STUDIES IN THE ECOLOGY OF COASTAL HEATH IN NEW SOUTH WALES

I. Vegetation Structure

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Synopsis

The structure of coastal heath has been studied at Mourawaring Point, New South Wales, using the DIVINF Classification programme of Lance and Williams (1968). Three main vegetation groups have been recognized in the area, based on divisions of an edaphic catenary sequence : (*a*) sand heath, (*b*) ground-water heath, and (*c*) peaty swamp. The sand heath may be divided into two groups, which are related to the depth of underlying water table : the " dry " sand heath (*Banksia serratifolia-Hypolaena fastigiata* group) and the " wet " sand heath (*Banksia ericifolia-Casuarina distyla-Hakea teretifolia-Schoenus brevifolius* group). The ground-water heath may be divided into a further three groups, based on the depth and nutrient status of the accompanying soils : the *Banksia ericifolia-Casuarina distyla-Hakea teretifolia-Cyathochaete diandra* group, the *Casuarina distyla-Themeda australis-Eragrostis* sp. group, and the *Casuarina nana-Banksia integrifolia-Westringia fruticosa* group. The peaty swamp is characterized as a *Baeckea imbricata-Juncus* sp. group.

Introduction

In any investigation of the distribution of a single species, or a group of species, a primary concern of an ecologist is to understand the whole system of which they form a part ; autecological studies alone remain incomplete until they are integrated into the synecology of the community (*cf.* Anderson, 1960). But various autecological data cannot be integrated to provide a synthetic picture of plant communities except in a strictly subjective sense (see Anderson, 1963). Although various quantitative methods are currently available for examining the composite structure of plant communities, however, it must be emphasized that such synecological studies alone remain unsatisfactory, since studies on so large a scale are likely to raise more questions than they can answer.

The present paper deals with an analysis of macrostructure of a heath located at Mourawaring Point on the central coast of New South Wales. This study has been supplemented by investigations of the microdistribution of the most abundant heath species together with related experimental work which will be reported in subsequent papers.

Numerous quantitative techniques are now available for examining the composite and gross structure of plant communities. These techniques are based on one of two basic concepts underlying the description of vegetation : classification and ordination (see Curtis and McIntosh, 1951 ; Bray and Curtis, 1957 ; Williams and Lambert, 1959, 1960, 1961 ; Lambert and Williams, 1962, 1966 ; Anderson, 1965 ; Williams, Lambert and Lance, 1966 ; McIntosh, 1967 ; Greig-Smith *et al.*, 1967, etc.). For the present analysis, there are good reasons to select a classification procedure for the preliminary analysis of heterogeneity (Siddiqi, 1971), and of the classification procedures available, the technique of divisive information analysis (Lance and Williams, 1968) has been preferred.

Description of the Area

Situated within Bouddi State Park, about 10 miles north-east of Gosford, New South Wales, Mourawaring Point is a headland which faces the sea. The area comprises two opposing slopes, separated by a narrow gully. A creek runs

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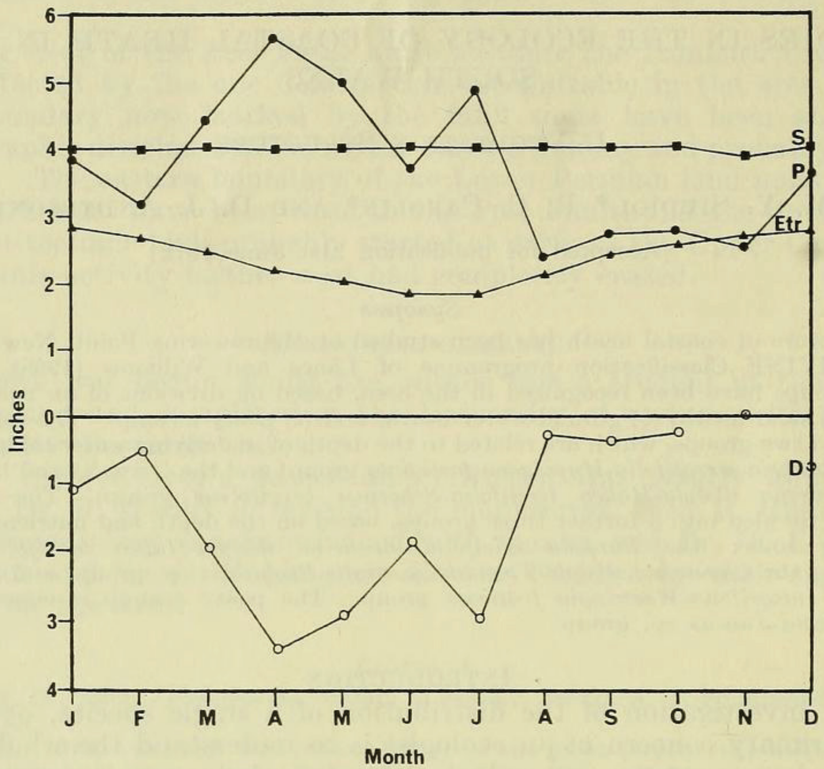

Fig. 1. Moisture budget of Sydney, calculated from climatic averages for thirty years (see text). Four inches are taken as the hypothetical maximum water storing capacity of soil.
S=Storage : P=Precipitation : Etr=Evapotranspiration : D=Drainage

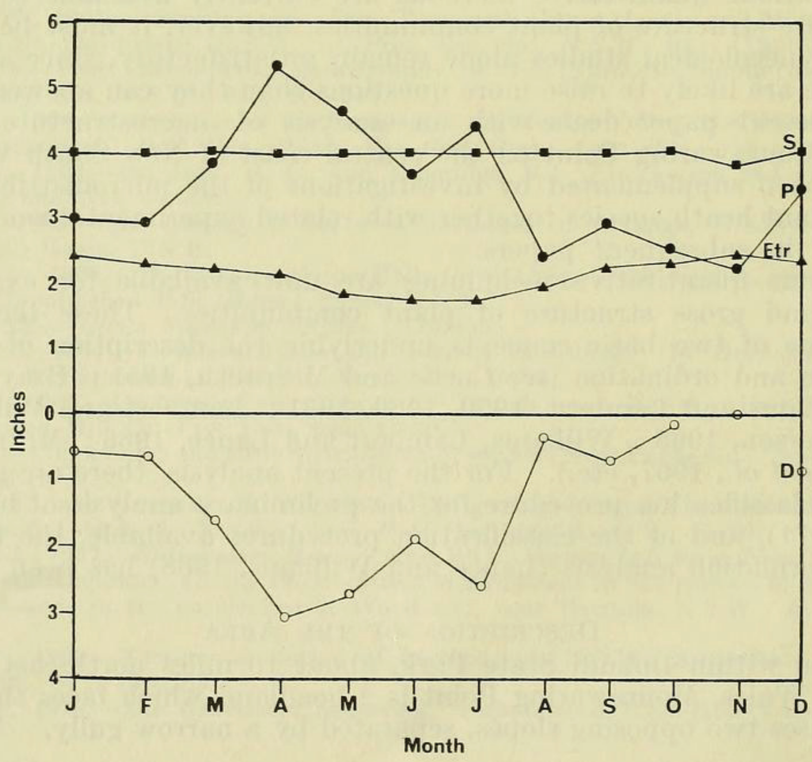

Fig. 2. Moisture budget of Newcastle, calculated from climatic averages for thirty years (see text). Four inches are taken as the hypothetical maximum water storing capacity of soil.
Symbols as in Fig. 1.

at the bottom of the gully and supports a typical swamp vegetation in its environs. The general topography of the area is shown in Fig. 3.

The east-facing slope has a deep sandy belt, surrounded by soils of higher clay content on either side. The transition between soil types is very sharp and is reflected in the equally sharp demarcation between the dominant vegetation types (see Fig. 4). The west-facing slope consists entirely of shallow clayey soil with iron-stones near the surface, with the exception of a narrow sandy belt at the top. The soils are derived from the shales and sandstone of the Gosford formation of the Narrabeen group within the Triassic series (see McElroy, 1957).

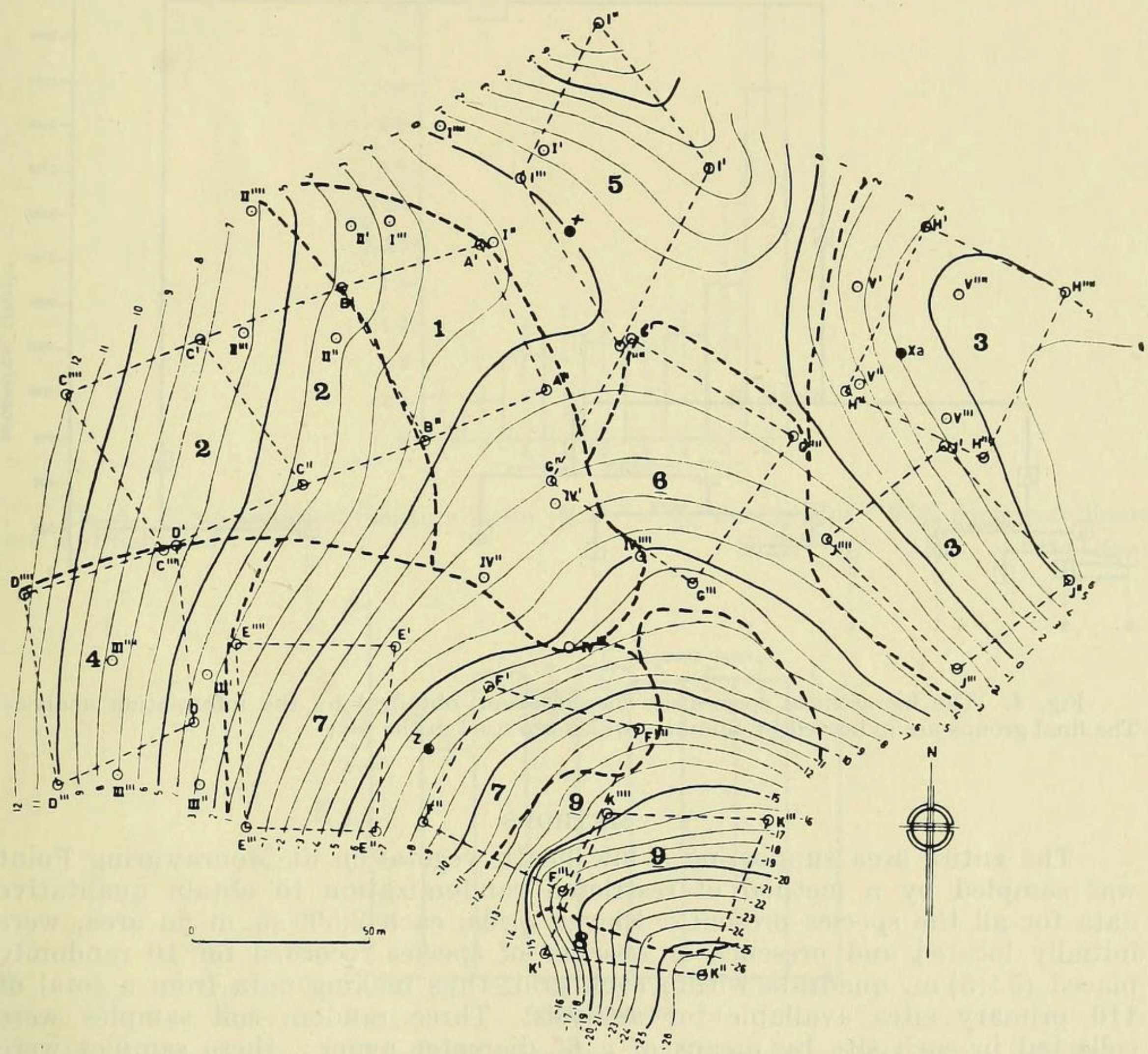

Fig. 3. Topographic map of the study area, showing location of sampling grids (light broken lines) and the distribution of the final groups (heavy broken lines) in relation to height contours. (Contour intervals in metres : large Roman numerals refer to Final Groups as shown in Fig. 5.)

Climatically, the area is situated in a moderately high rainfall belt along the east coast of Australia (mean rainfall = 47″). Figures 1 and 2 show the mean monthly precipitation and the moisture budgets for Sydney (*c.* 40 miles south) and Newcastle (*c.* 40 miles north), respectively the nearest meteorological stations available. The moisture budgets have been calculated according to Prescott, Collins and Shirpurkar (1952). The moisture index (Im) of Thornthwaite (1948) was calculated as +58 for Sydney and +62 for Newcastle. According to these indices the climate of Sydney would be described as B–2 humid (upper limit) and that of Newcastle as B–3 humid (lower limit).

The vegetation can be described as a typical heath (see, *e.g.*, Wood and Williams, 1960), with *Banksia serratifolia* as the most prominent shrub on the deep sandy ridge and *B. ericifolia*, *Hakea teretifolia* and *Casuarina distyla* the most prominent species on the clayey and sandy soils towards the gully. A typical swamp vegetation, dominated by *Baeckea imbricata* and *Juncus* sp., is present surrounding the creek on peaty water-logged soil.

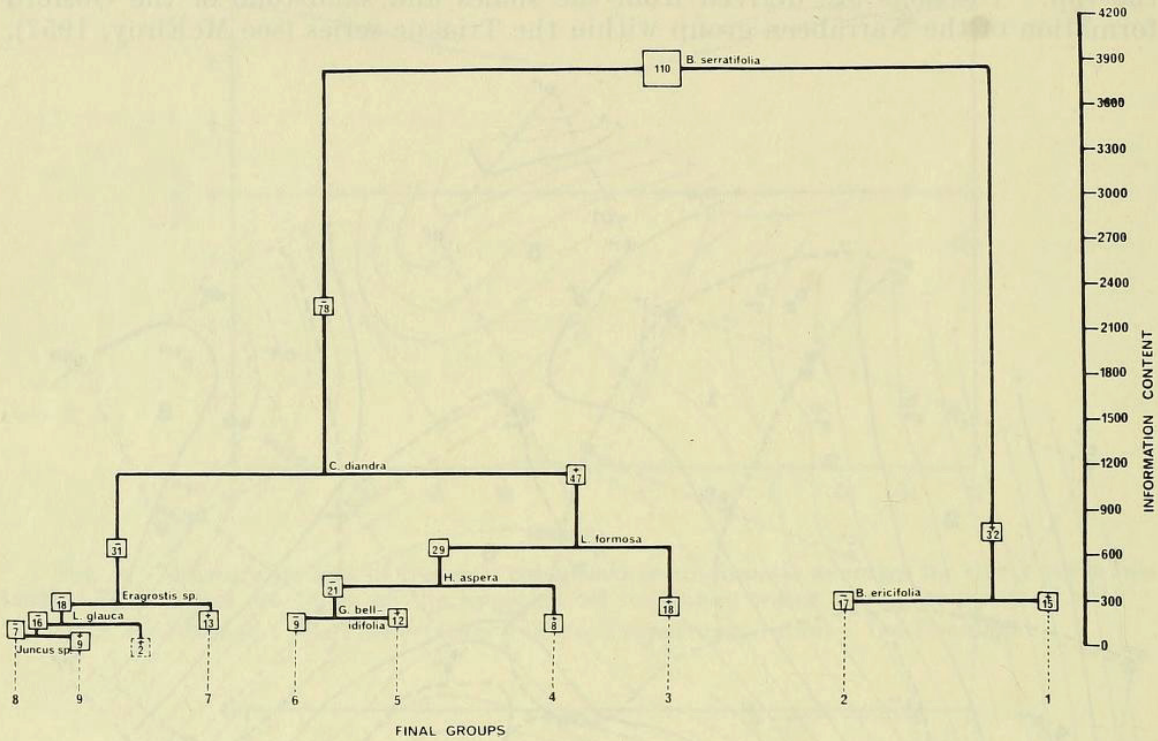

Fig. 4. The hierarchical species/site classification, obtained by the information analysis. The final groups are indicated by numbers which are used in the text.

METHODS

The entire area supporting a low heath vegetation at Mourawaring Point was sampled by a method of restricted randomization to obtain qualitative data for all the species present. Eleven grids, each 2,500 sq. m. in area, were initially located and presence or absence of species recorded for 10 randomly placed (5×5) m. quadrats within each grid, thus making data from a total of 110 primary sites available for analysis. Three random soil samples were collected in each site by means of a 6″ diameter auger ; these samples were pooled to give a representative sample for each site. Both vegetation and soils were sampled in March, 1968.

A total of 106 species were encountered over the sampled area. Since many of these occurred so infrequently, it was decided to limit the analysis to those species which were present in five or more quadrats, a total of 72 species. The program " DIVINF " used in the present analysis is available at the C.S.I.R.O. Division of Computing Research, Canberra, A.C.T.

The soil samples were air-dried. The moisture factors (defined as air dry weight $\times 100$/oven dry weight—Metson, 1956) were determined and subsequently the samples were analysed for pH, exchangeable Na, K, Ca, Mg, P, and total N.

The area has been topographically surveyed and the grids are mapped in relation to the contour intervals in Fig. 3.

Results

The results of the hierarchical monothetic species/site classification are shown in Fig. 4.

As programmed, 20 final groups have been obtained. It is apparent from Fig. 4 that the bulk of information content is carried by the first division, based on *Banksia serratifolia*. It would perhaps be appropriate to designate the two groups thus obtained as major groups, the group (+) *B. serratifolia* as major group I and the group (−) *B. serratifolia* as major group II.

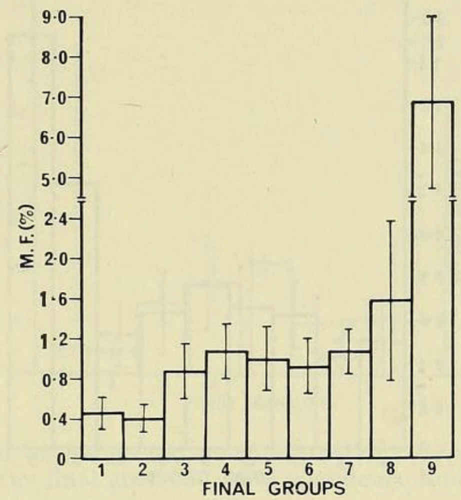

Fig. 5. Mean values of moisture factor (M.F.) of the final groups. 95% confidence limits are also indicated.

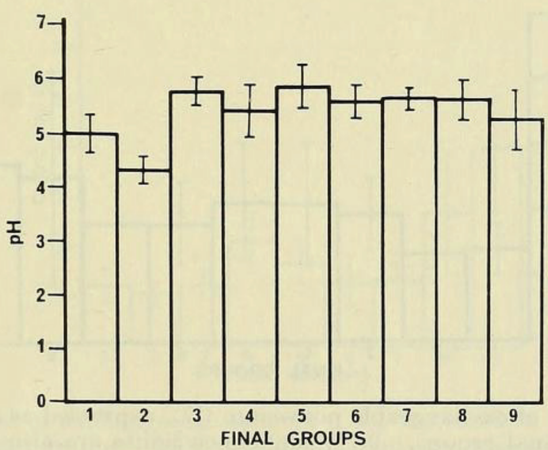

Fig. 6. Mean values of pH of the final groups. 95% confidence limits are also indicated.

An initial problem in the treatment of data is to select the hierarchical level below which the divisions can be considered insignificant. One approach to this problem is the objective one of using a significance test (twice the information fall may be taken as a conservative estimate of χ^2 see Webb *et al.*, 1967), thereby discarding all the divisions below that level. Alternatively, it is possible to be entirely subjective and accept all those groups which are explicable in ecological terms. The problem with the application of an entirely objective approach is that sometimes the divisions at a lower hierarchical level are ecologically more important than indicated statistically, and potentially valuable information may be lost by discarding these divisions. (This problem may arise as a result of great unevenness in the number of species in different groups, as has been observed in the present case, *e.g.* final groups 8 and 9). In the present instance, therefore, these groups below the formal level of significance (300 I.C.), which appear from field experience to be ecologically significant, have been accepted.

Using this criterion, nine groups are obtained. The distribution of these groups in the field is shown in Fig. 3.

The mean values of the soil variables calculated for the nine site groups are compared in Figs 5–12.

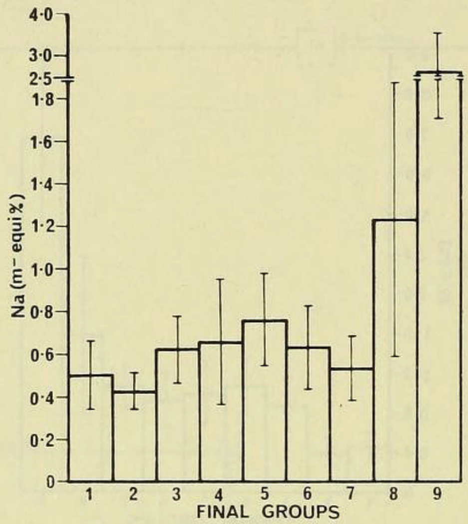

Fig. 7. Mean values of exchangeable sodium (Na), expressed as milliequivalent percentage of oven-dry soil, of the final groups. 95% confidence limits are also indicated.

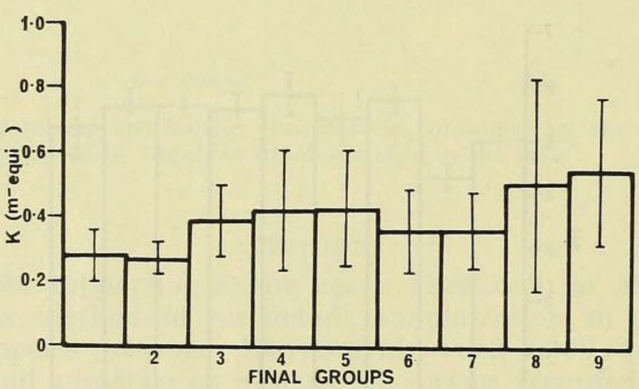

Fig. 8. Mean values of exchangeable potassium (K), expressed as milliequivalent percentage of oven-dry soil, of the final groups. 95% confidence limits are also indicated.

Unfortunately, a complete fire history is not available for the area. The only information available from non-authenticated sources is that the area was completely burnt 12–15 years prior to the date of collection of data in this study, followed by one or two small-scale, localized fires, the last being 3–4 years prior to collection of data (*c.* 1964). The pattern produced by the last burn can still be seen ; the tall, dense scrub of *Banksia ericifolia*, *Casuarina distyla* and *Hakea teretifolia* in the gully represents the site left unburnt in this last fire.

A comparison of the soil analyses indicates that the first division, based on *B. serratifolia*, distinguishes the vegetation into the major groups on the basis of the physical soil structure. Major group I, (+) *B. serratifolia*, is confined to those sites with an entirely sandy soil profile. The two final groups recognized within this major group represent a wetter situation (group 1, (+) *Banksia* *ericifolia*) with a shallower water table (*c.* 90–150 cm.) and higher pH ; and a drier situation (group 2, (−) *B. ericifolia*) with a very deep water table (considerably deeper than 180 cm.—the exact extent was not determined, but it seems to be below the level where it may be important for root growth) and more acid in reaction. The nutrient status of soils from the two groups is strikingly similar except for Na, which is relatively higher in the group 1 soils (Figs 5–12).

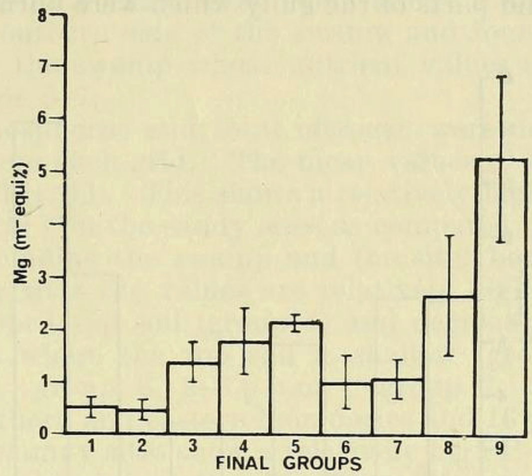

Fig. 9. Mean values of exchangeable magnesium (Mg), expressed as milliequivalent percentage of oven-dry soil, of the final groups. 95% confidence limits are also indicated.

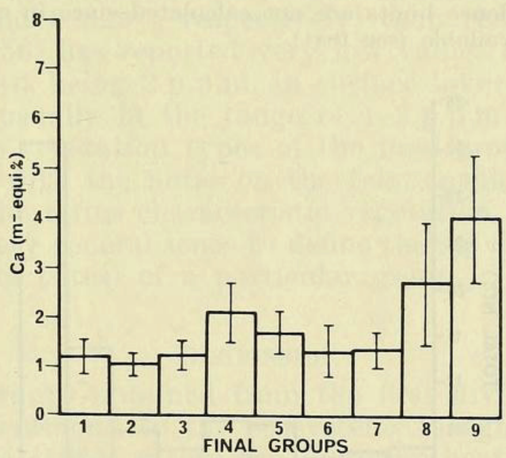

Fig. 10. Mean values of exchangeable calcium (Ca), expressed as milliequivalent percentage of oven-dry soil, of the final groups. 95% confidence limits are also indicated.

Major group II includes seven final groups (3–9). The first division within this major group is based on *Cyathochaete diandra*, which differentiates a habitat with a shallow horizon of sandy loam, a shallow or deep horizon of clayey loam over a relatively impermeable clay layer, (+) *C. diandra* section, from a (−) *C. diandra* section which contains three varied habitats : (*a*) a steep slope with little or no sandy top soil, a thin loamy horizon over a thin clay layer (with exposed rock faces at some sites), bordering on swamp on one edge ; (*b*) a clayey ridge with relatively well developed loamy and clayey horizons, extending to the opposing edge of the swamp ; and (*c*) the peaty swamp.

The next division in the (+) *C. diandra* section is based on *Lambertia formosa*. The sub-section (+) *L. formosa* (group 3) consists of sites located on the west-facing slope, with a shallow loamy horizon on clay with iron-stones on the surface.

The sub-section (—) *L. formosa* consists of two distinct habitats: (*a*) with a deep loamy horizon, and (*b*) with a shallow loamy horizon, which are distinguished in the next division of this sub-section, based on *Hibbertia aspera*. Group 4 ((+) *H. aspera*) represents the sites with a fairly prominent, deep loamy horizon over relatively impermeable clay, whereas the (—) *H. aspera* part of the division represents the sites with a shallow loamy horizon. The subsequent division of this part is based on *Goodenia bellidifolia*, group 5 ((+) *G. bellidifolia*) represents the slopes and parts of the gully which were burnt in the previous fire;

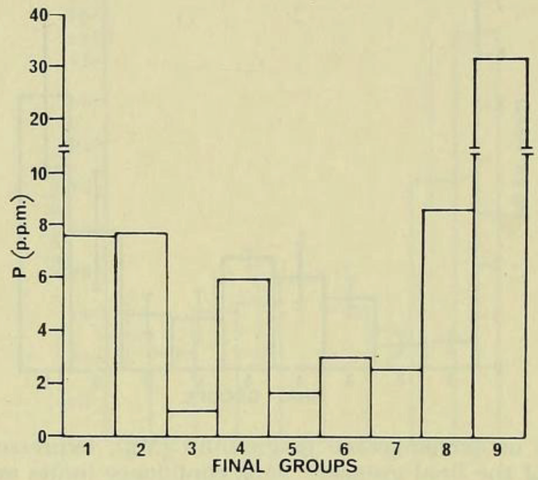

Fig. 11. Mean values of exchangeable phosphorus (P), expressed as parts per million (p.p.m.), of the final groups. Confidence limits are not calculated since in some final groups only few degrees of freedom were available (see text).

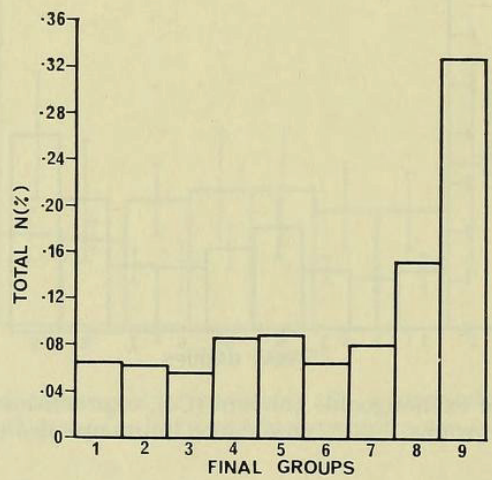

Fig. 12. Mean values of total nitrogen (N), expressed as percentage of oven-dry soil, of the final groups. Confidence limits are not calculated since in some final groups only few degrees of freedom were available (see text).

whereas group 6 ((—) *G. bellidifolia*) represents that part of the gully which has not been burnt for the last 12–15 years and which supports a tall, dense scrub of *Banksia ericifolia*, *Casuarina distyla* and *Hakea teretifolia*. Although the soils of groups 5 and 6 are more or less similar in their profiles, the soils of group 5 show an increase in the mean nutrient status.

The next division in the *C. diandra* section is on *Eragrostis* sp. Group 7 ((+) *Eragrostis* sp.) consists of sites with a truncated profile, with a shallow clayey layer, bordering on the swamp on one edge. The section (—) *Eragrostis* sp. shows a lower level of heterogeneity on the hierarchical level, but ecologically it is still very heterogeneous, including both swampy and non-swampy sites. The next division in this section is on *Lomandra glauca*, the (+) *L. glauca* group separating the two sites on the west-facing slope with loose yellow sand, from (−) *L. glauca* section with the remaining non-swampy sites bordering on the swamp and the swampy sites. The division in this section, based on *Juncus* sp., separates the non-swampy sites, group 8 ((+) *Juncus* sp.). Group 8 is still somewhat heterogeneous, consisting of three sites on the nutritionally richer clayey ridge on the southern side of the swamp and four sites on the northern and eastern banks of the swamp whose nutrient values are comparable to the mean values of groups 3–7.

Exchangeable phosphorus and total nitrogen were determined for a batch of 44 samples, four from each grid. The mean values of P-content for the final groups are plotted in Fig. 11. This shows a relatively high P-content for groups 1 and 2 soils (7–9 p.p.m.) on the sandy sites as compared to most of the ground-water heath sites, excluding the swamp and the sites bordering on it. Within the loamy and clayey sites the values are relatively higher (5–7 p.p.m.) on the sites with well developed top soil (group 4) and decrease to a minimum of *ca.* 1 p.p.m. on the sites where the top soil is shallow (group 3, *ca.* 1–2 p.p.m.; group 5, 1–2 p.p.m.; group 6, 2–3 p.p.m.; group 7, 2–5 p.p.m.; group 8, 2–5 p.p.m. on the northern and eastern boundaries and 16 p.p.m. on the southern clayey ridge). The swampy sites show a relatively high P-content, *ca.* 40 p.p.m., which is probably due in part to the dissolution of organic matter.

The mean values of total nitrogen for the final groups are compared in Fig. 12. This figure shows a degree of uniformity among the soils of all the groups, except for the soils of groups 8 and 9, which show a relatively high N-content (0·152% and 0·329% respectively) than the rest (0·057–0·088%). However, Hannon (1956) has reported very low values for nitrate nitrogen for similar soils, the highest being 2 p.p.m. in surface layer of a swamp, with the ammoniacal nitrogen usually in the range of 1–2 p.p.m.

The characteristic vegetation types of the final groups are summarized in Appendix 1, together with the notes on the relationship of species within the two major groups. The terms characteristic vegetation type and characteristic species are used in a very general sense to define the species which occur in all or nearly all the quadrats (sites) of a particular group.

Discussion

The two major groups obtained from the first division based on *Banksia serratifolia* broadly correspond to the ecosystems recognized by Groves (1964) and Groves and Specht (1965) within the Victorian heath formation, on a sub-formation level, *viz.* " sand heath " (major group I) and " ground-water heath " (major group II). By contrast with the results of Groves (1964) and Groves and Specht (1965), however, a clear-cut floristic and structural differentiation between the two ecosystems is indicated in the present case. In sand heath, *B. serratifolia* is dominant on the deep sandy ridge where the water table is very deep (group 2), whereas in the gully, where the water table is shallow, *B. ericifolia*, *Casuarina distyla* and *Hakea teretifolia* become dominant (similar to the ground-water heath). However, in both the situations more than 50% of the characteristic species are those which occur exclusively in the sand heath, the proportion being greater (70%) in group 2 than group 1 (52%). On the other hand, major group II (except the swamp and the sites bordering on it) is dominated by *B. ericifolia*, *C. distyla* and *H. teretifolia*, and *c.* 30% of the characteristic species are those which occur exclusively in major group II.

The exclusive occurrence of these species in any one situation within a small area presents an intriguing problem. Although the sand heath sites and the ground-water heath sites differ in their nutrient status, the difference is relatively slight among many sites. It is difficult to imagine that so small a difference would produce such a sharp zonation among so large a number of species. Groves (1964) and Groves and Specht (1965) have attributed the difference in the growth curves of their heath ecosystems to the drying out of the top soil in the ground-water heath during the summer dry periods. At Mourawaring Point, however, the rainfall is high and scattered through the year. An examination of the moisture budget (see Figs 1 and 2) indicates that no severe water deficiency is experienced throughout the course of most years. Another important factor operating in the present area is the variation in water table, but this variation does not serve to explain the delimitation of these species since the depth of water table in the gully in sand heath is about the same as at most of the ground-water heath sites, although it seems to affect the overall structure of the community due to the taller growth of the shrub species *B. ericifolia*, *C. distyla* and *H. teretifolia* in this habitat.

Under these climatic conditions, the aeration of the top soil may be expected to be very different between the sandy sites and the ground-water heath sites. Flocker *et al.* (1959) and Pearson (1966) have suggested that in moist compact soils inadequate aeration is the most important factor in controlling root growth. The heathland species, with the bulk of their root system within the top few inches of soil (*cf.* Specht and Rayson (1957*b*) ; Botany Department, Sydney University (unpublished data from Myall Lakes) ; Clarke (1967)) are therefore likely to be affected by this aeration factor to a considerable extent. Thus, since the depth of the water table is similar in the wet sand heath and most of the ground-water heath, it seems reasonable to suggest that the physical soil structure through its control of aeration is probably the most important determinant in the delimitation of the exclusive sand heath species. Another important factor which requires consideration is competition, especially in a case of such a sharp zonation among a large number of species within a small area. It may well be that these species are capable of growing in the ground-water heath, but that their competitive ability is greatly reduced under poor aeration that they are eliminated by the more aggressive species of this habitat. Similarly, the converse may be true for the exclusive ground-water heath species. Loach (1964), Sheikh (1969*a*, 1969*b*, 1970) and Sheikh and Rutter (1969) have studied English wet heath vegetation in relation to aeration, and suggest that the exclusion of *Erica tetralix* from well-aerated soils is mainly due to competition with *Molinia*, a very aggressive species in this habitat. Bannister (1964) has also demonstrated the operation of an interspecific competition factor, operating between individuals of *Calluna* and *Erica*, which results in the eventual elimination of the latter.

The difference in the structure and composition of the " wet " sand heath (sand heath in the gully where the water table is shallow) and the " dry " sand heath (sand heath at the deep sandy ridge with deep water table) may be attributed either to a (seasonally) high water table, or competition, or a combination of both. That is, the absence in dry sand heath of such species as *Banksia ericifolia*, *B. aspleniifolia*, *Casuarina distyla* and *Hakea teretifolia* (which are dominant in the " wet " sand heath) may be attributed either to a relatively low water availability due to a deep water table or to their inability to compete with the species which are more aggressive at the sites with a deep water table and well-aerated top soil, or to a combination of both. Conversely, their occurrence in the " wet " sand heath in a dominant role may be attributed to an increased water availability due to shallower water table or to a much reduced intensity of competition with the otherwise aggressive species of sand heath, *e.g. B. serratifolia*. The reduction in density of *B. serratifolia* in " wet " sand heath is evident from a casual examination of the area. Rutter (1955) has similarly shown a clear relationship of vegetation with water table in samples of British wet heaths and suggests that although the water table depth may have important direct effects, some of the changes in abundance of a particular species may be due largely to changes in the competitive power of its associates.

Within the ground-water heath, the general structure of vegetation seems to be rather similar (except the swamp and the sites bordering on it) with most of the characteristic species being common in all the groups. The dominant species in all these groups (except group 7) are *Banksia ericifolia*, *Casuarina distyla* and *Hakea teretifolia*. Group 6 marks the 12–15 years old fire line, the area which supports mature, tall, dense scrub of the three dominant species. This area is species-poor (*c.* 15 species/25 sq. m.) in comparison to the groups 3–5 (*c.* 20 species/25 sq. m.), which contain the seedlings of the three dominant species with no tall storey and represent an area which was burnt 3–4 years prior to collection of data. Group 6, among its 10 characteristic species contains only low herbaceous species apart from the three dominants, whereas groups 3–5 have few other richly represented shrubs among their 15–20 characteristic species. It seems likely that this differentiation within the ground-water heath is primarily due to an open canopy as a result of fire and the composition of vegetation in these groups would perhaps be similar as a result of elimination of photophilic species which seem to have relatively narrow tolerance ranges. In general, the nutrient status of soils of these groups is similar except that phosphorus is relatively higher in group 4 soils and magnesium and calcium are slightly higher in groups 4 and 5 soils, than the rest.

The occurrence of *Lambertia formosa* only on the group 3 sites (situated on the west-facing slope) is associated both with aspect and the presence of iron-stones near the soil surface. The association of *L. formosa* with iron-stones has also been noticed on slopes of other than west-aspect.

Group 4 represents sites found on the east-facing slope which exhibit a well-defined deep loamy horizon, with a relatively impermeable clay layer at a depth of more than 90 cm. The generally improved nutrient status (especially phosphorus) of the soils of this group is associated with deep loamy horizon, in which a relatively large biomass of roots are found, compared to the sites where the impermeable clay layer is closer to the surface. Following a fire, the decay of these dead roots results in a gradual release of nutrients, particularly phosphorus (Groves (1964) and Jeffrey (1964, 1967) have shown that the roots of *Banksia ornata* and *B. serrata*, especially the proteoid roots, store large amounts of phosphorus). The species which occur exclusively in this group are *Banksia spinulosa*, *Hibbertia aspera*, *Scaevola ramosissima* and *Lasiopetalum ferrugineum*. Their exclusive occurrence in this area may be attributed either to an improved nutrient status (particularly of phosphorus) or to a deeper water table as compared to the other sites of the ground-water heath.

Group 5 is very similar to group 6 in the development of soil profiles and associated nutrient status, except for magnesium, which is relatively high in the soils of this group. The segregation of this group from group 6 seems to be due to the introduction and propagation of photophilic species in the absence of a tall storey, *e.g. Banksia aspleniifolia*, *Goodenia bellidifolia*, etc.

Soils of group 7 sites are shallow, with a truncated profile overlying the rock bed. There is some evidence of top soil erosion, which may be due in part to wind since this area lies at the mouth of a " wind-funnel ". This subjection to frequent wind cut may account for the abundance of low-grown shallow-rooted species in these sites.

Group 8 includes three sites on the north-facing clayey ridge which have a markedly higher nutrient status in comparison to all other non-swampy sites. These sites contain *Banksia integrifolia* and *Casuarina nana*, which occur here exclusively. There is no obvious explanation available for such an increase in soil nutrients except that this area is a nesting place for sea birds, being close to the sea and *Casuarina nana* bushes providing adequate shelter. The remaining sites in this group lie at the boundary of swamp and are nutritionally similar to the other ground-water heath sites.

Group 9 consists entirely of the swampy sites which remain waterlogged throughout the year. This area is dominated by tall *Baeckea imbricata* bushes.

Thus, it seems that fire regimes, physical structure of soil (aeration), depth of water table and, to a lesser extent, nutrient status of soil are the main determinants of the large-scale mosaic of vegetation (site groups). It may be pointed out, however, that these hypotheses regarding the relationship of various species with the environmental factors, and with each other, require substantiation from analysis of their small-scale distribution as related to edaphic factors and experimental evidence. This will be presented in subsequent communications.

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APPENDIX I

CHARACTERISTIC VEGETATION TYPES OF THE FINAL GROUPS

* indicates presence exclusively in that major group.

** indicates the presence of the species in both the major groups.

The numbers in parentheses indicate the groups which contain that particular species, within the major group.

Authorities for the binomials as in Beadle, Evans and Carolin, " Flora of the Sydney Region " Reeds (in press).

MAJOR GROUP I

GROUP 1. (+) BANKSIA ERICIFOLIA

Lomandra glauca ..	**	(1 and 2)
Hypolaena fastigiata ..	*	(1 and 2)
Schoenus brevifolius ..	**	(1)
Casuarina distyla ..	**	(1 and 2)
Hakea teretifolia ..	**	(1 and 2)
Banksia aspleniifolia ..	**	(1 and 2)
Banksia serratifolia ..	*	(1 and 2)
Banksia ericifolia ..	**	(1)
Acacia suaveolens ..	*	(1 and 2)
Bossiaea ensata ..	*	(1 and 2)
Aotus ericoides ..	*	(1 and 2)
Eriostemon lanceolatus ..	*	(1 and 2)
Hibbertia obtusifolia ..	*	(1 and 2)
Hibbertia fasciculata ..	*	(1 and 2)
Haloragis teucrioides ..	**	(1 and 2)
Pimelia linifolia ..	**	(1 and 2)
Actinotus helianthi ..	**	(1)
Platysace linearifolia ..	*	(1 and 2)
Dampiera stricta ..	**	(1 and 2)

GROUP 2. (−) BANKSIA ERICIFOLIA

Lomandra glauca ..	**	(2 and 1)
Lomandra micrantha ..	**	(2)
Hypolaena fastigiata ..	*	(2 and 1)
Anisopogon avenaceus ..	*	(2)
Banksia serratifolia ..	*	(2 and 1)
Acacia ulicifolia ..	*	(2)
Acacia suaveolens ..	*	(2 and 1)
Bossiaea ensata ..	*	(2 and 1)
Aotus ericoides ..	*	(2 and 1)
Eriostemon lanceolatus ..	*	(2 and 1)
Hibbertia obtusifolia ..	*	(2 and 1)
Hibbertia fasciculata ..	*	(2 and 1)
Haloragis teucrioides ..	**	(2 and 1)
Pimelia linifolia ..	**	(2 and 1)
Platysace linearifolia ..	*	(2 and 1)
Dampiera stricta ..	**	(2 and 1)

Major Group II

Group 3. (+) Lambertia formosa

Lomandra glauca	**	(3, 5)
Cyathochaete diandra	**	(3, 4, 5, 6)
Schoenus brevifolius	**	(3, 5)
Casuarina distyla	**	(3, 4, 5, 6, 7)
Petrophile fucifolia	**	(3)
Hakea teretifolia	**	(3, 4, 5, 6)
Lambertia formosa	*	(3)
Banksia ericifolia	**	(3, 4, 5, 6)
Acacia myrtifolia	*	(3, 4, 5, 6)
Callistemon citrinus	**	(3, 6)
Pimelia linifolia	**	(3, 4, 7)
Actinotus helianthi	**	(3)
Leucopogon esquamatus	**	(3, 5)
Epacris pulchella	**	(3, 5, 6)
Goodenia bellidifolia	*	(3, 5)

Group 4. (+) Hibbertia aspera

Machaerina teretifolia	*	(4)
Cyathochaete diandra	**	(4, 3, 5, 6)
Casuarina distyla	**	(4, 3, 5, 6, 7)
Hakea teretifolia	**	(4, 3, 5, 6)
Banksia aspleniifolia	**	(4, 5)
Banksia ericifolia	**	(4, 3, 5, 6)
Banksia spinulosa	*	(4)
Acacia myrtifolia	*	(4, 3, 5, 6)
Hibbertia aspera	*	(4)
Haloragis teucrioides	**	(4, 5, 6, 7)
Leptospermum flavescens	**	(4)
Pimelia linifolia	**	(4, 3, 7)
Scaevola ramosissima	*	(4)
Lasiopetalum ferrugineum	*	(4)

Group 5. (+) Goodenia bellidifolia

Selaginella uliginosa	**	(5)
Lomandra glauca	**	(5, 3)
Cyathochaete diandra	**	(5, 3, 4, 6)
Schoenus brevifolius	**	(5, 3)
Lepidosperma limicola	*	(5, 6)
Themeda australis	*	(5, 7)
Casuarina distyla	**	(5, 3, 4, 6, 7)
Hakea teretifolia	**	(5, 3, 4, 6)
Banksia aspleniifolia	**	(5, 4)

Group 5.—*Continued*

Banksia ericifolia	**	(5, 3, 4, 6)
Acacia myrtifolia	*	(5, 3, 4, 6)
Mirbelia rubiifolia	*	(5, 6)
Haloragis teucrioides	**	(5, 4, 6, 7)
Leucopogon esquamatus	**	(5, 3)
Epacris pulchella	**	(5, 3, 6)
Goodenia bellidifolia	*	(5, 3)

Group 6. (−) Goodenia bellidifolia

Cyathochaete diandra	**	(6, 3, 4, 5)
Lepidosperma limicola	*	(6, 5)
Casuarina distyla	**	(6, 3, 4, 5, 7)
Hakea teretifolia	**	(6, 3, 4, 5)
Banksia ericifolia	**	(6, 3, 4, 5)
Acacia myrtifolia	*	(6, 5)
Mirbelia rubiifolia	*	(6, 5)
Haloragis teucrioides	**	(6, 4, 5, 7)
Callistemon citrinus	**	(6, 3)
Epacris pulchella	**	(6, 3, 5)

Group 7. (+) Eragrostis sp.

Themeda australis	*	(7, 8)
Eragrostis sp.	*	(7)
Casuarina distyla	**	(7, 3, 4, 5, 6)
Haloragis teucrioides	**	(7, 4, 5, 6)
Pimelia linifolia	**	(7, 3, 4)
Operculia aspera	*	(7)
Rulingia hermaniifolia	*	(7)

(*Hakea teretifolia* and *Banksia ericifolia* are also present, but less frequently.)

Group 8. (−) Juncus sp.

Lomandra longifolia	**	(8)
Themeda australis	*	(8, 7)
Westringia fruticosa	*	(8)

(No species is represented in all the sites of the group.)

Group 9. (+) Juncus sp.

Juncus sp.	*	(9)
Baeckea imbricata	*	(9)
Hydrocotyle bonariensis	*	(9)
Lobelia alata	*	(9)