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A Method for the Characterisation of Range-Type Vegetation

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In the last 30 years spectacular advances have been made in the production and use of pasture. In particular, these developments have taken place on the better soils and in temperate climatic regions. In many parts of the world today, however, increasing attention is now being focussed on the more extensively used permanent grazings which are inherently unsuited to intensive husbandry techniques. Davies (1960) has recently discussed these grasslands and classified them on a global basis into five categories according to their productivity. The two lowest categories, accounting for 68 percent of the total permanent grassland area of the world, he describes as "extensive" and "very extensive" carrying ten "cattle units" and one to five such units per 100 acres, respectively. The cattle ranches of the western hemisphere, Africa and Australia, together with the upland grazings of Western Europe, come into the "extensive" pastoral group, while the "very extensive" group includes those of Patagonia, Northern Australia and many types in Africa. Fundamentally, the problems of these grazings are ecological and generally the management techniques evolved in regions of more intensive production cannot be applied to them. Similarly, many of the well established techniques in pasture research are not appropriate for studies under extensive management regimes and special methods are often needed.

In Great Britian, there are approximately 14 million acres of upland "rough grazings" of low productivity used for livestock production and this area comprises 29 percent of the available agricultural land. The vegetation of this range land, within a fenced or unfenced grazing unit of 300-1,000 or more acres, may exhibit a high degree of botanical uniformity being composed essentially of a single vegetation type, e.g. a community dominated by purple moor-grass (*Molinia caerulea* (L.) Moench), mat-grass (*Nardus stricta* L.), Bent/fescue species (*Agrostis* L./*Festuca* L.) or heather (*Calluna vulgaris* (L.) Hull). Much more commonly, however, the vegetation is distributed as a mosaic of several different types or shows well defined altitudinal zonation. As the stocking rate is generally low, e.g. three to eight acres per sheep or 20 or more acres per cattle beast, large plots are usually required in grazing studies. Where the vegetation within the plot enclosure is mixed, with pronounced spatial heterogeneity, it becomes difficult to characterise the area and follow vegetation changes without adopting laborious and time-consuming methods. The technique described in this paper was developed for use under such conditions.

Requirements of the Technique and its Use

The need for a suitable survey method arose with the establishment of a grazing experiment in 1950. This involved a simple comparison of two contiguous plots, each of approximately 40 acres, on deeply dissected terrain bearing a distinct vegetational mosaic. Callunetum[2] was the largest single community, but though heather was strongly dominant throughout its range, there were important changes in associated species with altitude.

An aerial photograph of the

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[1] *The authors wish to acknowledge the advice given on the statistical analysis by Dr. M. R. Sampford of the Agricultural Research Council Unit of Statistics, Aberdeen and also for the assistance of Miss P. F. Ritches of the Hill Farming Research Organization. The authors are also indebted to the British Air Ministry for permission to publish the aerial photograph in Figure 1.*

[2] *The suffix* -etum *added to the generic name of the dominant species is the technical name of the consociation i.e. the community formed where a single species dominates a portion of an association. For example, Callunetum and Pteridietum being heather dominant and bracken dominant communities, respectively.*

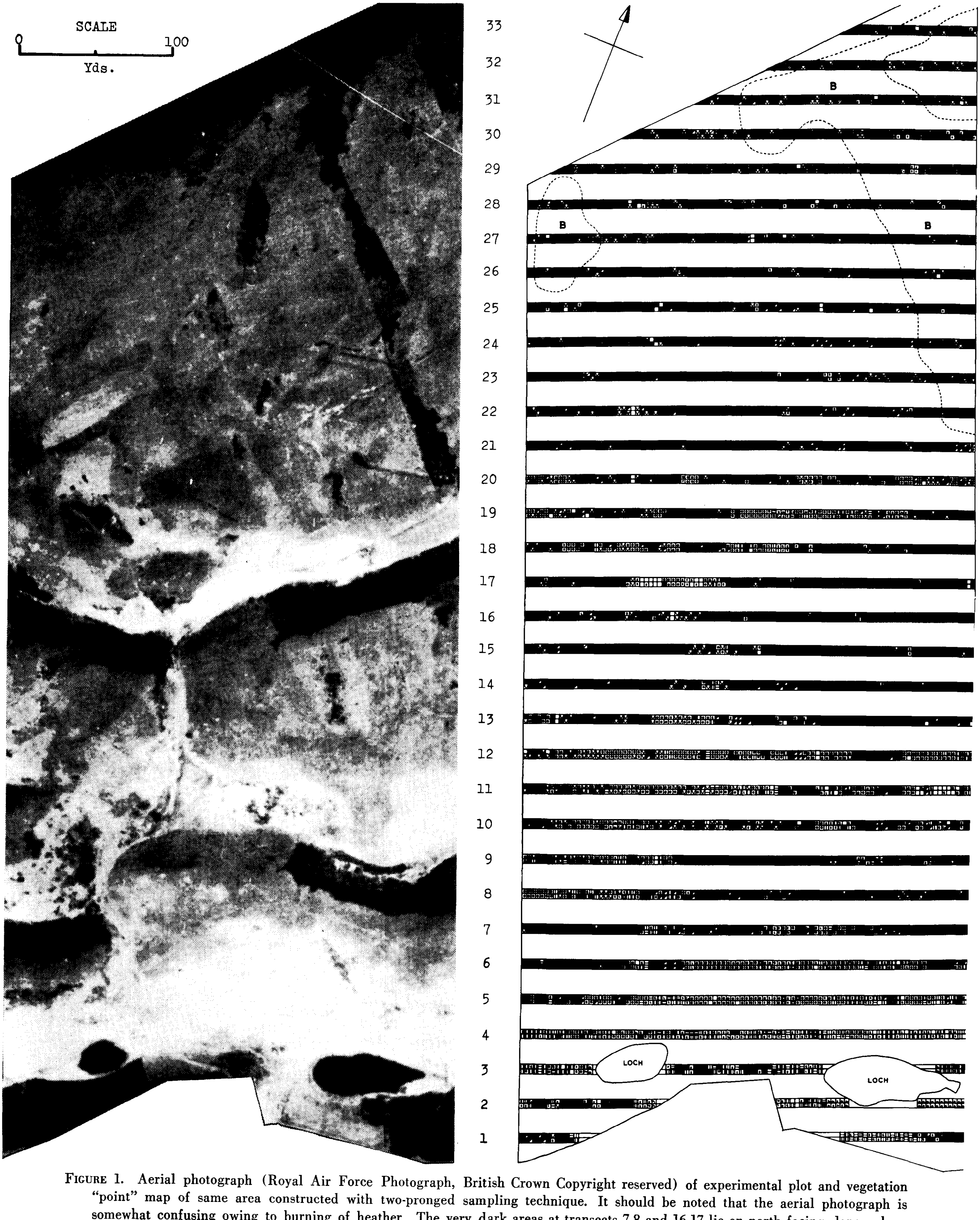

FIGURE 1. Aerial photograph (Royal Air Force Photograph, British Crown Copyright reserved) of experimental plot and vegetation "point" map of same area constructed with two-pronged sampling technique. It should be noted that the aerial photograph is somewhat confusing owing to burning of heather. The very dark areas at transects 7-8 and 16-17 lie on north facing slopes where the vegetation was too wet to burn.

area (Figure 1) gave useful information, but further data were needed for its detailed interpretation. The following requirements were considered necessary in the design of a suitable technique.

1. Speed of operation in making periodic measurements on each plot or part of it.
2. Representation of the spatial distribution and extent of the main communities and their variants.
3. A sufficient measure of the specific composition of communities to enable variation to be detected where this was not expressed in the character of the dominant.

The requirements therefore combined the essential features of mapping with those of more detailed vegetational analysis.

Methods of surveying and measuring vegetation have been reviewed by Brown (1954). Briefly, it can be said that conventional techniques were not readily applicable to the experimental area or suitable for the experimental requirements either because of their laborious nature or, as in the case of reconnaissance methods, because of their limitation in terms of accuracy and detail.

Outline of the Method

The method finally developed was based on point sampling using a two pronged fork[3].

Since the boundaries of communities were required, there was little alternative to systematic sampling if stations were to be restricted to a manageable number. The sampling stations were therefore sited at regular intervals along a series of equidistant transects. The plot taken as an example in this paper measured 300 by 750 yards and transects were laid out at right angles to the long axis at 22-yard intervals, measured horizontally irrespective of slope. There were 34 transects, most of which were 300 yards long, the sampling interval along each transect being three yards. The area was thus divided into squares three by 33 yards with samples taken at the grid intersections. Sampling with two points at each station and recording only the first species hit by the descending needles (with a distance of three inches between prongs) gave the minimum number of points necessary to provide some information on species relationships over the mosaic. This procedure enabled the data to be used for mathematical characterisation of the vegetation and also for the construction of a "point" map to show its distribution (Figure 1).

In the field, transects laid out with a theodolite were permanently marked at various points according to the terrain. The three-yard sampling interval was estimated by pacing after previous practice under various slope and other conditions. Although the transects were accurately positioned, the vertical axes of the grid were thus only estimated. As the errors in pacing were different for each transect, the vertical axes therefore departed from straight lines according to the magnitude of the errors on each transverse. In practice, as shown later, this did not constitute a serious limitation of the method.

Construction of the Map

The outline of the map (Figure 1) is drawn to scale and the transects shown as belts, stations being represented by 99 pairs of squares straddling the center line. Intervals between stations are eliminated and the stations are represented by a sequence of contiguous squares in which the appropriate species symbols are drawn.

Statistical Treatment

In this paper, statistical work is restricted to an examination of the associations between each of three selected species and all other species. The main purpose of this is to indicate, by application of a chi-square test, how the data can be used to give considerably more information about the vegetation than by the use of frequency alone. (For an account of a similar approach using a more critical technique, see Williams and Lambert [1959 and 1960].)

In preparing the data for analysis contingency tables were constructed showing the class frequencies (number of stations) of all relevant paired occurrences. Only class frequencies with expected values of >5 were examined and the significance level was fixed at $P < .05$.

Examination of the Method

Field Work

The most laborious part of the work lay in marking out the parallel transects, a procedure which required one theodolite operator and two assistants. The time taken per transect varied with topography and thus the distance which could be ranged from the theodolite without changing its position. On moderately sloping ground, however, any incompleted section of line was easily continued by unaided visual ranging with surveyor's poles. On the easiest terrain the transects were marked out almost as rapidly as the position of the theodolite could be changed. The sampling time for a 300-yard-long transect varied from about ten minutes in shrubby communities to about thirty-five minutes where short close-grazed turf predominated.

Accuracy in Delineating Plant Communities

A comparison between the "point map" and the aerial pho-

[3] *The authors are indebted to Mr. P. J. Faulks, Senior Lecturer in Botany, University of Aberdeen, who advocated the use of a two-pronged fork for vegetational analysis and who made many valuable comments in the early stages of the work.*

tograph (Figure 1) shows a close similarity in the vegetational pattern as expressed by the two methods. The main zones of heather dominance for example are clearly shown, together with the peripheral *Pteridietum.* It should also be noted that in the aerial photograph the top section of the plot is shown in fairly uniform dark shades (apart from the patchwork caused by the burning pattern) giving no indication of the species associated with the dominant. The map shows that a variety of species are present in this area and that the main heather areas lack uniformity both in the associated species and in their frequency.

A series of measurements on the photograph and on the map have been used to estimate the error in delineating community boundaries along each transect. Differences as low as 0.3 percent have been found where the ground was fairly level, though in one or two cases on very broken ground discrepancies as high as 13 percent have been found[4]. To mitigate the tendency for high errors on undulating terrain it is an advantage if several vertical lines are laid down at right angles to the transects to reduce the cumulative pacing error.

Floristic Composition and Species Relationships

The species recorded on the map and the appropriate symbols or index letters used are shown in the list below.

As the first species hit by each needle of the sampling fork is the only one recorded there is a tendency for the shorter or prostrate species to be underestimated. The most detailed information on the composition of the community is therefore given in short single-layered types, but even in tall dense vegetation such as vigorous Callunetum or bracken stands, differences in community structure are revealed except where the upper canopy is completely closed. In many types of extensive characterisation, however, any lack of detail in this respect may not be regarded as a serious disadvantage, particularly as any further information considered necessary can be acquired by more detailed local studies as and when required.

Heather *(Calluna vulgaris* (L.) Hull)
Cv Mouse-eared chickweed *(Cerastium vulgatum L.)*
T Marsh thistle *(Cirsium palustre* (L.) Scop.)
Crowberry *(Empetrum nigrum* L.)
Bell-heather *(Erica cinerea* L.)
Crossleaved heather *(E. tetralix* L.)
G Heath bedstraw *(Galium hercynicum* Weigel)
P Common tormentil *(Potentilla erecta* (L.) Rausch)
R Sheep's sorrel *(Rumex acetosella* L.)
W White clover *(Trifolium repens* L.)
Blaeberry *(Vaccinium myrtillus* L.)
Cowberry *(V. vitis-ideae* L.)
Z Speedwells *(Veronica* L. spp.)
Cx Sedges *(Carex* L. spp.)
Ea Common cotton-grass *(Eriophorum angustifolium* Honck.)
Ev Draw-moss *(E. vaginatum* L.)
Je Soft rush *(Juncus effusus* L.)
Heath rush *(J. squarrosus* L.)
L Woodrush *(Luzula* Dc. spp.)
N Bog asphodel *(Narthecium ossifragum* (L.) Huds.)
Brown bent-grass *(Agrostis canina* L.)
Common bent-grass *(A. tenuis* Sibth.)
Ao Sweet vernal-grass *(Anthoxanthum odoratum* L.)
Ap Early hair-grass *(Aira praecox* L.)
Wavy hair-grass *(Deschampsia flexuosa* (L.) Trin.)
Sheep's fescue *(Festuca ovina* L.)
Red fescue *(F. rubra* L.)
Hl Yorkshire fog *(Holcus lanatus* L.)
H *Holcus* L. spp.
Lo Perennial rye-grass *(Lolium perenne* L.)
Pa Annual meadow-grass *(Poa annua* L.)
Pt Rough-stalked meadow-grass *(P. trivialis* L.)
Bracken fern *(Pteridium aquilinum* (L.) Kuhn)
8 Misc. mosses
Bare ground

Although the use of a two-pronged fork imposes some statistical restrictions, it is of interest to ascertain whether the associations of species pairs recorded in this way can give useful guidance on the classification of communities with the area as a whole.

Table 1 shows a chi-square matrix for the whole area for those pairs which occur with a high enough class frequency for analysis. Summations for rows and columns, which include positive and negative associations, are also shown. Taking heather, a significant positive association occurs with blaeberry (five percent level), while associations with species of fescue, *Holcus* spp., heath bedstraw and "miscellaneous dicotyledonous spe-

[4] *It should be noted that the aerial photograph was not specially taken for the purpose and as the projection is not vertical, some discrepancy is inevitable. As it was intended to use the same photograph for successive ground surveys, however, this objection is not unduly serious.*

Table 1. Chi-square matrix for transects 1-34 (whole plot area)

	Bell Heather	Wavy Hair-grass	Heath Rush	Crowberry	Blaeberry	Cowberry	Misc. Mosses	Bare Ground	Fescue	*Holcus*	Heath Bedstraw	Misc. Mono-cot. Species	Misc. Dicot Species	Total
Heather	3	2	1	7	4*	2	0	1	9**	6*	35**	1	10*	81**
Bent grasses	13**	13**	0	10**	24**	5*	7**	2	33**	—	120**	—	—	227**
Bracken	0	0	—	8**	1	—	—	1	0	0	2	0	—	12
Total	16**	15**	1	25**	29**	7	7*	4	42**	6*	157**	1	10**	320**

(Values of chi-square not calculated for expected values < 5)

For column totals, chi-square = 6.0 (5%)
= 9.2 (1%)

For row totals, chi-square = 15.5 (5%)
= 20.1 (1%)

Degree of association of:

Heather with blaeberry* Bent grasses with misc. mosses,** fescue** and heath bedstraw** Bracken	More than Expected

Degree of association of:

Heather with fescues**, *Holcus**, heath bedstraw** and misc. dicot species.* Bent grasses with bell heather**, wavy hair-grass**, crowberry** and blaeberry** Bracken with crowberry**	Less than Expected

The area was further examined by division into three zones, namely:

(1) Transects 1 - 9, characterised by a predominance of gramineous communities, bracken communities and zones of heather dominance.

(2) Transects 10 - 20, consisting mainly of heather but also containing small graminaceous and bracken areas.

(3) Transects 21 - 34, containing mainly heather.

These zones can be picked out on the "point" map and specific frequencies for each zone are shown in Figure 2. Contingency tables were prepared for each zone, but owing to the large number of expected frequencies of < five in zones (2) and (3) and the high self: self occurrences, especially of heather, a valid analysis of these zones was not possible.

The chi-square matrix for zone (1) is shown in Table 2. Heather is positively associated only with wavy hair-grass, which in this area has received

cies" occur with a frequency less than the expectation. The bent-grasses are positively associated with the fescues, mosses and heath bedstraw and negatively with bell heather, wavy hair-grass, crowberry and blaeberry. Bracken fern shows a positive association with no other species and is negatively associated with crowberry (one percent level). The main species groupings demonstrated by this analysis are thus:

a) heather/blaeberry
b) bent/fescue grassland

The exclusion of the large number of self: self occurrences from the analysis obscures the existence of large areas of relatively pure heather though in the case of bracken areas the absence of significant associations with other plants indicates its presence in relatively pure stands.

Table 2. Chi-square matrix for transects 1-9

	Bell Heather	Wavy Hair-grass	Heath Rush	Crowberry	Blaeberry	Cowberry	Misc. Mosses	Bare Ground	Fescue	*Holcus*	Heath Bedstraw	Misc. Mono-cot. Species	Misc. Dicot Species	Total
Heather	1	21**	—	—	1	—	0	—	3	—	16**	0	3	45**
Bent grasses	5*	19**	—	—	3	—	0	—	4*	—	15**	—	—	46**
Bracken	—	1	—	—	—	—	—	—	0	—	0	—	—	1
Total	6*	41**	—	—	4	—	—	—	7*	—	31**	—	3	92**

(Values of chi-square not calculated for expected values < 5)

Degree of association of:

Heather with wavy hair-grass** Bent grasses with fescues* and heath bedstraw** Bracken	More than Expected

Degree of association of:

Heather with heath bedstraw** Bent grasses with bell heather* and wavy hair-grass** Bracken	Less than Expected

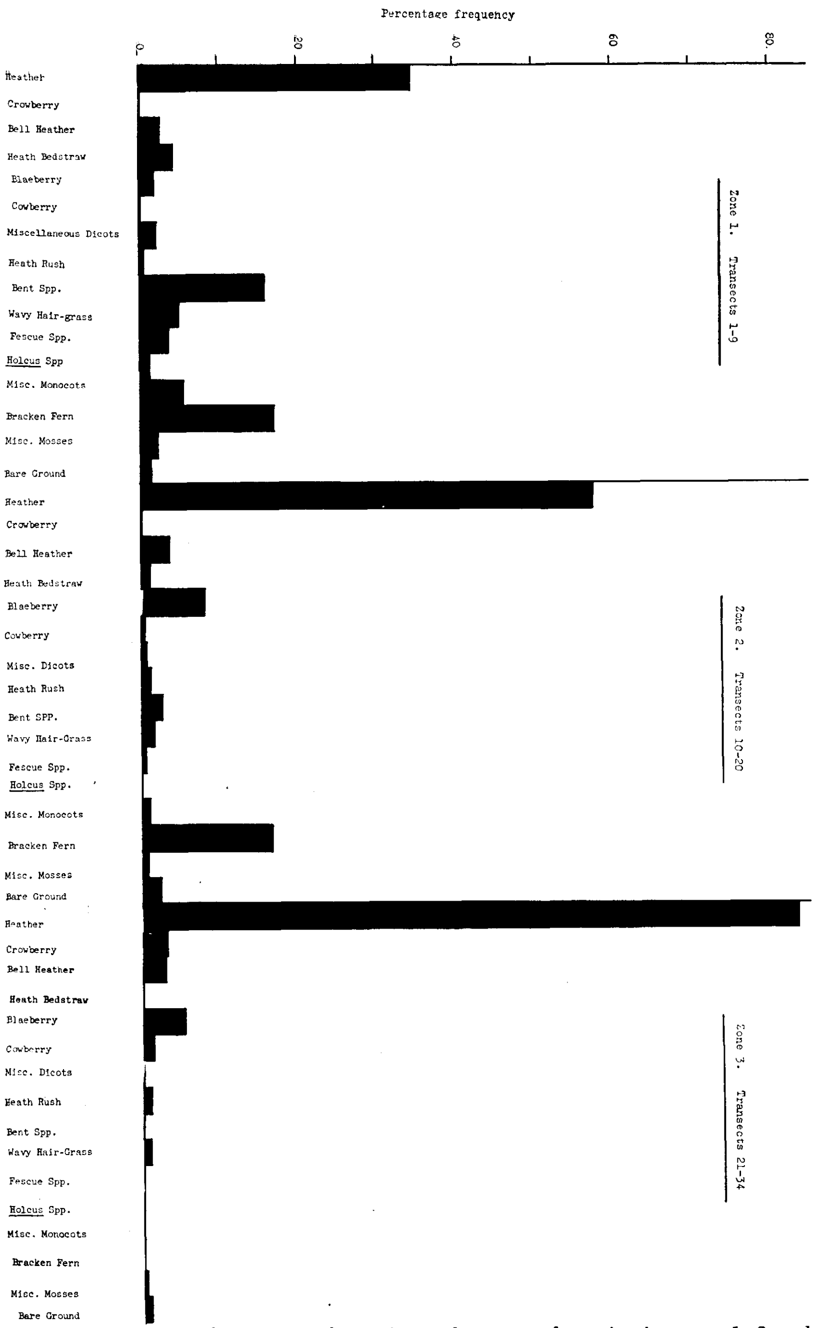

FIGURE 2. Percentage frequency of species and groups of species in zones 1, 2 and 3.

one of the principal constituents of bent/fescue grassland. The bent-grasses are positively associated with fescues and heath bedstraw and negatively with bell heather and wavy hair-grass. Bracken shows no significant associations.

Floristic Change

The comparisons discussed above are concerned with spatial differences in vegetation at a given time. Two areas of strongly dominant heather, at the north end of the area (between transects 21 and 34), were burnt however after the first analysis in 1956. The effect of burning on the vegetation and the subsequent nature of regeneration is illustrated diagrammatically by construction of the "point" maps in Figure 3. Map A shows the condition before burning, Map B two years later and Map C eight years after burning.

Table 3 shows the percentage frequency of species for transects 22 - 34 in the burnt and unburnt areas for the three years 1954, 1958 and 1961. The general rise in frequency of heather in the unburnt area reflects the increasing dominance of the plant. In 1958, two years after burning area B (the area was practically devoid of vegetation after the burn in 1956) considerable recolonisation had taken place. Heather had greatly increased and bare ground was only 18 percent. Other species including wavy hair-grass were a competitive advantage as a result of burning and heavy grazing pressure. On suitable soils the succession from heather to bent/fescue grassland appears to have been completed as a result of these two factors, and the separation of soils on this basis received added emphasis by the highly significant negative association (one percent level) of heather with heath bedstraw,

Table 3. Floristic changes in burnt and unburnt areas, 1954-61 (percent frequency)

	Unburnt			Burnt		
	1954	1958	1961	1954	1958	1961
Heather	82.8	89.9	94.3	83.7	55.3	74.4
Blaeberry	5.1	0.9	0.7	5.6	9.1	7.1
Cowberry	1.6	0.6	0.3	2.0	3.7	2.4
Heath rush	1.1	0.9	0.4	2.2	4.5	3.5
Wavy hair-grass	1.0	0.6	0.2	0.4	4.1	3.3
Other species	7.1	6.0	4.0	5.4	5.3	6.0
Bare ground	1.3	1.1	0.1	0.7	18.0	3.3
	100.0	100.0	100.0	100.0	100.0	100.0

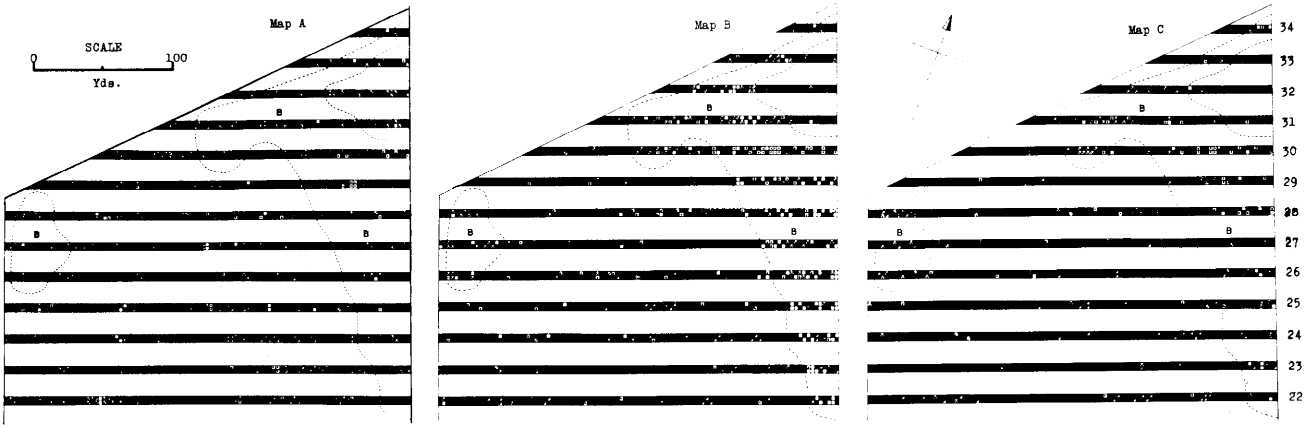

FIGURE 3. "Point" maps of area covered by transects 22-34. Map A shows vegetation in 1954, Map B in 1958 two years after burning and Map C in 1961. Areas marked B on all maps indicate location of 1956 burn.

contributing noticeably to the vegetation. By 1961 the succession was considerably more advanced with heather approaching its former prominent position. Other species were correspondingly reduced though still more prominent than before burning.

Unfortunately the sampling intensity was such that the data available from the two small burnt areas were considered to be insufficient to allow a valid chi-square analysis to be carried out at the various successional phases. The use of frequency and preparation of a series of "point" maps for comparisons in time, however, do demonstrate the manner in which segments of the survey area can be isolated easily for more specific study without repetition of the entire survey.

Conclusions

The technique has been found to satisfy the requirements for certain agronomic studies in terms of speed and accuracy in the general characterisation of spatial pattern over an area, or on a given area at different times. It is simple and objective to operate and a map of considerable value can be produced readily. It is thought that the method might be applicable to a wide range of vegetation types, but from present evidence it is most suitable for use when the vegetation is disposed as a mosaic of different communities, rather than where extensive uniform areas occur. For many purposes, at least in preliminary work, it may be unnecessary to record individual species and in this case the use of a life form characterisation may be adequate, thus considerably reducing the work.

The dimensions of the sampling fork i.e., the length of the prongs and their distances apart will depend on the nature of the vegetation, particularly regarding its height and whether closed or open communities are being studied. Although two independent points recorded at each station would be statistically more acceptable, experience has shown that even this departure from the technique adds considerably to the sampling time.

LITERATURE CITED

DAVIES, WILLIAM. 1960. Pastoral systems in relation to world food supplies. The Advancement of Science, 17, 67, 272-280.

BROWN, DOROTHY. 1954. Methods of Surveying and Measuring Vegetation. Commonwealth Bureau of Pastures and Field Crops Bulletin 42.

WILLIAMS, W. T. AND LAMBERT, J. M. 1959 and 1960. Multivariate Methods in Plant Ecology.

I Association analysis in plant communities. Jour. of Ecol. 47: 83-101.

II The use of an electronic digital computer for association analysis. Jour. of Ecol. 48: 689-710.