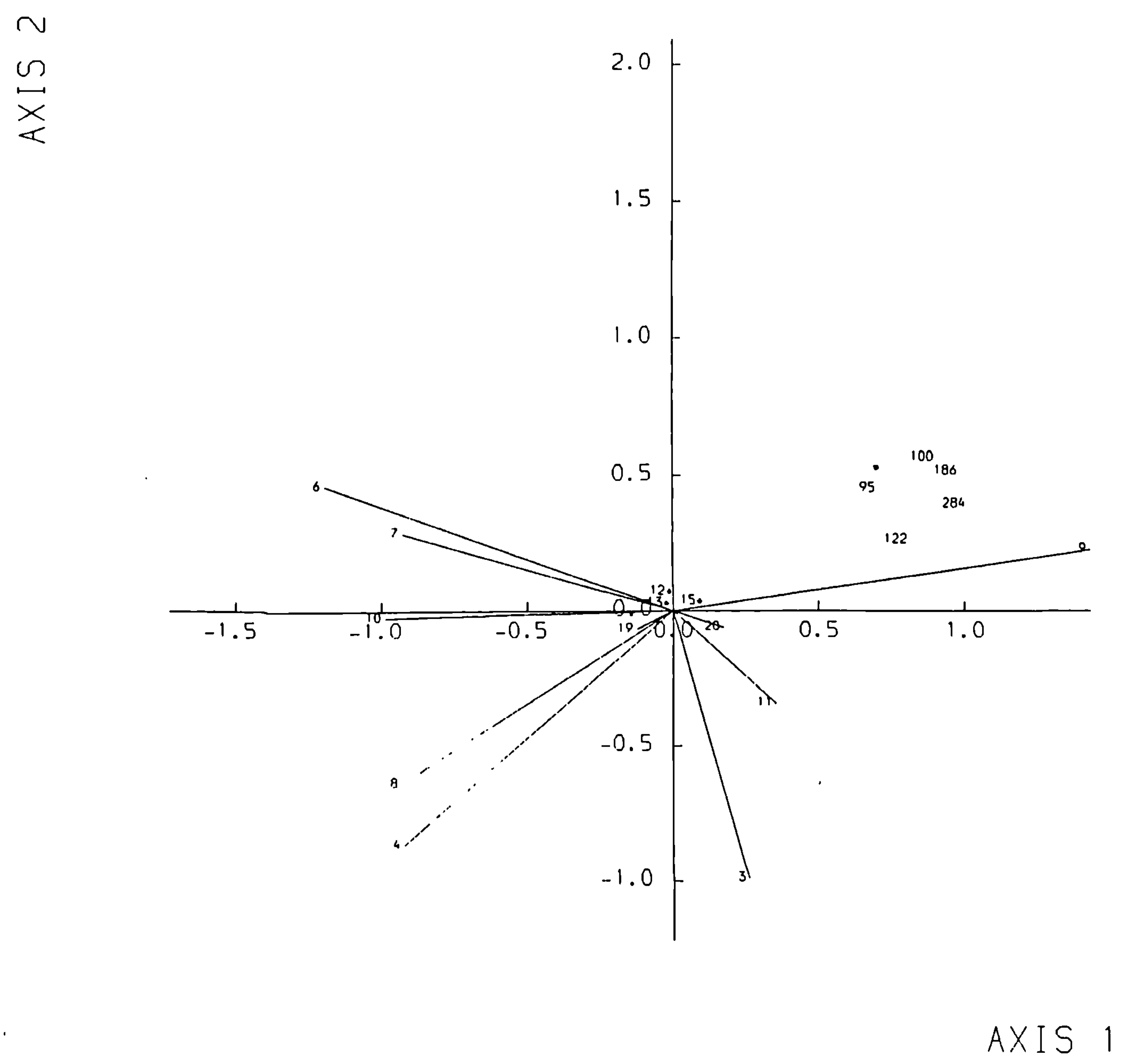


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 9) *FIGURE 8-9.*

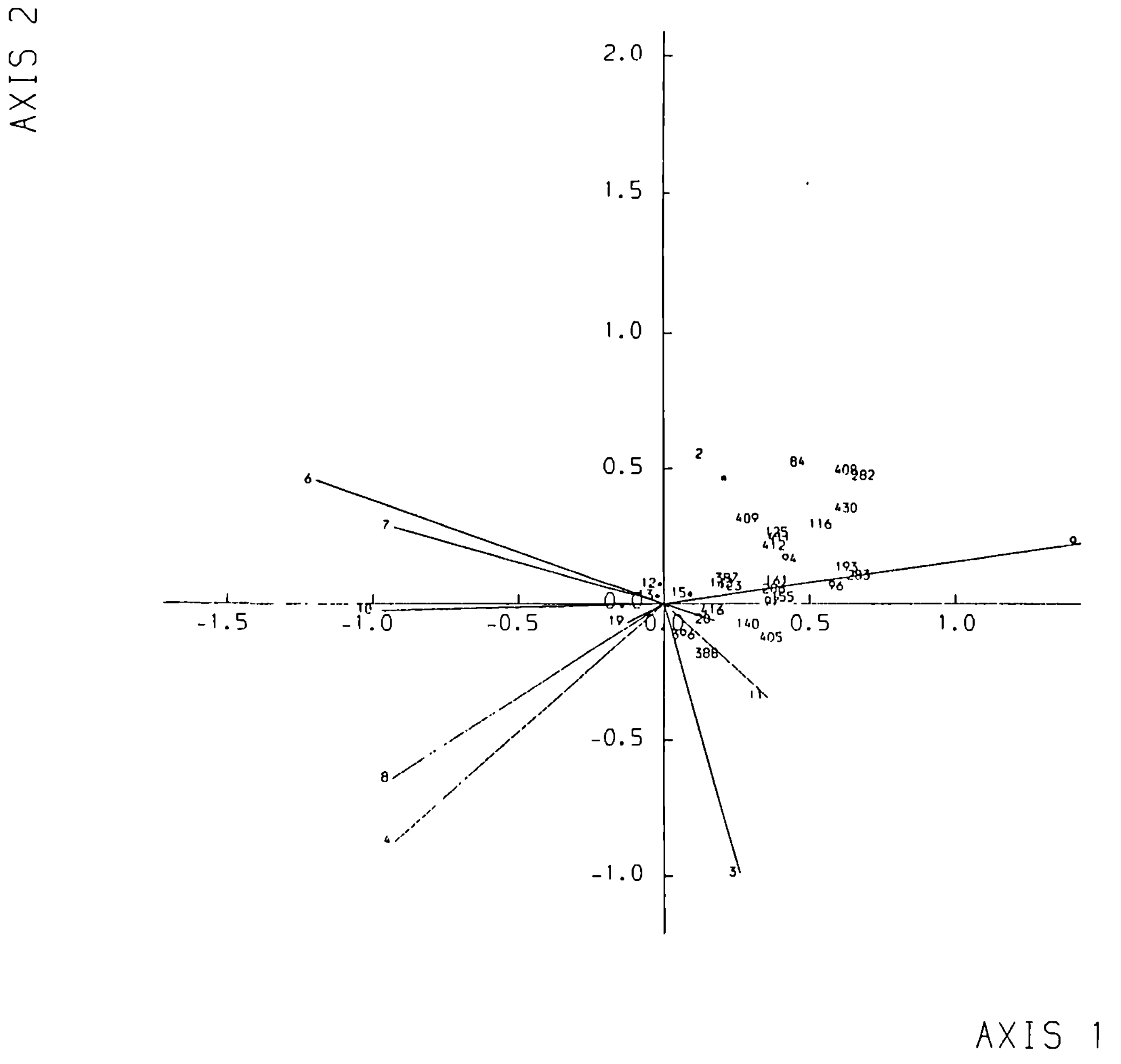


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 10

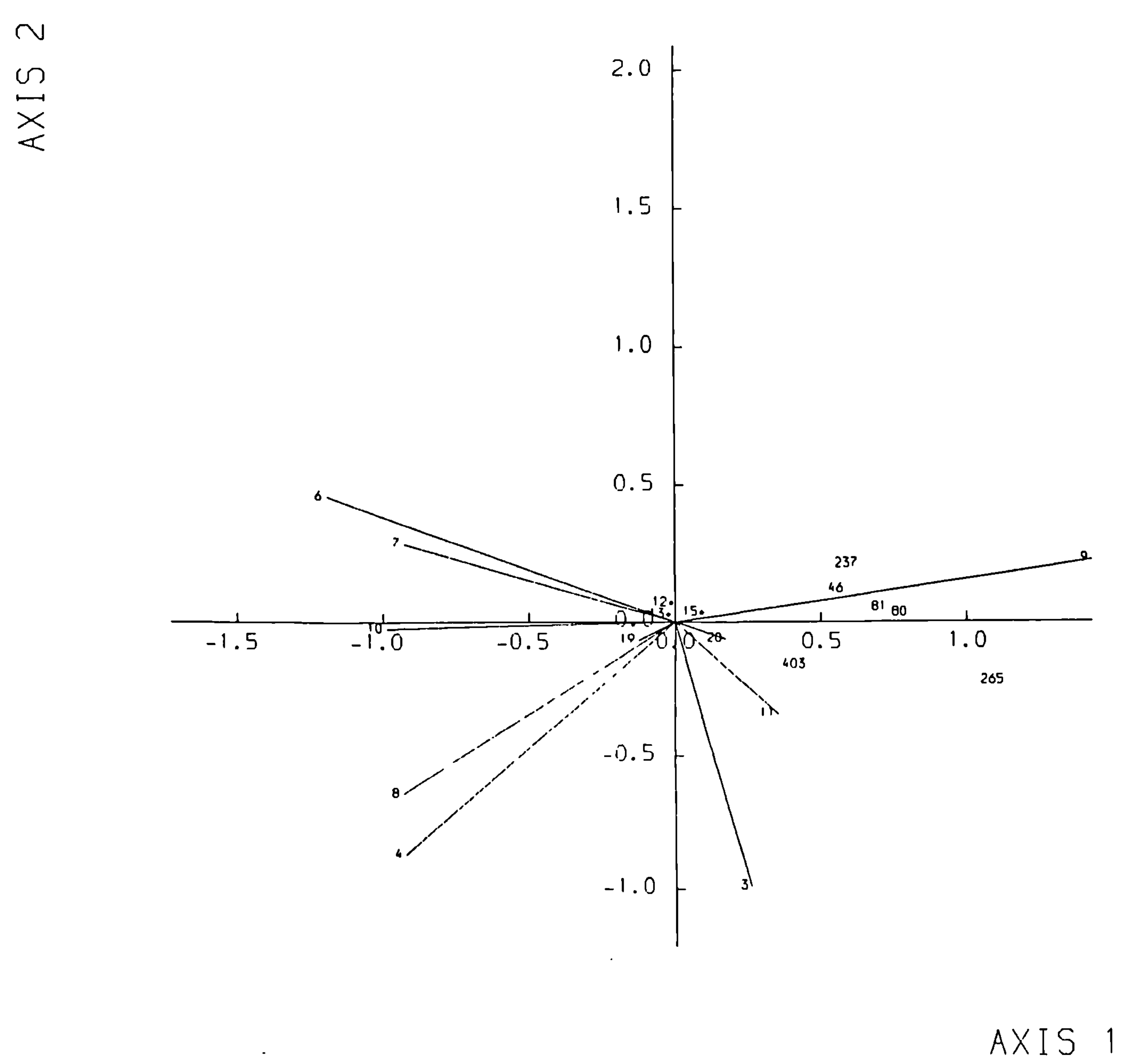
FIGURE 8-10.



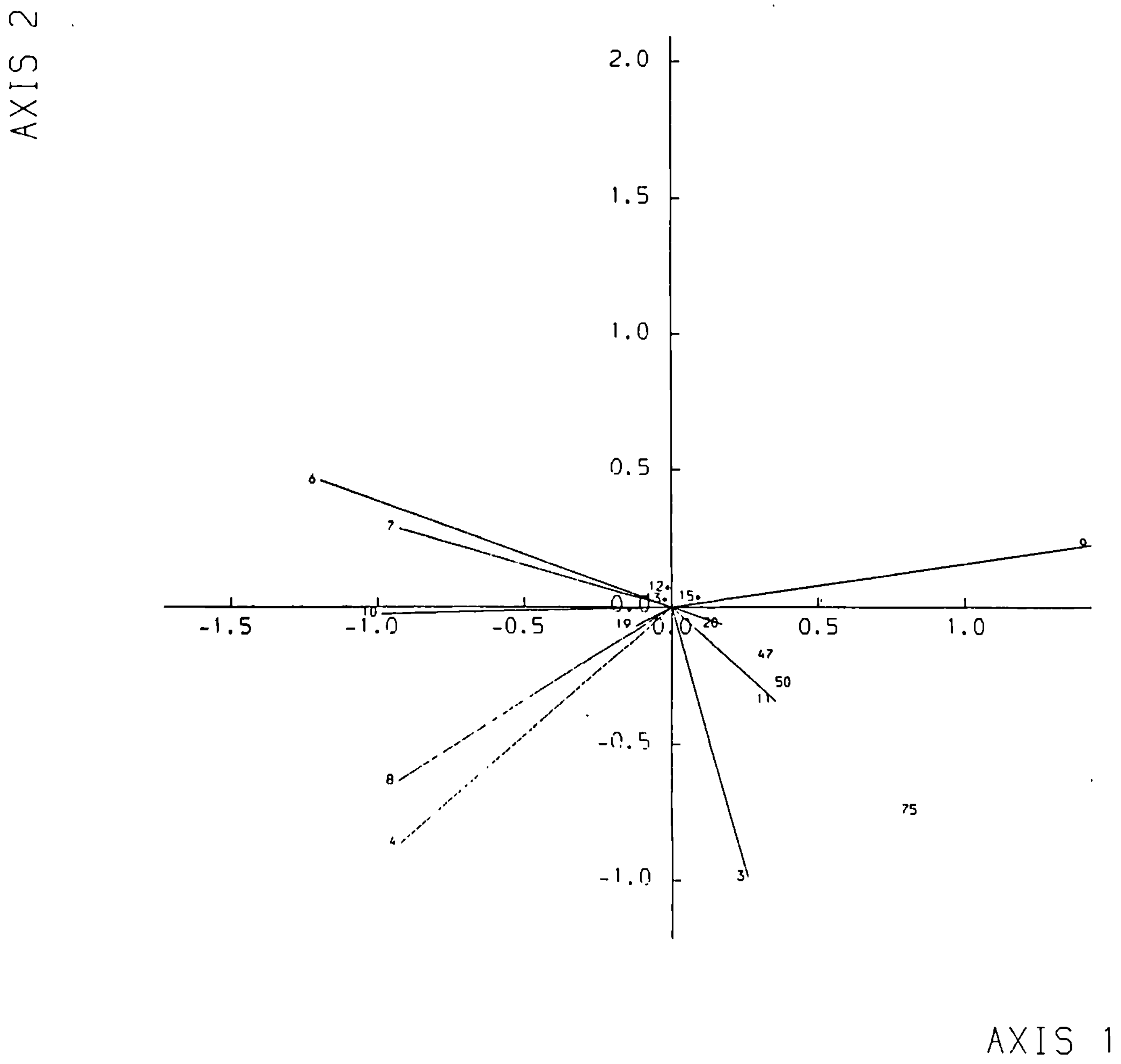
BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 11) *FIGURE 8-11.*



BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 12) *FIGURE 8-12.*

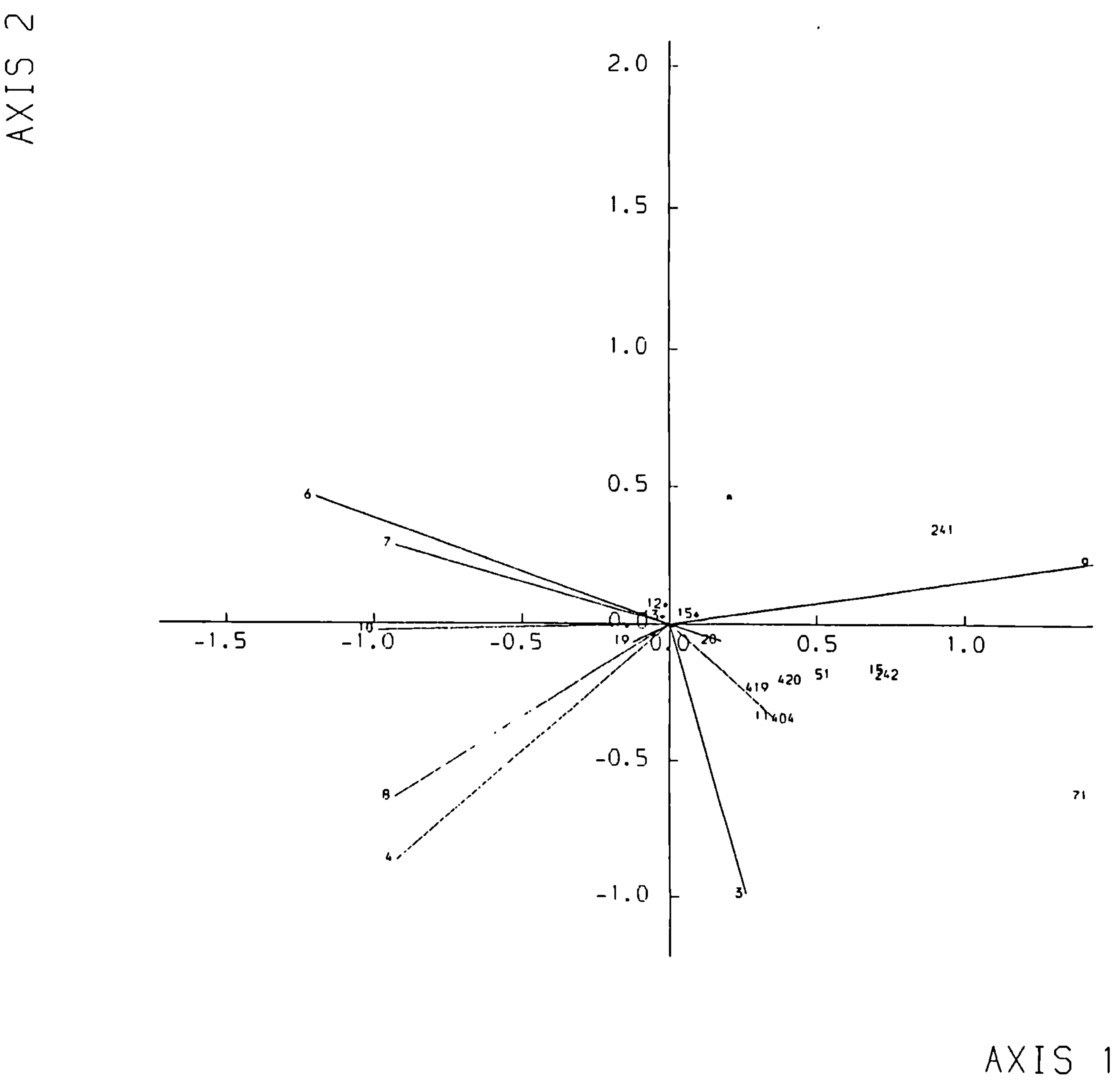


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 13) *FIGURE 8-13.*

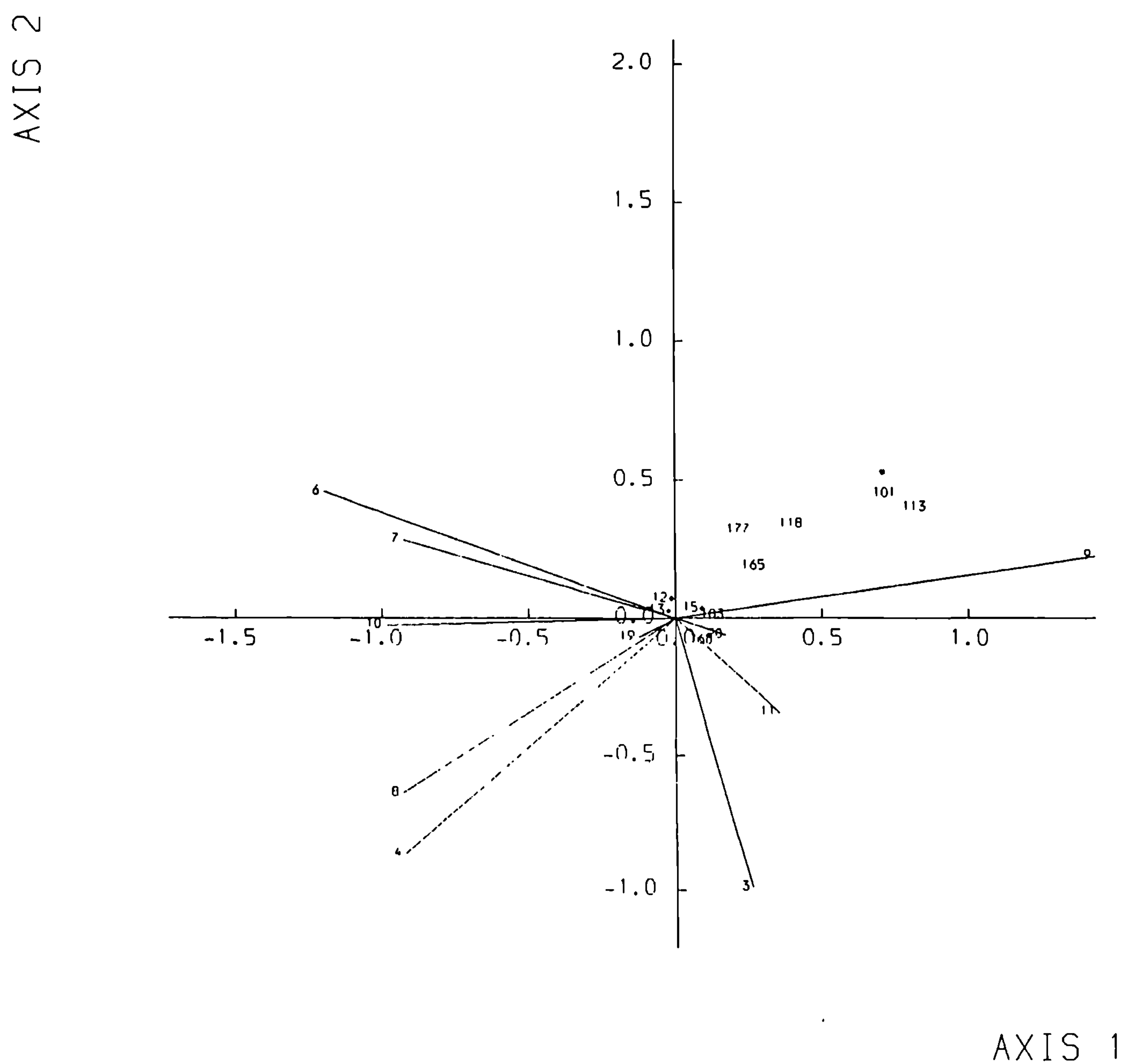


BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 14)

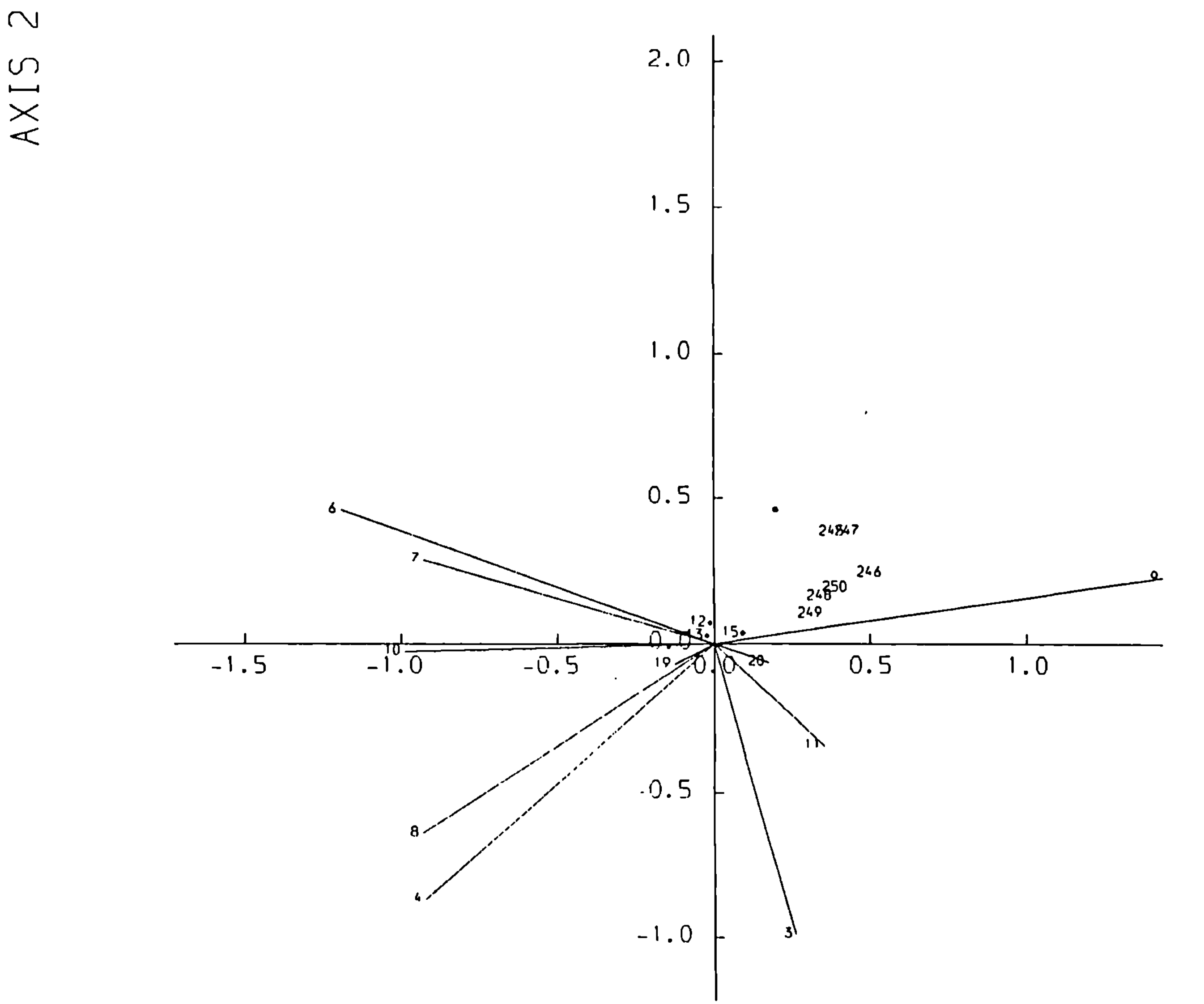
FIGURE 8-14.



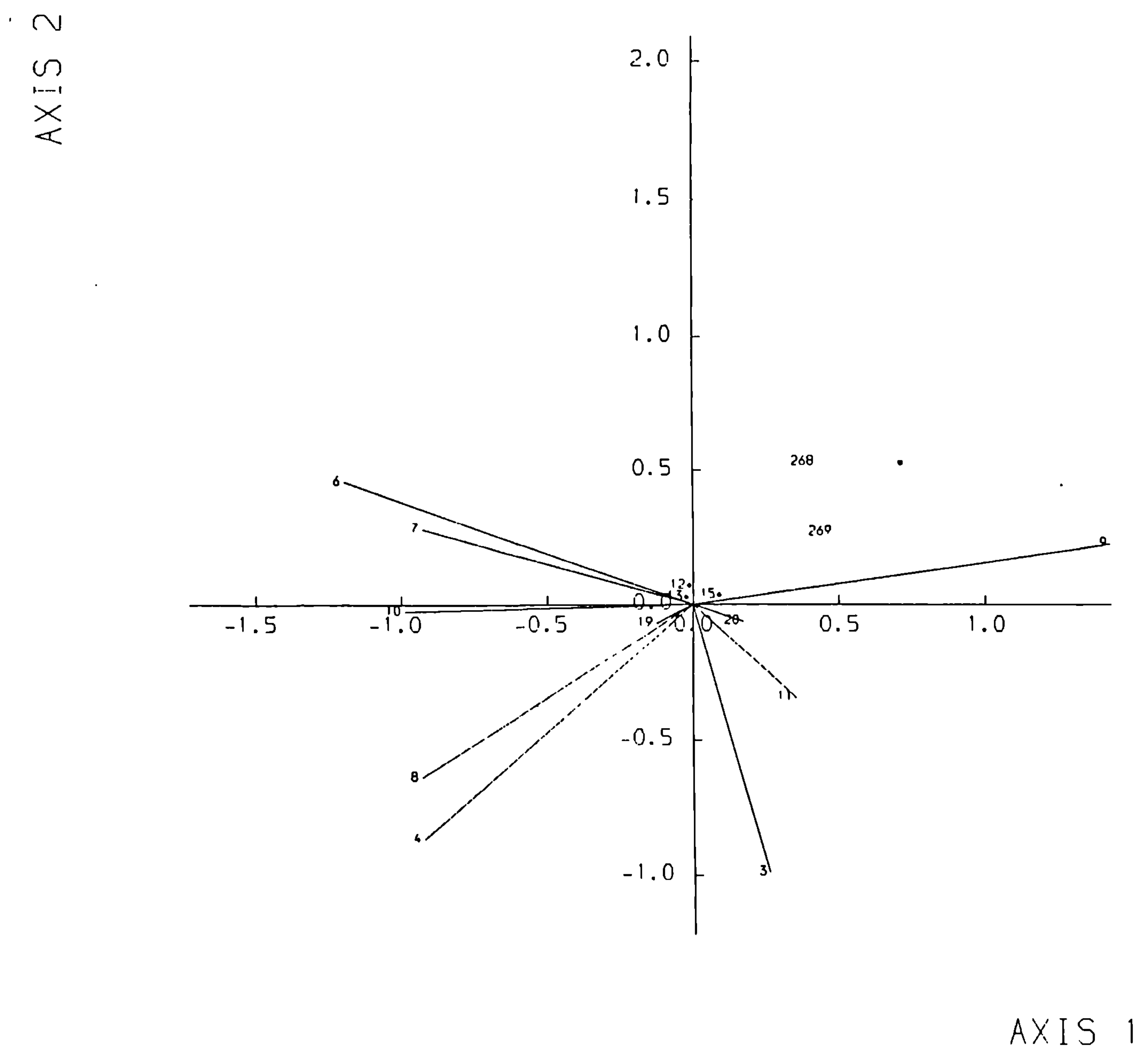
BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 15) *FIGURE 8-15*



BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 16) *FIGURE 8-16.*



BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 17) *FIGURE 8-17.*



BIPLOT OF AXIS 1 VS AXIS 2 (NODUM 18) *FIGURE 8-18.*

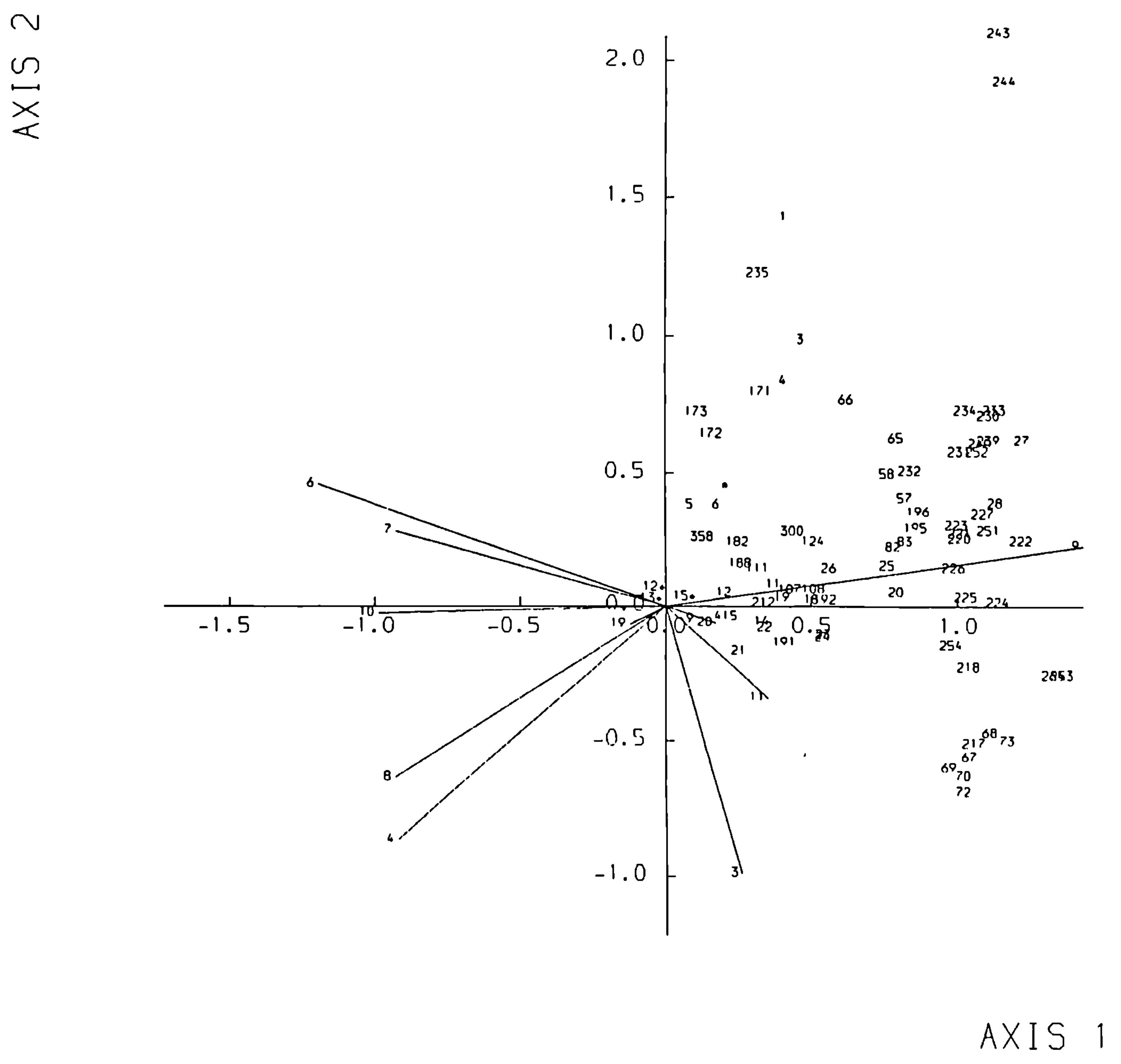


TABLE 7 - Management and environment variables for noda

Notes:

Values given are means, with standard deviations calculated as:

$$\sqrt{\frac{\sum x^2 - \frac{\left(\sum x\right)^2}{n}}{n - 1}}$$

Where not all samples within any particular nodum had valid values for any variable, the number of samples with information, i.e. used in the calculations of the mean and standard deviation, is given in brackets following the values in the table.

For manuring and liming, N corresponds to 'no' and Y to 'yes'.

For grazing, B corresponds to 'both cattle and sheep'
S corresponds to 'sheep' and
C corresponds to 'cattle'.

For crop taken, H corresponds to 'hay' and S to 'silage'.

Any specific notes, indicated by numeric superscripts, are given below each table.

TABLE 7 - Management and environment variables for noda

Nodum	I	II	III	IV	V
No. of samples	11	3	57	15	120
No. of species /releve	28.9 +/- 5.9	32.3 +/- 6.4	28.4 +/- 4.9	23.1 +/- 7.1	23.2 +/- 4.3
Altitude (m)	7.3 +/- 4.1	198.3 +/- 75.1	258.6 +/- 102.9	248.0 +/- 140.4	222.6 +/- 78.6
Slope (°)	0.0 +/- 0.0	1.7 +/- 2.9	7.9 +/- 10.4	7.6 +/- 9.7	5.7 +/- 8.0
pH	6.6 +/- 1.1 (9)	4.7 +/- 0.1	5.1 +/- 0.8 (50)	4.8 +/- 0.5 (4)	5.3 +/- 0.7 (79)
Cut-date (day)	224.4 +/- 8.5 (9)	188.3 +/- 5.8	207.3 +/- 13.7 (47)	210.0 +/- 9.5 (11)	196.9 +/- 12.5 (108)
Shut-up period (days)	108.9 +/- 18.8 (9)	60.0 (1)	88.1 +/- 22.1 (39)	87.5 +/- 25.1 (10)	67.5 +/- 22.6 (97)
Age (years)	>12	99.0 +/- 0.0	99.0 +/- 0.0 (35)	86.4 +/- 21.5 (7)	83.9 +/- 27.9 (69)
Fertiliser (cwt/ac)	0.0[1] (1)	0.0 +/- 0.0	0.7 +/- 0.9 (42)	0.9 +/- 1.3 (10)	1.3 +/- 1.1 (83)
Manure	N (19)	N	Y/N (50)	N (11)	N/Y (98)
Lime	N (10)	N	N (46)	N (12)	N (98)
Grazing	B (10)	B	B/S (48)[2]	S/B/C (11)	B/S (106)[3]
Crop	H (8)[4]	H	H (50)[5]	H (14)	H (111)[6]

1 Information may be inaccurate.
2 1 field not grazed.
3 2 fields not grazed.
4 2 fields not cut.
5 4 fields not cut.
6 6 fields not cut.

Nodum	VI	VII	VIII	IX	X
No. of samples	49	6	28	4	5
No. of species	25.7 +/- 3.8	26.3 +/- 6.0	22.6 +/- 4.6	23.0 +/- 7.4	12.8 +/- 4.3
Altitude	267.4 +/- 70.1	245.0 +/- 63.5	269.1 +/- 96.5	153.8 +/- 82.5	218.0 +/- 46.2
Slope	2.8 +/- 6.5	7.7 +/- 16.0	1.4 +/- 2.0	2.0 +/- 2.4	0.6 +/- 0.9
pH	5.1 +/- 0.5 (10)	4.7 (1)	5.2 +/- 0.7 (11)	- - -	5.7 (1)
Cut-date	193.9 +/- 11.4 (47)	188.8 +/- 7.5 (4)	201.1 +/- 11.7	193.8 +/- 17.5	198.0 +/- 14.4
Shut up period	67.9 +/- 26.3 (46)	52.5 +/- 17.7 (2)	62.8 +/- 16.5 (25)	35.0 +/- 0.0 (3)	69.0 +/- 26.1
Age	89.5 +/- 22.5 (41)	69.5 +/- 41.7 (2)	84.9 +/- 22.9 (24)	99.0 +/- 0.0 (3)	66.3 +/- 30.0 (3)
Fertiliser	1.8 +/- 1.1 (38)	1.6 +/- 0.6 (4)	1.8 +/- 1.0 (19)	- - -	2.6 +/- 1.5
Manure	Y/N (48)	Y/N	Y (27)	- - -	Y/N
Lime	N (38)	N (5)	N (23)	- - -	Y/N
Grazing	B/S (46)[1]	B	S/B	S (3)	S/B
Crop	H (46)[2]	H (4)[3]	H	H	H

[1] 1 field not grazed.

[2] 2 fields not cut.

[3] 2 fields not cut.

Nodum	XI	XII	XIII	XIV	XV
No. of samples	26	6	3	8	7
No. of species	19.4 +/- 4.4	21.8 +/- 1.7	23.3 +/- 2.1	19.5 +/- 1.3	14.6 +/- 4.1
Altitude	239.8 +/- 64.4	244.2 +/- 63.9	160.0 +/- 34.6	253.1 +/- 81.0	340.7 +/- 105.7
Slope	1.8 +/- 2.8	0.5 +/- 1.2	0.0 +/- 0.0	1.9 +/- 2.2	0.6 +/- 0.8
pH	5.5 +/- 0.5 (14)	4.8 (1)	- - -	5.0 +/- 0.2 (3)	5.5 (1)
Cut-date	193.5 +/- 11.2 (23)	186.7 +/- 8.2	178.3 +/- 5.8	185.6 +/- 5.0	200.0 +/- 12.3
Shut up period	63.3 +/- 21.3 (23)	50.0 +/- 11.6 (4)	65.0 +/- 43.3	56.9 +/- 24.2	73.6 +/- 17.0
Age	80.8 +/- 24.2 (18)	84.2 +/- 33.1 (5)	99.0 +/- 0.0	88.3 +/- 26.1 (6)	99.0 +/- 0.0 (4)
Fertiliser	2.5 +/- 1.1 (23)	3.7 +/- 0.6 (3)	3.5 +/- 0.9	2.7 +/- 0.9	2.5 +/- 0.6 (4)
Manure	Y (25)	Y (5)	Y	Y	Y/N
Lime	N (22)	Y/N (5)	Y	Y/N	Y/N (6)
Grazing	B (25)	B	B/C	B	S/B/C
Crop	H (25)	H	H	H	H

Nodum	XVI	XVII	XVIII	ALL
No. of samples	6	2	74	430
No. of species	12.2 +/- 1.2	15.0 +/- 1.4	18.0 +/- 5.6	
Altitude	201.7 +/- 2.6	30.0 +/- 0.0	232.1 +/- 66.4	234.7 +/- 234.9
Slope	0.3 +/- 0.8	0.0 +/- 0.0	1.7 +/- 2.6	3.9 +/- 7.2
pH	5.1 +/- 0.2	- - -	4.9 +/- 0.7 (11)	5.3 +/- 0.7 (204)
Cut-date	210.0 +/- 0.0 (4)[1]	/[2]	190.3 +/- 12.4 (61)	197.4 +/- 174.2 (378)
Shut up period	75.0 +/- 0.0 (4)[1]	/[2]	67.3 +/- 20.3 (56)	70.3 +/- 24.2 (342)
Age	40.0 +/- 0.0 (4)	25.0 +/- 0.0	51.4 +/- 39.0 (44)	80.8 +/- 30.1 (273)
Fertiliser	3.0 +/- 0.0	1.0 +/- 0.0	2.4 +/- 1.1 (39)	1.7 +/- 1.3 (293)
Manure	Y	N	Y (60)	
Lime	N	N	N (55)	
Grazing	S	B	B (63)	
Crop	H [1]	/[2]	H (63)	

[1] 2 fields not cut.

[2] No fields cut, any longer.

found at higher altitudes. The samples in nodum 3 are also from old swards but some receive some artificial fertilisation. Manure is also applied and although the cut-date is generally late and the shut-up period, long, these are more variable. A range of altitudes are found amongst the samples in this nodum and some of the samples are from steeply sloping sites. Nodum 4 is very similar to nodum 3 in its position and thus its management/environmental profile: the samples come from old swards at high altitude, steeply sloping sites. Some of the samples receive artificial fertilisation.

Noda 5, 6 and 7 fall in the middle of the plot. They can be considered to be intermediate in their environmental and management variables within the data set. Moderate fertilisation dosages are applied, the altitudes of the samples are moderate and the swards tend to have been ploughed in the distant past. Noda 8 and 9 are found higher on the CANOCO plots than noda 5 to 7, suggesting lower altitude, flatter sites with heavier fertilisation. Nodum 9 has a short shut-up period.

Nodum 10 receives high artificial fertilisation levels, with a mean of 2.6 cwt/ac. The swards sampled tend to be relatively young. Nodum 11 has a similar position to nodum 10, with young, flat swards which receive heavy dosages of artificial fertilisers. The samples in nodum 11 tend to come from higher altitude sites than those in nodum 10. Nodum 12 has high artificial fertilisation levels, with a mean application rate of 3.7 cwt/ac. Lime is applied to the samples within nodum 13, which also receive high dosages of artificial fertilisers. Nodum 14 also contains some samples which are limed regularly and receive heavy fertiliser inputs. Noda 15 and 16 are distinguished by high fertilisation levels. The samples in nodum 17 are from young swards at low altitudes. The samples in nodum 18 form a broader scatter on the CANOCO plot, indicating a range of relatively high artificial fertilisation dosages and a range of sward ages, with a bias towards younger swards.

The impact of management and environmental factors on the fauna and microflora of meadows has not been studied during this project. The effect of fertilisation on invertebrates and microflora has been studied by, inter alia, Spedding (1975); Andrzejewska (1976a and 1976b); Jakubczyk (1976); Olechowicz (1976); Makulec (1976); Petal (1976); Wasilewska (1976); Zyromska-Rudzka (1976). The effects of cutting have been studied by Morris (e.g. 1978b, 1979a, 1979b, 1981a, 1981b, 1983) and Purvis and Curry (1981). Two further papers by Morris give a more general review of the impact of various farming practices on invertebrate populations (Morris, 1971 and 1978a). Nowak (1976) noted a decline in earthworms on fertilisation and Gilbey (1986), both a decline and relatively more Allolobophora spp. compared with Lumbricus terrestris following reseeding.

CONCLUSIONS - CONSERVATION AND AGRICULTURE

This study has described the range of meadow vegetation types found within upland Britain and has made tentative attempts to explain the communities identified in terms of not only the environmental conditions under which they are found but also the management they receive. 18 vegetation types were recognised, all of which fall within the class Molinio-Arrhenatheretea Tx. 1937. Age of sward, length of shut-up period, cutting date and artificial fertilisation dosage were all correlated with the pattern in the vegetation revealed by ordination.

With anthropogenic ecosystems such as meadows, it is necessary to consider the nature of Man's activities as they impinge upon these semi-natural communities. The description and understanding of these meadow vegetation types is not of purely academic interest. The loss of flower-filled hay meadows from the landscape of much of Britain has been noticed and decried too late for most areas. 95% lowland neutral grasslands, including herb-rich hay meadows, now lack significant wildlife interest and only 3% are undamaged by agricultural intensification (Nature Conservancy Council, 1984).

In agricultural terms, herb-rich, species-diverse hay meadows resulting from and maintained by a traditional low-input system can be regarded as relicts of an anachronistic style of farming that is economically untenable. However, in recent years, even the grant-aiding structure of the European Economic Community has begun to reflect the view, long-preached by some environmentalists (e.g. Potter, 1983; MacEwen and Sinclair, 1983) that it is irresponsible of society to support a high-output system of farming in an already wastefully over-producing area, particularly when this high-input:high-output system is also environmentally damaging. In Britain, degradation and loss of traditionally-managed meadows are considered to be among the most alarming consequences of modern agriculture.

Despite the publicity for 'meadow flower seeds mixes' for amenity grassland (e.g. Wells, Bell and Frost, 1981; Baines and Smart, 1984), there is no evidence that herb-rich meadow vegetation can be recreated on an agricultural scale and it is, frankly, difficult to imagine many farmers who would wish to try. Those who suggest that a valuable field ploughed today will have the same species-rich community in 100 years' time that it had yesterday have yet to be proved right or wrong - and in 100 years, it will be too late to revise our attitudes and actions in the light of the results of this 'experiment'. It can be argued that some meadows judged valuable today were ploughed during the Napoleonic wars and a century and a half later they include some of our richest fields. There are, however, few parallels between a brief period of management as emergency arable land and the treatment that a meadow receives today during and after ploughing - drainage, reseeding with artificial seed mixes (rather than barn-sweepings), herbicide treatment, heavy and repeated inorganic fertilisation etc. In addition, given the absence of many meadows with an unbroken history of use as hay meadows over many centuries, it is impossible for us to assess species loss and degradation of communities resulting from even this 'gentle' break in meadow exploitation of the fields. Work on soil seed banks beneath meadows has indicated that there is little correlation between the composition of swards and that of seed banks found beneath them (e.g. Chancellor, 1979). Some seeds may be short-lived (e.g. Roberts, 1986) and so are no insurance against loss of species from the sward. Poa trivialis has a long-lived seed (Wright, in discussion following Dibb and Haggar, 1979) and so when poaching leads to gaps in the sward, the Poa seeds germinate and once they have come into the sward are very difficult to remove. If we value these ancient, species-rich, herb-rich hay meadows and wish to conserve the wildlife they sustain and that part of our cultural heritage which they represent, then we must conserve and continue traditional management of our few remaining herb-rich meadows. This chapter discusses how this is being carried out and the conflicts and ethical judgments that arise in such conservation procedures.

During this study, many different meadow vegetation types have been defined and described. Not all of these will be considered to be of value in nature conservation terms. Subjective judgments will always have to be made but some attempt must be made to define what constitutes a sward or field worthy of conservation. Reference should be made to the Nature Conservation Review (Ratcliffe, 1979) for a more detailed exposition of the criteria used to assess the conservation value of any particular site.

A 'good' meadow can be described as one which has suffered little intensive agricultural disturbance. Since the major effects of such disturbance - ploughing, heavy and prolonged inorganic fertilisation, very heavy grazing etc. - are a reduction in species diversity, a loss in meadow species sensitive to such practices or their effects and an increase in 'preferred' species (usually those species found in seeds mixes) and weed species, one can define a 'good' meadow as one with:

* high species diversity
* a large proportion of 'sensitive' meadow species
* a low proportion of arable weeds
* a low proportion of agricultural/'preferred' species

Arable weeds found in meadows include Sinapis arvensis, Matricaria matricarioides, Stellaria media, Capsella bursa-pastoris, Agropyron repens, some Bromus spp. and

Rumex obtusifolius. Sown species include Lolium perenne, Phleum pratense, Dactylis glomerata and Trifolium repens. Some of the herbs which we associate in our minds with traditional meadows actually appear to be quite robust, for example, Geranium sylvaticum and some Alchemilla microspecies are found in heavily fertilised fields and occasionally in reseeded fields. Other such species tend to be restricted in habitat and therefore not of great value as general meadow indicators. Chapter 7 discusses the relationships between various species and the management regimes under which they are able to thrive and also the loss of species diversity following various farming activities.

From this study, one can see that the 'good' meadows, as defined above, are associated with low artificial fertilisation, late cutting dates and a long period since last ploughing and reseeding. Thus, in order to preserve these rich swards, one would advocate no/low artificial fertilisation, a late cutting date and no ploughing disturbance. The Nature Conservancy Council general guidelines suggest the following (pers. comm.):

* no artificial fertilisation
* 10 tons/ac farmyard manure every 3 years
* no ploughing
* no supplementary feeding of stock on the field
* no pesticides/herbicides
* cutting each year

The cessation of cutting results in a decline in species diversity; e.g. Oomes and Mooi (1981) found a reduction from 52 to 38 species in a $100m^2$ sample of Arrhenatheretum elatioris. NCC offers no guidelines on stocking density and place no restrictions on liming. In the regions, local Nature Conservancy Council (N.C.C.) staff may offer more specific advice. In the Yorkshire Dales, the following advice is given to those concerned with conserving valuable hay meadow swards (pers. comm.):

* no ploughing
* no heavy harrowing
* no re-seeding
* no stock feeding on the fields
* no changes in grazing patterns; avoid poaching
* no change from hay to silage
* fields must be cut, and late in the year
* no artificial fertilisers
* FYM infrequently

* no slurry
* lime infrequently
* no pesticides or herbicides
* no dumping
* no burning
* new drainage only with consent
* no storage of materials on the fields, e.g. bale silage

Recently, the designation of the north Pennine Dales as an Environmentally Sensitive Area by the government, in part as a result of the high value placed on the hay meadows found in these dales, has demanded a careful assessment of management which does not harm but rather retains the rich meadows sward of the area. Negotiation between the National Farmers' Union and the N.C.C. has produced the following guidelines for farmers (M.A.F.F. PD/ESA/4), which represent a compromise reached by two sides with vastly disparate attitudes, aims and intentions:

* no ploughing
* no reseeding
* shut-up period to be more than 7 weeks
* a late cut-date
* if silage is taken, it must be wilted and turned on the field
* less than 10 tons FYM per acre per annum, in light doses
* low artificial fertilisation dosages (less than 20 units N, 10 units P and 10 units K per acre per annum; i.e. only one 50kg - approximately 1 cwt - bag per acre each year)
* no pesticides
* restrictive use of contact herbicides
* infrequent use of lime
* drainage only when required, and with care

Slurry is damaging to rich grassland swards as a result of its high concentration of relatively quickly-releasing nitrogen. In addition, it is relatively rich in K and poor in P (Scottish Agricultural Colleges, 1983) and so can result in imbalances in the sward and in the grazing animals (see table, below). In fact, high K levels result in low magnesium uptake and can therefore cause hypomagnesaemia in animals (M.A.F.F., 1983b). Additionally, slurry is an inefficient method of using the nitrogen in the manure because losses through volatilisation of ammonia are very high (Sherwood, 1983). In southern Germany, Austria, Switzerland and northern Italy, the use of milk for Emmental and

Parmesan cheeses makes it illegal to feed silage, which has a tainting effect of the flavour of the hard cheeses, to the dairy herds (Bischoff, Meuther and Wandel, 1980).

Comparison of average available nutrient content of FYM and slurry (from M.A.F.F., 1983a and 1983b)

	N	P	K
FYM[1] - cow	1.5	2.0	4.0
- poultry	10.0	n/a	n/a
Slurry[2] - cow	2.5	1.0	4.5
- poultry	9.0	n/a	n/a

[1] kg/tonne, in fresh manure.
[2] kg/m^3, undiluted and spread in spring.

It is likely that different types of cutter, with their different heights of cutting and different methods of slicing through the vegetation, will effect the botanical composition of the meadow swards but there has been little work in this area. Black and Alexander (1967) is a rare example of a study of the different types of cutter on the sward but is now out-of-date, following technical advances in cutter design in the past 20 years.

More research is urgently needed to assess more precisely the effects of the various techniques applied in modern agricultural treatment of fodder fields. This study, with its emphasis on broad survey, did not elucidate details of the impact of liming, manuring and grazing on the swards. Only with more detailed research, on well-defined sward types, can one hope to come to understand the factors affecting the delicate competitive balances of these anthropogenic communities, for they are fragile; as Smith and Crampton wrote in 1914:

> 'Such grassland is liable to change since it is only a phase artificially introduced into the history of other types of vegetation.'

In the future, there may well soon be a consolidation of the more environmentally-enlightened views which have led to the discussions in parliaments on restricting the inputs into farming in order to reduce the embarrassing food surpluses seen in the west today. The post-1945 emphasis on improving agricultural efficiency may now, finally, be swinging towards a more balanced viewpoint, one kinder to the environment. However, the farming community is notoriously conservative in its attitudes and slow to adopt new ideas. It is as a result of this very characteristic that there are any ancient hay meadows left today at all, given the financial encouragement given to farmers over the last forty years or so to reseed and fertilise their meadows. It will take many years or even decades of publicity for the so-called 'environmentally-friendly farming' before the years of high efficiency propaganda can be overcome. This may be too late to save the few remaining valuable hay meadows. Obviously, the attitudes of farmers and conservationists must one day come together in order to ensure nature conservation in this country, where agriculture occupies so much of the land area. In the short-term, however, the preservation of ancient hay meadows will in many cases be possible only by ignoring the wishes of the farmer.

Hill farming is rarely satisfactorily profitable. The upland landscapes study concluded that about 50% farms in the Uplands are non-viable, that is, no change in the resource combination of size and enterprise could be made to remove the economic rent deficit (Sinclair, 1983). The life of a hill-farming family must be one of the most arduous and least rewarding in this country. Many manage to maintain themselves only at a standard of living so low and unsophisticated as to be unimaginable to most modern town-dwellers. It has been calculated that for most hill farmers, almost their entire profit margin consists of E.E.C. and government grant aid (Institute of Terrestrial Ecology, 1978). Since much of this (still) concentrates on making farming more efficient, it is likely to be to the detriment of any semi-natural agricultural habitats. One cannot expect farmers to preserve a system which is of no apparent interest to them and which is agriculturally archaic and indeed indefensible. Most hill and upland farmers are lining their stomachs with their income, not their pockets. The farmers deserve an adequate income for the work they do and their livelihoods cannot be jeopardised by fashion - some would regard the recent emphasis on conservation of the environment as just another fashion. Farmers have been encouraged to carry out activities which conservationists may regard as damaging to the environment by a system of grant-aiding which encouraged and encourages high output above all other considerations. The N.C.C., in its fight to preserve those landscapes associated with more traditional farming methods, has been providing government funds to counteract the Ministry of Agriculture's aid. Perhaps the establishment of Environmentally Sensitive Areas, with its declared aim of resolving these anomalies, will turn the tide of opinion within those groups which hold power over the landscape.

The success of the current system of conserving valuable hay meadows, operated by the N.C.C. and, occasionally, county conservation trusts is questionable. The farmer may well wish neither to be fettered by management agreements, even financially beneficial ones, nor to sell his land, which is both his capital and usually his heritage. Even those farmers interested in conservation and keen to preserve traditional methods as far as is economically possible may well be unsympathetic to the perhaps more reasoned views of the professional nature conservationists. Many consider the publicity ensuing from the scheduling of a site as more harmful than general ignorance, quite apart from their feelings that habitats created by management are better maintained by the 'manager' rather than according to the supposedly (and sometimes undoubtedly deservedly) less well-proven and perhaps less well-researched plans of the conservationist. This leaves the conservationist who is involved in guaranteeing the future of the remaining old meadows in a difficult situation. One might feel that a truly sympathetic farmer is the best manager of such a field but even where one is fortunate enough to find such a man, or woman, in the future the delicate economic balance may tilt such that the farmer overcomes his scruples and acts in the best interests of his bank balance; additionally, the next generation or new purchasers are unlikely to have similar views.

One option is to 'write off' the most valuable field or fields on a farm as far as economic fodder production is concerned, relying on alternative, less valuable fields on the farm that could be managed in a high-input:high-output fashion. This, however, further marginalises the traditional hay field, rendering it even more likely to find a place only as a 'museum' piece.

Whilst never forgetting that these fields were created by farmers and that their role, as the producer of winter fodder, is of unrivalled importance on the upland farm, the value of the herb-rich hay meadow renders them a resource worthy of preservation.

The botanical importance of hay meadows has been elucidated above. Many of Britain's rarer species find refuge in the few remaining traditionally-managed hay fields. The value of a habitat for wildlife conservation is, in part, a function of its species diversity and hay meadows provide some of the most diverse communities in Britain, not only in terms of plants but also of invertebrates. These, in turn, support a large number of increasingly uncommon mammals and birds. The late, tall grass provides cover for nest-sites for many birds, for example partridges and the elusive corn-crake. The wildlife value of meadows is also, in large part, a reflection of the paucity of alternative habitats and in particular the rarity of natural habitats, for the species they harbour. Many tall-herb species are intolerant of grazing and dense shade and are now restricted to meadows, their natural habitat of open, upland woodlands having been almost totally destroyed by millenia of woodland clearance and intense grazing.

Much of Britain's archaeological heritage lies in the sub-soil of the Uplands. Many Iron Age and early Roman sites have been destroyed by deep-ploughing. Many of the few remaining unimproved, traditionally-managed hay fields are thus also sites of archaeological importance. Medieval field systems, with ancient ploughing ridge and furrow, are confined today to those few meadows and pastures whose traditional management has kept them free from ploughing in recent centuries. A detailed history of fields is given in Baker and Butlin (1973).

The aesthetic value of old meadows in summer is rarely matched - the fields are a riotous mix of colours, textures and heights. The change, associated with enclosure, from shared ownership of large fields has produced an appealing landscape in many upland valleys, where small fields are walled, often with little hay barns (so-called hogg houses) between adjacent fields (see plates 1 and 2). No longer, however, are farm workers employed to maintain the walls; the additional movement towards a more intensive farming system with frequent ploughing and the use of large silage machines has encouraged the removal of walls, whilst the old hay barns are redundant and left to decay. Thus, the maintenance of traditional methods of hay production has an importance for landscape conservation over and above its value for biological conservation.

Landscape quality cannot easily be defined or quantified and so has long suffered ignorance in favour of other objectives more easily defined, e.g. food production (Feist, 1978). Bowers and Cheshire (1983) provide a detailed explanation of the way in which economics has guided recent agricultural programmes. As Sinclair (1983) expressed it, the landscape is a 'manmade artifice that reflects the economic incentives which sustain it'. However, perhaps, to most, it is the beauty of these ancient, traditionally-managed meadows which is of major importance. As Bryn Green once said, perhaps S.S.S.I. should stand not for site of special scientific interest but rather for site of special sensual inspiration (Green, unpub.)! Stapledon, perhaps the driving force behind ploughing and reseeding in the Uplands of this country, felt that uniform and bright green fields were as appealing as the more muted and varied shades of nature:

> 'Hill scenery owes everything to contrast; the clean and well grazed fescue pastures are of a more vivid green than any other association. To extend the areas in vivid green is to heighten the light and shade effect, and to widen the contrasts. . . The

PLATE 1 - In-bye land near Keld, Upper Swaledale, showing hogg houses and walling of meadows

PLATE 2 - Meadows in Upper Swaledale

grassland improver with some justification can claim to be an artist on a huge canvas; he enhances the beauty of the landscape and does not detract from it.'

(Stapledon, 1937, pp. 65-66)

Now that we have a superabundance of his 'clean' green fields, I doubt many would agree with him.

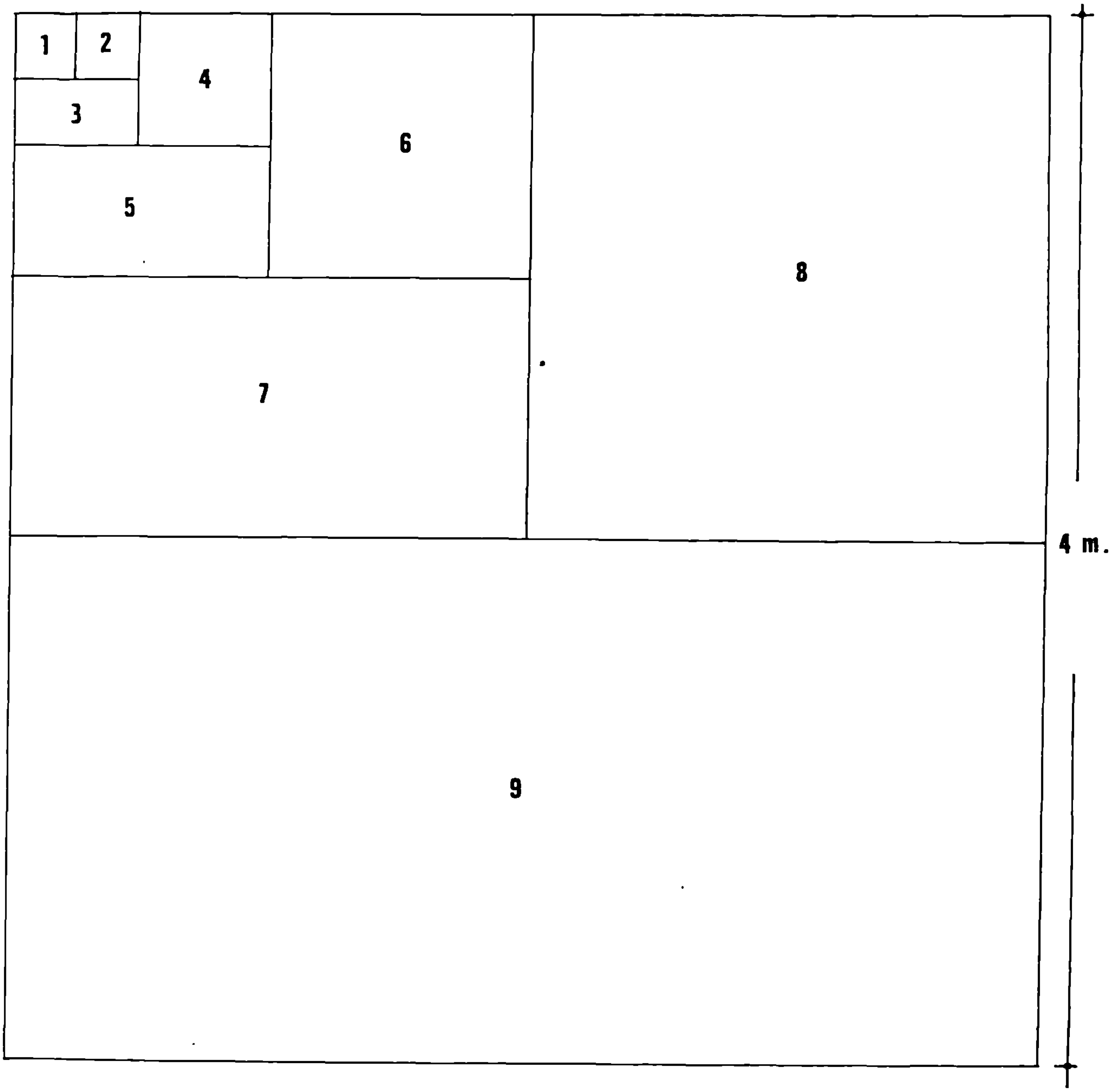
APPENDIX 1 - MINIMAL AREA STUDIES

As a result both of the natural spacing of some species and of the heterogeneity of vegetation, the number of species recorded from a surface area quadrat is dependent on the size of the quadrat studied. It is a well-known fact that above a certain size, the number of species added as the area sampled is increased becomes a very small proportion of the total number of species recorded. Thus, a curve of quadrat size versus species number rises steeply at first and then flattens out. For a student of vegetation, the shape of this curve is important. Only if a community is sampled by a quadrat of the area at which the number of species begins to increase only very slowly, that is, at roughly the point of inflection of the curve, can one say that the community has been sampled both adequately and efficiently. A smaller quadrat would omit an unacceptably high proportion of the species found in the community; a larger quadrat would take more time to study than was justified by the one or two extra species recorded.

Early workers described the curves for many communities and, defining many different means of recognising the point of inflection at which the so-called minimal area was reached, published minimal area values for different communities. The various methods used are described in, for example, Grieg-Smith (1983) and Hopkins (1957). Some workers felt that study of species number/area curves did not yield a valid minimal area value. Other characteristics of the community were therefore used and various ways of recognising the minimal area, derived. More recently, some workers have questioned the validity of the concept of minimal area itself (e.g. Hopkins, 1957). Notwithstanding these theoretical objections, it is a valuable exercise to study the increase in species number seen with increasing quadrat size. Studies of temperate grasslands by early workers suggested that a $4m^2$ quadrat provided an adequate representation of the communities. Some work in Britain has, nonetheless, used a $1m^2$ quadrat.

Five fields in northern England were studied, during July, in order to examine the influence of size of quadrat on the number of species recorded. Three fields were unploughed but were examples of a relatively species-poor sward (fields 1 to 3); two were of Site of Special Scientific Interest hay meadow quality (fields 4 and 5). In each, a grid was laid out as in figure 9 and the species recorded, firstly in the smallest area (1/16th m^2) and then additional species recorded for each area which when added to that already sampled gave a doubling of the area sampled. From this, the following totals were recorded.

FIGURE 9-- GRID FOR MINIMAL AREA STUDY.

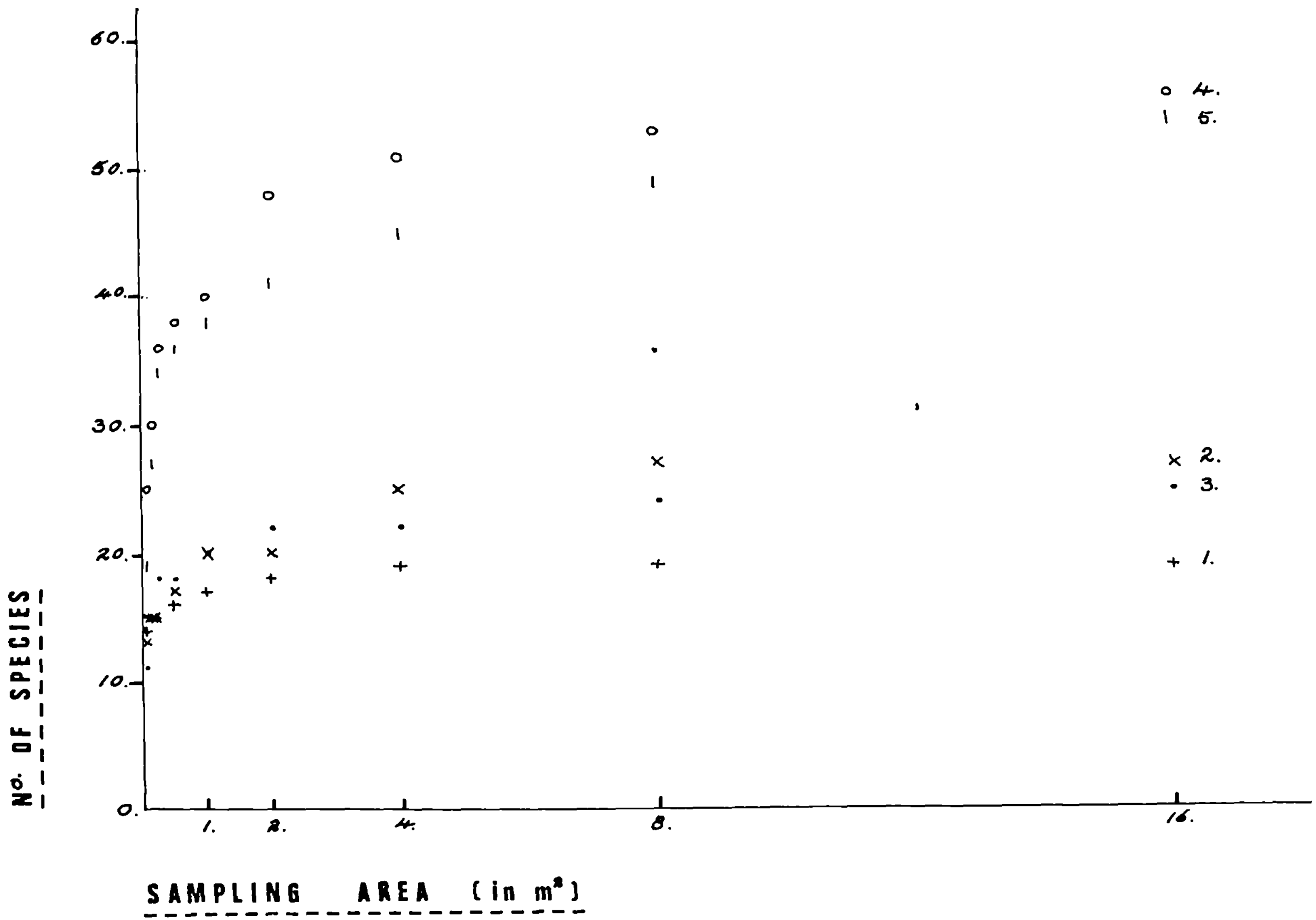


Numbers of species recorded in contiguous quadrats of varying sizes in five fields:

Size of quadrat (m^2)	Field number 1	2	3	4	5
1/16	14	13	11	25	18
1/8	15	15	15	30	26
1/4	15	15	18	36	33
1/2	16	17	18	38	35
1	17	20	20	40	37
2	18	20	22	48	40
4	19	25	22	51	44
8	19	27	24	53	48
16	19	27	25	56	53

The method of calculating the minimal area sought to locate the so-called point of inflexion of the curve of species number versus area of sample - that point at which the rate of change of the gradient of the curve is greatest. A log transformation of the species number values was carried out to linearise the relationships and then the log species number was linearly regressed onto the area of sample. Using the line so obtained, the first, second and third derivatives were obtained and hence the radius of curvature for all points on the number of species/area curve, that is, for all values of area, iterating by successive approximation to obtain the minimum radius, i.e. the point of inflexion of the curve. This was carried out for each field. The curves are illustrated in figure 10. The areas of sample at the point of inflexion are given below.

FIGURE 10 -- NUMBER OF SPECIES VERSUS SAMPLING AREA



Field	Area at point of inflexion
1	0.7 m^2
2	4.0 m^2
3	2.0 m^2
4	1.6 m^2
5	4.0 m^2

One can see that a quadrat size of $4m^2$ can be considered to give adequate representation of the hay meadow vegetation both in the species-rich and the species-poorer swards.

APPENDIX 2 - METHODS OF GRASSLAND RECORDING

A brief study was carried out to compare different sampling methods that have been used on grassland. This work was influenced by a similar study carried out by Poissonet and Poissonet (1969) (see also, Poissonet et al, 1973). Similar early work includes Davies (1931), de Vries (1937, 1958), de Vries and de Boer (1959) and Brown (1954). Perhaps the method to incur most debate is that of point quadrats (e.g. Levy and Madden, 1933; Fenton, 1933; Goodall, 1952).

This study was carried out during June 1986 on a more-or-less uniform area of unimproved meadow in Upper Swaledale. A grid 32m x 32m was laid out, with string defining 64 squares each 4m x 4m. Two secondary and tertiary grids were laid out in each quadrant of the main grid, with 1m x 1m and 0.5m x 0.5m squares, respectively (see figure 11 and plate 3). Five sampling techniques were used (see table 8), chosen to represent the range of methods which have been used in grassland surveying:

* Line transects
* Bayonet point-quadrats
* Multiple point-quadrat frame
* $0.25m^2$ surface quadrat shapes
* 2m x 2m surface quadrats randomly

Line transects

128 25cm contiguous sectors were studied, running down the entire length of the G line (see figure 11). All species lying in the line of study were recorded.

Bayonet point-quadrats

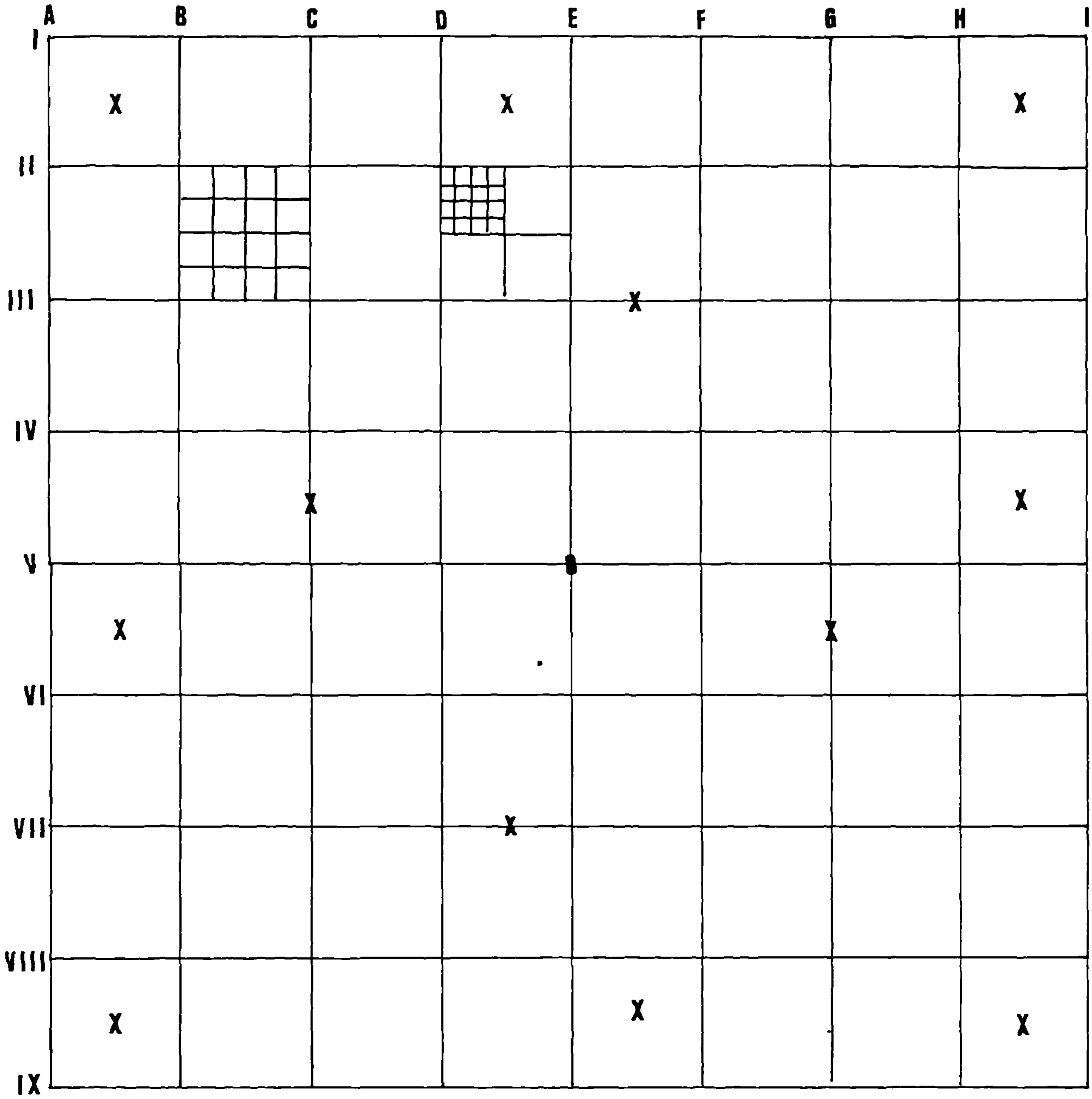
A bayonet designed for use in tall grassland vegetation by Poissonet et al (1972) was used (see plate 4). All leaves touching the blade edge were recorded. Four methods of sampling were used in each quadrant:

* a grid of 20 points 0.5m apart (using the 3° grid)

* a grid of 20 points 1m apart (using the 2° grid)

* a grid of 20 points 4m apart (using the 1° grid)

FIGURE 11-- SAMPLING GRID FOR STUDY OF METHODS OF GRASSLAND SURVEY.



SCALE :- 1 cm = 2 m

NOTES :- (i) X Marks position of surface area samples.
(ii) 2° and 3° grids repeated in all quadrants.

PLATE 3 - Sampling grid used for study of methods of grassland survey, Keld, Upper Swaledale

TABLE 8 - Species recorded using different methods

TAXA	METHOD									
	1	2	3	4	5	6	7	8	9	10
Agropyron repens	35.9	17.5	8.8	22.5	26.3	6.9	66.7 (3)	91.7 (2)	83.3 (2)	2
Agrostis stolonifera		2.5								
Agrostis tenuis	19.5	11.3	15.0	20.0	3.7	7.8	41.7 (4)	41.7 (3)	41.7 (3)	
Alopecurus pratensis	10.9	3.8	1.3	6.3	1.3	0.6		8.3 (3)	8.3 (3)	3
Anthoxanthum odoratum	75.0	52.5	46.3	42.5	36.3	34.7	100.0 (5)	100.0 (5)	100.0 (5)	6
Arrhenatherum elatius	1.6		1.3		2.5	0.9			8.3 (2	
Bromus mollis	7.8									
Cynosurus cristatus	86.7	53.8	48.8	26.3	65.0	39.4	83.3 (3)	91.7 (3)	91.7 (3)	3
Dactylis glomerata	76.7	37.5	40.0	32.5	40.0	18.8	100.0 (4)	100.0 (4)	100.0 (3)	3
Festuca rubra	97.7	75.0	76.3	80.0	78.8	47.5	100.0 (5)	100.0 (6)	100.0 (5)	5
Helictotrichon pubescens	56.3	20.0	13.8	17.5	22.5	9.1	66.7 (?)	75.0 (2)	83.3 (2)	2
Holcus lanatus	75.8	11.3	33.8	27.5	43.8	27.5	100.0 (4)	100.0 (4)	100.0 (4)	3
Lolium perenne			3.8							
Phleum pratense		2.5	1.3				8.3 (1)	8.3 (1)	8.3 (1)	
Poa pratensis	38.3	28.8	17.5	20.0	21.3	7.8	58.3 (3)	50.0 (3)	50.0 (3)	4
Poa trivialis		1.3	1.3	1.3		0.3	16.7 (2)	16.7 (2)	16.7 (2)	
Trisetum flavescens	5.5	5.0	5.0	2.5	6.3	1.6	16.7 (2)	16.7 (2)	8.3 2	
Ajuga reptans	0.8			1.3						
Alchemilla glabra	0.8									2
Anemone nemorosa	4.7	1.3	1.3							
Bellis perennis	38.3	7.5	10.0	7.5	5.0	8.1	91.7 (3)	91.7 (3)	91.7 (3)	4
Cardamine hirsuta						0.3				
Cardamine pratensis	21.9	3.8	5.0	3.8	1.3	2.2	66.7 (2)	66.7 (2)	75.0 (2)	2
Cardamine sp.							16.7 (2)	16.7 (2)	16.7 (2)	
Cerastium holosteoides	54.7	20.0	11.3	12.5	18.8	16.6	91.7 (3)	91.7 (3)	91.7 (3)	4
Conopodium majus	46.1	11.3	7.5	13.8	8.8	8.4	91.7 (3)	100.0 (4)	100.0 (4)	3
Crataegus monogyna							8.3 (1)	8.3 (1)	8.3 (1)	
Filipendula ulmaria	4.7									
Heracleum sphondylium				3.8						
Lathyrus pratensis	3.9	2.5			1.3		8.3 (2)	8.3 (2)	8.3 (2)	
Leontodon autumnalis						0.9	8.3 (2)		8.3 (2)	
Luzula camp./mult.	48.4	11.3	7.5	17.5	16.3	12.2	91.7(2)	83.3 (3)	83.3 (3)	1
Plantago lanceolata	63.3	17.5	12.5	12.5	13.8	21.3	100.0 (5)	100.0 (4)	100.0 (5)	5
Ranunculus acris	70.3	32.5	16.3	16.3	22.5	14.7	83.3 (4)	83.3 (5)	66.7 (5)	3
Ranunculus bulbosus	41.4	17.5	10.0	23.8	15.0	12.5	83.3 (3)	83.3 (3)	83.3 (4)	4
Ranunculus ficaria	39.8	22.5	11.3	20.0	15.0	7.5	66.7 (4)	58.3 (4)	66.7 (4)	2
Ranunculus repens		1.3				10.9	8.3 (1)	8.3 (1)	25.0 (3)	
Ranunculus sp.	7.8	5.0	5.0	5.0		2.8				
Rumex acetosa	31.3	11.3	15.0	7.5	6.3	3.8	91.7 (3)	91.7 (3)	91.7 (4)	4
Taraxacum officinale agg.						0.6				2
Trifolium pratense	1.6					0.3		16.7 (2)	8.3 (2)	1
Trifolium repens	62.5	16.3	23.8	26.3	23.8	9.1	100.0 (4)	100.0 (4)	100.0 (4)	4
Veronica chamaedrys	20.3	2.5		1.3	2.5	2.8	58.3 (2)	58.3 (2)	58.3 (2)	1
Veronica serpyllifolia	1.6		1.3			0.9	16.7 (2)	8.3 (2)	8.3 (2)	
Brachythecium rutabulum	32.0	10.0	12.5	8.8	8.8	8.8	91.7 (3)	75.0 (3)	83.3 (3)	3
Calliergon cuspidatum								8.3 (2)	8.3 (2)	
Eurhynchium praelongum	35.2	16.3	11.3	11.3	13.8	13.8	66.7 (2)	58.3 (3)	66.7 (3)	3
Rhizomnium sp.							8.3 (2)			
Rhytidiadelphus squarrosus	6.3		2.5	7.5	1.3	0.6	41.7 (2)	41.7 (3)	41.7 (3)	
TOTAL NO. OF TAXA (49)	36	31	32	29	30	36	33	34	36	26

Methods

1 Line transect - % frequency of occurrence
2 0.5m bayonet - % frequency
3 1m bayonet - % frequency
4 4m bayonet - % frequency
5 Random bayonet - % frequency
6 Multiple point-quadrat frame - % frequency
7 Rectangle surface quadrat - % frequency (median Domin value)
8 Square surface quadrat - % frequency (median Domin value)
9 Circle surface quadrat - % frequency (median Domin value)
10 Random $4m^2$ surface quadrat - median Domin value

* 20 randomly positioned points (using randomly generated numbers as co-ordinates of the grid)

Multiple point-quadrat frame

This frame was produced according to the design of Long et al (1972), to which reference should be made for the reasoning behind the features of the instrument (see plate 5). The frame was placed once in each quadrant and all plants touched by each descent of the fine pin were recorded. Each frame placement records 80 positions at 2.5cm intervals.

Surface quadrat shapes

Three $0.25m^2$ metal frames were used, shaped in a square, a rectangle and a circle. They were placed with the centre of the shapes constant. Three placements were carried out in each quadrant at the positions marked on figure 11. The order of sampling between the three shapes at each placement was varied. All species present and their value on the Domin scale of cover/abundance were recorded.

Random surface quadrats

Two 2m x 2m samples were taken at 'random' within the 32m x 32m grid. All species present and their value on the Domin scale of cover/abundance were recorded.

All methods were carried out within five days. The time spent on each method was recorded. Observations were made by four experienced field botanists. Between-observer variance was not assessed since all observers took samples in all methods used.

Comparison of methods

The purpose of each and any of these methods is to give one an adequate description of the vegetation which is being sampled. It is, however, difficult to define what an 'adequate' description is. Poissonet and Poissonet (1969) worked on the basis that the point-quadrat frame provided the most accurate and faithful description of vegetation and so compared, via the calculation of various mathematical descriptors, the other methods used with the results obtained by the point-quadrat frame method. An important

PLATE 4 - Bayonet used for sampling

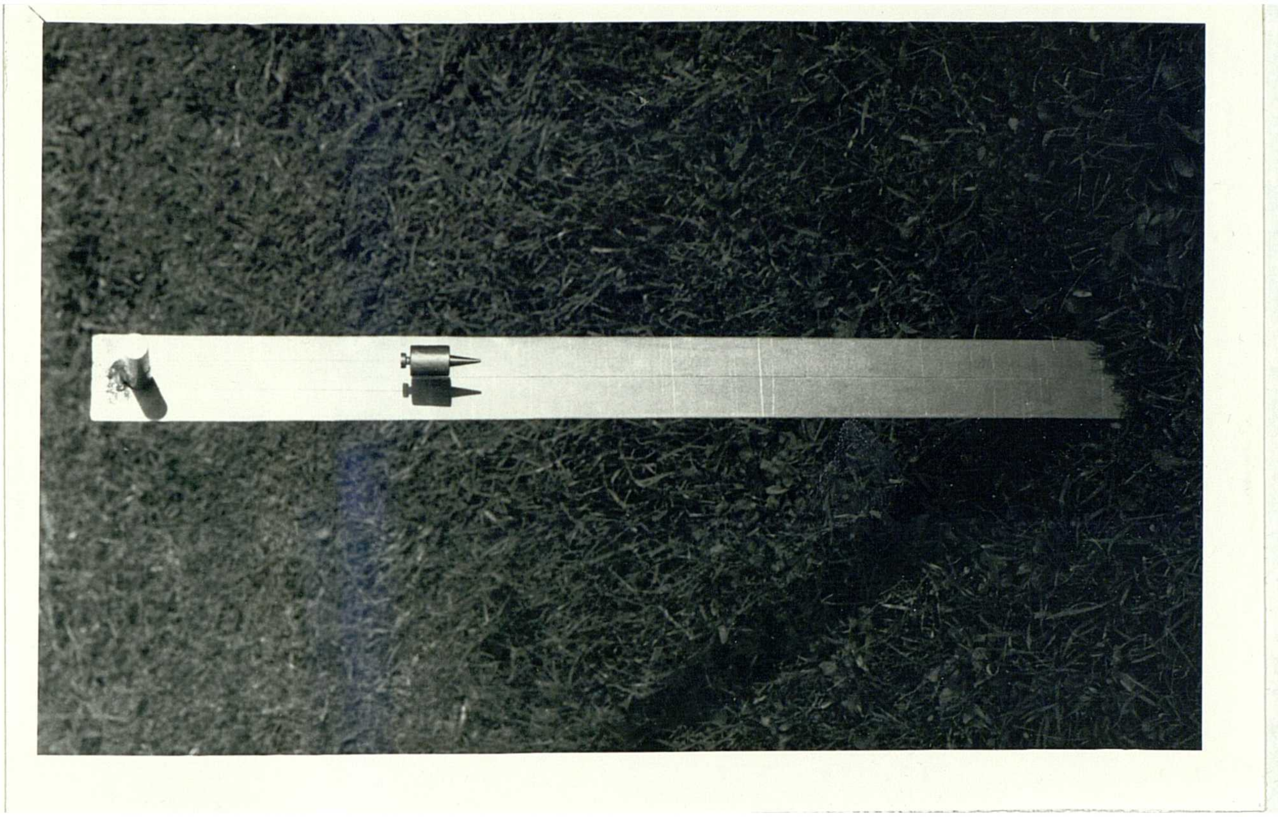
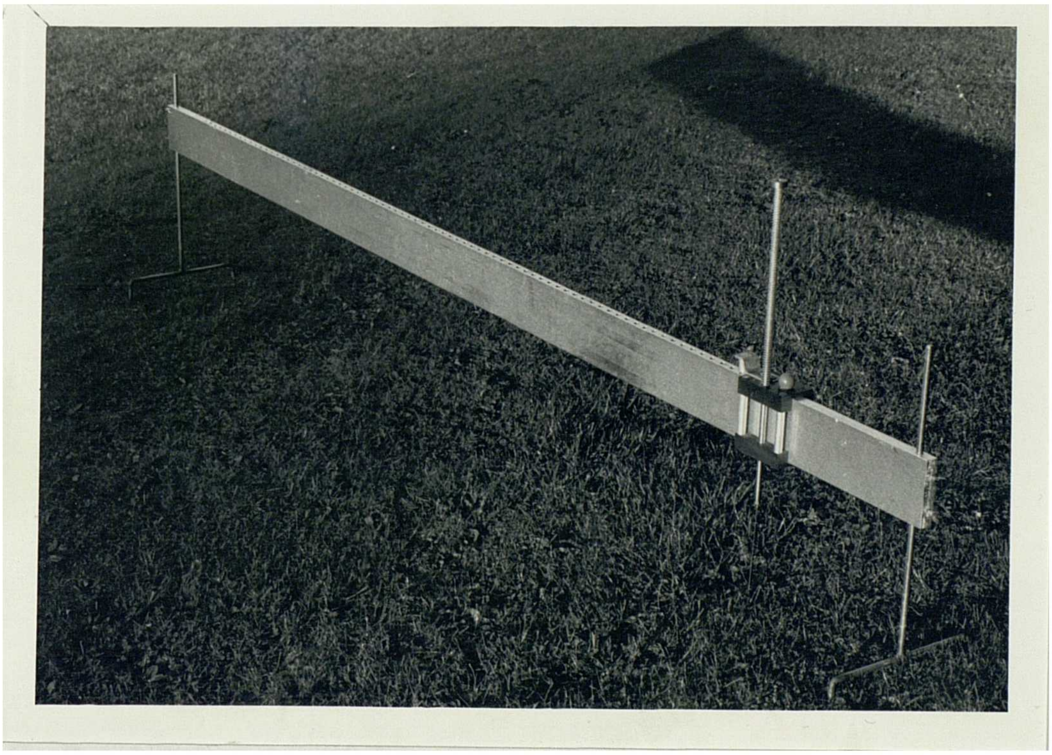


PLATE 5 - Multiple point-quadrat frame used for sampling



point to emphasise is that a method can only be compared usefully with another method if both have been correctly used. Inevitably, as one takes more samples from the vegetation, whichever method one uses, the accuracy of description of the vegetation will rise. Eventually, the increase in such accuracy will be very small and it will be deemed to be an inefficient use of time and resources to continue sampling; this point will often be defined by some more-or-less subjective criterion. The number of samples which must be taken to reach this point of 'practical maximum accuracy of description' will vary between methods. It would be meaningless to compare two methods unless this point had been reached in both methods.

For the purposes of the comparison, in this study the number of species recorded was used as a measure of the 'success' of the method used. It should not be forgotten, however, that the number of species recorded is not the only criterion which could be considered when assessing these methods. All the methods except the transect of contiguous segments gave one quantitative information for each sample (see table 9). Obviously, the precision of this information and how well the vegetation is described by these data is important. However, this is difficult to assess and an easier method of allowing a comparison between methods is to compare their ability to record the species present, taking no account of how well the amount of any one species present is noted.

The transect ran through the two eastern quadrants and so has been assessed against the total number of species found in this eastern half of the study grid. The two randomly-positioned 2m x 2m quadrats were samples of the entire grid. The other surface area quadrats can similarly be taken as sampling the entire grid. There are 12 samples of each of the three sampling shapes. In calculating the number of samples/number of species recorded values (see table 9), care was taken not to consider the three samples within one quadrant together before moving onto a second quadrant; in this way, heterogeneity in the vegetation would have produced an uneven increase in total species numbers recorded. Rather, samples were taken from each quadrant in turn.

The various bayonet methods were assessed for each quadrant, since the spacing of the samples was important and amalgamating samples from different quadrants would (except for the 4m spacing) have disturbed the continuity of this spacing. In order to allow comparisons between the different spacings, the 4m-spaced bayonet method was also assessed for each quadrant, rather than for the entire area.

The frame of points is a more difficult method to consider. The frame has 80 points which therefore restricts the sample size to multiples of 80. One can thus assess either the number of points required to sample a certain proportion of the species present in an

TABLE 9 - Comparison of methods of recording grassland vegetation.

METHOD	NO. OF SAMPLES	TIME (MIN)	TOTAL NO. OF SPECIES	NO. OF PEOPLE	INFO.[1]
Transect of segments	128	303	36	2	L
Bayonets - 0.5m	80	137	31	2	N
- 1m	80	120	32	2	N
- 4m	80	208	29	2	N
- random	80	186	30	2	N
Point quadrat frame	4 x 80	339	36	2	N
Surface quadrats - rectangle	12	125[2]	33	1	N
- square	12	124[2]	34	1	N
- circle	12	98[2]	36	1	N
Random 2m x 2m	2	20	26	1	N

[1] L corresponds to qualitative data; N corresponds to quantitative data (see text).

[2] These timing values are not directly comparable, since unfortunately the rectangular and circular samples were sampled after the square samples more often than before.

area, although this is unlikely to correspond exactly to an absolute number of placements of the frame, or one can consider the number of species recorded by each placement of the frame within a larger area. Since only four placements of the frame were used in this study and each placement, to some extent, records different species, then the order in which one considers the placements can affect the number of species recorded by the ascending number of placements. Therefore, in this study, the proportion of species found in the relevant quadrant by the pins in each placement of the frame was considered.

Results

In order to linearise the relationships, the results were plotted on semi-logarithm paper. These plots of percentage of total species recorded versus the log of number of samples taken are found in figures 12a-e. Since the transect of segments passed only through the two eastern quadrants and some species additional to those recorded by the other methods carried out were recorded by the transect of segments, the total number of species recorded in the two eastern quadrants exceeded that for the two western quadrats (40 and 39, as compared with 36 and 34). As a result, the proportion of total species number recorded by any one method in one of the two eastern quadrants tends to be smaller than that recorded by the same method in one of the two western quadrants, although the actual number of species may be very similar in both cases. The plots were therefore restricted to individual quadrant results, comparisons between methods being made only within any one quadrant (for those methods assessed on a quadrant basis). The results for the surface area samples, which were assessed on an entire area basis, and the transect of segments are shown on a fifth plot.

The number of samples required to give 80% total number of species recorded in the sample area (be it quadrant or entire sample area etc.) was read off the plots, for each method. The mean number of samples required to give 80% total number of species was then calculated where there were four plots, one for each quadrant. Given the mean time taken to collect each sample, the time taken to take the mean number of samples calculated above was then worked out. These are shown below, in order of increasing time required.

FIGURE 12a -- N.E. QUADRANT - Number of species versus number of samples.

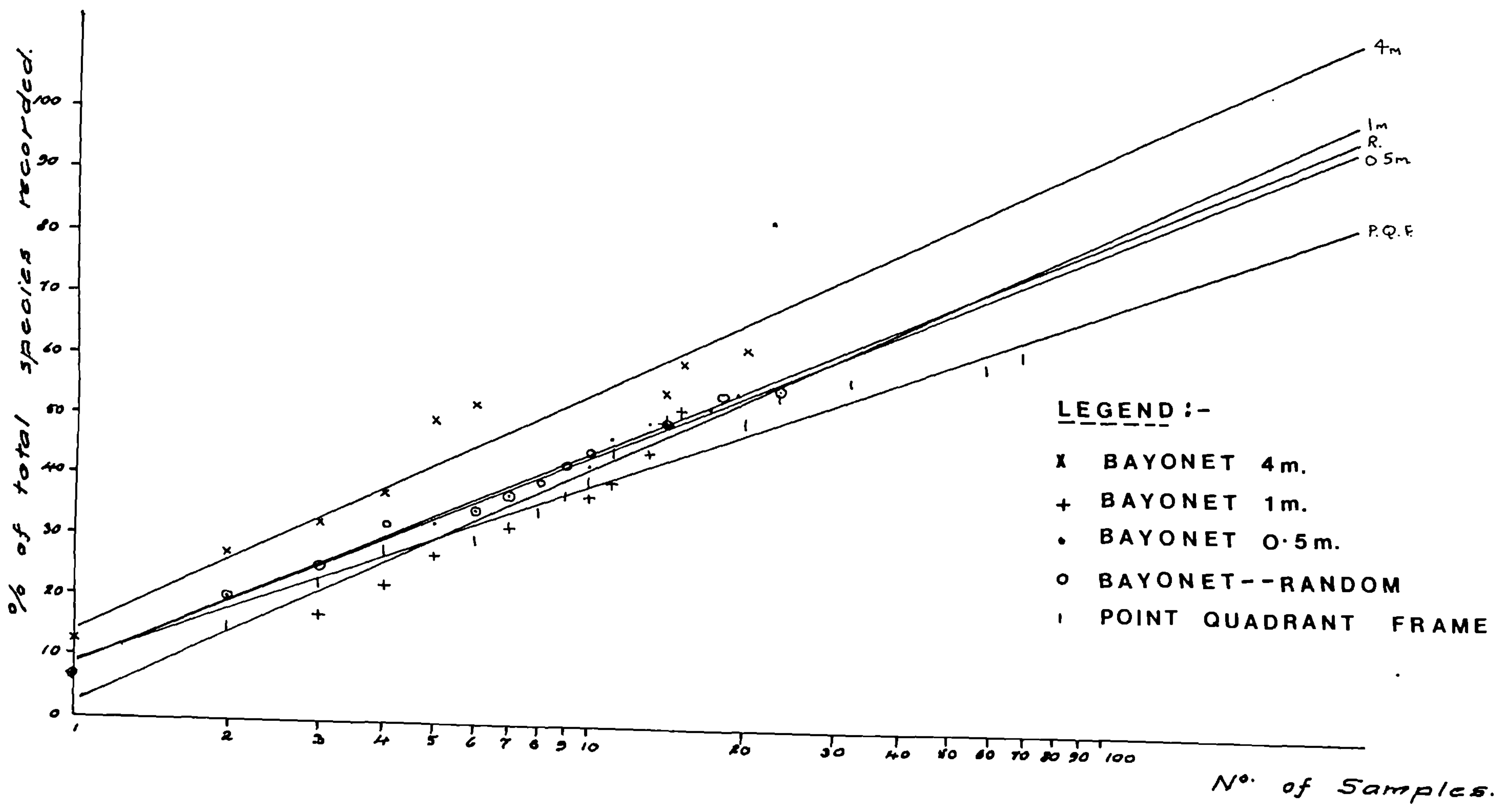


FIGURE 12b-- N.W. QUADRANT- Number of species versus number of samples.

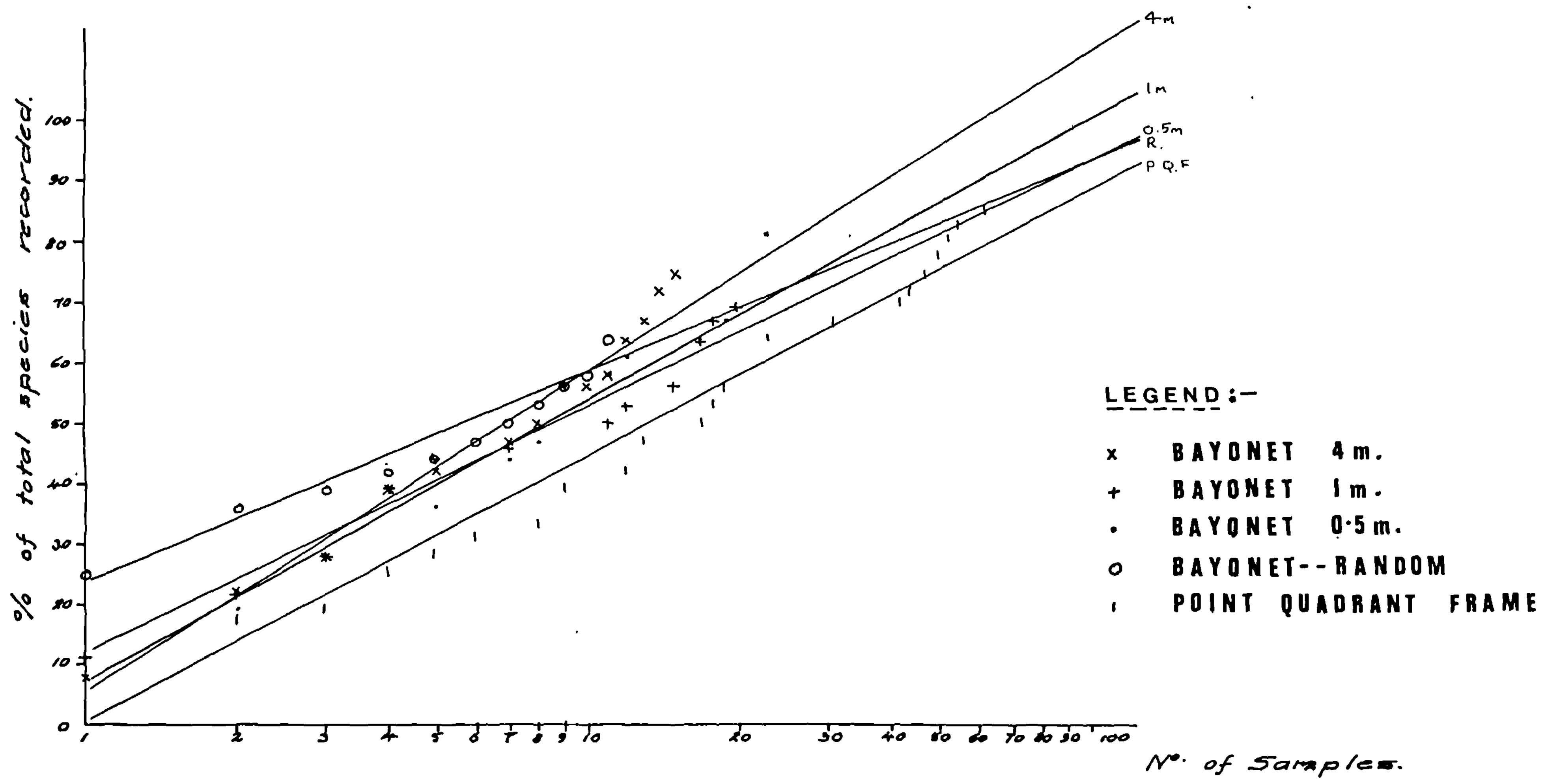


FIGURE 12c -- S.E. QUADRANT - Number of species versus number of samples.

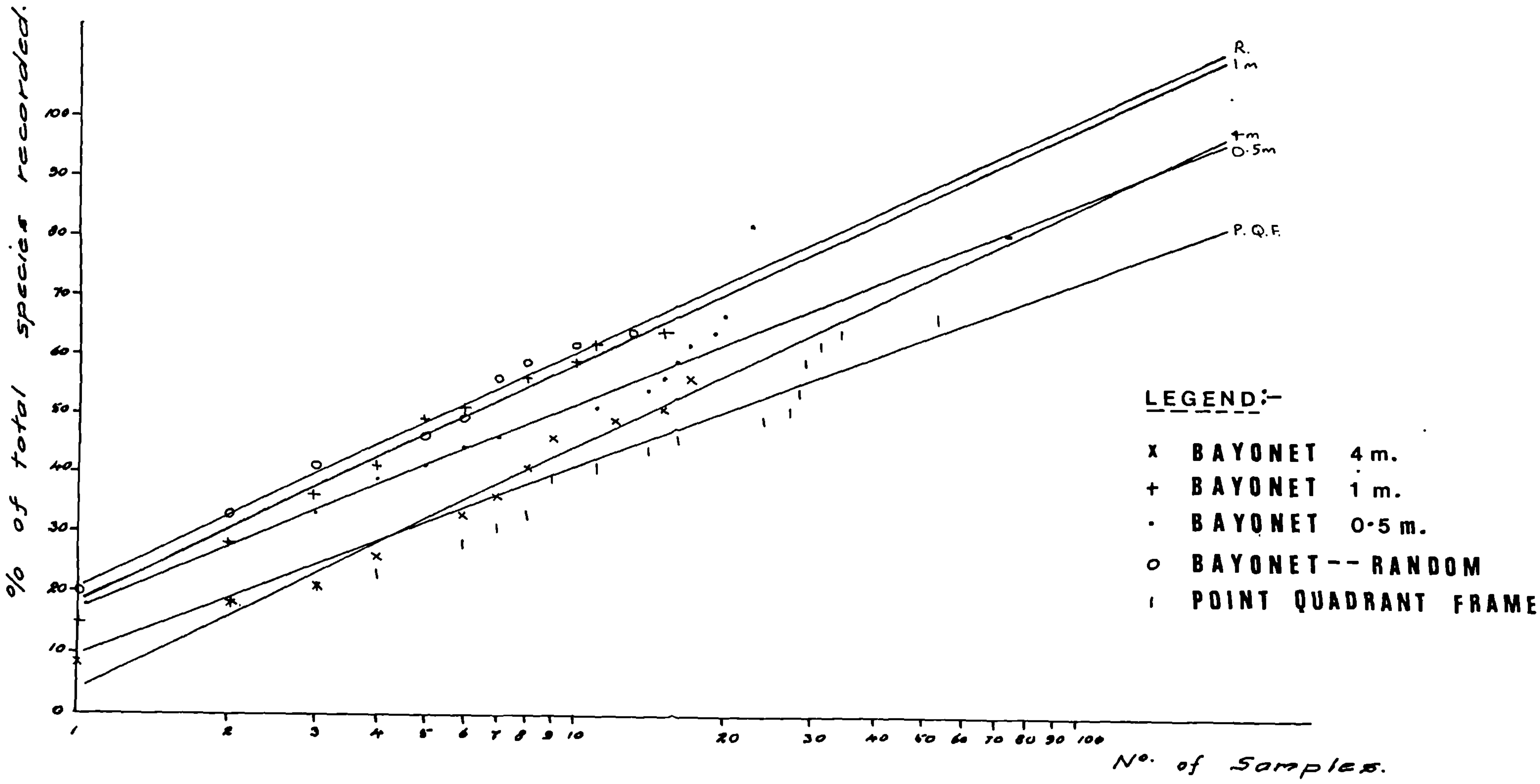


FIGURE 12d-- S.W. QUADRANT - Number of species versus Number of samples.

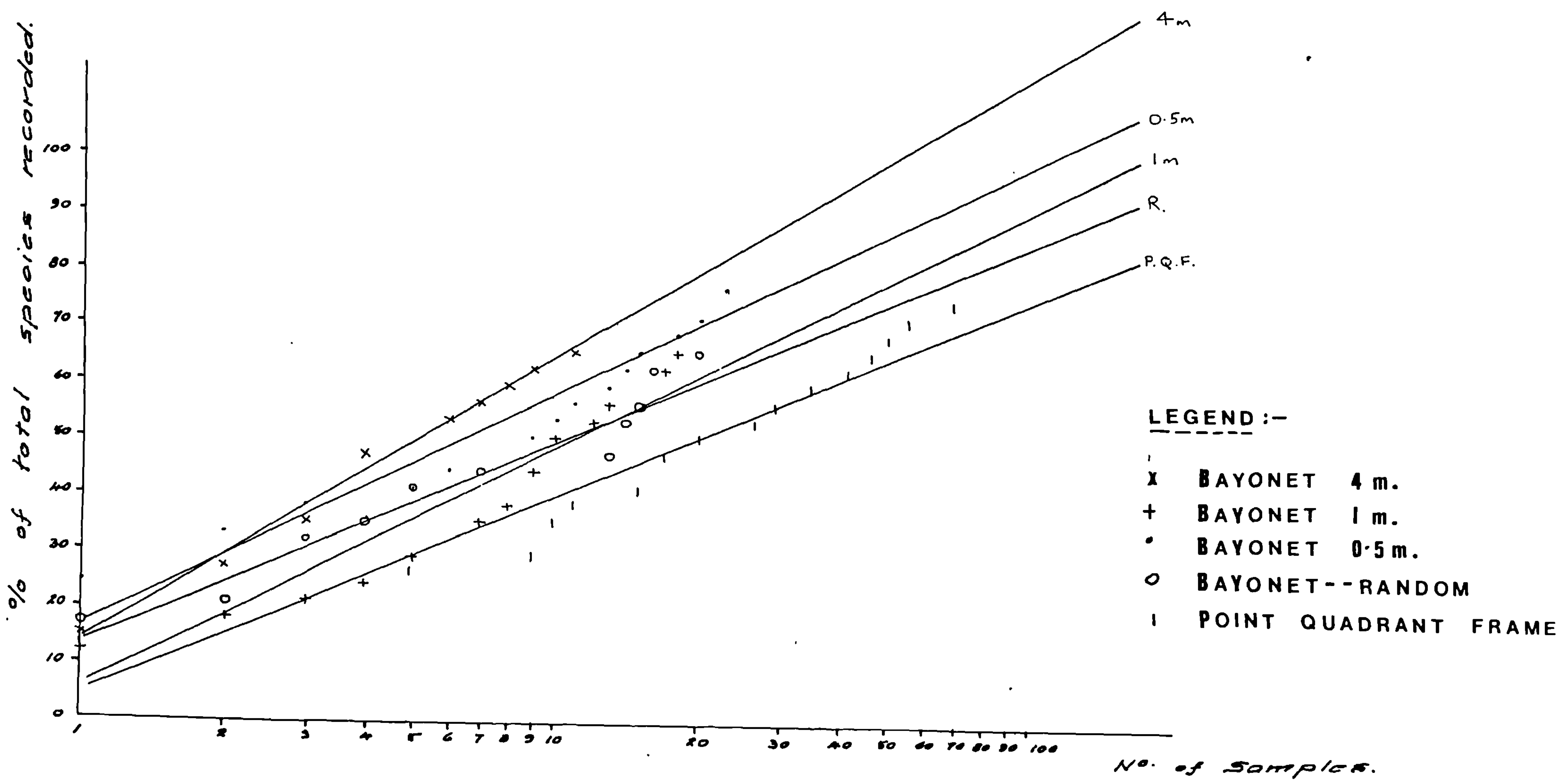
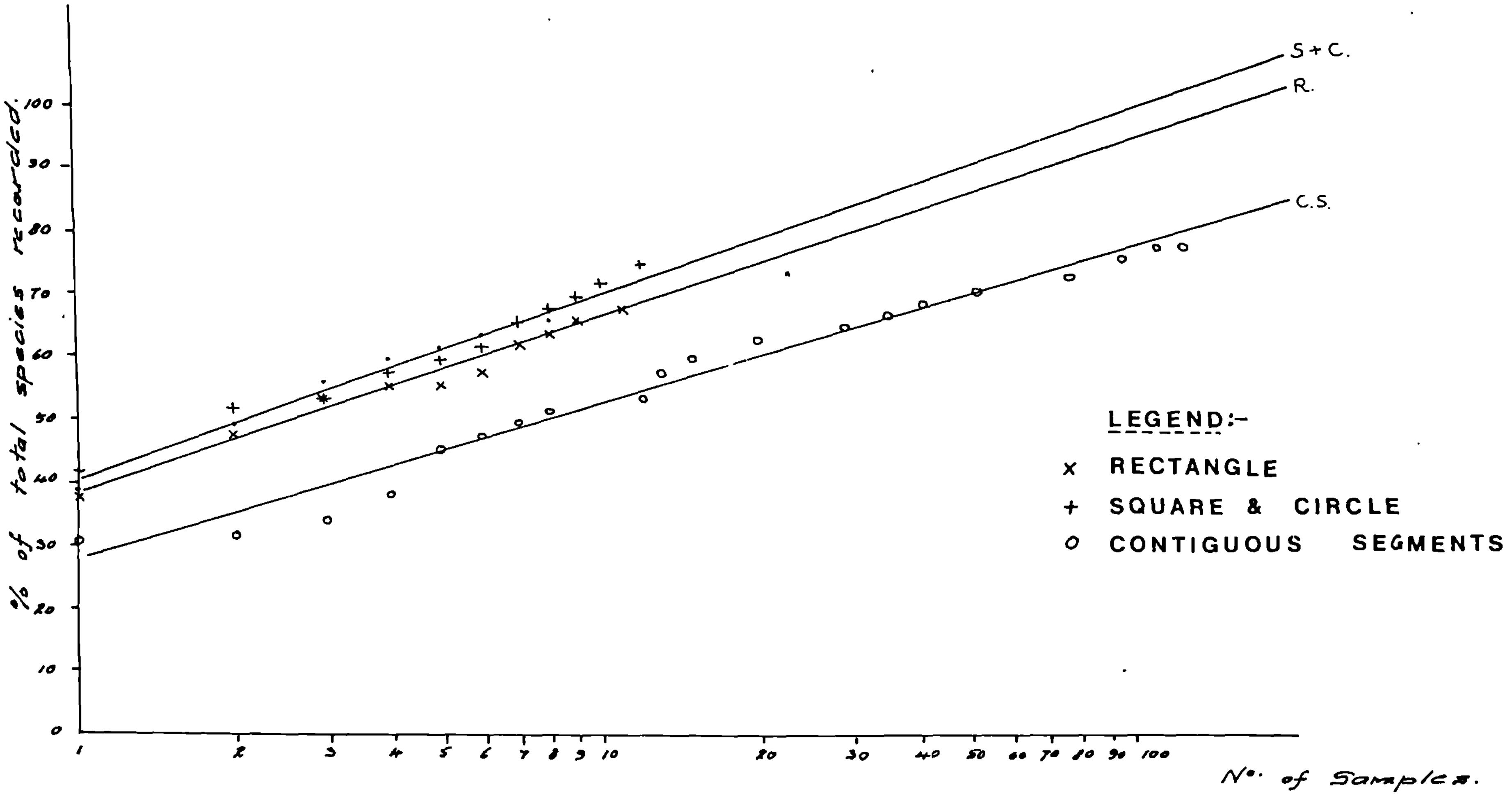


FIGURE 12e--Number of species versus number of samples- surface areas and segments.



Number of samples and time required to record 80% species in sample area:

Method	(Mean) no. of samples	Time (min)
1m bayonets	55.8 +/- 23.3	84
0.5m bayonets	58.8 +/- 30.6	101
4m bayonets	40.5 +/- 24.2	105
Random bayonets	59.0 +/- 29.0	137
Point q. frame	144.5 +/- 61.6	153*
Circle q.	23	207
Square q.	23	238
Segments	130	308
Rectangle q.	31	323

* For two placements of the frame (160 points), 170 minutes are required.

It should be remembered that the time taken to carry out any one method is to some extent a function of the number of times that method is used. It would be unwise to attach too much significance to the increased number of rectangular quadrats required, when compared with the other two shapes of surface area quadrats, to sample 80% species, since only two curves were used to calculate these values. As can be seen from the standard deviation figures given above, there is much variation in the number of samples required to record 80% species; to some extent, this is as a result of the total number of species recorded in each quadrant (the comparative richness of the eastern quadrants, as discussed above).

These results vary quite markedly from those obtained by Poissonet and Poissonet (1969), who found, for example, that the segments and the surface area quadrats were amongst the most rapid methods. It is possible that with an increased number of samples of each method, results closer to those of the comprehensive French study would have been obtained.

APPENDIX 3 - TEMPORAL CHANGES IN MEADOW VEGETATION

A number of permanent 2m x 2m quadrats were established in hay meadows in upper Swaledale, northern England, by placing corner posts in the ground, at soil surface level so as not to prevent the passage of agricultural machinery. Every two weeks or so, from May until September (the period over which the animals are out of the fields), the quadrats were relocated and a standard relevé taken, recording the species observed, using the Domin scale of cover/abundance, as during the main survey. Although only a limited number of species was found in these quadrats, a standard recording form was not used, so that each recording of the quadrat should be, as far as was possible, uninfluenced by the previous one. A two-week interval was chosen as being sufficiently long to allow the development of a measure of unfamiliarity with the quadrats but also short enough to allow a sufficient number of samples to be taken during the season. Problems were encountered in trying to relocate the quadrats once the grass was growing tall, despite careful pacing and the use of nails in the wooden posts to allow a metal detector to be used. Thus, although 20 permanent quadrats were established, only 12 were followed throughout the season and some of these were not recorded on every visit. Following the cutting of the hay crop, the species present in the stubble could not all be identified for several days and so most quadrats were not sampled if a visit followed closely after the fodder removal.

The results are shown in tables 10a to 10f. Oblique strokes are used to indicate unrecorded dates. From the species totals at the base of the columns, one can note the following general trends: an increase in the number of species recorded until the time of cutting, after which fewer species are recorded, with the number recorded increasing once again after a few weeks. Anyone who observes vegetation, even casually, will be aware of the seasonal developments that take place. Some species may be absent early in the season. Others may die down and disappear. In the early stages of their growth, some species are morphologically distinct from their mature forms; this is perhaps especially true of annuals. Two or more species which are vegetatively very similar may remain undistinguished until they flower, since floral morphology is generally more distinct. Thus, small amounts of one grass amongst large amounts of another may remain unobserved until the plant flowers. The relative cover values of the species in the community may alter during the season, reflecting the different species' abilities to expand.

When the number of species recorded declines rather than rising, this can be attributed to a denser sward masking some species present, particularly those smaller and more poorly represented species. Following cutting, a fall in species number is to be expected

TABLE 10a - Species recorded in fixed quadrats during the growing season from Field 1

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Poa trivialis	-	-	2	/	/	-	M	-	-	3	/	/	-	-
Anthoxanthum odoratum	5	4	6	/	/	3		5	M	5	/	/	3	2
Lolium perenne	5	-	-	/	/	-								
Holcus lanatus	5	5	4	/	/	5		5		3	/	/	6	5
Dactylis glomerata	3	4	4	/	/	5		4		5	/	/	6	5
Helictotrichon pubescens	3	2	2	/	/	4		-		4	/	/	2	3
Festuca rubra	4	5	7	/	/	6		4		5	/	/	7	7
Arrhenatherum elatius	2	-	-	/	/	-								
Cynosurus cristatus	-	3	4	/	/	-		-		3	/	/	2	2
Poa pratensis	-	2	-	/	/	-		-		-	/	/	-	2
Agropyron repens	-	2	-	/	/	2		-		4	/	/	-	3
Rumex acetosa	5	4	4	/	/	5		4		5	/	/	5	5
Cerastium holosteoides	4	3	4	/	/	2		3		4	/	/	3	2
Plantago lanceolata	4	5	5	/	/	7		4		5	/	/	6	6
Trifolium repens	4	7	7	/	/	6		3		7	/	/	7	5
Conopodium majus	5	5	6	/	/	-		7		5	/	/	-	-
Ranunculus ficaria	3	2	-	/	/	-		4		-	/	/	-	-
Bellis perennis	3	3	3	/	/	3		3		3	/	/	3	3
Ranunculus bulbosus	5	5	4	/	/	-		-		3	/	/	-	-
Cardamine sp.	3	2	2	/	/	3		2		2	/	/	3	3
Alchemilla glabra	1	-	1	/	/	-								
Anemone nemorosa	2	1	-	/	/	-		2		-	/	/	-	-
Veronica chamaedrys	1	1	2	/	/	1		1		2	/	/	2	-
Lathyrus pratensis	-	1	2	/	/	-		3		-	/	/	-	-
Ranunculus acris	-	6	5	/	/	6		4		7	/	/	4	5
Trifolium pratense	-	4	4	/	/	-		-		+	/	/	2	-
Heracleum sphondylium	-	-	1	/	/	-								
Luzula camp./mult.	3	3	3	/	/	2		3		2	/	/	2	2
Brachythecium rutabulum	3	-	-	/	/	3		2		3	/	/	-	4
Eurhynchium praelongum	2	3	3	/	/	3		2		-	/	/	-	3
Rhytidiadelphus squarrosus	-	-	2	/	/	-		2		-	/	/	-	-
Trisetum flavescens	-	-	2	/	/	-		-		2	/	/	-	-
Agrostis tenuis	-	-	-	/	/	2								
Bromus mollis								-		2	/	/	-	-
TOTAL	22	24	25			17		20		22			16	18

TABLE 10b - Species recorded in fixed quadrats during the growing season from Field 2

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Anthoxanthum odoratum	5	4	5	5	/	-	M	4	4	5	M	/	2	3
Holcus lanatus	6	4	4	6	/	5		5	3	3		/	6	5
Poa pratensis	2	-	2	2	/	-		2	3	2		/	-	3
Agrostis tenuis	2	3	5	3	/	-		-	3	5		/	3	3
Dactylis glomerata	4	3	2	4	/	5		3	3	5		/	4	5
Bromus mollis	2	-	-	-	/	-		2	-	-		/	-	-
Festuca rubra	5	5	5	6	/	7		6	6	7		/	7	8
Alopecurus pratensis	2	-	-	-	/	-		-	-	-		/	-	1
Poa trivialis	-	4	3	3	/	-		-	4	2		/	-	-
Helictotrichon pubescens	-	2	3	2	/	2		-	-	-		/	2	-
Cynosurus cristatus	-	-	3	3	/	-		-	-	4		/	-	-
Trisetum flavescens	-	-	3	5	/	-								
Agrostis canina								2	-	-		/	-	-
Luzula camp./mult.	3	2	3	2	/	2		3	2	3		/	2	3
Rumex acetosa	5	4	5	5	/	3		5	4	3		/	2	4
Cerastium holosteoides	2	2	3	3	/	2		2	2	3		/	3	3
Conopodium majus	8	7	8	7	/	-		8	7	7		/	-	-
Ranunculus acris	4	4	-	2	/	2		3	4	3		/	4	4
Heracleum sphondylium	2	2	4	4	/	4		2	4	4		/	3	2
Trifolium repens	3	7	7	5	/	6		2	4	7		/	7	5
Plantago lanceolata	2	5	4	4	/	4		4	5	4		/	6	-
Veronica chamaedrys	1	1	2	2	/	2		3	1	2		/	2	2
Anemone nemorosa	1	2	-	-	/	-		3	2	2		/	-	-
Achillea millefolium	2	3	3	3	/	3		-	1	-		/	+	3
Prunella vulgaris	1	-	-	-	/	-		1	-	-		/	1	-
Ranunculus bulbosus	-	4	6	4	/	-		-	2	4		/	-	-
Trifolium pratense	-	3	-	2	/	2		-	-	2		/	2	2
Succisa pratensis								2	1	1		/	2	-
Lathyrus pratensis								1	-	1		/	1	-
Potentilla erecta								1	1	2		/	1	-
Lotus corniculatus								1	1	3		/	2	2
Myosotis discolor								-	-	1		/	-	-
Ajuga reptans								-	-	-		/	1	-
Eurhynchium praelongum	2	2	-	3	/	3		2	2	4		/	3	5
Rhytidiadelphus squarrosus	2	-	-	3	/	-		2	2	-		/	-	3
Brachythecium rutabulum	-	4	6	3	/	3								
Mnium hornum								-	-	2		/	-	1
TOTAL	22	22	21	25		16		25	24	27			22	20

TABLE 10c - Species recorded in fixed quadrats during the growing season from Field 3

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Trisetum flavescens	-	-	3	3	/	M	M	-	2	-	M	M	M	M
Anthoxanthum odoratum	5	5	5	5	/			6	5	5				
Dactylis glomerata	2	3	2	3	/			5	2	2				
Holcus lanatus	5	6	4	6	/			5	4	4				
Agrostis tenuis	2	4	4	6	/			-	-	4				
Bromus mollis	2	-	-	1	/			-	-	2				
Festuca rubra	-	6	6	6	/			5	5	4				
Agropyron repens								-	2	-				
Cynosurus cristatus	-	-	4	3	/			-	-	3				
Poa trivialis	-	-	-	3	/			-	-	2				
Lolium perenne	-	-	-	2	/			-	-	2				
Phleum pratense								-	-	+				
Luzula camp./mult.	3	2	3	3	/			3	2	2				
Ranunculus acris	3	-	4	4	/			3	4	3				
Bellis perennis	4	-	+	-	/			-	3	3				
Conopodium majus	5	7	7	4	/			7	7	5				
Plantago lanceolata	4	4	6	7	/			4	6	6				
Heracleum sphondylium	2	2	4	2	/			2	4	4				
Leontodon hispidus	4	-	-	-	/			-	6	7				
Veronica chamaedrys	3	-	+	1	/			-	1	3				
Cerastium holosteoides	3	2	2	3	/			3	2	2				
Alchemilla glabra	3	3	3	-	/			3	4	4				
Rhinanthus minor	3	2	3	3	/			3	2	4				
Leontodon autumnalis	3	-	-	-	/			-	2	1				
Lotus corniculatus	2	-	-	-	/			-	-	1				
Rumex acetosa	2	5	4	5	/			5	2	3				
Cardamine sp.	2	-	-	-	/			-	-	2				
Trifolium repens	2	5	5	4	/			3	4	4				
Geranium sylvaticum	1	+	1	-	/			1	-	+				
Prunella vulgaris	2	-	-	1	/			-	-	2				
Filipendula ulmaria	2	3	2	1	/			2	3	4				
Centaurea nigra	1	-	-	-	/			-	2	2				
Ranunculus bulbosus	-	2	4	-	/			-	2	3				
Taraxacum officinale agg.								-	2	1				
Trifolium pratense	-	-	4	2	/			2	3	4				
Lathyrus pratensis								-	1	-				
Myosotis discolor								-	-	1				
Ranunculus ficaria								2	-	-				
Alchemilla xanthochlora								-	-	+				
Cirsium dissectus								-	-	+				
Brachythecium rutabulum	5	-	-	3	/			4	4	4				
Eurhynchium praelongum	-	3	4	4	/			2	-	4				
Eurhynchium swartzii	-	-	-	2	/									
TOTAL	26	17	22	26				20	27	34				

TABLE 10d - Species recorded in fixed quadrats during the growing season from Field 4

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Alopecurus pratensis	7	-	8	M	/	2	M	5	7	6	M	/	2	5
Lolium perenne	4	-	-		/	-		-	-	3		/	-	2
Poa pratensis	3	5	2		/	3		6	4	2		/	-	4
Poa subcaerulea	3	-	-		/	-								
Bromus mollis	-	-	3		/	-		2	4	4		/	-	2
Alopecurus geniculatus	-	7	5		/	4								
Poa trivialis	-	2	4		/	-		-	3	3		/	-	-
Holcus lanatus	-	2	-		/	3		-	-	2		/	5	3
Agropyron repens	-	2	-		/	-		-	2	-		/	3	-
Anthoxanthum odoratum								-	2	3		/	-	-
Festuca rubra								-	4	-		/	-	4
Poa annua	-	-	2		/	-								
Agrostis tenuis	-	-	4		/	3		-	-	4		/	2	3
Helictotrichon pubescens								-	-	-		/	3	3
Deschampsia cespitosa	-	-	-		/	+								
Rumex acetosa	5	5	4		/	5		5	5	4		/	5	5
Ranunculus acris	5	5	4		/	-		5	4	4		/	5	5
Bellis perennis	3	+	2		/	2		2	1	2		/	3	2
Montia fontana	7	7	8		/	3		6	7	8		/	3	4
Cerastium holosteoides	3	3	3		/	2		3	2	2		/	2	3
Veronica chamaedrys								3	1	3		/	1	-
Cardamine sp.								1	-	-		/	2	3
Stellaria media	-	-	1		/	-		3	4	3		/	-	2
Taraxacum officinale agg.	-	+	-		/	-		1	2	2		/	1	1
Cardamine flexuosa	-	1	-		/	-		-	1	1		/	-	-
Trifolium repens	-	4	4		/	5		-	-	3		/	4	3
Veronica arvensis								-	3	1		/	-	-
Cerastium glomeratum	-	-	4		/	-		-	-	3		/	-	-
Myosotis discolor	-	-	1		/	-		-	-	3		/	-	-
TOTAL	9	12	17			11		12	18	22			15	18

TABLE 10e - Species recorded in fixed quadrats during the growing season from Field 5

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Alopecurus pratensis	6	3	4	/	/	2	-	5	5	5	M	/	M	M
Poa pratensis	7	4	2	/	/	4	5	5	6	2				
Lolium perenne	4	-	5	/	/	3	2	4	4	5				
Dactylis glomerata	2	2	3	/	/	4	3	3	3	4				
Phleum pratense	1	-	-	/	/	-	-	4	-	-				
Poa annua	-	2	2	/	/	-	-	-	4	3				
Anthoxanthum odoratum	-	3	3	/	/	2	2	-	3	4				
Agropyron repens	-	2	-	/	/	2	-	-	3	-				
Poa trivialis	-	7	7	/	/	-	-	-	-	6				
Bromus mollis	-	5	5	/	/	3	4							
Conopodium majus	3	1	3	/	/	-	-	1	1	1				
Ranunculus repens	6	6	8	/	/	6	7	7	8	9				
Bellis perennis	3	4	3	/	/	2	3	3	2	2				
Rumex acetosa	5	5	5	/	/	7	7	5	5	5				
Cerastium holosteoides	3	3	3	/	/	2	2	3	3	3				
Trifolium repens	3	5	5	/	/	5	3	2	1	-				
Leontodon autumnalis	2	1	-	/	/	2	2							
Cardamine sp.	1	-	3	/	/	3	3							
Veronica serpyllifolia	1	-	-	/	/	-	-							
Taraxacum officinale agg.	-	-	-	/	/	1	2	-	2	1				
Ranunculus acris	-	2	4	/	/	-	5	2	2	4				
Cardamine flexuosa	-	2	-	/	/	-	-	+	3	1				
Plantago lanceolata	-	-	-	/	/	-	2	1	2	-				
Hypochoeris radicata	-	-	1	/	/	-	-							
Veronica chamaedrys	-	-	-	/	/	1	-							
Cardamine pratensis	-	1	-	/	/	-	-	-	-	+				
Festuca rubra	-	4	4	/	/	-	-							
Holcus lanatus	-	2	2	/	/	3	6							
Cynosurus cristatus	-	2	2	/	/	3	-							
Agrostis tenuis	-	-	-	/	/	4	2							
Helictotrichon pubescens	-	-	-	/	/	2	-							
Brachythecium rutabulum	-	-	-	/	/	4	2							
TOTAL	14	21	20			21	18	13	17	15				

TABLE 10f - Species recorded in fixed quadrats during the growing season from Field 6

	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept	28 May	11 June	24 June	11 July	24 July	12 Aug	2 Sept
Bromus mollis	3	3	3	/	/	-	2	3	3	4	/	/	2	2
Anthoxanthum odoratum	4	6	5	/	/	-	2	3	3	4	/	/	-	2
Dactylis glomerata	3	2	4	/	/	5	5	3	2	2	/	/	4	3
Lolium perenne	3	-	3	/	/	2	-	3	-	4	/	/	2	5
Holcus lanatus	3	-	4	/	/	4	5	2	2	3	/	/	4	5
Poa pratensis	3	5	2	/	/	-	3	5	4	-	/	/	2	3
Alopecurus pratensis	2	3	-	/	/	-	2	-	3	-	/	/	2	-
Festuca rubra	3	4	5	/	/	6	5	-	3	3	/	/	-	5
Agropyron repens	-	5	-	/	/	-	-	-	3	-	/	/	-	-
Poa trivialis	-	-	3	/	/	-	-	-	4	2	/	/	-	-
Agrostis tenuis	-	-	4	/	/	3	-	2	-	4	/	/	3	-
Festuca pratensis	-	-	1	/	/	-	-							
Cynosurus cristatus	-	-	2	/	/	-	4	-	-	2	/	/	-	-
Phleum pratense	-	-	2	/	/	-	-	-	-	2	/	/	-	-
Helictotrichon pubescens	-	-	1	/	/	-	2	-	-	-	/	/	2	-
Luzula camp./mult.	2	-	1	/	/	2	2	-	-	1	/	/	-	-
Geranium sylvaticum	4	2	5	/	/	5	5	2	1	2	/	/	4	-
Filipendula ulmaria	2	2	2	/	/	2	3	-	2	+	/	/	-	-
Ranunculus ficaria	2	3	-	/	/	-	-	3	1	-	/	/	-	-
Ranunculus acris	4	4	5	/	/	6	6	5	4	7	/	/	7	7
Plantago lanceolata	4	4	5	/	/	7	5	4	3	5	/	/	6	4
Heracleum sphondylium	1	1	1	/	/	2	1	1	1	1	/	/	2	1
Trifolium pratense	2	-	5	/	/	2	-	5	1	5	/	/	4	2
Bellis perennis	3	2	4	/	/	2	3	3	2	3	/	/	3	3
Taraxacum officinale agg.	1	-	-	/	/	-	-							
Alchemilla glabra	4	-	2	/	/	-	2	-	1	1	/	/	-	4
Cardamine sp.	1	1	-	/	/	-	1	1	1	-	/	/	2	2
Rhinanthus minor	2	3	2	/	/	-	-	3	2	4	/	/	-	-
Conopodium majus	3	2	2	/	/	-	-	3	3	3	/	/	-	-
Rumex acetosa	3	3	2	/	/	2	2	4	3	3	/	/	2	2
Trifolium repens	4	4	6	/	/	7	7	5	4	8	/	/	7	7
Cerastium holosteoides	1	2	2	/	/	-	2	3	2	2	/	/	3	3
Ranunculus bulbosus	2	2	2	/	/	-	-	4	3	2	/	/	-	-
Lathyrus pratensis	1	1	2	/	/	1	2	1	-	1	/	/	-	-
Leontodon hispidus	1	-	2	/	/	2	4	1	1	2	/	/	4	3
Centaurea nigra	1	3	2	/	/	3	1	4	3	2	/	/	5	5
Alchemilla xanthochlora	-	1	-	/	/	4	-	3	-	2	/	/	4	-
Prunella vulgaris	-	1	-	/	/	-	-	-	-	+	/	/	-	-
Myosotis discolor	-	-	2	/	/	-	-	-	-	3	/	/	-	-
Veronica serpyllifolia	-	-	1	/	/	-	-							
Veronica chamaedrys	-	-	2	/	/	1	-	1	1	1	/	/	1	-
Crataegus monogyna								1	-	-	/	/	-	-
Ranunculus repens								-	-	-	/	/	2	1
Euphrasia officinalis agg.								-	-	1	/	/	-	-
Stellaria media								-	-	1	/	/	-	-
Cerastium glomeratum								-	-	-	/	/	1	-
Bare soil								5	5	4	/	/	-	-
Brachythecium rutabulum	4	-	-	/	/	-	3	3	-	2	/	/	-	3
Eurhynchium praelongum	3	-	-	/	/	-	2	-	-	-	/	/	3	3
TOTAL	31	25	34			20	26	29	29	34			25	22

- few, if any, of the small number of annuals found in hay meadow vegetation will now be seen and many perennial herbs do not shoot again following such dramatic defoliation and so will be unobserved. After a few weeks of growth, more perennial species will have recovered and grow again, if conditions are suitable. Later in the season, the less hardy species will die back and so a decline in numbers will be seen.

In addition to these features of the plant communities, observer error must be considered. However careful and experienced the recorder is, some species may be inadvertently omitted from a survey. The tendency to over-estimate cover values for flowering species is also recognised. Those species which were flowering at any one time of sampling are underlined on the tables.

From the results, some specific observations can be made.

Species lost after cutting included the following:

Ranunculus bulbosus (c.f. R. acris and R. repens)
Conopodium majus
Rhinanthus minor
Filipendula ulmaria
Myosotis discolor
Anthoxanthum odoratum
Poa trivialis

Species recorded only early in the season included:

Ranunculus ficaria
Anemone nemorosa

Species recorded only later in the season included:

Poa trivialis
Cynosurus cristatus
Helictotrichon pubescens
Veronica spp.
Ranunculus repens
Trifolium repens
Taraxacum officinale agg.
Brachythecium rutabulum

Trisetum flavescens)
Bromus mollis)
Alopecurus geniculatus) - first recorded on
Poa annua) flowering
Festuca rubra)

Species inconsistently recorded included:

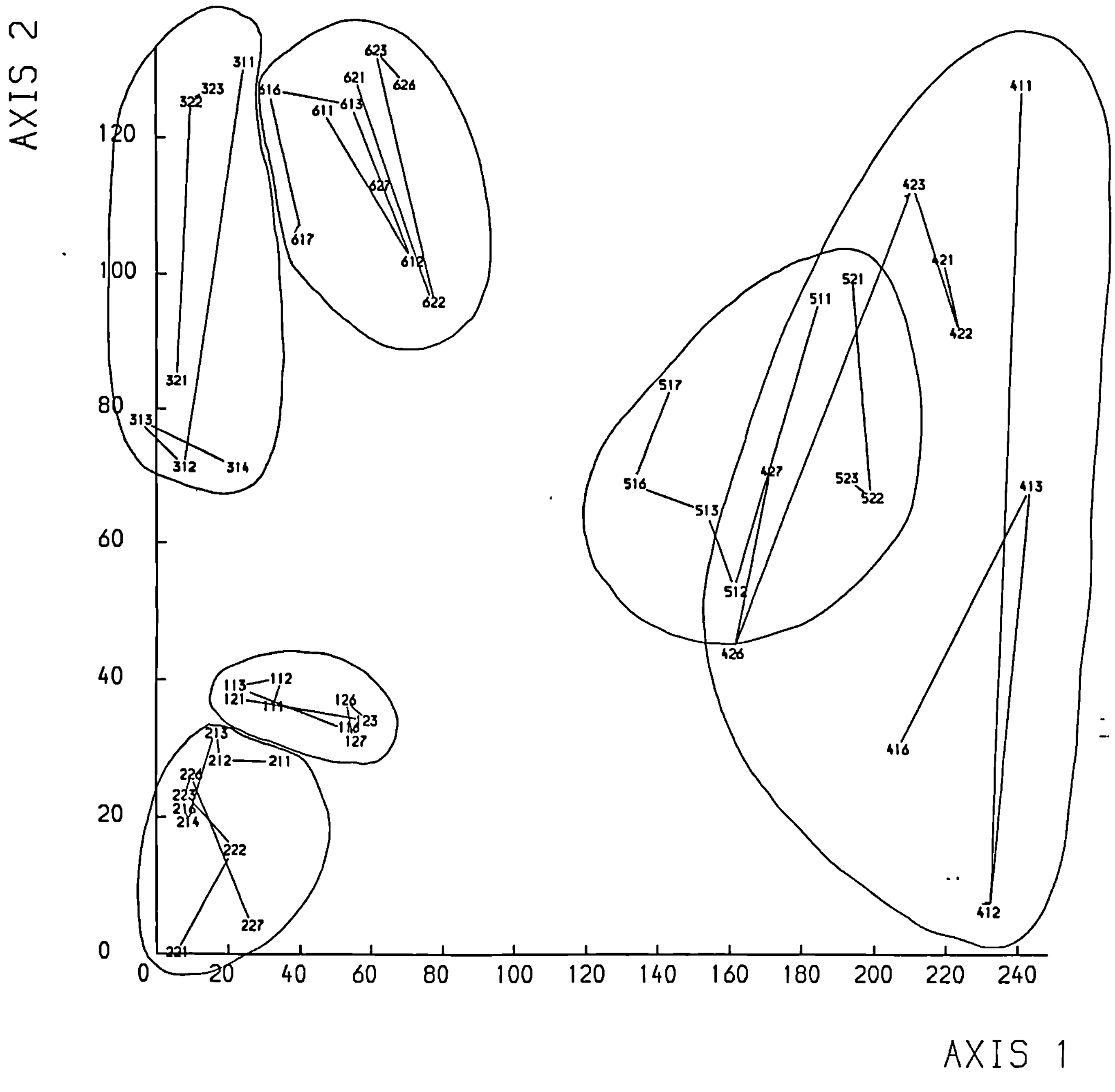
Poa pratensis
Agropyron repens
Lolium perenne
Alopecurus pratensis
Phleum pratense
Agrostis tenuis
Alchemilla spp.
Mosses

Agrostis tenuis and Helictotrichon pratense tend to grow vigorously following cutting. Smith (1985) looked at two meadows in the Yorkshire Dales between mid-May and late June and similarly saw an inconsistency in the recorded cover values for Lolium perenne and Alopecurus pratensis. French workers have also recorded a decline in Conopodium majus levels during the season (Jacquard et al, 1968; Daget-Bertoletti, Daget and Poissonet, 1978). In addition, a fall in Ranunculus bulbosus (Daget-Bertoletti, Daget and Poissonet, 1978) and a rise in Trifolium repens (Jacquard et al, 1968) have been seen.

The ultimate question is not whether the date of sampling affects the species recorded and how, but rather does it affect the species recorded so markedly that samples from the same site or community taken at different dates would not be considered to be part of the same site or community. That is, is the time of sampling genuinely a primary determinant of the vegetation comparable in its effect to the various environmental and management variables recorded. A DECORANA treatment of this temporal series data indicates that samples remain, even within this same data set, more-or-less distinct (see figure 13). The samples are numbered as follows and the consecutive records from the same quadrat are joined, with the two samples from the same field circled.

Each sample has a three-digit identification number; the first digit refers to the field, the second, to whether the sample was the first or second of the two samples from that field, and the final digit refers to the date, where 1 represents the first sampling date, 2, the

FIGURE 13 DECORANA SCORES OF TEMPORAL SAMPLES



second sampling date and so on. Thus, number 616 is the first sample from field 6 surveyed on the sixth sampling date.

Thus, one can conclude that the date of sampling has not introduced unacceptable bias into the results.

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SPECIES OMITTED FROM VEGETATION TABLES.

Nodum 1 - Species omitted from table:

378 - Poa annua 2, Lolium perenne 2, Phleum pratense 1, Potentilla palustris 1, Alopecurus geniculatus 1, Dactylorchis incarnata 1, Odontites verna 1, Rumex sp. 1, Senecio jacobaea 1; 380 - Cardamine pratensis 1, Plagiomnium undulatum 2, Poa annua 1, Potentilla palustris 2, Epilobium palustre 1, Dactylorchis incarnata 1; 363 - Carex ovalis +; 373 - Iris pseudacorus +, Leontodon autumnalis 1, Epilobium palustre 1, Dactylorchis c.f. D. purpurella +; 375 - Cardamine pratensis 1, Galium palustre 2, Senecio aquaticus 1, Phragmites communis 2, Myosotis caespitosa 2, Bellis perennis 1, Hypnum cupressiforme 2; 376 - Iris pseudacorus 2, Lophocolea bidentata 2, Dactylorchis c.f. D purpurella 2, Bellis perennis 2; 362 - Ranunculus flammula +, Galium palustre +, Poa annua 2, Lolium perenne +, Phleum pratense +, Iris pseudacorus +, Leontodon autumnalis +, Potentilla palustris +, Senecio aquaticus +; 364 - Poa annua 2, Senecio aquaticus +, Oenanthe lachenalii 2; 365 - Plagiomnium undulatum 1, Leontodon autumnalis 1, Senecio aquaticus 1, Oenanthe lachenalii 1, Eurhynchium praelongum 2, Lophocolea bidentata 2, Pellia sp. 1; 366 - Phleum pratense 2, Chrysanthemum leucanthemum +.

Nodum 2 - Species omitted from table:

340 - Cirsium palustre 2, Sieglingia decumbens 2, Juncus squarrosus +, Viola palustris 2, Ranunculus flammula 1, Galium palustre +, Polygala serpyllifolia +, Plagiomnium undulatum 2; 303 - Carex pallescens 2, Carex pulicaris 1, Potentilla reptans 2, Cardamine sp. 1, Cirsium palustre 1, Epilobium sp. 1, Taraxacum officinale agg. 1, Ajuga reptans +; 304 - Cardamine sp. 2, Cardamine pratensis +.

Nodum 3 - Species omitted from table:

174 - Lychnis flos-cuculi 2, Achillea ptarmica 2; 345 - Ajuga reptans +; 352 - Vicia sativa 2, Cirsium vulgare +; 354 - Campanula rotundifolia 2, Listera ovata 2; 355 - Listera ovata 1, Knautia arvensis 1; 363 - Deschampsia cespitosa 1, Carex flacca 1, Juncus acutiflorus 2, Carex ovalis +; 367 - Equisetum fluviatile 1, Carex flacca 2, Angelica

sylvatica 1, Carex panicea 1; 379 - Lychnis flos-cuculi 1, Juncus acutiflorus 2; 433 - Lychnis flos-cuculi 2, Montia fontana 2, Ajuga reptans 3, Cardamine sp. 1, Nardus stricta 2, Carex panicea 2, Juncus squarrosus 2, Sagina sp. 1, Juncus squarrosus 2; 29 - Campanula rotundifolia 2; 30 - Betonica officinalis 1; 88 - Carex sp. 2, Holcus mollis 2; 114 - Deschampsia cespitosa 1; 145 - Vicia sativa 2, Geum rivale 1; 203 Plagiomnium affine 1; 204 - Campanula rotundifolia 1; 205 - Phleum pratense 1, Lathyrus montanus 2; 206 - Phleum pratense 1; 259 - Phleum pratense 2; 281 - Cirsium arvense +; 297 - Stellaria graminea 1, Rhizomnium punctatum 1; 298 - Stellaria graminea 1, Rhizomnium punctatum 1, Cardamine sp. 1; 311 - Vicia sativa 2, Carex c.f. C. binervis 1, Pimpinella saxifraga 1, Tragopogon pratensis 1; 317 - Rumex obtusifolius 1; 326 - Platanthera chlorantha 1; 327 - Primula veris 1; 328 - Vicia sepium 1; 330 - Plagiomnium ellipticum 2; 332 - Achillea ptarmica 2, Juncus acutiflorus 2; 333 - Betonica officinalis 2, Deschampsia cespitosa +, Lathyrus montanus 1, Pseudoscleropodium purum 2; 334 - Gymnadenia conopsea 1; 336 - Betonica officinalis 1; 338 - Dactylorchis c.f. O. maculata 1; 339 - Betonica officinalis 2, Serratula tinctoria 1; 341 - Betonica officinalis 2, Dactylorchis sp. 3; 342 - Carex sp. 2, Anemone nemorosa 1; 347 - Vicia sativa 1; 348 - Vicia sativa; 382 - Cirsium arvense +; 383 Arrhenatherum elatius 2.

Nodum 4 - Species omitted from table:

166 - Ranunculus repens 2, Senecio sp. 1; 316 - Carex sp. 2, Ajuga reptans 2, Cynosurus cristatus 2, Leontodon autumnalis 2, Prunella vulgaris 1, Leontodon hispidus 1, Plagiomnium undulatum 2; 390 - Veronica chamaedrys +; 175 - Briza media 1, Sieglingia decumbens 1, Carex sp. 1, Gymnadenia conopsea 2, Ajuga reptans 1; 211 - Cynosurus cristatus 1, Endymion non-scriptus 2, Hieracium pilosella 2, Alchemilla xanthochlora 1, Heracleum sphondylium 1, Veronica serpyllifolia 1; 214 - Ranunculus repens 2, Poa pratensis 2, Poa subcaerulea 1, Leontodon autumnalis 2, Trifolium dubium 2, Pedicularis sylvatica +; 262 - Endymion non-scriptus 2, Pedicularis sylvatica 1, Lolium perenne 2, Veronica chamaedrys 1, Viola sp. 1, Pteridium aquilinum +; 266 - Veronica chamaedrys 1; 267 - Veronica chamaedrys 1; 270 - Heracleum sphondylium 2; 271 - Prunella vulgaris 1.

Nodum 5 - Species omitted from table:

397 - Lychnis flos-cuculi 1, Achillea ptarmica 1, x Festulolium loliaceum 1, Cardamine sp. 1; 414 - Geranium sylvaticum 1; 421 - Geranium sylvaticum 1, Alchemilla subcrenata

2; 423 - Veronica serpyllifolia 2, Geranium sylvaticum +, Senecio jacobaea +; 424 - Veronica serpyllifolia 1, Geranium sylvaticum +, Alchemilla acutiloba 2, Geranium pratense +; 425 - Ajuga reptans +, Cardamine sp. 1; 426 - Ajuga reptans 2, Senecio jacobaea 1; 427 - Veronica serpyllifolia 1; 16 - Veronica serpyllifolia 2, Cirsium arvensis 2; 17 - Cirsium arvense 2; 61 - Geranium sylvaticum 2, Achillea ptarmica 1, Mnium hornum 2; 117 - Geranium sylvaticum 1; 119 - Veronica serpyllifolia 1, Geranium sylvaticum 2; 170 - Ajuga reptans 1, Viola riviniana 1, Pseudoscleropodium purum 2; 194 - Medicago lupulina 1; 208 - Lychnis flos-cuculi 2; 228 - Cirsium arvense 2; 294 - Cirsium arvense +, Quercus robur +; 325 - Cirsium vulgare 1; 385 - Cardamine sp. 1; 185 - Veronica serpyllifolia 1; 187 - x Festulolium loliaceum 1; 216 - Veronica officinalis 2; 261 - Sinapis sp. 1; 279 - Equisetum arvense +; 296 - Cirsium arvense 1; 307 - Cirsium vulgare 1; 312 - Hypericum sp. 1; 314 - Veronica serpyllifolia 1, Pteridium aquilinum 2, Lotus pedunculatus +; 357 - Senecio jacobaea 1; 37 - Veronica serpyllifolia 1, Achillea ptarmica 2; 38 - Rumex obtusifolius 2, Veronica serpyllifolia 2; 42 - Succisa pratensis 1; 109 - Veronica serpyllifolia 1; 110 - Rumex obtusifolius 1, Veronica serpyllifolia 1; 127 - Rumex obtusifolius 1; 198 - Pteridium aquilinum +; 199 - Rumex crispus 1; 209 - Veronica serpyllifolia 2; 213 - Veronica serpyllifolia 2; 215 - Veronica serpyllifolia 1; 236 - Rumex obtusifolius 1, Cirsium arvense 2; 299 - Veronica serpyllifolia +; 309 - Rumex obtusifolius 2; 310 - Rumex obtusifolius 1; 319 - Veronica serpyllifolia 1, Matricaria matricarioides 2; 349 - Senecio jacobaea 1; 370 - Equisetum arvense 2, Cirsium vulgare 1, Senecio jacobaea 1, Odontites verna 1; 371 - Odontites verna 2; 377 - Agropyron repens +, Equisetum arvense 1, Cirsium vulgare +, Senecio jacobaea 1, Odontites verna 1; 417 - Rumex obtusifolius 1.

Nodum 6 - Species omitted from table:

44 - Vicia cracca 1; 55 - Chrysanthemum leucanthemum 1, Endymion non-scripta 1; 56 - Chrysanthemum leucanthemum 1, Succisa pratensis 1, Anemone nemorosa +; 59 - Chrysanthemum leucanthemum 2; 60 - Chrysanthemum leucanthemum 2; 62 - Chrysanthemum leucanthemum 1, Veronica officinalis 2; 63 - Chrysanthemum leucanthemum 2, Equisetum fluviatile 2; 64 - Chrysanthemum leucanthemum 2; 79 - Anemone nemorosa 2, Primula vulgaris 2; 87 - Veronica arvensis 1, Trifolium dubium 2; 104 - Agropyron repens 2, Vicia cracca 1; 106 - Succisa pratensis 1, Veronica arvensis 1, Vicia sativa 1; 115 - Eurhynchium speciosum 1; 121 - Prunella vulgaris 1, Plagiomnium cuspidatum 2, Cirriphyllum piliferum 2; 130 - Rumex obtusifolius 1, Polygonum bistorta 1; 139 - Chrysanthemum leucanthemum +; 144 - Euphrasia officinalis 1, Vicia sativa 2; 146 - Vicia cracca 1, Chrysanthemum leucanthemum 1; 147

- Achillea ptarmica 1; 152 - Lathyrus montanus 1; 169 - Anemone nemorosa 1; 179 - Arrhenatherum elatius 1; 210 - Vicia cracca 2; 238 - Juncus acutiflorus 2; 256 - Anagallis arvensis 1; 401 - Prunella vulgaris 1, Cardamine sp. 2, Sagina sp. 1; 402 - Cardamine sp. 2; 407 - Prunella vulgaris 1; 428 - Veronica arvensis 1, Cardamine sp. 2; 432 - Deschampsia cespitosa 2, Myosotis c.f. M. scorpioides 1.

Nodum 7 - Species omitted from table:

41 - Festuca pratensis 2, Sanguisorba officinalis +; 74 - Luzula campestris/multiflora 2, Alchemilla xanthochlora 2, Thuidium tamariscinum 2; 112 - Alchemilla xanthochlora, Phleum pratense 1, Geranium sylvaticum 2, Cardamine flexuosa 1; 219 - Luzula campestris/multiflora 2, Plantago lanceolata 1, Cardamine pratensis 2, Leontodon autumnalis 2, Lotus corniculatus 2, Crataegus monogyna 1, Heracleum sphondylium 1, Lathyrus pratensis 1, Taraxacum officinale agg. 1, Veronica serpyllifolia 1, Hylocomium splendens 1, Anagallis arvensis 2; 360 - Lathyrus pratensis 2, Poa annua 1, Carex ovalis 1, Veronica arvensis 2, Alchemilla glabra 1, Cirsium palustre 1, Prunella vulgaris 1, Ranunculus bulbosus 1, Stellaria graminea +; 361 - Luzula campestris/multiflora 2, Phleum pratense 2, Leontodon autumnalis 1, Lathyrus pratensis 1, Poa annua 1, Alchemilla glabra 1, Bellis perennis 1, Rumex crispus +, Trifolium pratense +.

Nodum 8 - Species omitted from table:

105 - Geranium sylvaticum 1; 120 - Dactylis glomerata 2, Geranium sylvaticum 1; 142 - Poa annua 1; 143 - Achillea ptarmica 2; 148 - Poa annua 1, Lychnis flos-cuculi 2, Bromus lepidus 1; 154 - Conopodium majus 1, Trifolium dubium 1; 157 - Stellaria media 2; 158 - Achillea ptarmica 1; 176 - Dactylis glomerata 2, Leontodon hispidus 2, Lychnis flos-cuculi 2, Centaurea nigra 2, Succisa pratensis 2, Deschampsia cespitosa 2, Carex flacca 2, Equisetum arvense 2; 202 - Dactylis glomerata 2; 288 - Ranunculus bulbosus 2, Achillea millefolium 2, Luzula campestris/multiflora 1; 301 - Poa annua 1, Cardamine sp. 2; 410 - Rumex crispus 1; 39 - Lychnis flos-cuculi 1; 40 - Luzula campestris/multiflora 1; 85 - Trifolium dubium 1, Carex flacca 2, Juncus acutiflorus 2; 86 - Trifolium dubium 2; 131 - Poa annua 1; 138 - Conopodium majus 1; 160 - Conopodium majus 1, Lychnis flos-cuculi 1, Geranium sylvaticum 1, Angelica sylvestris 1, Cirsium palustre 1; 280 - Ranunculus sceleratus 2, Cardamine sp. 2; 429 - Poa annua 1, Rumex obtusifolius 1.

Nodum 9 - Species omitted from table:

149 - Anthoxanthum odoratum 2, Poa trivialis 2, Angelica sylvestris 2, Galium aparine 1, Geum rivale 1; 150 - Galium aparine 1, Geum rivale 1, Taraxacum officinale agg. 2, Cirsium palustre 1, Dactylorchis fuchsii 1, Ranunculus ficaria 1, Achillea ptarmica 1; 151 - Poa trivialis 2, Galium aparine 1, Lathyrus montanus 2, Succisa pratensis 2, Cardamine pratensis 1, Leontodon hispidus 1; 273 - Angelica sylvestris +, Achillea ptarmica +, Agrostis tenuis 2.

Nodum 10 - Species omitted from table:

95 - Poa annua 2, Cerastium holosteoides 2, Heracleum sphondylium 1, Lathyrus pratensis 1, Veronica arvensis 1; 122 - Poa pratensis 2, Trifolium repens 2, Rhinanthus minor 1; 186 - Trifolium repens 1, Ranunculus repens 2, Rumex obtusifolius 1.

Nodum 11 - Species omitted from table:

94 - Agropyron repens 2; 193 - Cerastium glomeratum 2; 283 - Ranunculus ficaria 2, Endymion non-scriptus 2; 388 - Endymion non-scriptus 2; 396 - Vicia sativa 2, Cardamine sp. 1; 84 - Myosotis scorpioides 1, Vicia sativa 1; 140 - Chrysanthemum leucanthemum 2; 155 - Cardamine pratensis 2; 161 - x Festulolium loliaceum 1; 405 - Ranunculus ficaria 1; 408 - Agropyron repens 2, Cerastium glomeratum 2, Saxifraga granulata 1; 411 - Alchemilla glabra 1; 412 - Trisetum flavescens 2; 416 - Trisetum flavescens 2.

Nodum 12 - Species omitted from table:

80 - Veronica officinalis 2; 237 - Veronica officinalis 1; 260 - Centaurea nigra 1, Trifolium dubium 2, Endymion non-scriptus 1.

Nodum 13 - Species omitted from table:

50 - Centaurea nigra 1; 75 - Filipendula ulmaria 2, Prunella vulgaris 1.

Nodum 14 - Species omitted from table:

242 - Brassica napus 2; 404 - Alchemilla glabra 1; 419 - Leontodon hispidus 1, Veronica arvensis 1; 420 - Veronica arvensis 1, Trisetum flavescens 2; 241 - Rumex crispus 1.

Nodum 15 - Species omitted from table:

101 - Anthriscus sylvestris 1, Rumex obtusifolius 1; 103 - Rhinanthus minor 2; 118 - Rhinanthus minor 1, Trifolium pratense 1; 177 - Rumex obtusifolius 1, Festuca ovina 2; 113 - Rumex obtusifolius 1.

Nodum 16 - Species omitted from table:

245 - Rumex obtusifolius 1; 246 - Montia fontana 1; 247 - Myosotis scorpioides +; 248 - Veronica serpyllifolia 1; 249 - Cirsium arvense 1.

Nodum 17 - Species omitted from table:

268 - Veronica serpyllifolia 1, Vicia sepium 1; 269 - Poa pratensis 2, Taraxacum officinale agg. 1, Eurhynchium praelongum 2.

Nodum 18 - Species omitted from table:

14 - Chrysanthemum leucanthemum 2, Geranium sylvaticum 2; 21 - Geranium sylvaticum 1; 24 - Rhytidiadelphus squarrosus 2; 67 - Rhytidiadelphus squarrosus 1; 69 - Ranunculus ficaria 1; 9 - Lychnis flos-cuculi 2, Eurhynchium swartzii 2; 12 - Eurhynchium swartzii 2, Heracleum sphondylium 1; 65 - Vicia sepium 1; 72 - Ranunculus ficaria 2, Vicia sepium 1; 212 - Vicia cracca 2; 18 - Chrysanthemum

leucanthemum 2; 19 - Heracleum sphondylium 1, Chrysanthemum leucanthemum 1; 20 - Chrysanthemum leucanthemum 1; 73 - Ranunculus ficaria 2; 220 - Medicago lupulina 1; 224 - Alchemilla vestita 2; 251 - Anagallis arvensis 2; 415 - Trisetum flavescens 2; 26 - Leontodon hispidus 1; 111 - Geranium sylvaticum 1; 173 - Geranium columbinum 1; 182 - Urtica dioica 1; 254 - Carex sp. 2, Sagina procumbens 2; 300 - Alchemilla glabra 1; 5 - Cirsium arvense 2, Leontodon hispidus 2; 358 - Cirsium arvense 1, Chrysanthemum leucanthemum +, Prunella vulgaris +, Galium verum +; 3 - Poa subcaerulea 2; 66 - Stellaria alsine 1; 217 - Rhytidiadelphus squarrosus 1, Rumex crispus 1, Brassica napus 1, Crepis biennis 1; 222 - Urtica dioica 1; 223 - Urtica dioica 1; 253 - Rumex crispus 1; 27 - Urtica dioica +; 57 - Cirsium arvense +, Urtica dioica +; 58 - Urtica dioica 1; 68 - Rhytidiadelphus squarrosus 1; 227 - Ranunculus ficaria 1, Amblystegium serpens 2; 230 - Sinapis arvensis 1; 231 - Cirsium arvense 1; 234 - Juncus effusus 1; 244 - Cirsium arvense 1, Matricaria matricarioides 2.

Synoptic table - Species omitted from table:

1 - Galium palustre 2, Ranunculus flammula 1, Hypnum cupressiforme 1, Carex flacca 1, Lophocolea bidentata 1, Valeriana officinalis 1, Senecio jacobaea 1, Plantago maritima 1, Iris pseudacorus 2, Potentilla palustris 2, Oenanthe lachenalii 2, Triglochin maritima 1, Eleocharis palustris 2, Bryum pseudotriquetrum 1, Pellia sp. 1, Myosotis caespitosa 1, Odontites verna 1, Epilobium palustre 1, Dactylorchis c.f. D. purpurella 1, Phragmites communis 1, Dactylorchis incarnata 1, Rumex sp. 1; 2 - Festuca ovina 2, Galium palustre 2, Ranunculus flammula 2, Carex flacca 2, Potentilla reptans 2, Pseudoscleropodium purum 2, Sieglingia decumbens 2, Thuidium delicatulum 2, Hylocomium splendens 2, Lotus pedunculatus 2, Juncus conglomeratus 2, Carex pallescens 2, Carex pulicaris 2, Epilobium sp. 2, Dactylorchis c.f. D. maculata 2, Juncus squarrosus 2, Wahlenbergia hederacea 2, Viola palustris 2, Polygala serpyllifolia 2; 3 - Festuca ovina 1, Cirsium arvense 1, Sanguisorba officinalis 1, Eurhyncghium swartzii 1, Montia fontana 1, Campanula rotundifolia 1, Betonica officinalis 1, Vicia sativa 1, Endymion non-scriptus 2, Anemone nemorosa 1, Mnium hornum 1, Pteridium aquilinum 1, Plagiomnium cuspidatum 1, Thuidium tamariscinum 1, Trifolium dubium 2, Carex flacca 1, Galium verum 1, Potentilla reptans 1, Linum catharticum 1, Cirriphyllum piliferum 1, Lophocolea bidentata 1, Lathyrus montanus 1, Pseudoscleropodium purum 1, Trifolium medium 1, Gymnadenia conopsea 1, Medicago lupulina 1, Crepis capillaris 1, Plagiomnium affine 1, Thuidium delicatulum 1, Trisetum flavescens 1, Stellaria graminea 1, Barbula sp. 1, Rhizomnium punctatum 1, Lotus pedunculatus 1, Pleuridium sp. 1, Cirsium vulgare 1, Carex c.f. C. binervis 1, Pimpinella saxifraga 1, Tragopogon

pratensis 1, Plagiomnium ellipticum 1, Platanthera chlorantha 1, Primula veris 1, Pohlia sp. 1, Vicia orobus 1, Brachythecium albicans 1, Hieracium sp. 1, Dactylorchis c.f. D. maculata 1, Serratula tinctoria 1, Juncus squarrosus 1, Dactylorchis sp. 1, Senecio jacobaea 1, Equisetum sylvaticum 1, Helictotrichon pubescens 1, Listera ovata 1, Knautia arvensis 1, Carex ovalis 1, Plantago maritima 1, Daucus carota 1, Odontites verna 1, Sagina sp. 1; 4 - Festuca ovina 1, Poa subcaerulea 1, Campanula rotundifolia 2, Endymion non-scriptus 1, Galium saxatile 1, Pteridium aquilinum 1, Hypnum cupressiforme 1, Trifolium dubium 1, Lophocolea bidentata 2, Cirsium heterophyllum 1, Senecio sp. 1, Deschampsia flexuosa 1, Viola tricolor 1, Pseudoscleropodium purum 1, Trifolium medium 1, Sieglingia decumbens 1, Gymnadenia conopsea 1, Hieracium pilosella 1, Hylocomium splendens 1, Viola sp. 1, Stellaria graminea 1, Valeriana officinalis 1, Pimpinella saxifraga 1, Plagiomnium ellipticum 1; 5 - Festuca ovina 1, Poa subcaerulea 1, Cirsium arvense 1, Sanguisorba officinalis 1, Eurhynchium swartzii 1, Eurhynchium speciosum 1, Plantago major 1, Veronica officinalis 1, Veronica arvensis 1, Vicia sativa 1, Endymion non-scriptus 1, Anemone nemorosa 1, Mnium hornum 1, Pteridium aquilinum 1, Trifolium dubium 1, Linum catharticum 1, Lathyrus montanus 1, x Festulolium loliaceum 1, Viola riviniana 1, Pseudoscleropodium purum 1, Medicago lupulina 1, Crepis capillaris 1, Rumex crispus 1, Trisetum flavescens 1, Matricaria matricarioides 1, Sinapis sp. 1, Quercus robur 1, Lotus pedunculatus 1, Cirsium vulgare 1, Hypericum sp. 1, Senecio jacobaea 1, Helictotrichon pubescens 1, Odontites verna 1, Alchemilla monticola 1, Alchemilla subcrenata 1, Alchemilla acutiloba 1, Geranium pratense 1; 6 - Festuca ovina 1, Poa subcaerulea 1, Anagallis arvensis 1, Sanguisorba officinalis 1, Eurhynchium swartzii 1, Eurhynchium speciosum 1, Plantago major 1, Veronica officinalis 1, Montia fontana 1, Betonica officinalis 1, Veronica arvensis 1, Vicia sativa 1, Endymion non-scripta 1, Anemone nemorosa 1, Plagiomnium cuspidatum 1, Primula vulgaris 1, Trifolium dubium 1, Galium cruciata 1, Cirriphyllum piliferum 1, Bryum sp. 1, Polygonum bistorta 1, Cirsium heterophyllum 1, Lathyrus montanus 1, Trisetum flavescens 1, Senecio jacobaea 1, Helictotrichon pubescens 1, Sagina sp. 2, Myosotis c.f. M. scorpioides 1; 7 - Anagallis arvensis 1, Sanguisorba officinalis 1, Veronica arvensis 1, Mnium hornum 1, Galium saxatile 1, Pteridium aquilinum 1, Dicranum scoparium 1, Hypnum cupressiforme 1, Plagiomnium cuspidatum 1, Thuidium tamarascinum 1, Viola riviniana 1, Rumex crispus 1, Plagiomnium affine 1, Hylocomium splendens 1, Crataegus monogyna 1, Stellaria graminea 1, Senecio jacobaea 2, Carex ovalis 1; 8 - Eurhynchium swartzii 1, Montia fontana 2, Veronica arvensis 1, Galium palustre 1, Ranunculus ficaria 1, Myosotis scorpioides 1, Vicia sativa 1, Stellaria alsine 1, Trifolium dubium 1, Carex flacca 1, Galium cruciata 1, Polygonum bistorta 1, Myosotis sylvatica 1, Brachythecium rivulàre 1, Equisetum palustre 1, Rumex crispus 1, Alopecurus geniculatus 1, Juncus bufonius 1, Ranunculus sceleratus 1; 9 -

Galium palustre 2, Galium cruciata 2, Cirsium heterophyllum 2, Equisetum palustre 2, Lathyrus montanus 2, Valeriana officinalis 2; 10 - Veronica arvensis 1; 11 - Veronica arvensis 2, Myosotis scorpioides 1, Vicia sativa 1, Endymion non-scriptus 1, Cerastium glomeratum 1, Trifolium dubium 1, x Festulolium loliaceum 1, Saxifraga granulata 1; 12 - Veronica officinalis 2, Cerastium glomeratum 1, Trisetum flavescens 1; 13 - Sanguisorba officinalis 2, Montia fontana 2; 14 - Cirsium arvense 2, Veronica arvensis 2, Cerastium glomeratum 1, Rumex crispus 1, Brassica napus 1, Trisetum flavescens 1; 15 - Festuca ovina 1, Carex flacca 1; 16 - Cirsium arvense 1, Montia fontana 1, Myosotis scorpioides 1; 18 - Festuca ovina 1, Anagallis arvensis 1, Cirsium arvense 1, Sanguisorba officinalis 1, Eurhynchium swartzii 1, Plantago major 1, Veronica officinalis 2, Montia fontana 1, Urtica dioica 1, Veronica arvensis 1, Ranunculus flammula 1, Cerastium glomeratum 1, Stellaria alsine 1, Trifolium dubium 1, Galium verum 1, Geranium columbinum 1, Medicago lupulina 1, Crepis capillaris 1, Rumex crispus 1, Brassica napus 1, Crepis biennis 1, Geranium molle 1, Alchemilla vestita 1, Amblystegium serpens 1, Trisetum flavescens 1, Sinapis arvensis 1, Capsella bursa-pastoris 1, Matricaria matricarioides 1, Sagina procumbens 1, Senecio jacobaea 1.

Upland Meadow vegetation survey - 1984-6 - Nodum 18 - J.C. Hughes

Releve code nos.	14	21	22	24	25	67	69	70	9	11	12	65	72	108	191	192	212	18	19	20	23	107	124	73	195	218	220	221	224	225	226	251	415	6	26	83	111	171	172	173	182	188	254	264	300	5	358	3	4	66	82	217	222	223	240	253	27	28	57	58	68	196	227	231	239	252	230	232	233	234	235	1	243	244
Date 1	30	2	2	2	2	26	26	26	30	30	30	28	27	15	30	30	8	2	2	2	2	15	14	26	30	11	4	4	4	4	4	7	21	26	2	12	15	26	25	25	28	30	7	7	13	26	16	24	24	26	12	11	4	4	6	7	2	2	29	29	26	30	4	6	6	7	6	6	6	6	6	24	4	4
Date 2	5	6	6	6	6	5	5	5	5	5	5	5	5	6	5	5	6	6	6	6	6	6	6	5	5	6	6	6	6	6	6	6	6	5	6	6	6	5	5	5	6	6	5	6	6	5	7	5	5	5	6	6	6	6	6	5	6	6	5	5	5	5	6	6	6	5	6	6	6	6	6	5	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	86	84	84	84	84	84	84	84	84	84	84	84	85	84	85	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
Grid ref 1	35	35	35	35	35	44	44	44	35	35	35	35	44	35	35	35	23	35	35	35	35	35	35	44	35	33	33	33	33	33	33	33	44	44	35	34	35	45	45	45	36	36	33	33	22	44	36	44	44	35	34	33	33	33	33	33	35	35	35	35	44	35	33	33	33	33	33	33	33	33	33	44	33	33
Grid ref 2	294	503	503	364	367	38	38	38	148	148	148	775	45	679	217	217	890	503	503	503	364	679	832	45	217	53	161	161	196	196	196	122	134	644	367	888	678	658	661	661	393	678	35	96	928	644	62	743	743	775	888	53	159	159	125	35	365	365	584	584	38	217	196	149	125	122	149	147	147	154	154	743	161	161
Grid ref 3	237	184	184	307	307	984	984	984	213	213	212	53	983	523	345	345	502	184	184	184	307	523	561	983	344	486	327	327	405	405	406	308	813	988	307	891	525	48	47	47	534	566	284	282	217	988	435	943	943	53	891	486	328	328	455	284	306	306	444	444	984	344	406	524	455	308	524	522	522	513	513	943	441	441
Altitude (m)	200	285	285	240	225	215	215	215	90	90	90	215	200	210	200	200	250	285	285	285	240	210	230	200	205	290	275	275	370	370	380	355	245	185	225	310	205	175	190	190	330	240	230	230	255	185	275	145	145	215	310	290	270	270	275	230	230	230	229	229	215	205	380	140	275	355	140	110	110	240	240	145	200	200
Slope	0	1	1	0	0	5	0	0	0	0	0	0	3	0	0	2	3	1	1	1	0	0	1	3	1	2	1	2	1	1	1	3	3	0	0	1	0	0	0	0	15	2	0	0	10	2	10	2	4	0	2	3	1	10	2	0	0	0	1	1	0	2	2	2	4	2	1	1	0	4	1	2	1	3
Aspect		135	135			0							0			180	270	180	182	180			315	0	0	180	0	270	90	90	90	270	160			180					180	135			90	90	45	135	135		180	180	0	0	0				68	68		180	90	270	0	270	90	90		90	90	180	270	270
Lolium perenne	7	7	4	5	7	7	7	6	4	4	3	4	4	6	4	2	3	4	6	5	7	4	6	6	5	5	6	7	7	7	6	5	6	6	5	4	5	4	3	4	7	7	4	5	7	6	7	5	4	5	6	6	7	7	7	6	8	7	7	6	8	7	7	8	7	7	9	9	7	6	4	4	3	2
Cerastium holosteoides	2	3	3	2	1	3	2	3	2	2	2	2	3	3	2		2	3	3	3	2	3	2	3	3	2	2	3	3	3	2	2	3	2	2	2	4	2	2	3	3	3		2	3	4	5	3	1	2	3	2	2	3		2	2	4	4	4	4				1	3		2	2	1	2			3
Bellis perennis	3	3	4	4	3	4	2	2	4	5	2	3	2	4	2	2	3	3	4	2	4	5	4	6	4	4	3	7	3	2	3	3	5	4	2	3	5	6	3	4	3	5	3	1	3	4	2		2		4	4	3	4	2	3	3	4	6	4	2	2	3	1	2	4								
Taraxacum officinale agg	5	2	2	2	1	1		1	1	2	1	7	2	2	1	1	2	4	2	4	4	4	4	4	6	3			4	5	3	2	2	3	2		2	2	1	2				1	1	2	1	5	2	4	4	2			2		1	3		1	1	5	2	1	3	2		1				2		2
Trifolium repens	2	3	2		2	3	2	2	4		2			2	3		5	2		4	4	4	5	2	3	6	6	5	7	7	5	5	7	5	6	5	4	5	8	7	6	4	6		3	5				3	6	6	6	7	6	4	1		7	6	3	3	2	2	5	5		2		3				
Bromus mollis	1		3	3	2	4	2	2	4	4	4	1	7	5	4	5	4	4	4	4	3	5	4	6	7	5	6	5	2	3	5	7	4		4	3	3		1		1	3		5	1						3	5	4	4	1	4	4	4	2	4	3	8	4		1	5							5	4
Phleum pratense				1	2	2	1		2	3	3	3					4	3	3	2		4	4	1'	3	1	2	2	3	3	3	3			3	4	5	4					2		6	1	5	2	2			3	1	2	4	1	2	4	3	2		3	2	3	5	4	3	1	6	4	3		4	4
Dactylis glomerata	3	4	4	3	4	2	2	2	3	2	2	2	2	3	2	4	2	3	2	2	3	3			3	2	2		3	3	3	3	2	1	2	2	2		3	2	5	5	2	3		4	2	3	2	2	2		2	2	2			2	4	5	2	3	3		1	3				3		2		
Poa annua	2		2	2	3			2		1		4	1		2	3		3	3	3		1	4	2	3	1	3	2	2	2	1	3	3		1	4			2	3			2				1	4	5	4	4	1	2	2	2		3	3	3	2		3			3	4		1		2	2	2	3	4
Rumex acetosa		4	4	3	2	4	5	4	3	3	3		4		3	4	4	4	4	4	4		3	2	2	1	2	1		2	2				2	4	2				1	4	2	3	5	3	3		2	2	4	2		2		2					3	2											2	2
Anthoxanthum odoratum	4	2	2	1			1	3	2	2	2	2	3	4	3	2	3	3	3		2	4	3	3					2	1	1	2	2		2	1	3	3	5	5			2	4	6				2	2						1							2											
Poa pratensis		3	3		4				3	3	4	4	1	2	4	3	3	5		2	2	2		1	3		3	3	3						6	2	2	2	1					4		3		4	4	4			3	5		3																		3
Poa trivialis	2			2	4				2	1	1			3			3					3	4	1		5						2	6		2	3	3				3	3	3	3	3						2	5		3	4	1						3		3	3		4	4	4			5		
Veronica serpyllifolia	1		2	3	2	3		2		1	2		2	1			2	2	3	2				2			2					3			2		2		2						2		1	1			1						2	2	2	3	2				1	2								
Conopodium majus	2	1	4	1	3	2		2	2			2	2	2	2	3	2	2			2	4																									+														2													
Ranunculus bulbosus	1	3	1	3		4	5	4	2				5	2	3	2	4		1		2	1							5	3		3	5																												3							+	1					
Veronica chamaedrys	3		3	3		2			1	1			3	4	2			3	1					2					3		4		1				4	2						2			3												3	2														
Ranunculus acris	3	1	2	2	2	1			1		4	3			2	3		3	2	2	3	3	5	3	2		1								4	3	4	3				2					5				4						1			2														
Plantago lanceolata	3	2	3	2	2	3	2	3		2	1		2		3		3	4	5	2	3		4	2		2							6	1			3								4	3	3					3							2		2		1											
Brachythecium rutabulum		1	2			2		1	2		2			2	2		1										5			2										3	6		3			1	6				3	3	2	2									2											
Myosotis discolor				1					2		1		1			1	2		1	3			1	1:		2	1	1	1	3	1		2				3	1	1			1		1			2					1	2	1																				
Agrostis tenuis	1					1	2	2	3	2		3						2																			3	4	3		4	5						4	4	3																								
Holcus lanatus			2			2			3	3	3			5	2	6						2	3											3	1		4	2	4	4	5		2	5	2		3			3						2				2	1	3	5					2			5	3		
Cynosurus cristatus			1							1							3	1	2			5	1		1	5	2	4	1		2		3	4		4			2	2	6	4	6	1	5	4	6					5	1	2		2																		
Ranunculus repens			1							2			2				1									2								3		3	5				2	3	4	3	2	4	2	3	3		4	1	1	2		4			3	4				1										2
Stellaria media				2	2	2	1	1					2								2					1										3							2						2		5	3					3	2		2	3	1	2	1		2	3	2	3	2			5	7
Veronica officinalis																				3	1					3	3	3	3	3	2																				2	3	3	3	2	2							2		1									
Rumex obtusifolius														1				2	1	1	1		4				2	2	1	1			1												+			2	2	1	2		3	2	4	1	2						2		2	1	1	1				2	4	2
Sanguisorba officinalis		1							6	5	3		2					1	1	2																									1																													
Plantago major		3	3	3		2														2	2		4																														1														1							
Alchemilla xanthochlora		2	4	1									3					3	2	2	2		1	3																							5																											
Trifolium pratense	3	4	2	5		2												2	5	2	2		4	1		2							2												3		2																											
Leontodon autumnalis	1	3	4																															1											2						4																							
Filipendula ulmaria										1	4			1	1									3																																																		
Rhinanthus minor											4		4		2	2	4									2																										3																						
Festuca rubra	3					3			3				3				2	3				3		5									3	2	4		4									2			3																									
Alopecurus pratensis				1									3	1								2	2												2	4							2								2																							
Festuca ovina		4	5											3																								6	5	4						1		3																										
Eurhynchium praelongum		3	2						2		2						3				3								3								5		3	4						3	2					3																						
Cerastium glomeratum						2										2								3			3		3	3		4				3								4						1	1		2																1					
Cardamine pratensis		2				2				1	1		2	1																													2	3	1					2	3										2													
Cardamine flexuosa								3										1		1				1					2	1	2					1																	2	2	1	1		2						1										1
Agrostis stolonifera									2							3								1											4					2						2	5	4	4	5					2					2											7	3		
Centaurea nigra				1						3	1																																																															
Anthriscus sylvestris			1																	4																																																						
Bromus lepidus														1		4						3																																																				
Lathyrus pratensis											2			1					1																												4																											
Arrhenatherum elatius														4																										2																																		
Achillea millefolium						2											2													3																	+					3																						
Caltha palustris																																													4					6																								
Trifolium dubium																	3									2																										4																						
Veronica arvensis																							1										1									3																																
Montia fontana																																			4	3							4								4					4																		
Agropyron repens																																																																								6	7	5
Capsella bursa-pastoris																																																																									4	5
Ranunculus flammula																																											3																															
Senecio jacobaea																																															3																											
Total number of taxa (89)	21	23	29	25	17	26	14	18	26	23	27	14	26	24	20	18	26	26	24	24	21	20	22	25	13	20	19	13	21	19	16	15	20	12	21	20	23	14	17	15	15	14	20	17	22	19	29	15	17	17	22	26	19	19	13	18	13	11	14	17	16	12	16	10	13	12	7	11	7	7	7	9	10	16

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Releve code nos.	44	48	49	52	53	54	55	56	59	60	62	63	64	79	87	102	104	106	115	121	129
Date 1	3	31	31	31	31	31	31	31	29	29	29	29	29	26	20	21	21	22	15	15	14
Date 2	7	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
Grid ref 1	35	34	34	34	34	34	34	34	35	35	35	35	35	44	36	36	36	36	35	35	35
Grid ref 2	458	715	715	757	757	758	758	758	688	688	688	688	688	44	892	428	412	412	847	946	792
Grid ref 3	24	871	871	898	898	898	898	898	269	269	268	268	268	982	62	180	127	127	414	399	498
Altitude (m)	155	140	140	230	230	230	230	230	220	220	215	215	215	210	195	245	170	170	415	295	295
Slope	3	0	0	0	0	0	0	0	3	2	2	3	3	0	1	0	0	0	0	3	0
Aspect	270								270	225	270	270	270		135					180	
Ranunculus acris	4	4	6	6	6	5	4	5	4	4	2	4			5	5	4	5	3	4	4
Rumex acetosa	3			4	3	4	3	3	4	3	3	3		4	5	5	3	4	4		5
Cerastium holosteoides	3	3	3	2	3	2	3	3	2	2	2	2	2		3	2	2	2	1	3	
Anthoxanthum odoratum	2	4	4	4	4	3	3	3	3	3	3	3	3	4	4	4	2	6	4	3	5
Holcus lanatus	5	4	4	3	3	3	4	4	4	2	4	4		4	4	3	2	4	2		2
Dactylis glomerata	4		2	2	2	2	2		4	4	2	3	2	3	3	5	4	4	4		4
Festuca rubra	4	4	5	3	3		3		4	4	5	3	5	5	4	4	5	5	4	3	
Lolium perenne		4	4	3	4	3	4	3	5	5	3	4	3	3	5	4	4			5	5
Plantago lanceolata	3	4	2	2	4	2	3	3		2	3	3	3	3	2			2	5	5	3
Trifolium repens	4			2	2	2	2			2		5	5	2	4	3	4		3	3	2
Alchemilla xanthochlora		2	2	2	3	3	2	3	1				5	4		4				1	
Bellis perennis		4	5	4	5	3	4	4		1		4		2	4	4	3	2	1	4	1
Trifolium pratense		2	+	4	+	1	+	2	2	4		3	3		4	1		+	3	5	
Conopodium majus	2			3	2	1	1	1			2		3	5	1	2		5	5	1	4
Rhinanthus minor	3			2	1	1	2	2	3	3	2	3	3		3	1		4	5	3	3
Cynosurus cristatus	5								4	3	3	2	2		5	4	4	3	4	4	5
Bromus mollis	4			3	3	3	3	3		1	3	3			4	4	1	2			1
Taraxacum officinale agg		2	3		1		+	2	3	2		2	1				4				
Alopecurus pratensis		3					2	2	4	4	2	2	3		4	3	5	4	6		
Poa trivialis	3						3								3	2	4		1		
Veronica chamaedrys	2				4	1	2							3	2	2		+	2		
Geranium sylvaticum				1	+	2	1	+			8		2		5	5	4	4	1	1	
Eurhynchium praelongum				2							3	1		2	1		3			3	
Brachythecium rutabulum	4			3							2	3		3	2		5	1		1	
Poa pratensis		3	3	2		3								2	2	3				2	1
Leontodon autumnalis	2	3	2				1	2				2	4							1	
Anthriscus sylvestris	2					3	4	2	4	4	3		1							1	
Ranunculus bulbosus					3	2	1				3		3	3						1	
Luzula campestris/multiflora						1							1	2					2	1	3
Agrostis tenuis	4	2					2		3	4	2		2	3			3	5		3	
Veronica serpyllifolia		2	3	3			2	2		2		2	2	2	1	1					
Heracleum sphondylium	4		+			+							1							1	
Filipendula ulmaria					2		4	4				6				4	4	3		1	
Lathyrus pratensis	2							2	1	3						2	1	2			
Myosotis discolor	2							1	2	1			3		2	1	1	2		3	
Phleum pratense									3								6			3	
Ranunculus repens														1			3				
Poa annua		3			2						2	2						1			
Caltha palustris		4						4													
Centaurea nigra	2		1									2	3	3							
Cardamine flexuosa					2	2	3														
Plantago major					2	2					1								2		
Montia fontana				2	4			4													
Festuca pratensis	4															2	2				
Vicia sepium			3				2	1		3						2	2				
Festuca ovina						3														4	5
Achillea millefolium	2													2							
Leontodon hispidus	4					4								2							
Hypochoeris radicata															3		1		1		
Cardamine pratensis			2			3								+		1					
Sanguisorba officinalis	+						3														
Rhytidiadelphus squarrosus													3	2						2	5
Ajuga reptans							+							+							
Equisetum arvense																		1			
Bromus lepidus																4					3
Ranunculus ficaria					1		1	1						3							
Plagiomnium rostratum														1							
Alchemilla glabra																	4				
Agrostis stolonifera																					
Helictotrichon pubescens																					
Galium cruciata																+					
Poa subcaerulea																					2
Senecio jacobaea																					
Trisetum flavescens																					
Bryum sp																			3		
Cirsium heterophyllum																					
Geum rivale																					
Eurhynchium swartzii																					
Total number of taxa (97)	29	18	19	22	26	27	34	29	20	24	24	26	27	30	28	30	30	27	23	31	19

Releve code nos.	130	133	134	135	139	141	144	146	147	152	153	159	169	178	179	181	210	238	255	256	359	401	402	407	413	428	431	432
Date 1	14	14	14	14	26	26	26	26	26	22	22	27	25	26	26	26	11	8	7	7	16	19	19	20	21	23	25	25
Date 2	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	6	6	6	5	7	6	6	6	6	6	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85	86	86	86	86	86	86	86
Grid ref 1	35	35	35	35	35	35	35	35	35	35	35	35	45	34	34	34	23	33	33	33	36	34	34	34	44	35	35	35
Grid ref 2	792	792	792	793	953	953	876	876	876	448	448	846	658	901	901	916	897	191	34	34	62	887	887	855	57	862	928	928
Grid ref 3	498	500	500	503	486	486	385	385	385	965	965	487	48	982	982	977	508	539	285	285	435	757	758	803	834	308	228	228
Altitude (m)	295	325	325	360	355	355	305	305	305	245	245	335	175	365	365	240	260	240	235	235	275	290	290	375	235	420	340	340
Slope	0	0	3	2	2	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	5	5	4	25	10	30	0	25
Aspect			225	225	90						90						180				45	235	235	260	120	270		0
Ranunculus acris	6	4	4	4	4	3	4	4	2	2	4	4	3	5	4	3		4	5	4	5	6	7	6	6	6	6	7
Rumex acetosa	3	4	4	5	4	4	3	3	4	4	4	4	4	2	3	5	4	3	4	3	3	4	5	5	4	3	5	6
Cerastium holosteoides	1	3	3	3	2	2	3	1	2		3	2	2	2	3	3	2	2	3	2	5	3	3	1	2		3	2
Anthoxanthum odoratum	5		4	4			4	4	3	2	2	1	3	3	3		3	5	4	4		4	4	5	3	5	5	6
Holcus lanatus	6	4	5	3	2	3	2	4	2	4	4		4	4	3	3	3	4	3	3	5		2	+	2		3	3
Dactylis glomerata	2	2	2	1	5	5	4	2	5	5	2	2	4	3	3	3	4	2	3	3		2	4	3	3		3	4
Festuca rubra	5	6	5	4	4	6	3	5	3	6	5				3	5	4	5	2	4		4	5	6	5	5	4	4
Lolium perenne	4	4	5	5	5	4	4	3	2			5	5	3	4	5	5		6	4	6	4	4	2	4	4	2	
Plantago lanceolata	2	3	2	5	4	5	5	5	4	3		4	2	4	4	3	4	2	3	3	3				5		3	4
Trifolium repens	2	6	4	5	4	5	5	1	2	1	2	4	4	3	4	3	5		6	5	6	6	5	3	5	7		2
Alchemilla xanthochlora		4	4	1	1	2	2	2	2				3	4	5	2	1	1	4	1	4				1	1		
Bellis perennis		2	2	4	4	4		1		2	4	4	2	2	3	3	2		3	3	2	4	5	5	3	4		2
Trifolium pratense	1		1	1	2	2	5	5	2	+		4	2		1		+	2		1	4	2	1		5	4	4	+
Conopodium majus	2	4	5	1	2	2	2	5		5	4	1	5	5	4	3		+	2	3			1	+	5		4	4
Rhinanthus minor	2	1		2			3		1	+	1	1	2			2	3	3						1	1	4	2	2
Cynosurus cristatus	6	3	4	5	4		4	3	1	4	4	4	4				4	4	4	4	5		2			3		3
Bromus mollis		2	4	1		3			2			3	2		3	2	3		2	4		2	3		1	2	2	
Taraxacum officinale agg			4	2	2	1	1				4	4	2	2	1		2	2	2	2	2	3	2	2		2	2	1
Alopecurus pratensis	1	1			4	3	4	4	5	+		5		3	5			3					2	6		4	6	6
Poa trivialis	2	3		1	4	4			4	2	4	5					2	2	3		3	5	5	5	2	2	5	5
Veronica chamaedrys	1		2		+	2	1	2		3	4	2	2		2	3		2			2			1	2	1		
Geranium sylvaticum		2	4		4	5	6	1	6	5				5	5										1		6	7
Eurhynchium praelongum		5	5	4	4		3	4	2				3			3			5	3	2	5	5	5	4		2	
Brachythecium rutabulum		5		4	2		3	4					3			3					6	5	5	5	3			
Poa pratensis				2				2				3		1	2	2	3	2				3				2	2	2
Leontodon autumnalis				1																		2	4					
Anthriscus sylvestris					2	2			4									+						1				
Ranunculus bulbosus			4		2					1						5												
Luzula campestris/multiflora	1			1									2			2		2			1							
Agrostis tenuis										5	5			6	5	6								3				
Veronica serpyllifolia		1	2	1											2	2			2	2	1			+				
Heracleum sphondylium					+		5	4							4			1							1	1	5	
Filipendula ulmaria									5							2		4				2						
Lathyrus pratensis	2							2	3	2	4					1		3	2		3	2			3			
Myosotis discolor	1									1	3	1						1				2				2	2	3
Phleum pratense				3	6									2			3	2		2	6	2	3					
Ranunculus repens	2		2					1				4					4	4	3			2	3					
Poa annua			1				3	1							3													
Caltha palustris																		+										
Centaurea nigra														4	2			4										
Cardamine flexuosa															2													
Plantago major															2		3											
Montia fontana																										7		
Festuca pratensis					6	4				3		3																
Vicia sepium										+	+				2			+										
Festuca ovina	4												7															
Achillea millefolium						2													3									
Leontodon hispidus						1					2			2									4					
Hypochoeris radicata			1			2	4	2																				
Cardamine pratensis	2		1															1	1	1					1			
Sanguisorba officinalis						3																2			1			
Rhytidiadelphus squarrosus	4		5						3	4			5															
Ajuga reptans													1									3	1					
Equisetum arvense							1		3																			
Bromus lepidus					2	2	2	5	5	5																		
Ranunculus ficaria														3	4	3									3			
Plagiomnium rostratum				1																					3			
Alchemilla glabra							2	1			1											4			2			
Agrostis stolonifera														1	4						7	5						
Helictotrichon pubescens																									3		2	2
Galium cruciata									4																			
Poa subcaerulea											3																	
Senecio jacobaea																					4					1		
Trisetum flavescens																									3	3		
Bryum sp																												
Cirsium heterophyllum									6																			
Geum rivale																		3										
Eurhynchium swartzii																									3			
Total number of taxa (97)	26	21	27	27	28	26	29	30	28	26	22	22	25	22	31	25	22	32	23	22	22	29	25	22	31	24	22	23

Upland Meadow vegetation survey – 1984-6 – Nodum 18 – J.C. Hughes

Releve code nos.	14	21	22	24	25	67	69	70	9	11	12	65	72	108	191	192	212	18	19	20	23	107	124	73	195	218	220	221	224	225	226	251	415	6	26	83	111	171	172	173	182	188	254	264	300	5	358	3	4	66	82	217	222	223	240	253	27	28	57	58	68	196	227	231	239	252	230	232	233	234	235	1	243	244
Date 1	30	2	2	2	2	26	26	26	30	30	30	28	27	15	30	30	8	2	2	2	2	15	14	26	30	11	4	4	4	4	4	7	21	26	2	12	15	26	25	25	28	30	7	7	13	26	16	24	24	26	12	11	4	4	6	7	2	2	29	29	26	30	4	6	6	7	6	6	6	6	6	24	4	4
Date 2	5	6	6	6	6	5	5	5	5	5	5	5	5	6	5	5	6	6	6	6	6	6	6	5	5	6	6	6	6	6	6	6	6	5	6	6	6	5	5	5	6	6	5	6	6	5	7	5	5	5	6	6	6	6	6	5	6	6	5	5	5	5	6	6	6	5	6	6	6	6	6	5	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	86	84	84	84	84	84	84	84	84	84	84	84	85	84	85	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
Grid ref 1	35	35	35	35	35	44	44	44	35	35	35	35	44	35	35	35	23	35	35	35	35	35	35	44	35	33	33	33	33	33	33	33	44	44	35	34	35	45	45	45	36	36	33	33	22	44	36	44	44	35	34	33	33	33	33	33	35	35	35	35	44	35	33	33	33	33	33	33	33	33	33	44	33	33
Grid ref 2	294	503	503	364	367	38	38	38	148	148	148	775	45	679	217	217	890	503	503	503	364	679	832	45	217	53	161	161	196	196	196	122	134	644	367	888	678	658	661	661	393	678	35	96	928	644	62	743	743	775	888	53	159	159	125	35	365	365	584	584	38	217	196	149	125	122	149	147	147	154	154	743	161	161
Grid ref 3	237	184	184	307	307	984	984	984	213	213	212	53	983	523	345	345	502	184	184	184	307	523	561	983	344	486	327	327	405	405	406	308	813	988	307	891	525	48	47	47	534	566	284	282	217	988	435	943	943	53	891	486	328	328	455	284	306	306	444	444	984	344	406	524	455	308	524	522	522	513	513	943	441	441
Altitude (m)	200	285	285	240	225	215	215	215	90	90	90	215	200	210	200	200	250	285	285	285	240	210	230	200	205	290	275	275	370	370	380	355	245	185	225	310	205	175	190	190	330	240	230	230	255	185	275	145	145	215	310	290	270	270	275	230	230	230	229	229	215	205	380	140	275	355	140	110	110	240	240	145	200	200
Slope	0	1	1	0	0	5	0	0	0	0	0	0	3	0	0	2	3	1	1	1	0	0	1	3.	1	2	1	2	1	1	1	3	3	0	0	1	0	0	0	0	15	2	0	0	10	2	10	2	4	0	2	3	1	10	2	0	0	0	1	1	0	2	2	2	4	2	1	1	0	4	1	2	1	3
Aspect		135	135			0							0			180	270	180	182	180			315	0	0	180	0	270	90	90	90	270	160			180					180	135			90	90	45	135	135		180	180	0	0	0				68	68		180	90	270	0	270	90	90		90	90	180	270	270
Lolium perenne	7	7	4	5	7	7	7	6	4	4	3	4	4	6	4	2	3	4	6	5	7	4	6	6	5	5	6	7	7	7	6	5	6	6	5	4	5	4	3	4	7	7	4	5	7	6	7	5	4	5	6	6	7	7	7	6	8	7	7	6	8	7	7	8	7	7	9	9	7	6	4	4	3	2
Cerastium holosteoides	2	3	3	2	1	3	2	3	2	2	2	2	3	3	2		2	3	3	3	2	3	2	3	3	2	2	3	3	3	2	2	3	2	2	2	4	2	2	3	3	3		2	3	4	5	3	1	2	3	2	2	3		2	2	4	4	4	4				1	3		2	2	1	2			3
Bellis perennis	3	3	4	4	3	4	2	2	4	5	2	3	2	4	2	2	3	3	4	2	4	5	4	6	4	4	3	7	3	2	3	3	5	4	2	3	5	6	3	4	3	5	3	1	3	4	2		2		4	4	3	4	2	3	3	4	6	4	2	2	3	1	2	4								
Taraxacum officinale agg	5	2	2	2	1	1		1	1	2	1	7	2	2	1	1	2	4	2	4	4	4	4	4	6	3			4	5	3	2	2	3	2		2	2	1	2				1	1	2	1	5	2	4	4	2			2		1	3		1	1	5	2	1	3	2		1				2		2
Trifolium repens	2	3	2		2	3	2	2	4		2			2	3		5	2		4	4	4	5	2	3	6	6	5	7	7	5	5	7	5	6	5	4	5	8	7	6	4	6		3	5				3	6	6	6	7	6	4	1		7	6	3	3	2	2	5	5		2		3				
Bromus mollis	1		3	3	2	4	2	2	4	4	4	1	7	5	4	5	4	4	4	4	3	5	4	6	7	5	6	5	2	3	5	7	4		4	3	3		1		1	3		5	1						3	5	4	4	1	4	4	4	2	4	3	8	4		1	5							5	4
Phleum pratense				1	2	2	1		2	3	3	3					4	3	3	2		4	4	1'	3	1	2	2	3	3	3	3			3	4	5	4					2		6	1	5	2	2			3	1	2	4	1	2	4	3	2		3	2	3	5	4	3	1	6	4	3		4	4
Dactylis glomerata	3	4	4	3	4	2	2	2	3	2	2	2	2	3	2	4	2	3	2	2	3	3			3	2	2		3	3	3	3	2	1	2	2	2		3	2	5	5	2	3		4	2	3	2	2	2		2	2	2			2	4	5	2	3	3		1	3				3		2		
Poa annua	2		2	2	3			2		1		4	1		2	3		3	3	3		1	4	2	3	1	3	2	2	2	1	3	3		1	4			2	3			2				1	4	5	4	4	1	2	2	2		3	3	3	2		3			3	4		1		2	2	2	3	4
Rumex acetosa		4	4	3	2	4	5	4	3	3	3		4		3	4	4	4	4	4	4		3	2	2	1	2	1		2	2				2	4	2				1	4	2	3	5	3	3		2	2	4	2		2		2					3	2											2	2
Anthoxanthum odoratum	4	2	2	1			1	3	2	2	2	2	3	4	3	2	3	3	3		2	4	3	3					2	1	1	2	2		2	1	3	3	5	5			2	4	6				2	2						1							2											
Poa pratensis		3	3		4				3	3	4	4	1	2	4	3	3	5		2	2	2		1	3		3	3	3						6	2	2	2	1					4		3		4	4	4			3	5		3																		3
Poa trivialis	2			2	4				2	1	1			3			3					3	4	1		5						2	6		2	3	3				3	3	3	3	3						2	5		3	4	1						3		3	3		4	4	4			5		
Veronica serpyllifolia	1		2	3	2	3		2		1	2		2	1			2	2	3	2				2			2					3			2		2		2						2		1	1			1						2	2	2	3	2				1	2								
Conopodium majus	2	1	4	1	3	2		2	2			2	2	2	2	3	2	2			2	4																									+														2													
Ranunculus bulbosus	1	3	1	3		4	5	4	2				5	2	3	2	4		1		2	1							5	3		3	5																												3							+	1					
Veronica chamaedrys	3		3	3		2			1	1			3	4	2			3	1					2					3		4		1				4	2						2			3												3	2														
Ranunculus acris	3	1	2	2	2	1			1		4	3			2	3		3	2	2	3	3	5	3	2		1								4	3	4	3				2					5				4						1			2														
Plantago lanceolata	3	2	3	2	2	3	2	3		2	1		2		3		3	4	5	2	3		4	2		2							6	1			3								4	3	3					3							2		2		1											
Brachythecium rutabulum		1	2			2		1	2		2			2	2		1										5			2										3	6		3			1	6				3	3	2	2									2											
Myosotis discolor				1					2		1		1			1	2		1	3			1	1		2	1	1	1	3	1		2				3	1	1			1		1			2					1	2	1																				
Agrostis tenuis	1					1	2	2	3	2		3						2																			3	4	3		4	5						4	4	3																								
Holcus lanatus			2			2			3	3	3			5	2	6						2	3											3	1		4	2	4	4	5		2	5	2		3			3						2				2	1	3	5					2			5	3		
Cynosurus cristatus			1							1							3	1	2			5	1		1	5	2	4	1		2		3	4		4			2	2	6	4	6	1	5	4	6					5	1	2		2																		
Ranunculus repens			1							2			2				1									2								3		3	5				2	3	4	3	2	4	2	3	3		4	1	1	2		4			3	4				1										2
Stellaria media				2	2	2	1	1					2								2					1										3							2						2		5	3					3	2		2	3	1	2	1		2	3	2	3	2			5	7
Veronica officinalis																				3	1					3	3	3	3	3	2																				2	3	3	3	2	2							2		1									
Rumex obtusifolius														1				2	1	1	1		4				2	2	1	1			1												+			2	2	1	2		3	2	4	1	2						2		2	1	1	1				2	4	2
Sanguisorba officinalis		1							6	5	3		2					1	1	2																									1																													
Plantago major		3	3	3		2														2	2		4																														1														1							
Alchemilla xanthochlora		2	4	1									3					3	2	2	2		1	3																							5																											
Trifolium pratense	3	4	2	5		2												2	5	2	2		4	1		[illegible]							2												3		2																											
Leontodon autumnalis	1	3	4																															1											2						4																							
Filipendula ulmaria										1	4			1	1									3																																																		
Rhinanthus minor											4		4		2	2	4									2																										3																						
Festuca rubra	3					3			3				3				2	3				3		5									3	2	4		4									2			3																									
Alopecurus pratensis				1									3	1								2	2												2	4							2								2																							
Festuca ovina		4	5											3																								6	5	4						1		3																										
Eurhynchium praelongum		3	2						2		2						3				3								3								5		3	4						3	2					3																						
Cerastium glomeratum						2										2								3			3		3	3		4				3								4						1	1		2																1					
Cardamine pratensis		2				2				1	1		2	1																													2	3	1					2	3										2													
Cardamine flexuosa								3										1		1				1					2	1	2					1																	2	2	1	1		2						1										1
Agrostis stolonifera									2							3								1											4					2						2	5	4	4	5					2					2											7	3		
Centaurea nigra				1						3	1																																																															
Anthriscus sylvestris			1																	4																																																						
Bromus lepidus														1		4						3																																																				
Lathyrus pratensis											2			1					1																												4																											
Arrhenatherum elatius														4																										2																																		
Achillea millefolium						2											2													3																	+					3																						
Caltha palustris																																													4					6																								
Trifolium dubium																	3									2																										4																						
Veronica arvensis																							1										1									3																																
Montia fontana																																			4	3							4								4					4																		
Agropyron repens																																																																								6	7	5
Capsella bursa-pastoris																																																																									4	5
Ranunculus flammula																																											3																															
Senecio jacobaea																																															3																											
Total number of taxa (89)	21	23	29	25	17	26	14	18	26	23	27	14	26	24	20	18	26	26	24	24	21	20	22	25	13	20	19	13	21	19	16	15	20	12	21	20	23	14	17	15	15	14	20	17	22	19	29	15	17	17	22	26	19	19	13	18	13	11	14	17	16	12	16	10	13	12	7	11	7	7	7	9	10	16

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Releve code nos.	41	74	112	219	360	361
Date 1	3	27	15	4	18	18
Date 2	7	5	6	6	7	7
Date 3	84	84	84	84	85	85
Grid ref 1	35	44	35	33	26	26
Grid ref 2	458	45	742	161	646	646
Grid ref 3	29	983	417	327	446	446
Altitude (m)	160	200	345	275	245	245
Slope	0	6	0	40	0	0
Aspect		0		0		
Rumex acetosa	6	4	5	4	5	4
Rhytidiadelphus squarrosus	2	3	4	6	2	5
Dactylis glomerata	4	2	4	3	4	4
Trifolium repens	+	3	5	3	4	6
Anthoxanthum odoratum	3	2	4	2	3	4
Lolium perenne	2	4	2	5	2	2
Cerastium holosteoides	2	2	1	2	2	3
Conopodium majus	1	3	3	3		
Holcus lanatus	6		5	5	6	6
Agrostis tenuis	6		2	2	6	6
Eurhynchium praelongum	3		1	3	2	1
Ranunculus repens	6		4		4	4
Poa trivialis	3		2		5	4
Festuca rubra		4	4	3	4	5
Veronica chamaedrys		2	2	2		3
Ranunculus acris		2	2		4	5
Holcus mollis		6			6	2
Achillea ptarmica		1			3	2
Agrostis stolonifera		2		3		
Poa pratensis			3	4		
Alopecurus pratensis			6		2	
Arrhenatherum elatius			6		2	
Brachythecium rutabulum			2		3	
Achillea millefolium				2		6
Senecio jacobaea					5	5
Cynosurus cristatus					4	5
Plagiomnium undulatum					3	3
Rhinanthus minor	3					
Dicranum scoparium		6				
Galium saxatile		5				
Carex nigra		3				
Geum rivale		3				
Pteridium aquilinum		3				
Hypnum cupressiforme		3				
Plagiomnium cuspidatum		3				
Lychnis flos-cuculi			3			
Viola riviniana				3		
Calliergon cuspidatum				3		
Mnium hornum				3		
Plagiomnium affine				3		
Total number of taxa (70)	16	24	25	32	31	30

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Releve code nos.	101	103	118	177	113	165	168	245	246	247	248	249	250	268	269
Date 1	21	21	15	17	15	27	27	9	9	9	9	9	9	7	7
Date 2	6	6	6	7	6	6	6	7	7	7	7	7	7	8	8
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84
Grid ref 1	36	36	35	35	35	35	35	23	23	23	23	23	23	26	26
Grid ref 2	815	428	946	825	742	774	776	692	692	692	692	693	693	2	2
Grid ref 3	207	180	398	333	417	444	446	568	568	569	569	569	569	858	858
Altitude (m)	180	245	295	450	345	445	425	200	200	205	205	200	200	30	30
Slope	0	0	0	2	0	1	1	0	2	0	0	0	0	0	0
Aspect				270		0	180		90						
Ranunculus repens	5	4	4	8	4	7	5	5	6	7	3	2	3	7	6
Poa trivialis	6	5	6	5	5	4	3	4	4	3	3	3	4	3	
Lolium perenne	5	4	2	2	2	1		7	6	5	5	4	5	7	5
Holcus lanatus	2		3	4	1	6	5	5	3	5	5	3	6	5	6
Cerastium holosteoides	1	2		2		2	2	4	2	2	3	1	2	3	2
Rumex acetosa	2	4		3		4	5				2	5	4	3	3
Ranunculus acris		3	2			5	5				3		1	2	2
Caltha palustris		8	7	4		2									
Bellis perennis		1	1	1		4									
Cardamine pratensis		1	1	1		2			1						
Festuca rubra		4				4	4	2							
Alopecurus pratensis	5	5	4	5	8	4	7	3	5	5	4	2	5		
Anthoxanthum odoratum		2	2	3		3		1	3	5	5	5	3		
Cynosurus cristatus		3	2					2	+		2	4			
Trifolium repens		2	2	5				4	5	5	4	4	4	2	1
Agrostis tenuis								5	2	4	5	4	6	2	
Stellaria media	4		5		3								1	2	2
Dactylis glomerata			4		2									4	5
Bromus mollis	2		1											4	3
Alchemilla glabra														1	3
Festuca pratensis		3		5											
Agrostis stolonifera				4		1									
Poa annua					3	3		3							
Conopodium majus					1		4								
Brachythecium rutabulum						3	3								
Carex flacca		4													
Filipendula ulmaria		5													
Myosotis discolor		3													
Deschampsia cespitosa				4											
Achillea ptarmica				3											
Holcus mollis														5	
Total number of taxa (45)	11	19	17	18	10	16	10	13	12	10	13	12	12	16	14

Upland Meadow vegetation survey - 1984-6 - Nodum 10 - J.C. Hughes

Releve code nos.	95	100	284	122	186
Date 1	19	21	5	15	30
Date 2	6	6	6	6	6
Date 3	84	84	85	84	84
Grid ref 1	35	36	20	35	36
Grid ref 2	818	815	517	946	685
Grid ref 3	988	207	785	396	510
Altitude (m)	175	180	225	290	220
Slope	0	1	0	2	0
Aspect		0		180	
Bromus mollis	8	3	7	5	6
Lolium perenne	2	6	7	5	2
Poa trivialis	4	3	6	4	3
Dactylis glomerata	3	2	3	2	5
Taraxacum officinale agg	2	1	2	4	2
Alopecurus pratensis	3	3	+	4	5
Anthriscus sylvestris	9	10		6	7
Stellaria media	1	5		2	2
Ranunculus acris	3	7	+		
Agropyron repens	3	+			
Ranunculus bulbosus	3			4	
Rumex acetosa	3			4	3
Bellis perennis	1			2	1
Phleum pratense				2	6
Total number of taxa (24)	18	10	7	15	14

Upland Meadow vegetation survey - 1984-6 - Nodum 9 - J.C. Hughes

Releve code nos.	149	150	151	273
Date 1	22	22	22	11
Date 2	6	6	6	8
Date 3	84	84	84	84
Grid ref 1	36	36	36	17
Grid ref 2	402	402	402	818
Grid ref 3	47	47	47	635
Altitude (m)	195	195	195	30
Slope	3	5	0	0
Aspect	270	270		
Filipendula ulmaria	8	7	4	6
Juncus articulatus	4	5	4	5
Holcus lanatus	4	3	5	4
Rumex acetosa	2	3	4	4
Geranium sylvaticum	6	7	6	
Dactylis glomerata	5	4	5	
Deschampsia cespitosa	4	2	5	
Bromus lepidus	5	1	4	
Festuca rubra	2	4	4	
Lathyrus pratensis	2	3	3	
Veronica chamaedrys	2	2	3	
Potentilla erecta	1	2	4	
Centaurea nigra	2	2	1	
Ranunculus acris	2		2	2
Ranunculus repens	1			3
Alopecurus pratensis	4	3		
Crepis paludosa	1	4		
Trollius europaeus		8	2	
Molinia caerulea		5	5	
Conopodium majus		2	5	
Equisetum arvense		2	3	
Cirsium heterophyllum	6			
Equisetum palustre	5			
Carex sp	4			
Galium palustre	3			
Brachythecium rutabulum	3			
Eurhynchium praelongum	3			
Plantago lanceolata			4	
Galium cruciata			3	
Arrhenatherum elatius				5
Juncus effusus				5
Valeriana officinalis				5
Total number of taxa (47)	28	26	26	12

Upland Meadow vegetation survey - 1984-6 - Nodum 3 - J.C. Hughes

Releve code nos.	174	345	346	352	353	354	355	363	367	369	372	379	433	29	30	88	89	114	145	203	204	205	206	259	260	277	278	281	295	297
Date 1	17	9	9	9	9	10	10	24	25	25	26	27	17	4	4	20	20	15	26	10	10	10	10	8	8	4	4	4	10	13
Date 2	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	7	7	7	7	6	6	6	6	6	6	6
Date 3	84	85	85	85	85	85	85	85	85	85	85	85	86	84	84	84	84	84	84	84	84	84	84	84	84	85	85	85	85	85
Grid ref 1	35	43	43	43	43	43	43	8	8	8	8	8	35	35	35	36	36	35	35	23	23	23	23	23	23	20	20	20	32	22
Grid ref 2	829	176	176	188	188	129	129	767	762	762	735	744	829	245	245	916	916	847	876	711	711	709	709	991	991	656	656	687	202	992
Grid ref 3	328	807	807	641	641	785	785	415	387	387	189	673	328	14	14	62	62	414	385	432	432	426	426	499	499	796	796	781	177	273
Altitude (m)	445	205	205	310	310	365	365	6	5	5	7	15	445	215	215	155	155	415	305	205	205	210	210	330	330	375	375	300	170	315
Slope	3	0	0	8	10	0	0	0	0	0	0	0	10	0	0	0	0	1	0	5	8	2	4	4	2	3	0	0	0	0
Aspect	225			170	90								135					180		248	270	225	225	270	270	225				
Cynosurus cristatus	6	4	5	4	8	4	5	4	4			5	4	6	5	4	3	5	4	4	5	6	7	3	4	4	4	6	5	5
Plantago lanceolata	5	6	6	4	3	6	7	4	5	3	5	3	2	5	4	8	5	1	5	5	4	4	5	6	4	5	5	3	5	5
Trifolium pratense		6	6	2	5	5	6	2	6	5	2	5	5	4	5	5	6	4		5	6	5	2	3	5	7	6	3	2	9
Festuca rubra		2	3	4	6	6	6		5	7	4	5	4	4	3	4	6	3	5	6	6	4	4	5	4	5	6	5		4
Trifolium repens	5	4		8	8			5	1	8	8	6	4	5	5	2	5		6	4	4	5	7	2	2	4	6	5	2	5
Holcus lanatus	5	4	5	5	5	4	4	7	4	3	7	3	5	3	4		2		2	4	3		3	2	4	2		3		4
Cerastium holosteoides	1			3	2	3	4	3	2	1	3	2	2	3	4	2	2	1	2	3	2	2	2	2	2	3	3	3	3	4
Anthoxanthum odoratum	5	3	4	3	4	4	6	7	5			1	4		3	5	3	5	3			2		5	4	5	4	4	5	6
Rhinanthus minor	4	6	6			6	6		5	6	4	6	5			4	3	4	2			5	5	5	4	6	6	3	7	3
Rumex acetosa	3	2		3	2			2		2		3	1	2	3	3	2	3		2		3	4	4	4	3	3	3		1
Euphrasia officinalis agg	4	4	5						3	8	4	1	5	3	3	6	5	4	4	4	5	5	5	4	3	4	5	4	4	
Brachythecium rutabulum	3	7	3						3			2	6	1		5	5		3	3	2	4		4		3	6			6
Ranunculus acris	4	5	5	5	5	4	2	5	5	2	2	5	3	5	4			4	3	2	3	2	3	3	2		2			2
Hypochoeris radicata			1	1	5			5			1	3		2	2			4	4	3	2			3	4	2	2	4	1	+
Dactylis glomerata	2	3	4	4	5	5	4					2				2	2		2	3	5	5	5	2	3	4	4	4	2	2
Leontodon autumnalis	3								1	1		3	3	2	3			4		3	2	4	3	1	1	3	3	2		
Luzula campestris/multiflora	2		2		2	2	2	2	3				2			3		1						2	3	3	3	2	1	2
Centaurea nigra		4	4							1				3	3		4			4	5	4		1	1	+	1	1	1	+
Agrostis tenuis		5	6	4	4			1					3	6	7	2						4	4					4		4
Eurhynchium praelongum		6	2			3			1					3	3	5	5	1	4				3	2						6
Conopodium majus						1	1							2		5	5	1	5		1					3	2	2		7
Prunella vulgaris	4		5		2	2	+		1	1	2	+	3	2		1	1		1	3	4	3	3				2			
Poa trivialis					1	1		2			3			7	5													3	3	1
Chrysanthemum leucanthemum		6	5	3	5	5	6			5									4	2	2	+	1	2	3		+	2		
Ranunculus bulbosus							2									4	4								3	6	6	4	2	5
Lotus corniculatus			6						4							2	3			3	3	3		1		3	4			
Lolium perenne	2			3		1			3			2						4	3	4	5	3			2			5	6	2
Bellis perennis	3						1		1	1			2					2	2	2	3	2	3	3	3					1
Myosotis discolor	1											1	2			2	1							2	3			+		+
Leontodon hispidus		4	6										2						2					1		5	6	2		
Heracleum sphondylium		5	4	1	1	1	2																						2	1
Lathyrus pratensis		1	2		1			1									1		3		2					1	2			
Veronica chamaedrys																3	3		1					3	2	2	2			1
Taraxacum officinale agg													2	2								2	2	1	2	2	2	1	2	1
Bromus mollis					1					+						3	2							3					3	2
Rhytidiadelphus squarrosus				7	5													2	4		3		1	4	6					5
Achillea millefolium										1						1	2			3	5	4	3	2	3	+				2
Potentilla erecta														1	1						1						2			
Trifolium dubium																								4	2			3	2	
Endymion non-scriptus																								1	1	2	+	+		1
Festuca pratensis	3	4	4			3	2						2																	
Agrostis stolonifera	3			5							1	6																		
Briza media						6	5						+			4														
Polygonum amphibium								3	1		4	3																		
Trisetum flavescens				5	3	5	4																	2						
Dactylorchis fuchsii								3	3		3																			
Succisa pratensis	2	1							6				2	1																
Vicia cracca			2				2		2	1												2								
Ranunculus repens	2									2	1	2	1									3				3	2			
Poa pratensis	3									1			2			3	3			2								1		
Poa annua												2												1						
Alchemilla xanthochlora																4	5	4	2										1	3
Equisetum arvense			4						1	1	1	1																		
Helictotrichon pubescens			4	3		4	7																							
Agropyron repens												3	2																	
Cirriphyllum piliferum																		3	2							1				
Lophocolea bidentata									1									2			3									
Calliergon cuspidatum																			2				2			3				
Mnium hornum																						1								
Sanguisorba officinalis		4																												1
Vicia orobus																														
Hieracium sp																														
Plagiomnium undulatum													2																	
Equisetum sylvaticum		6	5																											
Carex nigra	1							6	6																					
Juncus articulatus	4												3																	
Caltha palustris	3												4																	
Trollius europaeus	4												5																	
Potentilla anserina									4	5	4																			
Daucus carota										7	2																			
Odontites verna										1	3																			
Alchemilla glabra	3												2									4								
Potentilla reptans													2				3													
Galium verum																1	3													
Geranium sylvaticum																		5	2											
Linum catharticum																				3	4									
Filipendula ulmaria	1																													
Barbula sp										3																				
Pteridium aquilinum																					+								3	3
Plagiomnium cuspidatum																						1						5		
Lotus pedunculatus																														
Festuca ovina	5																													3
Trifolium medium	3																													
Eurhynchium swartzii							5																							
Plantago maritima									4																					
Cardamine flexuosa													4																	
Thuidium tamariscinum													3																	
Bromus lepidus																			3											
Thuidium delicatulum																					3									
Medicago lupulina																										3				
Alopecurus pratensis																											3			
Crepis capillaris																												3		
Pleuridium sp																														3
Pohlia sp																														
Brachythecium albicans																														
Dactylorchis sp																														
Total number of taxa (142)	33	26	27	22	23	24	25	21	30	26	22	27	43	23	19	29	28	23	30	24	29	30	23	34	28	29	30	30	22	36

Releve code nos.	298	311	317	318	322	326	327	328	329	330	331	332	333	334	335	336	337	338	339	341	342	347	348	381	382	383	400
Date 1	13	15	28	28	28	29	29	29	29	3	3	3	3	4	4	4	4	4	4	4	4	9	9	14	14	14	19
Date 2	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6
Date 3	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	86	86	86	86
Grid ref 1	22	32	32	32	32	32	32	32	32	22	22	22	22	22	22	22	22	22	22	22	22	43	43	43	43	43	44
Grid ref 2	992	303	161	161	114	246	246	247	247	905	905	983	983	905	905	897	897	898	898	952	952	237	237	175	175	162	54
Grid ref 3	273	314	532	532	603	318	318	317	317	204	204	726	726	644	644	670	670	670	670	700	700	778	778	669	669	664	632
Altitude (m)	315	265	345	345	320	300	300	315	315	170	170	280	280	310	310	360	360	340	340	245	245	230	230	305	300	270	250
Slope	0	0	20	30	25	5	15	25	30	0	0	0	0	15	15	10	20	10	30	30	25	20	20	5	3	3	35
Aspect			270	320	80	190	110	50	60					140	110	150	50	70	90	60	60	170	170	155	155	80	230
Cynosurus cristatus	5	+	6	6	5	5	4	6	6	6	5	5	5	6	5	5	5	5	4	4	4	4	5	6	6	5	5
Plantago lanceolata	6	5	5	4	4	5	5	5	6	2	5	3	4			6	6	7	6	5	5	7	7	6	7	7	6
Trifolium pratense	7	5	4	4	5	8	7	7	6	7	7	4	5	5	6	6	5	5	5	6	6	6	5	4	5	4	4
Festuca rubra	6	5	4	5	7	5	5	6	5	5	7	6	6	6	7	7	7	8	7	6	5	2	2	5	5	6	5
Trifolium repens	7	4	7	8	2	3	3	3	3	5	4	7	5	5	4	5	4	6	5	3	6	3	4	6	6	3	6
Holcus lanatus	4	4	3	3	6	5	2	2	2	4	5	3	4	5	4	2	5	4	4	3	3	4	4	3	3	4	3
Cerastium holosteoides	4		3	2	3	3	2			4	3	2	2	3	3	3	3	3	3	3	3	4	5	3	3	4	3
Anthoxanthum odoratum	5	5	6	6	4	5	4	5	5	5	5	4	3	4	4	4	6	5			3	4	5	5	5	6	3
Rhinanthus minor	3		1	2		5	4	1	5	4	4	6	5	4	5	5	5	5	4	5	3	4	5				2
Rumex acetosa	+		5	4	4	4	4	3	3	3	3	3			2	3	2	4		4	4	4	4	3	1	3	5
Euphrasia officinalis agg			5	4		5	7	7	5	4	7	6	5	5	4	5	6	6	6	7	5						1
Brachythecium rutabulum	7	6	3	7			3	6	6	7	8	3	6	5		5	5	6	4	5	5	4	3	5	2	4	3
Ranunculus acris						2	6	3	2	6	7	7	3		2	2	2			2	2	+		5	5	6	
Hypochoeris radicata		5	4	5		4	4	4	4	3	1	2	2	4	5	6	5	5	5	4		4	2	2			4
Dactylis glomerata	+		2	2	3	4	4	3	3		4		2		4					3	5	4	3	2	3	3	
Leontodon autumnalis	2	3	3	3	2	2	3	3		3	4	4	4	3		5	5	3	3	3	3			4	5		1
Luzula campestris/multiflora		3			4	3	3	3			2		2	2	3	2	3	3	3	1	2	2	3	1		1	3
Centaurea nigra	2	2	1	1		5	4	1	2	5	5	4	5	2		2		1		6	4	2	1				
Agrostis tenuis	6	5	6	7	6	4	6	5	5	6	6	2	6	6	5			4	4	6	5	7	6	3			
Eurhynchium praelongum	7	6	5	7		8	8	4			4	5		3		4				6	2	4	4	4	6	6	3
Conopodium majus	7	6	1	4	4	2	1	1	2				3	3	4	5	5	2	4	4	4					5	4
Prunella vulgaris			3	2		3	3			5	5	1		2	5			1			4		3				
Poa trivialis	2		3	2	3	3	3	2	2	3		3	2	3	3		1	3	2	2				3	3	3	4
Chrysanthemum leucanthemum		2	1	3	1					3				2	5				1		2	4	3			3	
Ranunculus bulbosus	4	2	6	5	4	6	3	6	6					5	4	2		2		3	3			4	5	2	5
Lotus corniculatus		5		3	4	2	5	4	3				6	2	4	4	4		3	3	4		4				2
Lolium perenne							1	2		3	2											5	5				
Bellis perennis						+	+	1	2	2	3										2						1
Myosotis discolor					3		1					+	1														1
Leontodon hispidus		4	4	5		4	4	4	5	6	4	2	3	5	6					5	5						
Heracleum sphondylium	1	1		1		4	4	4	4		+		1		+						1	2	4		+		
Lathyrus pratensis	3			1					1															4	5	2	
Veronica chamaedrys	3				2																			2			2
Taraxacum officinale agg	2	2								1	2	2	1							1	1			3	2		
Bromus mollis		1	5	2	3	4	3		2		1	4	3					1									
Rhytidiadelphus squarrosus		3												3		5	5	7	5	7						2	
Achillea millefolium	3	3				2		3	+						1					1	3				6		1
Potentilla erecta						2	2	4	2			2	2	4	5	7	7	6	4	4	3						
Trifolium dubium			4		5	2				3	5	+	6	4	4	4		2	7				2				
Endymion non-scriptus	2													4	3	2	4	4	3	1	2						
Festuca pratensis																											
Agrostis stolonifera																											
Briza media																											
Polygonum amphibium																											
Trisetum flavescens																											2
Dactylorchis fuchsii						1	1																				
Succisa pratensis																											
Vicia cracca						2	1					1	2														
Ranunculus repens	4			1															1								
Poa pratensis								1		3	2																
Poa annua																											
Alchemilla xanthochlora	1	1	2																					3	3		3
Equisetum arvense							4	1																			
Helictotrichon pubescens						4	2																				
Agropyron repens																											
Cirriphyllum piliferum																						3	4		2		2
Lophocolea bidentata																									3	2	
Calliergon cuspidatum	1															2	2		2								
Mnium hornum										1			3			1				2	3						
Sanguisorba officinalis												4								6	2						
Vicia orobus										4				2	3				3		4						
Hieracium sp												7	8	3		2	3	7		5	5						
Plagiomnium undulatum														5	5			1	5	+	2						
Equisetum sylvaticum																	3	2	2	1							
Carex nigra																2	2		2	2	3				2		
Juncus articulatus																											
Caltha palustris																											
Trollius europaeus																											
Potentilla anserina																											
Daucus carota																											
Odontites verna																											
Alchemilla glabra																											
Potentilla reptans																											
Galium verum																											
Geranium sylvaticum																											
Linum catharticum																											
Filipendula ulmaria																											
Barbula sp											4																
Pteridium aquilinum																											
Plagiomnium cuspidatum																											
Lotus pedunculatus			1											6													
Festuca ovina											2																
Trifolium medium																											
Eurhynchium swartzii																											
Plantago maritima																											
Cardamine flexuosa																											
Thuidium tamariscinum																											
Bromus lepidus																											
Thuidium delicatulum																											
Medicago lupulina																											
Alopecurus pratensis																											
Crepis capillaris																											
Pleuridium sp																											
Pohlia sp							3																				
Brachythecium albicans														3													
Dactylorchis sp																			3								
Total number of taxa (142)	34	29	28	30	22	35	37	33	27	29	29	33	35	31	31	30	26	30	30	37	39	23	26	24	25	22	27

Upland Meadow vegetation survey - 1984-6 - Nodum 6 - J.C. Hughes

Releve code nos.	44	48	49	52	53	54	55	56	59	60	62	63	64	79	87	102	104	106	115	121	129	130	133	134	135	139	141	144	146	147	152	153	159	169	178	179	181	210	238	255	256	359	401	402	407	413	428	431	432
Date 1	3	31	31	31	31	31	31	31	29	29	29	29	29	26	20	21	21	22	15	15	14	14	14	14	14	26	26	26	26	26	22	22	27	25	26	26	26	11	8	7	7	16	19	19	20	21	23	25	25
Date 2	7	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	6	6	6	5	7	6	6	6	6	6	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85	86	86	86	86	86	86	86
Grid ref 1	35	34	34	34	34	34	34	34	35	35	35	35	35	44	36	36	36	36	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	45	34	34	34	23	33	33	33	36	34	34	34	44	35	35	35
Grid ref 2	458	715	715	757	757	758	758	758	688	688	688	688	688	44	892	428	412	412	847	946	792	792	792	792	793	953	953	876	876	876	448	448	846	658	901	901	916	897	191	34	34	62	887	887	855	57	862	928	928
Grid ref 3	24	871	871	898	898	898	898	898	269	269	268	268	268	982	62	180	127	127	414	399	498	498	500	500	503	486	486	385	385	385	965	965	487	48	982	982	977	508	539	285	285	435	757	758	803	834	308	228	228
Altitude (m)	155	140	140	230	230	230	230	230	220	220	215	215	215	210	195	245	170	170	415	295	295	295	325	325	360	355	355	305	305	305	245	245	335	175	365	365	240	260	240	235	235	275	290	290	375	235	420	340	340
Slope	3	0	0	0	0	0	0	0	3	2	2	3	3	0	1	0	0	0	0	3	0	0	0	3	2	2	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	5	5	4	25	10	30	0	25
Aspect	270								270	225	270	270	270		135					180				225	225	90						90						180				45	235	235	260	120	270		0
Ranunculus acris	4	4	6	6	6	5	4	5	4	4	2	4			5	5	4	5	3	4	4	6	4	4	4	4	3	4	4	2	2	4	4	3	5	4	3		4	5	4	5	6	7	6	6	6	6	7
Rumex acetosa	3			4	3	4	3	3	4	3	3	3		4	5	5	3	4	4		5	3	4	4	5	4	4	3	3	4	4	4	4	4	2	3	5	4	3	4	3	3	4	5	5	4	3	5	6
Cerastium holosteoides	3	3	3	2	3	2	3	3	2	2	2	2	2		3	2	2	2	1	3		1	3	3	3	2	2	3	1	2		3	2	2	2	3	3	2	2	3	2	5	3	3	1	2		3	2
Anthoxanthum odoratum	2	4	4	4	4	3	3	3	3	3	3	3	3	4	4	4	2	6	4	3	5	5		4	4			4	4	3	2	2	1	3	3	3		3	5	4	4		4	4	5	3	5	5	6
Holcus lanatus	5	4	4	3	3	3	4	4	4	2	4	4		4	4	3	2	4	2		2	6	4	5	3	2	3	2	4	2	4	4		4	4	3	3	3	4	3	3	5		2	+	2		3	3
Dactylis glomerata	4		2	2	2	2	2		4	4	2	3	2	3	3	5	4	4	4		4	2	2	2	1	5	5	4	2	5	5	2	2	4	3	3	3	4	2	3	3		2	4	3	3		3	4
Festuca rubra	4	4	5	3	3		3		4	4	5	3	5	5	4	4	5	5	4	3		5	6	5	4	4	6	3	5	3	6	5				3	5	4	5	2	4		4	5	6	5	5	4	4
Lolium perenne		4	4	3	4	3	4	3	5	5	3	4	3	3	5	4	4			5	5	4	4	5	5	5	4	4	3	2			5	5	3	4	5	5		6	4	6	4	4	2	4	4	2	
Plantago lanceolata	3	4	2	2	4	2	3	3		2	3	3	3	3	2			2	5	5	3	2	3	2	5	4	5	5	5	4	3		4	2	4	4	3	4	2	3	3	3				5		3	4
Trifolium repens	4			2	2	2	2			2		5	5	2	4	3	4		3	3	2	2	6	4	5	4	5	5	1	2	1	2	4	4	3	4	3	5		6	5	6	6	5	3	5	7		2
Alchemilla xanthochlora		2	2	2	3	3	2	3	1				5	4		4				1			4	4	1	1	2	2	2	2				3	4	5	2	1	1	4	1	4				1	1		
Bellis perennis		4	5	4	5	3	4	4		1		4		2	4	4	3	2	1	4	1		2	2	4	4	4		1		2	4	4	2	2	3	3	2		3	3	2	4	5	5	3	4		2
Trifolium pratense		2	+	4	+	1	+	2	2	4		3	3		4	1		+	3	5		1		1	1	2	2	5	5	2	+		4	2		1		+	2		1	4	2	1		5	4	4	+
Conopodium majus	2			3	2	1	1	1			2		3	5	1	2		5	5	1	4	2	4	5	1	2	2	2	5		5	4	1	5	5	4	3		+	2	3			1	+	5		4	4
Rhinanthus minor	3			2	1	1	2	2	3	3	2	3	3		3	1		4	5	3	3	2	1		2			3		1	+	1	1	2			2	3	3						1	1	4	2	2
Cynosurus cristatus	5								4	3	3	2	2		5	4	4	3	4	4	5	6	3	4	5	4		4	3	1	4	4	4	4				4	4	4	4	5		2			3		3
Bromus mollis	4			3	3	3	3	3		1	3	3			4	4	1	2			1		2	4	1		3			2			3	2		3	2	3		2	4		2	3		1	2	2	
Taraxacum officinale agg		2	3		1		+	2	3	2		2	1				4							4	2	2	1	1					4	4	2	2	1	2	2	2	2	2	3	2	2		2	2	1
Alopecurus pratensis		3					2	2	4	4	2	2	3		4	3	5	4	6			1	1			4	3	4	4	5	+		5		3	5			3					2	6		4	6	6
Poa trivialis	3						3								3	2	4		1			2	3		1	4	4			4	2	4	5					2	2	3		3	5	5	5	2	2	5	5
Veronica chamaedrys	2				4	1	2							3	2	2		+	2			1		2		+	2	1	2		3	4	2	2		2	3		2			2			1	2	1		
Geranium sylvaticum				1	+	2	1	+			8		2		5	5	4	4	1	1			2	4		4	5	6	1	6	5				5	5										1		6	7
Eurhynchium praelongum				2							3	1		2	1		3			3			5	5	4	4		3	4	2				3			3			5	3	2	5	5	5	4		2	
Brachythecium rutabulum	4			3							2	3		3	2		5	1		1			5		4	2		3	4					2			3					6	5	5	5	3			
Poa pratensis		3	3	2		3								2	2	3				2	1				2				2				3		1	2	2	3	2				3				2	2	2
Leontodon autumnalis	2	3	2				1	2				2	4							1					1																		2	4					
Anthriscus sylvestris	2					3	4	2	4	4	3		1							1						2	2			4									+						1				
Ranunculus bulbosus					3	2	1				3		3	3						2				4		2					1						5												
Luzula campestris/multiflora						1							1	2					2	1	3	1			1									2			2		2			1							
Agrostis tenuis	4	2					2		3	4	2		2	3			3	5		3											5	5			6	5	6								3				
Veronica serpyllifolia		2	3	3			2	2		2		2	2	2	1	1							1	2	1											2	2			2	2	1			+				
Heracleum sphondylium	4		+			+							1							1						+		5	4							4			1							1	'	5	
Filipendula ulmaria					2		4	4				6				4	4	3		1										5							2		4				2						
Lathyrus pratensis	2							2	1	3						2	1	2				2							2	3	2	4					1		3	2		3	2			3			
Myosotis discolor	2							1	2	1			3		2	1	1	2		3		1									1	3	1						1				2				2	2	3
Phleum pratense									3								6			3					3	6									2			3	2		2	6	2	3					
Ranunculus repens														1			3					2		2					1				4					4	4	3			2	3					
Poa annua		3			2						2	2						1						1				3	1							3													
Caltha palustris		4						4																															+										
Centaurea nigra	2		1									2	3	3																					4	2			4										
Cardamine flexuosa					2	2	3																													2													
Plantago major					2	2					1								2																	2		3											
Montia fontana				2	4			4																																							7		
Festuca pratensis	4															2	2									6	4				3		3																
Vicia sepium			3				2	1		3						2	2														+	+				2			+										
Festuca ovina						3														4	5	4												7															
Achillea millefolium	2													2													2													3									
Leontodon hispidus	4					4								2													1					2			2									4					
Hypochoeris radicata															3		1		1					1			2	4	2																				
Cardamine pratensis			2			3								+		1						2		1															1	1	1					1			
Sanguisorba officinalis	+						3																				3																2			1			
Rhytidiadelphus squarrosus													3	2						2	5	4		5						3	4			5															
Ajuga reptans							+							+																				1									3	1					
Equisetum arvense																		1										1		3																			
Bromus lepidus																4					3					2	2	2	5	5	5																		
Ranunculus ficaria					1		1	1						3																					3	4	3									3			
Plagiomnium rostratum														1											1																					3			
Alchemilla glabra																	4											2	1			1											4			2			
Agrostis stolonifera																																			1	4						7	5						
Helictotrichon pubescens																																														3	2	2	
Galium cruciata																+														4																			
Poa subcaerulea																					2											3																	
Senecio jacobaea																																										4					1		
Trisetum flavescens																																														3	3		
Bryum sp																			3																														
Cirsium heterophyllum																														6																			
Geum rivale																																							3										
Eurhynchium swartzii																																														3			
Total number of taxa (97)	29	18	19	22	26	27	34	29	20	24	24	26	27	30	28	30	30	27	23	31	19	26	21	27	27	28	26	29	30	28	26	22	22	25	22	31	25	22	32	23	22	22	29	25	22	31	24	22	23

Upland Meadow vegetation survey - 1984-6 - Nodum 3 - J.C. Hughes

Releve code nos.	174	345	346	352	353	354	355	363	367	369	372	379	433	29	30	88	89	114	145
Date 1	17	9	9	9	9	10	10	24	25	25	26	27	17	4	4	20	20	15	26
Date 2	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6
Date 3	84	85	85	85	85	85	85	85	85	85	85	85	86	84	84	84	84	84	84
Grid ref 1	35	43	43	43	43	43	43	8	8	8	8	8	35	35	35	36	36	35	35
Grid ref 2	829	176	176	188	188	129	129	767	762	762	735	744	829	245	245	916	916	847	876
Grid ref 3	328	807	807	641	641	785	785	415	387	387	189	673	328	14	14	62	62	414	385
Altitude (m)	445	205	205	310	310	365	365	6	5	5	7	15	445	215	215	155	155	415	305
Slope	3	0	0	8	10	0	0	0	0	0	0	0	10	0	0	0	0	1	0
Aspect	225		170	90									135					180	
Cynosurus cristatus	6	4	5	4	8	4	5	4	4			5	4	6	5	4	3	5	4
Plantago lanceolata	5	6	6	4	3	6	7	4	5	3	5	3	2	5	4	8	5	1	5
Trifolium pratense		6	6	2	5	5	6	2	6	5	2	5	5	4	5	5	6	4	
Festuca rubra		2	3	4	6	6	6		5	7	4	5	4	4	3	4	6	3	5
Trifolium repens	5	4		8	8			5	1	8	8	6	4	5	5	2	5		6
Holcus lanatus	5	4	5	5	5	4	4	7	4	3	7	3	5	3	4		2		2
Cerastium holosteoides	1			3	2	3	4	3	2	1	3	2	2	3	4	2	2	1	2
Anthoxanthum odoratum	5	3	4	3	4	4	6	7	5			1	4		3	5	3	5	3
Rhinanthus minor	4	6	6			6	6		5	6	4	6	5			4	3	4	2
Rumex acetosa	3	2		3	2			2		2		3	1	2	3	3	2	3	
Euphrasia officinalis agg	4	4	5						3	8	4	1	5	3	3	6	5	4	4
Brachythecium rutabulum	3	7	3						3			2	6	1		5	5		3
Ranunculus acris	4	5	5	5	5	4	2	5	5	2	2	5	3	5	4			4	3
Hypochoeris radicata			1	1	5			5			1	3		2	2			4	4
Dactylis glomerata	2	3	4	4	5	5	4					2				2	2		2
Leontodon autumnalis	3								1	1		3	3	2	3			4	
Luzula campestris/multiflora	2		2		2	2	2	2	3				2			3		1	
Centaurea nigra		4	4							1				3	3		4		
Agrostis tenuis		5	6	4	4			1				3	6	7	2				
Eurhynchium praelongum		6	2			3			1					3	3	5	5	1	4
Conopodium majus						1	1							2		5	5	1	5
Prunella vulgaris	4		5		2	2	+		1	1	2	+	3	2		1	1		1
Poa trivialis					1	1		2			3			7	5				
Chrysanthemum leucanthemum		6	5	3	5	5	6			5									4
Ranunculus bulbosus							2									4	4		
Lotus corniculatus			6						4							2	3		
Lolium perenne	2			3		1				3		2						4	3
Bellis perennis	3						1			1	1		2					2	2
Myosotis discolor	1											1	2			2	1		
Leontodon hispidus		4	6										2						2
Heracleum sphondylium		5	4	1	1	1	2												
Lathyrus pratensis		1	2		1			1									1		3
Veronica chamaedrys																3	3		1
Taraxacum officinale agg													2	2					
Bromus mollis					1					+						3	2		
Rhytidiadelphus squarrosus				7	5													2	4
Achillea millefolium										1						1	2		
Potentilla erecta														1	1				
Trifolium dubium																			
Endymion non-scriptus																			
Festuca pratensis	3	4	4			3	2						2						
Agrostis stolonifera	3			5							1	6							
Briza media						6	5						+			4			
Polygonum amphibium								3	1		4	3							
Trisetum flavescens				5	3	5	4												
Dactylorchis fuchsii								3	3		3								
Succisa pratensis	2	1							6				2	1					
Vicia cracca			2				2		2	1									
Ranunculus repens	2									2	1	2	1						
Poa pratensis	3									1			2			3	3		
Poa annua												2							
Alchemilla xanthochlora																4	5	4	2
Equisetum arvense			4						1	1	1	1							
Helictotrichon pubescens			4	3		4	7												
Agropyron repens												3	2						
Cirriphyllum piliferum																		3	2
Lophocolea bidentata									1									2	
Calliergon cuspidatum																			2
Mnium hornum																			
Sanguisorba officinalis		4																	
Vicia orobus																			
Hieracium sp																			
Plagiomnium undulatum													2						
Equisetum sylvaticum		6	5																
Carex nigra	1							6	6										
Juncus articulatus	4												3						
Caltha palustris	3												4						
Trollius europaeus	4												5						
Potentilla anserina									4	5	4								
Daucus carota										7	2								
Odontites verna										1	3								
Alchemilla glabra	3												2						
Potentilla reptans													2				3		
Galium verum																1	3		
Geranium sylvaticum																		5	2
Linum catharticum																			
Filipendula ulmaria	1																		
Barbula sp										3									
Pteridium aquilinum																			
Plagiomnium cuspidatum																			
Lotus pedunculatus																			
Festuca ovina	5																		
Trifolium medium	3																		
Eurhynchium swartzii							5												
Plantago maritima									4										
Cardamine flexuosa													4						
Thuidium tamariscinum													3						
Bromus lepidus																		3	
Thuidium delicatulum																			
Medicago lupulina																			
Alopecurus pratensis																			
Crepis capillaris																			
Pleuridium sp																			
Pohlia sp																			
Brachythecium albicans																			
Dactylorchis sp																			
Total number of taxa (142)	33	26	27	22	23	24	25	21	30	26	22	27	43	23	19	29	28	23	30

Releve code nos.	203	204	205	206	259	260	277	278	281	295	297	298	311	317	318	322
Date 1	10	10	10	10	8	8	4	4	4	10	13	13	15	28	28	28
Date 2	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6
Date 3	84	84	84	84	84	84	85	85	85	85	85	85	85	85	85	85
Grid ref 1	23	23	23	23	23	23	20	20	20	32	22	22	32	32	32	32
Grid ref 2	711	711	709	709	991	991	656	656	687	202	992	992	303	161	161	114
Grid ref 3	432	432	426	426	499	499	796	796	781	177	273	273	314	532	532	603
Altitude (m)	205	205	210	210	330	330	375	375	300	170	315	315	265	345	345	320
Slope	5	8	2	4	4	2	3	0	0	0	0	0	0	20	30	25
Aspect	248	270	225	225	270	270	225							270	320	80
Cynosurus cristatus	4	5	6	7	3	4	4	4	6	5	5	5	+	6	6	5
Plantago lanceolata	5	4	4	5	6	4	5	5	3	5	5	6	5	5	4	4
Trifolium pratense	5	6	5	2	3	5	7	6	3	2	9	7	5	4	4	5
Festuca rubra	6	6	4	4	5	4	5	6	5		4	6	5	4	5	7
Trifolium repens	4	4	5	7	2	2	4	6	5	2	5	7	4	7	8	2
Holcus lanatus	4	3		3	2	4	2		3		4	4	4	3	3	6
Cerastium holosteoides	3	2	2	2	2	2	3	3	3	3	4	4		3	2	3
Anthoxanthum odoratum			2		5	4	5	4	4	5	6	5	5	6	6	4
Rhinanthus minor			5	5	5	4	6	6	3	7	3	3		1	2	
Rumex acetosa	2		3	4	4	4	3	3	3		1	+		5	4	4
Euphrasia officinalis agg	4	5	5	5	4	3	4	5	4	4				5	4	
Brachythecium rutabulum	3	2	4		4		3	6			6	7	6	3	7	
Ranunculus acris	2	3	2	3	3	2		2			2					
Hypochoeris radicata	3	2			3	4	2	2	4	1	+		5	4	5	
Dactylis glomerata	3	5	5	5	2	3	4	4	4	2	2	+		2	2	3
Leontodon autumnalis	3	2	4	3	1	1	3	3	2			2	3	3	3	2
Luzula campestris/multiflora					2	3	3	3	2	1	2		3			4
Centaurea nigra	4	5	4		1	1	+	1	1	1	+	2	2	1	1	
Agrostis tenuis			4	4					4		4	6	5	6	7	6
Eurhynchium praelongum				3	2						6	7	6	5	7	
Conopodium majus		1					3	2	2		7	7	6	1	4	4
Prunella vulgaris	3	4	3	3				2						3	2	
Poa trivialis									3	3	1	2		3	2	3
Chrysanthemum leucanthemum	2	2	+	1	2	3		+	2				2	1	3	1
Ranunculus bulbosus						3	6	6	4	2	5	4	2	6	5	4
Lotus corniculatus	3	3	3		1		3	4					5		3	4
Lolium perenne	4	5	3			2			5	6	2					
Bellis perennis	2	3	2	3	3	3					1					
Myosotis discolor					2	3			+		+					3
Leontodon hispidus					1		5	6	2				4	4	5	
Heracleum sphondylium										2	1	1	1		1	
Lathyrus pratensis		2					1	2				3			1	
Veronica chamaedrys					3	2	2	2			1	3				2
Taraxacum officinale agg			2	2	1	2	2	2	1	2	1	2	2			
Bromus mollis					3					3	2		1	5	2	3
Rhytidiadelphus squarrosus		3		1	4	6					5		3			
Achillea millefolium	3	5	4	3	2	3	+				2	3	3			
Potentilla erecta		1						2								
Trifolium dubium					4	2			3	2				4		5
Endymion non-scriptus					1	1	2	+	+		1	2				
Festuca pratensis																
Agrostis stolonifera																
Briza media																
Polygonum amphibium																
Trisetum flavescens					2											
Dactylorchis fuchsii																
Succisa pratensis																
Vicia cracca			2													
Ranunculus repens			3				3	2				4			1	
Poa pratensis	2								1							
Poa annua					1											
Alchemilla xanthochlora										1	3	1	1	2		
Equisetum arvense																
Helictotrichon pubescens																
Agropyron repens																
Cirriphyllum piliferum							1									
Lophocolea bidentata		3														
Calliergon cuspidatum				2			3					1				
Mnium hornum			1								1					
Sanguisorba officinalis																
Vicia orobus																
Hieracium sp																
Plagiomnium undulatum																
Equisetum sylvaticum																
Carex nigra																
Juncus articulatus																
Caltha palustris																
Trollius europaeus																
Potentilla anserina																
Daucus carota																
Odontites verna																
Alchemilla glabra			4													
Potentilla reptans																
Galium verum																
Geranium sylvaticum																
Linum catharticum	3	4														
Filipendula ulmaria																
Barbula sp										3	3					
Pteridium aquilinum		+							5							
Plagiomnium cuspidatum			1											1		
Lotus pedunculatus											3					
Festuca ovina																
Trifolium medium																
Eurhynchium swartzii																
Plantago maritima																
Cardamine flexuosa																
Thuidium tamariscinum																
Bromus lepidus																
Thuidium delicatulum	3															
Medicago lupulina							3									
Alopecurus pratensis								3								
Crepis capillaris									3							
Pleuridium sp											3					
Pohlia sp																
Brachythecium albicans																
Dactylorchis sp																
Total number of taxa (142)	24	29	30	23	34	28	29	30	30	22	36	34	29	28	30	22

Releve code nos.	326	327	328	329	330	331	332	333	334	335	336	337	338	339	341	342	347	348	381	382	383	400
Date 1	29	29	29	29	3	3	3	3	4	4	4	4	4	4	4	4	9	9	14	14	14	19
Date 2	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6
Date 3	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	86	86	86	86
Grid ref 1	32	32	32	32	22	22	22	22	22	22	22	22	22	22	22	22	43	43	43	43	43	44
Grid ref 2	246	246	247	247	905	905	983	983	905	905	897	897	898	898	952	952	237	237	175	175	162	54
Grid ref 3	318	318	317	317	204	204	726	726	644	644	670	670	670	670	700	700	778	778	669	669	664	632
Altitude (m)	300	300	315	315	170	170	280	280	310	310	360	360	340	340	245	245	230	230	305	300	270	250
Slope	5	15	25	30	0	0	0	0	15	15	10	20	10	30	30	25	20	20	5	3	3	35
Aspect	190	110	50	60					140	110	150	50	70	90	60	60	170	170	155	155	80	230
Cynosurus cristatus	5	4	6	6	6	5	5	5	6	5	5	5	5	4	4	4	4	5	6	6	5	5
Plantago lanceolata	5	5	5	6	2	5	3	4			6	6	7	6	5	5	7	7	6	7	7	6
Trifolium pratense	8	7	7	6	7	7	4	5	5	6	6	5	5	5	6	6	6	5	4	5	4	4
Festuca rubra	5	5	6	5	5	7	6	6	6	7	7	7	8	7	6	5	2	2	5	5	6	5
Trifolium repens	3	3	3	3	5	4	7	5	5	4	5	4	6	5	3	6	3	4	6	6	3	6
Holcus lanatus	5	2	2	2	4	5	3	4	5	4	2	5	4	4	3	3	4	4	3	3	4	3
Cerastium holosteoides	3	2			4	3	2	2	3	3	3	3	3	3	3	3	4	5	3	3	4	3
Anthoxanthum odoratum	5	4	5	5	5	5	4	3	4	4	4	6	5			3	4	5	5	5	6	3
Rhinanthus minor	5	4	1	5	4	4	6	5	4	5	5	5	5	4	5	3	4	5				2
Rumex acetosa	4	4	3	3	3	3	3			2	3	2	4		4	4	4	4	3	1	3	5
Euphrasia officinalis agg	5	7	7	5	4	7	6	5	5	4	5	6	6	6	7	5						1
Brachythecium rutabulum		3	6	6	7	8	3	6	5		5	5	6	4	5	5	4	3	5	2	4	3
Ranunculus acris	2	6	3	2	6	7	7	3		2	2	2			2	2	+		5	5	6	
Hypochoeris radicata	4	4	4	4	3	1	2	2	4	5	6	5	5	5	4		4	2	2			4
Dactylis glomerata	4	4	3	3		4		2		4					3	5	4	3	2	3	3	
Leontodon autumnalis	2	3	3		3	4	4	4	3		5	5	3	3	3	3			4	5		1
Luzula campestris/multiflora	3	3	3			2		2	2	3	2	3	3	3	1	2	2	3	1		1	3
Centaurea nigra	5	4	1	2	5	5	4	5	2		2		1		6	4	2	1				
Agrostis tenuis	4	6	5	5	6	6	2	6	6	5			4	4	6	5	7	6	3			
Eurhynchium praelongum	8	8	4			4	5		3		4				6	2	4	4	4	6	6	3
Conopodium majus	2	1	1	2				3	3	4	5	5	2	4	4	4					5	4
Prunella vulgaris	3	3			5	5	1		2	5			1			4		3				
Poa trivialis	3	3	2	2	3		3	2	3	3		1	3	2	2				3	3	3	4
Chrysanthemum leucanthemum					3				2	5				1		2	4	3			3	
Ranunculus bulbosus	6	3	6	6					5	4	2		2		3	3			4	5	2	5
Lotus corniculatus	2	5	4	3				6	2	4	4	4		3	3	4		4				2
Lolium perenne		1	2		3	2											5	5				
Bellis perennis	+	+	1	2	2	3										2						1
Myosotis discolor		1					+	1														1
Leontodon hispidus	4	4	4	5	6	4	2	3	5	6					5	5						
Heracleum sphondylium	4	4	4	4		+		1		+						1	2	4		+		
Lathyrus pratensis				1															4	5	2	
Veronica chamaedrys																			2			2
Taraxacum officinale agg					1	2	2	1							1	1			3	2		
Bromus mollis	4	3		2		1	4	3					1									
Rhytidiadelphus squarrosus									3		5	5	7	5	7						2	
Achillea millefolium	2		3	+						1					1	3				6		1
Potentilla erecta	2	2	4	2			2	2	4	5	7	7	6	4	4	3						
Trifolium dubium	2				3	5	+	6	4	4	4		2	7				2				
Endymion non-scriptus									4	3	2	4	4	3	1	2						
Festuca pratensis																						
Agrostis stolonifera																						
Briza media																						
Polygonum amphibium																						
Trisetum flavescens																						2
Dactylorchis fuchsii	1	1																				
Succisa pratensis																						
Vicia cracca	2	1					1	2														
Ranunculus repens														1								
Poa pratensis			1		3	2																
Poa annua																						
Alchemilla xanthochlora																			3	3		3
Equisetum arvense		4	1																			
Helictotrichon pubescens	4	2																				
Agropyron repens																						
Cirriphyllum piliferum																	3	4		2		2
Lophocolea bidentata											2	2		2						3	2	
Calliergon cuspidatum					1			3			1				2	3						
Mnium hornum							4								6	2						
Sanguisorba officinalis					4				2	3				3		4						
Vicia orobus							7	8	3		2	3	7		5	5						
Hieracium sp									5	5			1	5	+	2						
Plagiomnium undulatum												3	2	2	1							
Equisetum sylvaticum											2	2		2	2	3						
Carex nigra																				2		
Juncus articulatus																						
Caltha palustris																						
Trollius europaeus																						
Potentilla anserina																						
Daucus carota																						
Odontites verna																						
Alchemilla glabra																						
Potentilla reptans																						
Galium verum																						
Geranium sylvaticum																						
Linum catharticum																						
Filipendula ulmaria						4																
Barbula sp																						
Pteridium aquilinum																						
Plagiomnium cuspidatum									6													
Lotus pedunculatus						2																
Festuca ovina																						
Trifolium medium																						
Eurhynchium swartzii																						
Plantago maritima																						
Cardamine flexuosa																						
Thuidium tamariscinum																						
Bromus lepidus																						
Thuidium delicatulum																						
Medicago lupulina																						
Alopecurus pratensis																						
Crepis capillaris																						
Pleuridium sp																						
Pohlia sp		3																				
Brachythecium albicans									3													
Dactylorchis sp														3								
Total number of taxa (142)	35	37	33	27	29	29	33	35	31	31	30	26	30	30	37	39	23	26	24	25	22	27

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Relevé code nos.	397	414	421	422	423	424	425	426	427	10	13	16	17	61	76	77	78	90	91	92	93	98	99	117	119	128	170	180	189	190	194	207	208	228	229	285	287	290
Date 1	19	21	22	22	22	22	23	23	23	30	30	25	25	29	26	26	26	20	20	19	19	21	21	15	15	14	26	26	20	20	30	11	11	6	6	7	7	7
Date 2	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	5	5	6	6	5	6	6	6	6	6	6	6
Date 3	86	86	86	86	86	86	86	86	86	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85	85	85
Grid ref 1	44	44	35	35	35	35	35	35	35	35	35	45	45	35	44	44	44	46	46	35	35	36	36	35	35	35	45	34	35	35	35	23	23	33	33	21	21	21
Grid ref 2	50	57	919	919	918	918	920	920	921	148	148	762	762	688	44	44	44	21	21	837	837	952	952	946	946	792	658	916	936	936	217	899	899	179	179	983	983	674
Grid ref 3	631	834	272	272	273	272	279	278	278	213	212	46	46	268	981	981	982	215	215	869	869	225	225	398	399	498	48	977	934	934	345	507	507	572	572	248	248	398
Altitude (m)	240	235	255	255	255	250	360	360	355	90	90	180	180	215	220	220	210	185	185	250	250	235	235	295	295	295	175	240	173	173	200	260	260	305	305	145	145	300
Slope	30	20	25	25	35	20	8	15	10	0	0	5	3	6	3	2	5	1	1	2	4	5	6	0	4	0	15	4	0	1	0	0	0	5	2	11	0	0
Aspect	170	75	220	220	220	220	245	240	240			135	135	270	0	0	0	0	0	135	135	180	180		90		315	315		180				135	135	180		
Total number of taxa (110)	36	27	25	20	31	35	28	30	29	24	25	24	23	32	17	17	18	24	22	19	17	23	23	24	27	15	21	19	22	22	29	24	25	21	16	16	31	22

Relevé code nos.	291	292	293	294	324	325	384	385	386	393	394	395	398	399	406	418	45	185	187	216	261	263	279	296	305	306	307	308	312	313	314	315	320	321	323	356	357	7
Date 1	7	7	7	10	28	28	14	14	14	15	15	15	19	19	20	21	3	30	30	8	8	8	4	10	14	14	15	15	18	18	18	18	28	28	28	15	15	26
Date 2	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	5
Date 3	85	85	85	85	85	85	86	86	86	86	86	86	86	86	86	86	84	84	84	84	84	84	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	84
Grid ref 1	21	21	21	32	32	32	43	43	43	43	43	43	44	44	34	44	35	36	36	23	23	23	20	32	22	22	32	32	33	33	33	33	32	32	32	36	36	44
Grid ref 2	674	749	749	202	114	115	162	239	239	996	996	46	50	54	948	135	458	685	683	889	991	991	686	202	907	907	225	225	31	31	78	78	133	133	114	141	141	644
Grid ref 3	398	477	477	177	608	612	664	618	618	808	808	924	631	632	917	814	24	510	512	503	499	498	779	177	331	331	195	195	24	24	125	125	528	528	603	87	87	988
Altitude (m)	300	265	265	170	300	300	270	195	195	260	260	245	240	250	275	250	155	220	220	250	330	330	300	170	260	260	190	190	330	330	150	150	240	240	320	145	145	185
Slope	0	3	3	0	30	30	4	8	8	15	26	7	0	15	25	10	5	0	1	0	2	3	0	0	15	30	3	5	2	5	0	0	10	15	20	5	5	1
Aspect		135	135		60	50	150	135	265	305	275	225		265	200	135	225		203		270	270			70	70	200	200	45	45			245	260	80	80	70	180
Total number of taxa (110)	23	18	18	28	25	26	21	25	24	27	24	20	23	22	24	28	26	26	23	28	32	19	30	25	26	23	23	20	28	28	23	24	25	21	22	28	26	18

Relevé code nos.	8	31	32	33	34	35	36	37	38	42	109	110	126	127	163	183	184	197	198	199	200	201	209	213	215	236	257	258	289	299	309	310	319	343	344	349	350	351	370	371	377	391	392	417
Date 1	26	4	4	4	4	4	4	4	4	3	15	15	14	14	27	28	30	10	10	10	10	9	11	8	8	8	7	7	7	13	15	15	28	8	8	9	9	9	26	26	27	15	15	21
Date 2	5	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	7	7	7	7	7	6	6	6	6	5	5	6	6	6	6	6	7	7	7	7	7	7	7	7	6	6	6
Date 3	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	84	85	85	85	85	85	85	85	85	85	85	85	85	85	86	86	86
Grid ref 1	44	35	35	35	35	35	35	35	35	35	35	35	35	35	35	36	36	23	23	23	23	23	23	23	23	33	33	33	21	22	32	32	32	43	43	43	43	43	8	8	8	43	43	44
Grid ref 2	644	246	246	201	201	199	199	333	333	458	678	678	828	828	849	393	685	584	584	583	583	607	897	890	889	186	33	33	802	928	297	297	133	110	111	238	195	195	736	736	732	14	14	135
Grid ref 3	988	14	14	8	8	8	8	97	97	29	525	525	564	564	485	534	510	488	488	486	486	587	508	502	503	584	286	286	343	217	319	319	528	655	656	778	626	626	175	175	687	866	866	814
Altitude (m)	185	215	215	75	75	75	75	115	115	160	205	205	230	230	330	330	220	120	120	85	85	130	260	250	250	220	270	270	390	255	295	295	240	375	380	215	220	220	8	8	15	200	200	250
Slope	3	1	0	0	0	0	0	0	4	2	0	0	0	0	1	15	0	3	6	4	2	4	0	2	0	0	0	0	3	0	0	0	10	0	0	15	5	5	0	0	0	10	10	8
Aspect	135	0							270	135					45	180		0	0	0	0	135		0					180				245			150	150	150				100	100	135
Total number of taxa (110)	15	19	23	21	25	23	21	30	26	23	19	21	24	21	23	15	24	20	23	21	20	15	22	22	20	23	26	27	20	23	21	22	28	25	22	19	21	25	16	20	24	18	17	21

Cerastium holosteoides
Lolium perenne
Rumex acetosa
Anthoxanthum odoratum
Holcus lanatus
Cynosurus cristatus
Trifolium repens
Plantago lanceolata
Festuca rubra
Dactylis glomerata
Trifolium pratense
Bromus mollis
Bellis perennis
Poa trivialis
Ranunculus acris
Rhinanthus minor
Conopodium majus
Ranunculus bulbosus
Taraxacum officinale agg
Brachythecium rutabulum
Eurhynchium praelongum
Agrostis tenuis
Luzula campestris/multiflora
Poa pratensis
Veronica chamaedrys
Lathyrus pratensis
Myosotis discolor
Alopecurus pratensis
Centaurea nigra
Heracleum sphondylium
Ranunculus repens
Leontodon autumnalis
Sanguisorba officinalis
Alchemilla monticola
Helictotrichon pubescens
Trisetum flavescens
Rhytidiadelphus squarrosus
Cardamine pratensis
Lotus corniculatus
Vicia sativa
Leontodon hispidus
Bromus lepidus
Alchemilla glabra
Anthriscus sylvestris
Alchemilla xanthochlora
Euphrasia officinalis agg
Achillea millefolium
Poa annua
Trifolium dubium
Hypochoeris radicata
Vicia sepium
Phleum pratense
Prunella vulgaris
Veronica arvensis
Filipendula ulmaria
Chrysanthemum leucanthemum
Vicia cracca
Festuca pratensis
Agrostis stolonifera
Festuca ovina
Poa subcaerulea
Stellaria media
Eurhynchium swartzii
Eurhynchium speciosum
Ranunculus ficaria
Endymion non-scriptus
Calliergon cuspidatum
Holcus mollis
Linum catharticum
Arrhenatherum elatius
Crepis paludosa
Crepis capillaris
Plagiomnium undulatum
Potentilla erecta
Plantago major
Carex sp
Anemone nemorosa
Deschampsia cespitosa
Juncus effusus
Lathyrus montanus