THE VEGETATION

OF THE

CAPE HANGKLIP AREA

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ABSTRACT

Approximately 11 500 ha of coastal plain and mountain vegetation in the Cape Hangklip area of the South-Western Cape Province of South Africa was studied. The suitability of homogeneity functions and of the association-analysis techniques for the analysis of large areas of the distinctive coastal and fynbos vegetation found in the Mediterranean type of climate in this region were investigated.

Data were collected at 150 sampling sites of 10 x 5 metres each, which were randomly located on grid intersections within physiographic-physiognomic units delimited on aerial photographs. Phytosociological techniques were used to arrange the data prior to further analysis using frequency modulated homogeneity functions. A classification of the vegetation into 32 communities is proposed with primary subdivisions into Broad-leaved Scrub and Fynbos. This classification is based on the results of the association-analysis of the data.

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CHAPTER 1

INTRODUCTION

The availability of high capacity electronic computers for the analysis of large quantities of data has provided a very necessary tool for the study of the complex fynbos vegetation of the South-Western Cape. This vegetation is characterized by a great diversity of species found in relatively small areas. A very complex vegetation results with genera and species of very localized distribution being commonly encountered. This factor alone makes the use of computer facilities particularly necessary for the analysis and evaluation of all but very small areas. This appears to be the reason for the very limited application of the traditional observational and descriptive techniques used to date in the fynbos vegetation.

Acocks (1953), in his survey of the Veld Types of South Africa, remarks of the fynbos vegetation, that, "it is a complex vegetation, and to divide it simply into Macchia (Veld Type 69) and False Macchia (Veld Type 70) is like dividing the tropical vegetation into grassveld and bushveld." Rycroft (1951) undertook the first purely quantitative work on South African vegetation when he surveyed the vegetation of the Biesievlei catchment, Jonkershoek. Subsequently Grobler (1964) and van der Merwe (1966) applied a few quantitative measures in their studies of the flora at Oudebosch, Betty's Bay and Swartboskloof, Jonkershoek. Taylor (1969b) applied the association-analysis techniques of Williams & Lambert (1959, 1960 and 1961) to data collected in the Cape of Good Hope Nature Reserve, as a test of their methods. In addition he successfully constructed phytosociological tables from the same quadrat data and thereby demonstrated the possible application of phytosociological techniques in the future studies of the fynbos vegetation. The phytosociological groups he obtained were further evaluated by statistical means. Hall (1970) described the performance of homogeneity functions in the analysis of data collected in the Bains Kloof area near Wellington. Werger, Kruger & Taylor (1972) further demonstrated the feasibility of the application of phytosociological methods in the analysis of fynbos vegetation, when the data are collected according to traditional phyto-sociological techniques, in their analysis of the vegetation in Swartboskloof and Sosyskloof at Jonkershoek.

Prior to this above period, very little ecological study of the fynbos vegetation of the South-Western Cape was undertaken. This would therefore exclude essentially floristic or plant geographical studies of the flora such as were undertaken by Marloth (1905), Bolus (1905) and Hutchinson (1946).

Haeckel in 1869 conceived the term "ecology" while Grisebach in 1872 recognized and defined the formation as a fundamental unit of vegetation, but it was not until the 1890's and early 1900's that the concepts of the plant formation and of plant succession became firmly established. Warming's "Oecology of Plants" of 1895 is regarded by many as the beginning of modern plant ecology. "It was left to Clements (1916), however, to elucidate the principles of plant succession and to put plant ecology on a systematic basis. Clements is rightly regarded as the father of dynamic ecology. The writings of Clements and the other workers mentioned (Warming, Cowles and Pound) gave great impetus to the study of vegetation all over the world and it was against this background that plant ecology in South Africa had its beginnings" (Killick, 1968). Marloth (1908) produced the first full-scale account of the vegetation of the Cape Province. He was the first to describe detailed subdivisions of the fynbos vegetation based on the physiognomy of typical species in selected localities. He touched briefly on successional trends and the factors causing them. Bews (1916) described the successional aspects of the Cape vegetation and briefly enumerated the factors involved. He stressed the fact that plant formations in South Africa are largely classified by climate. He appears to be the first author to use the local term "Fynbosch" (now spelt as "fynbos") for the Cape sclerophyll vegetation (Taylor (1969b) discusses the various terms used to describe this vegetation type). He defines it as "any sort of small woodland growth which does not include timber trees" (Bews, 1916). Besides stressing the lack of single-species dominance in the fynbos, he drew attention to the fact that fynbos, although it is the chief type in the South-Western Region, is not the only type; there is also "Bush" (= forest) and a distinct coastal vegetation; and that fynbos is not confined to the South-Western Region but extends along the mountain ranges such as the Natal Drakensberg at altitudes of 2 100 m to 2 400 m through the mountains of Central Tropical East Africa to the mountains of Abyssinia (Bews, 1925). Schönland (1919) recognized a "south-western hill-vegetation" which had a prevalence of fynbos elements in the Van Stadens mountains. Muir (1929) described the fynbos vegetation and its succession on the Langeberg, Aasvogelberg and ridges in the Riversdale district. Dyer (1937) described the fynbos vegetation on the mountain ridges in the Albany and Bathurst Divisions as "the survivors of the south-western flora in competition with many pioneer types of a flora definitely of tropical or temperate origin." Adamson (1938) drew attention to the occurrence of fynbos vegetation on the higher granite mountains of Namaqualand which had been overlooked in Pole Evan's vegetation map of 1936 of South Africa, notwithstanding Rennie (1935) having noted others in South West Africa. Story (1952) described a fynbos having a much poorer species composition from the Keiskammahoek district of the Eastern Cape Province. He found that fynbos is a much more xerophytic type of vegetation than forests and is characteristic of regions subject to periods of drought (including physiological drought). The fynbos described by Story is similar to that at present drawing the attention of botanists in the Amatole mountains of the Eastern Cape Province where it is being eradicated to improve pastures. Roberts (1961) recognized a fynbos community on the Thaba 'Nchu mountains in the South-Eastern Orange Free State and Killick (1963) found fynbos to be the climax community of the Subalpine Belt of the Cathedral Peak area of the Natal Drakensberg, where it "can be either pure with one species dominant or mixed with several dominants."

From the above it appears as if the description of the fynbos outliers, with their relatively simpler species composition, had not presented as much difficulty as that of the South-Western Cape.

A few relatively less detailed articles were published about the fynbos vegetation on a purely subjective basis. Adamson (1927, 1931 and 1935) discussed various aspects of the plant communities found on Table Mountain, including botanical features of the vegetation of the South-Western Cape (Adamson, Compton, van der Byl, Stephens & Levyns, 1929) and of Robben Island (Adamson, 1934). Duthie (1929) described the vegetation and flora of the Stellenbosch flats which has today largely disappeared due to urbanization while Jordaan (1946) described the vegetation of the Bredasdorp and Caledon districts. Grobler & Marais (1967) investigated the flora of the National Bontebok Park at Swellendam and recognized a few fynbos communities there.

Ecological aspects of the forests of which elements occur in the fynbos vegetation (Bews, 1916) have been discussed by Sim (1907), Phillips (1928 and 1931), Laughton (1935 and 1937), Thunberg & Kotze (1940), Taylor (1955 and 1961) and Heyns (1957) amongst many others.

From the above it is apparent that ecological studies of the fynbos vegetation of the South-Western Cape, and in particular of the mountainous regions, are not common in the literature.

Objections raised by Taylor (1969b) to sampling methods and the mapping potential of the classifications resulting from treatment of the data by means of the association-analysis methods of Williams & Lambert (1959, 1960 and 1961), could largely be overcome by changing certain sampling and other techniques employed (see Chapter 3). The present study was therefore to serve as a further test of this method, while at the same time evaluating the usefulness of homogeneity functions (Hall, 1967, 1969b and 1970) in the classification and description of vegetation data collected over a large area.

The Hangklip area has been mapped by Acocks (1953) as consisting entirely of fynbos (Veld Type 69), this could probably be attributed to the scale of mapping involved in his study. Along the coastal plain certain habitat conditions suggested that a vegetation more similar to Veld Type 47 (Coastal Macchia) rather than true fynbos might be found. Rycroft (1953) in a report on the vegetation of the Kogelberg State Forest described the mountain fynbos communities in very broad terms, while Grobler (1964) undertook a more detailed survey of a small portion of this state forest in the vicinity of Oudebosch near the mouth of the Palmiet River. A short popular account of the vegetation of the De Wet's Bay area, Betty's Bay has been given by Fourie (1972). The marine algal ecology along the coast has been treated by Isaac (1949) from Rooi Els to Gansbaai.

The stimuli for the choice of the Hangklip area for a study of the vegetation were:

1. The lack of information about the vegetation and flora in the area and therefore of its management.

2. The intention of developing large areas along the coastal plain into townships with the accompanying effects on the vegetation.

3. The proposed construction of an earthen walled water storage dam in the Buffels River to supply the new townships and another large dam near the mouth of the Palmiet River to augment the water supply from Steenbras Dam to Cape Town and environs. Extensive flooding of the river valleys would result from the construction of these dams and the vegetation, particularly along the rivers would be adversely affected.

4. The possibility of the construction of a dual lane highway through the Kogelberg State Forest and along a portion of the coastal plain. The effect of such a road would require prior information about the vegetation.

Extensive collecting by, amongst others, the late T.P. Stokoe, particularly after his retirement, resulted in the majority of the plant species being collected and named in the area but localities for these collections were in many cases extremely vague ('Hottentots Holland mountains', for instance). Extensive collecting of botanical specimens in the area was therefore also required because this area is generally regarded as being one of the richest in species, particularly of endemics, in the fynbos vegetation of the South-Western Cape. (More than 1 380 species have already been collected by the author, but this is by no means the total flora as isolated localized species have not all been encountered during their flowering periods).

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CHAPTER 2

DESCRIPTION OF THE STUDY AREA

2.1 Locality

The area involved in this survey is situated near the south-western extremity of the Cape Province, South Africa, forming the south-eastern limits of False Bay, approximately 30 km east of Cape Point. Cape Hangklip, the most southerly point in the area is about 72 km distant, by road, from Stellenbosch, if the route past Gordon's Bay, following the eastern shores of False Bay, is chosen (see fig. I). A longer access route would be via Sir Lowry's Pass, Houw Hoek Pass and Kleinmond. The area investigated extends from the mouth of the Rooi Els River in False Bay and includes the whole coastal tract to the Palmiet River mouth near Kleinmond. The eastern boundary of the investigated area is formed by the limits of the 1:50 000 Topographical Survey Sheet 3418BD Hangklip (Trigonometrical Survey, 1968). The northernmost boundary is formed by the northern limits of the above Survey Sheet between its north-eastern corner and the Dwars River to the West, which then forms the boundary till its junction with the Palmiet River, to the west of which the northern boundary is formed by the Louws and Rooi Els Rivers (see fig. II).

The north-eastern corner boundary is located on the portion of the farm Aries Kraal between the Palmiet River and the Kogelberg State Forest. This is in the south-western corner of the Elgin Basin.

Approximately 2 340 ha of the Kogelberg State Forest, between the above boundaries, which had been burnt recently, were excluded from the survey because of the problem of the identification of seedlings. An area of approximately 11 500 ha was studied.

2.2 Geology and topography

The geology and related features of an area influence the vegetation and are, therefore, considered in some detail in this study.

The Hangklip area is particularly attractive scenically in addition to its world renowned floral attributes. The mountains, which form the dominant feature of the scenery, are part of the Cape Folded Belt consisting of still intact anticlines of Permo-Triassic age (du Toit, 1939). Two main folding-zones are distinguishable in the Cape Folded Belt. (i) A western folding-zone which forms a wide arc having a general north-south trend and (ii) an eastern folding-zone in which the ranges have a general eastward trend. The western folding-zone has its southern end at Hangklip, and forms the Hottentots Holland range, the Drakenstein, Klein Drakenstein, Hawequas, Limiet and Elandskloof Mountains (Wellington, 1955).

The outward-facing slopes of the Hottentots Holland orographic line often takes "the form of a southward-facing escarpment formed by the limb of an anticlinal fold now destroyed by erosion" (Wellington, 1955). This feature is particularly evident in the steep mountain sides which form the eastern limits of False Bay in the region between Gordon's Bay and Rooi Els.

"At Hangklip Berg the western range of the north-south line of folds terminates abruptly. One might expect it to form a sheer cliff like Cape Point, but in fact the scarp of the eastward dipping sandstone ends a little more than a mile from the cape itself, and is bordered by a rock platform rising very gently from a few feet above sea-level to about 100 feet (30 m) at the foot of the scarp. This seemingly trivial fact has been mentioned because, although the coastline transects the folded range at various points, the ranges never form promontories, but terminate some distance from the coast. Cape Point is outside the folded zone proper; Cape Hangklip has this narrow rock platform."

"The general character of the coastline appears to be the expression of the resistance of the T.M.S. (Table Mountain Sandstone) to erosion coupled with a period of submarine peneplanation." (Wellington, 1955). This forms part of what he calls the southern coastal foreland. Mabbutt considers this to be the abrasion platform of the 18,3 m sea which has in addition been partially regraded at the 6 m to 7,6 m stage and at the 3,6 m to 4,3 m sub-stage of the

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succeeding regression. He considers the basal shingle to be evidence of this marine withdrawal. A marine re-advance is suggested as occurring after the last Pleistocene period, to result in a sea-level which was 2 m higher than the present sea-level (Mabbutt, 1955). The coastal foreland, which shows remnants of an old peneplain, declines seawards at an angle of about 1^{o} (Wellington, 1955). This gradual slope has resulted in local marshy conditions, and sometimes in lakes, such as the Groot Vleie and Skilpadvlei in the Hangklip area.

Recent and Quaternary dunes are found along the coastal plain. The older dunes have undergone consolidation, yet they are still relatively young (de Villiers, Jansen & Mulder, 1964). Near the surface a secondary enrichment zone of lime sometimes occurs which forms a harder layer around the soft and crumbly rock. This limestone is generally cross-layered which is characteristic of its origin from wind action.

River terrace gravel, originating from the sandy sediments weathered from the Table Mountain Sandstones, occur which pass, on the one hand, into scree and on the other into alluvium. They are of rare occurrence in the area being found at the junction of the Dwars, Louws and Palmiet Rivers.

The following geological groups and formations are known to occur in the area (their relative positions are illustrated in fig. III):

(i) The pre-Cape Klipheuwel group represented by the upper Klipheuwel beds in the Kogel Bay valley. (These have been fully described by Haughton (1933) and de Villiers, et al (1964)).

(ii) The T.M.S. of the Cape Supergroup dates from the Ordovician or Late Cambrian to the early Devonian period. The T.M.S. members are the principal contributors towars the rugged topography of the area. The following formations occur in the area (Rust, 1967):

(a) The Graafwater formation or basal shales which have a thickness of about 3 700 m.

(b) The Peninsula formation or lower sandstones and quartzites of about 1 700 m thickness.

(c) The Pakhuis formation or tillite which is of glacial origin.

(d) The Cedarberg formation or upper shale band which together with the Pakhuis formation is about 50 m thick.

(e) The Nardouw formation or upper sandstones and quartzites which are about 1 000 m thick.

The Graafwater formation, the oldest in this series, is only sporadically developed in the area and consists of occasional thin bands of reddish-purple mudstones and shales. This is overlaid by the Peninsula formation which is the white sandstone typical of Table Mountain. This formation is strongly seamed and folded. Brecciation along minor faults commonly occurs. The tillite or Pakhuis formation follows on the lower quartzites and sandstones and tends to form a rock face immediately under the upper shale band. The following members of the latter formation have been recognized by Rust (1967) as occurring in the area:

(i) The Sneeukop member which occupies synclinal troughs, is visible in the Kogelberg Mountain.

(ii) The Slanghoek member which is deposited on the Peninsula formation, except where the Sneeukop member occurs. The gradation that occurs between the Slangkop and Sneeukop members at Hangklip could be the result of deposition from a drifting lobe of the Sneeukop glacial sheet. The Sneeukop tillite is possibly an englacial moraine, deposited below sea-level and never subjected to reworking by water currents.

(iii) The Steenbras member is a poorly bedded, quartz-rich, pebbly, protosandstone, which is called a tillite because of its facetted and striated erratics, its relation to the glacial floor at its base and its fabric.

The Cedarberg formation or upper shale band can be traced as a well defined marker band from the Kogelberg Mountain, down the Dwars River Valley, to the Palmiet River, where it disappears abruptly due to faulting. This formation can further be traced along the western and southerly slopes of

Buffelstalberg, Platberg and Paardeberg Mountains, after which it is overlain by Quaternary sands. The Nardouw formation occurs between the upper shale band and the Bokkeveld beds. They differ but little in character from the main sandstones, seemingly having fewer pebbles and being more quartzitic. Along the Dwars River Mountain, this formation shows well-developed folding, although the shales below it are apparently undisturbed (Haughton, 1933).

The mixed deposit of aeolian and colluvial dune sand of marine and sandstone origin, between Groot Hangklip and Voorberg Mountains, has a similar elevation, of approximately 18 m, to the lowland gap that occurs on the Cape Peninsula between Fish Hoek Bay and Chapman's Bay. Taljaard (1948) considers that this lowland gap was a shallow sea strait during earlier geological times.

The Bokkeveld beds, which occur in the Elgin Basin, are associated with the folding in the T.M.S., but, because they are softer than the sandstones, have been eroded away from the ridges and are now found in the valleys, particularly where they have been preserved by faulting. The Bokkeveld shales of the Elgin Basin border closely on the area under investigation and their remnants appear to occur with the T.M.S. in the Somersfontein-Arieskraal portion of the area.

In the Kogel Bay valley, the softer and older Klipheuwel beds below the T.M.S., have been brought to the surface by the erosion of the folded T.M.S. mantle to reveal the Klipheuwel shales surrounded by precipitous sandstone mountain slopes.

The following major fault-zones have been recorded in the area and are illustrated in the geological map (fig. III): The longest zone of faulting follows a north-easterly direction from Rooi Els along the courses of the Rooi Els, Louws and portion of the lower Palmiet Rivers to beyond the eastern limits of the area. A short portion of a fault-zone occurs in the north-east corner of the area along the Klein Palmiet and portion of the Palmiet Rivers. A probable faulting-zone occurs to the east of the Kogelberg Mountain in a north-easterly direction, while another probably occurs between Rooi Els and Silver Sands Bay. The latter is obscured by the deposits of Quaternary and Recent sands.

Prior to the post-Karoo folding movements, the landscape sloped gently in a west-south-westerly direction with the three main rivers flowing down this gentle slope to the sea according to Cole (1949). Evidence suggests that there were two main rivers flowing into Kogel Bay; the northerly one formed by the upper reaches of the Palmiet River, the river to the south of this being formed by the Kraal, the upper portion of the Krom, the middle portion of the Palmiet and the Klein Palmiet Rivers. The Jan Niemands, the lower portion of the Krom, the lower Palmiet, the Louws and the Rooi Els Rivers formed one stream flowing into the sea at Rooi Els Bay. The orogenetic movements in the southern end of the Hottentots Holland range resulted in the courses of these rivers being altered considerably. The anticline forming the Kogelberg and the Dwars River Mountains and continuing into the Paardeberg Mountain effectively providing a barrier to the west-south-westerly flow of the streams, but a weaker zone where the anticline, which forms the Groot Hangklip, Voorberg, Platberg and Perdeberg Mountains, met the first anticline, offered an exit for the waters from the Elgin Basin to the sea. The result is the present intricate course of the Palmiet River which is the main drainage system and has its mouth in Sandown Bay. The lagoon at its mouth appears to be permanently open to the sea through a narrow channel in the sand bar. (The construction of a large dam as an additional water supply to Cape Town, near the mouth of the river, might result in the mouth closing completely during the dry season).

The other rivers in the area are the Cascades River which drains the Kogelberg State Forest through the Disa Kloof and Leopards Gorge and the Buffels River.

Deposits of graphite in the upper shale band between the Palmiet River mouth and Kleinmond have been investigated for mining purposes but the quantity and quality were found to be inadequate for their commercial exploitation (de Villiers, et al, 1964). Deposits of manganese oxide occur in a number of places and have been mined at Kogel Bay (Haughton, 1933). The deposits are usually associated with zones of brecciation.

The ore always has iron present, although the main mineral found is psilomelane. The quality of the ore deteriorates rapidly with an increase in depth. The combination of low quality, small deposits and rugged terrain are a deterrent to even the most optimistic prospector. This type of deposit in the T.M.S. originates from the leaching of the manganese content from the surrounding formations and their deposition near the surface in open structures (de Villiers, et al, 1964).

2.3 Soils

"Although they differ in important respects, the soil series can be regarded as being analogous to the plant species and to the rock type, and the soil system as being analogous to the veld type and to the geological system. In helping us to comprehend our soil resources and enabling us to predict the best ways of using land, the soil series and system fulfil much the same function for soil science as do the analogous classes in the botanical and geological sciences" (Macvicar, 1970).

Where the Table Mountain Series is the underlying geological formation, the country is generally mountainous and the soils are poorly developed. The grey sandstone facies weather rather slowly and, where the slopes are steep and the rainfall high, rapid run-off results in the removal of weathered products and bare rocky outcrops are the general rule. Where the relief is less acute a little soil material has accumulated amongst sandstone outcrops and rocks. On the gentler slopes at the foot of the mountains, somewhat deeper soils occur. They have mainly developed from accumulated colluvial material and may have various stages and kinds of development, depending on the local environment.

According to Cole (1949), the soils developed from Table Mountain Sandstones generally have a sandy texture, are very poor in all plant nutrients and water percolates rapidly through them, except in local depressions and lower-lying areas where they tend to become water-logged in winter due to a high water table. These soils are extremely acid.

At the contact zone between the Table Mountain Series and the younger Bokkeveld shales, Cole (1949) considers the soils to exhibit features intermediate between those of soils from either Table Mountain Sandstone and Bokkeveld shales, being both sandy and clayey.

The alluvial soils in the Palmiet River valley have developed from the weathering products of both the Bokkeveld shales and the Table Mountain Sandstones. As a result they vary from deep practically pure sand to a dark humous loam overlying a yellowish clay, so called "pot-clay" (Cole, 1949).

No published soil survey data about the Hangklip area is available but Mr. J.J.N. Lambrechts (senior lecturer in Soil Science at the University of Stellenbosch) has visited the area and identified and classified the soils according to the current National Soil Classification System (Loxton & Hunting, 1970). Additional information was obtained from Orchard (1969).

The following is a list of the dominant soil forms and individual series recognised, as well as their occurrence and genesis and the dominant vegetation types associated with them. The symbols, diagnostic horizon names, soil form and series names used are defined in the literature quoted above.

(1) Mispah Form: Fig. IV.1

These soils consist of an orthic A_1 horizon on either a C horizon, hard rock (R), or hard plinthite.

On the mountain slopes these skeletal soils are of an acid nature and belong to the Mispah Series. The vegetation is of the drier type of mixed ericoid and restioid fynbos usually found on the northerly slopes associated with rock outcrops (see Chapter 4.2, sections 2.4.3 and 2.4.6).

On the limestone outcrops on the coastal shelf, this type of soil is alkaline, calcareous and belongs to the Muden Series. The vegetation is of transitional nature with elements of dune scrub and fynbos.

(2) Fernwood Form: Fig. IV.2

These soils consist of an orthic A horizon on deep regic sand. Sandveld Series soils are usually found on gentler slopes than the Mispah soils and develop from colluvial material to have an acid reaction with very low accumulations of organic matter. The vegetation associated with these soils are of the drier mixed fynbos types found nearer the source of drainage lines.

The Warrington Series, encountered in low lying areas, are also acid but show abnormal accumulations of organic matter although the organic carbon content is less than 10%. Little lateral water movement occurs within these soils and consequently a bleached P horizon is absent. The vegetation is usually taller because of greater soil depth and better moisture conditions occur. Younger river terraces commonly have these soils.

The Langebaan Series are neutral to alkaline and are found nearer the coast, usually on coastal dunes with their associated type of broad leaved scrub.

(3) Champagne Form: Fig. IV.3

These soils are peaty with a very high organic carbon content which is usually more than 10% by weight. The highly acid form, pH less than 4, known as the Mposa Series is found on the steeper mountain slopes, generally with a southern aspect.

The continuous addition of organic material from the luxuriant growth of vegetation and hydromorphic conditions, result in a thick layer of relatively undecomposed organic material with very little mineral soil material in the O horizon. The flora found on these soils are often endemic or of restricted distribution, e.g.: *Orothamnus zeyheri*, *Mimetes argenteus*, *M. hottentoticus*, *M. capitulatus*, etc.

The Champagne Series is also a highly organic soil with a high water table but is less acid then the Mposa Series, the pH being greater than 4. This soil series is usually found under coastal bog conditions and vegetation such as the Brunia-Erica seepage fynbos might be found.

(4) Cartref Form: Fig. IV.4

These soils have a perched gley directly under an orthic A horizon.

The underlying impermeable to unweathered to poorly weathered rocks result in the development of a perched water table. Lateral movement of water occurs through the P horizon and results in the eluviation of reduced iron compounds, and development of bleached soil colours.

The Grovedale Series are found at higher altitudes than the Waterridge Series while the Cartref Series generally occur at the lowest altitudes where more clayey colluvial material has accumulated. The vegetation is generally of the mixed ericoid and restioid fynbos type found in the mesic drainage lines.

(5) Longlands Form: Fig. IV.5

The Longlands Series is very similar to the Cartref Form, having an orthic A and a perched gley P horizon, on a soft plinthic B horizon. Lateral movement of water occurs through the P horizon and mottles are evident in the B horizon which is subjected to alternating conditions of oxidation and reduction due to a fluctuating water table. The result is the segregation and accumulation of iron in local concentrations to form red or yellow mottles. The P horizon is of colluvial origin. This is a moister form than the Glencoe Form and generally has a taller mixed fynbos vegetation, rich in proteoid elements.

(6) Estcourt Form: Fig. IV.6

The Soldaatskraal Series in this form differs from the Longlands Form above in that a prismacutanic B horizon with a high clay content is present below the P horizon. The vegetation is similar to that of the Longlands Form but where the Estcourt Form is found on the Table Mountain Sandstone shale band, it is generally moister and a taller type of fynbos developes.

(7) Clovelly Form: Fig. IV.7

The representative Mossdale Series consists of soils having a yellow apedal B horizon directly below the surface A horizon and above a C or R horizon. The vegetation is of the drier Protea-Gerbera type of short fynbos and is very similar to that found on the Glencoe Form.

(8) Glencoe Form: Fig. IV.8

These are represented by the Weltevrede Series which differ from the Clovelly Form by the occurrence of a hard plinthic B horizon below the yellow apedal B horizon. The hard plinthite developed under similar but drier conditions than the soft plinthite of the Longlands Form. This resulted in the dehydration of the iron in the mottles to form hard concretions. This is presumably a relict material of a previous climatic cycle. The vegetation is similar to that found on the Clovelly Form.

The general location and relationships between the soil types are shown in figures IV.1-10. The relationship between moisture conditions and soil type can be illustrated according to the soil-drainage classes as defined by the United States Department of Agriculture (1951) (Table 2.1 on p.17).

2.4 C l i m a t e

1. Introduction

Climatic factors are recognized as being one of the major influences determining the distribution and more particularly the type of vegetation found in an area.

The Hangklip area, at a latitude of 34^{o} south is situated near the southern extremity of the African continent. The latitude and the close proximity to the Atlantic Ocean with the cold Benguela current, are the main reasons for the occurrence of a Mediterranean type of climate. "The rainfall in the northern regions of South Africa is almost exclusively a summer phenomenon; the further southwards one proceeds, the greater the increase in winter precipitation. The region with predominantly winter rainfall is limited to the extreme south-western corner of the subcontinent" (Weather Bureau, 1960b).

The weather "of most of Africa south of 20^{o} is dominated by the subtropical anticyclones of the general circulation. The South Atlantic anticyclone is centred well of the Namib coast and produces southwesterly onshore winds that blow over the cold Benguela current. Thus the cell withdraws in summer and advances towards the coast in winter. South of the anticyclones is a zone of the westerlies in which mid-latitude frontal depressions form and travel eastwards carrying their normal sequence of weather with them. An anticyclonic circulation is the predominant feature over the land and

TABLE 2.1 Soil-drainage classes as defined by the United States Department of Agriculture (1951)

Soil-drainage class:	Very poorly drained	Poorly drained	Imperfectly or poorly drained	Moderately well-drained	Well-drained	Somewhat excessively drained	Excessively drained
	0	1	2	3	4	5	6
	Mposa		Warrington		Soldaatskraal	Sandveld	
		Champagne	Grovedale			Mossdale	
Soil series		Longlands			Weltevrede	Muden	
							Mispah
						Langebaan	

apart from a weakening and southward movement of the system through a few degrees of latitude in summer, the essential features of the circulation in winter and summer are not essentially different" (Tyson, 1969). "The winter circulation of the South-Western Cape is associated with disturbances in the circumpolar westerly winds, taking the form of a succession of eastward moving cyclones (depressions) and anticyclones. Originating in areas of cyclogenesis far to the south and west of Southern Africa, these disturbances first bring rain to the south-western and later to the south and south-eastern coasts and may even extend far inland. Fronts are associated with the depressions" (Jackson & Tyson, 1971). Orographic rains occur which may last for several days, the rainfall being heavier in the mountains. As the depression passes the wind backs to south-westerly and later to southerly, with clearing showers and a drop in temperature. "It is under these conditions, also, that snow, associated with the passage of a cold front, may occur on the southern and south-eastern escarpment and that South Africa experiences a 'cold snap'" (Weather Bureau, 1960b). Fine weather following a depression may last for over a week.

"As the winter circulation of the South-Western Cape is distinctive, so is the circulation in the summer months, the dry and windy season. South and south-east winds prevail for about 60% of the time, with force and direction being modified to some extent by the alignment of the mountains. At times the anti-cyclonic Cape south-easters are notoriously strong and gusty, and in the vicinity of Cape Town may blow with gale force for two or three days at a time. These winds are not usually associated with bad weather, but with typical fair weather clouds capping the mountains, as in the case of the 'table-cloth' on Table Mountain. Occasionally a 'black' south-easter may bring some rain to the south-western and southern coast (while the normal cloud cap on the mountain is associated only with wind)" (Jackson & Tyson, 1971).

Prolonged spring and autumn seasons and the fact that the so-called summer and winter phenomena are not entirely confined to these seasons, gives rise to a very equable climate.

According to the Köppen classification systems, which is primarily based on the twenty year temperature averages, the climate is either of the Csb type at the lower altitudes or "no doubt a number of places in the mountainous areas of the South Western Cape could be found which would show the formula Cfsa or Cfsb" (Schulze, 1947).

C = Warm temperature rainy climates; at least one month with mean temperature below 16°C and at least eight months with mean temperature above 1°C; coldest month above -3°C.

f = Sufficient rain during all months, with precipitation of driest month exceeding one third of wettest month.

a = Mean temperature of warmest month over 22°C.

b = Mean temperature of warmest month below 22°C.

s = Dry season in summer. (Swart, 1956).

According to the Thornthwaite classification system, the climate is BB's or a humid warm climate with a dry summer. The precipitation to evaporation ratio is more than 80. (Schulze, 1947).

2. Winds

The main characteristic of the winter weather of the South-Western Cape, is the prevalence of strong north-westerly winds, bringing low cloud and rain. Occasionally these winds reach gale force. Grobler (1964) recorded storm damage in the form of limited damage to plants from a north-westerly gale near Oudebosch but he found no storm damage from the south-easterly winds during the summer months although these winds do occasionally reach gale force. At Cape Town the southerly winds abate from 45% in March to 22% in May, while the north-westerly winds increase during the same period from 5% to 22% (Swart, 1956). The passage of a typical cold front results in the following phenomena: After a few days of north-westerly winds and rainy weather, the north-wester increases to storm strength over night. With the passing of the cold front, the wind changes to a south-westerly direction and it becomes colder. Continuous heavy rains fall for a short period, followed by intermittent showers. The sky remains cloudy with stratus clouds (Tyson, 1969).

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In spring the south-east winds start increasing from 25% in September to 55% in November at Cape Town (Swart, 1956). The Cape south-easter is one of the characteristics of the weather in the Hangklip area particularly during the summer and can reach gale force for a few days. This condition is relatively stable during the summer. The wind usually abates suddenly when a depression approaches the coast. During a south-easter the mountain tops are usually engulfed in stratus clouds formed by the condensation of moisture in the stable air being forced up the mountains. Sometimes the clouds are dark and black and drizzle falls on the mountains. This is the so-called "black south-easter". It is usually a cool wind, particularly near the summits of the mountains. The pressure increases till a period of southern winds follows behind a cold front. At Cape Point, on the opposite side of Table Bay, south-easters of 16 to 40 km per hour occur regularly during the summer, gusting up to 102 km per hour.

Plants growing on the mountain peaks where they are exposed to the full force of the south-east and north-west winds, are often deformed by the strength of the winds. Taller individuals are usually only found where rocks and crevices offer some protection. The vegetation along the coast shows characteristic deformation particularly from the constant direction of the south-east wind. The strong persistent south-easters blow during the fire season and are instrumental in the formation of dunes, particularly in the recently burnt areas. At Blesberg, the addition of new sand from the beaches to the large dune on the side of the mountain, is being prevented by the protection of the intervening vegetation from fire. The persistent south-east winds are now slowly whittling away this large dune into the already established vegetation in the surroundings and it is rapidly becoming reduced in size.

During the autumn months especially when some calm days occur, south-westerly onshore breezes are often experienced. These breezes are moisture laden but never attain much force and usually abate shortly after sundown.

Warm, dry berg winds occur on a limited number of occasions.

The force and direction of the winds vary considerably within the area because of the variations in relief. The coastal shelf at Stony Point and at Cape Hangklip for instance are exposed to much greater strengths of south-east and north-west winds than Oudebosch for instance in the Kogelberg State Forest, where the surrounding high mountains afford a certain amount of shelter. Protea cynaroides has been found to vary in floral character and growth form according to variations in wind strengths, amongst other factors, at various localities (Vogts, 1971).

Wind data from the area is only available for 1971 from Stony Point (recorded by Mr. G. Affleck). This data serves as an indication of the wind tendencies (see table 2.2 on p. 22).

3. Precipitation

The South-Western Cape "enjoys a climate similar to Mediterranean countries, receiving the bulk of its rainfall in the winter from about May to September, and having a warm to hot and dry summer. The rainfall is profoundly influenced by the very pronounced orographical features, resulting in annual amounts of the order of over 3 000 mm (120 inches) in some mountain kloofs, as against 400 to 500 mm (16 to 20 inches) on the Cape Flats and less than 250 mm (10 inches) in the Breede River valley - the latter being a typical 'rain shadow' effect. During the season of maximum rainfall one may normally expect 12 to 15 rain days per month whilst in the dry season Cape Town and environs experience four to five rain days per month. The rainfall is mainly cyclonic and orographic" (Schulze, 1965). The study area has, on average between 80 and 120 days of rain per year when at least 0,25 mm of rain falls per day of which about 80 days have more than 1,00 mm and ten days have 10 mm or more of rain per day (Weather Bureau, 1957).

"The mean deviation of annual rainfall as a percentage of the normal is between 15% and 20% in the South-Western Cape which counts among the most reliable regions in South Africa" (Weather Bureau, 1960b). Three quarters of the rain in the South-Western Cape falls during the six winter months

TABLE 2.2. Analysis of Wind Directions (Velocities of 19 km.p.h. and greater) - Stony Point, Betty's Bay (in days).

1971	N NW	NW N	W SW	SW S	S SE	SE E	E NE	NE N	Calm and Lt. vars.
January	-	5	3	3	1	15	-	-	4
February	-	-	5	1	1	15	1	-	5
March	-	8	2	-	-	13	-	-	8
April	1	5	1	-	-	10	-	-	13
May	-	6	1	1	3	7	1	-	12
June	-	11	3	-	-	4	-	-	12
July	-	6	2	2	1	5	-	-	15
August	-	12	3	-	-	7	-	-	9
September	1	7	3	2	-	7	-	-	10
October	1	6	4	1	-	16	-	-	3
November	-	1	3	1	2	17	-	-	6
December	-	6	1	-	-	16	-	-	8
Total no. of days	3	73	31	11	8	132	2	-	105

and 8% during December to February - "under these circumstances it is justifiable to call our summer practically rainless, although sometimes a single summer month may show as much as three inches (76,2 mm) of rain" (Marloth, 1903).

Not all the areas in the South-Western Cape experience this dry summer period to the same extent. Marloth showed this in his classic experiments demonstrating the condensation of moisture by plants from the south-east mist on Table Mountain (Marloth, 1903 and 1906). Recent experiments on Table Mountain (Nagel, 1955 and 1962) showed that precipitation from mist and rainfall was 3 294 mm during 1954-55 in contrast to 1 940 mm from rainfall alone. Fine weather south-east cloud was found to contribute less towards the precipitation than rain clouds. Low south-east cloud is often present on the mountains in the Hangklip area but no measurements have been made in the mountains. A number of species on the higher peaks have much divided or very hairy leaves (Spatalla setacea or Mimetes argenteus and other members of the Proteaceae, for instance) which appear to function as fog traps "catching" the moisture. The very dense vegetation found on the upper southerly slopes, in very shallow soil, could be dependant on these mists for survival during long rainless periods such as often occur during the summer.

The variation in precipitation over different parts of the area is considerable. The available figures (see table 2.3) for the Silver Sands area are considerably less (by more than 200 mm) than those for Betty's Bay which is 4,8 km distant and is also located on the coastal plain. Betty's Bay, in contrast to Silver Sands is located at the immediate foot of a fairly high mountain chain which could be the reason for the higher figures (Newlands, on the Cape Peninsula at the foot of Table Mountain, shows similar tendencies). The comparison between the Silver Sands rainfall averages, and those for the Highlands State Forest on the Perdeberg Mountain, 6,5 km east of this survey area, shows that a higher rainfall is experienced particularly during the autumn and spring months. The annual average rainfall at the latter station is similar to that at Betty's Bay but again a higher average rainfall occurs during the autumn and spring months. At Steenbras dam, which is to the north of the Hangklip area, an annual average rainfall of 1 050,7 mm over a period of 26 years, at recording station number six (altitude = 579 m), has been recorded, in contrast to another recording station (number one) at 338 m altitude where the annual average is 874,0 mm (Weather Bureau, 1960a).

The vegetation found in the north-eastern portion of the area, on the edge of the Elgin Basin, generally gives the appearance of being a much drier type with markedly xerophytic species being found in abundance (e.g. Restionaceae and short wiry Ericaceae). This could be the result of a rain shadow effect from fairly distant but surrounding high mountains particularly to the north-west and south-east.

The Hottentots Holland range appears to be the dividing line between the area receiving its rainfall predominantly in winter to the north and that receiving a greater proportion during the summer which increases in a south-easterly direction. The mountains in the Hangklip area appear to be located on this dividing line. This might be one of the reasons for the great diversity of species found in the area.

Thunderstorms are experienced on about five occasions per year in the South-Western Cape (Schulze, 1965).

"Hail is a rare phenomenon. The mountains are occasionally snow-capped but the snow layer never persists throughout the winter. On the average, snow occurs on about five occasions per year, mainly in winter and early spring" (Schulze, 1965). In the Hangklip area, the close proximity to the sea and the relatively low altitudes reduces the number of occurrences and the duration of the snow persistance. The dense vegetation on the mountains makes the snow-falls less conspicuous except in areas which are denuded of vegetation.

Mists generally occur during autumn but no month is necessarily free of mist. Mists are usually formed over the oceans and are driven inshore by light winds (Swart, 1956). Some of the plants in the fore-dune communities were found, on occasion, to be very moist during the late afternoons, particularly on south-easter free days during the autumn, from moisture condensed from the onshore afternoon breezes.

Heavy dew falls have been recorded in the area during the winter months (Grobler, 1964).

Moisture appears to be one of the major factors determining the type of community which developes at a particular location. Its importance as a limiting factor must be stressed in all the communities.

TABLE 2.3 Table of average monthly rainfall data

Month	Betty's Bay	Steen-bras No. 1	High-lands	Silver Sands	Average number of days rain at Silver Sands
	mm	mm	mm	mm	
Jan.	41,15	26,9	33,9	34,8	7
Feb.	39,12	30,3	41,2	27,3	7
March	31,24	31,5	50,2	25,3	7
April	72,90	83,2	90,7	39,3	8
May	95,00	126,5	125,0	59,9	9
June	152,65	135,5	124,1	112,9	13
July	150,37	118,9	122,8	103,0	13
Aug.	126,49	110,5	114,1	123,7	16
Sept.	83,82	80,0	94,7	60,7	11
Oct.	76,96	62,3	77,4	73,5	10
Nov.	36,32	40,7	50,7	25,2	8
Dec.	33,53	27,7	31,1	32,2	7
Average annual	939,55	874,0	955,9	717,9	116

(1) Betty's Bay: Averages calculated from data collected weekly by Mr. D. Heesom at "The Box", Betty's Bay. The data were collected over the period September, 1966 to February, 1972. The altitude is approximately 35 m.

(2) Steenbras No. 1: Averages obtained from W.B.29 (Weather Bureau, 1960a) over a period of 38 years. Altitude 338 m. This station is about 8 km to the north of the survey area.

(3) Highlands: Data were obtained from Highlands Forest Station (Grobler, 1964). This station is 6,5 km east of the survey area at an altitude of 366 m. The data were collected over a 22 year period.

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(4) Silver Sands: Averages have been obtained from data collected by Mr. G. Affleck at "The Four Seasons", Stony Point, Betty's Bay over a period of three years (1969-71). The altitude is less than 15 m.

4. <u>Temperature</u>

Temperature data available from the area are very limited. At Silver Sands, records have been kept for three years and are presented in table 2.4. This recording station is located on the coastal plain and appears to be reasonably representative of this portion of the area with regard to temperature. The main reason for the equable climate experienced along the coast is the close proximity to the sea. The average annual range between the mean daily maximum and minimum temperatures is 7,1^{o}C in comparison to 4,2^{o}C at Cape Point which is almost completely surrounded by the sea and is regarded as having the narrowest average range in the Republic (Weather Bureau, 1954). The coastal land temperatures, being affected by the proximity of the sea, would be expected to show slight local variation because the sea temperatures along the coast between Cape Hangklip and Rooi Els are colder (minimum temperature of 10^{o}C), due to a local upwelling which occurs during periods of prevailing strong south-east winds (Cram, 1970), than at Silver Sands (table 2.4).

In contrast to the coastal plain, the temperatures experienced in the portion of the area bordering the Elgin Basin are more similar to those recorded at the Elgin recording station, where frosts are of common occurrence, particularly in winter (table 2.4).

The recording station at Steenbras dam, to the north of the area, is located at an altitude of 338 m. Lower and higher average temperatures are experienced here than at Silver Sands but without the extremes recorded at Elgin. The Steenbras dam recording station data give an indication of the temperature variations experienced on the lower mountain ranges in the area. No frosts have been recorded at this station over the last 30 years. In the Kogelberg State Forest, temperatures can fall to below freezing point (Grobler, 1964).

The average annual range between the maximum and minimum

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daily temperatures at Elgin is 28,1°C and at Steenbras dam it is 22,3°C (Weather Bureau, 1954) in contrast to the 7,1°C at Silver Sands. The lowest average daily maximum and minimum temperatures occur during July and the highest in January and February. The maximum average monthly temperature range occurs between February and April.

The prevailing strong south-east winds usually result in a cooler climate being experienced, particularly during the summer months. Falls of snow and sleet during the winter are also associated with a drop in temperature.

Insolation is less on the southerly facing slopes, to the extent of being absent on the steeper slopes, than on the northern slopes. The result is cooler conditions on the southerly facing slopes. The moister condition of some of the southern slopes is probably associated with the reduced insolation, amongst other factors .

TABLE 2.4 Table of average monthly temperature data

Month	Silver Sands		Steenbras No. 1		Elgin	
	Maximum	Minimum	Mean maximum	Mean minimum	Mean maximum	Mean minimum
Jan.	23,9	16,4	32,8	9,7	34,9	6,6
Feb.	23,0	15,8	32,2	11,2	35,1	6,6
Mar.	22,5	15,4	30,4	8,9	33,2	5,2
Apr.	19,8	13,5	30,1	7,3	32,1	2,3
May	18,8	12,1	26,3	4,7	27,3	-0,4
June	17,7	10,7	24,1	3,0	24,8	-1,8
July	16,7	9,6	22,7	2,4	23,2	-1,9
Aug.	17,2	10,2	25,4	2,9	27,2	-1,4
Sept.	17,6	10,3	26,6	4,6	28,4	0,2
Oct.	19,6	13,1	28,1	5,2	30,2	1,8
Nov.	20,6	13,8	30,7	6,9	33,3	4,3
Dec.	22,1	15,4	31,4	8,2	34,1	5,6

The location of the Silver Sands and the Steenbras number one recording stations are given in table 2.3. Elgin: 34° 09'S and 19°02'E at an altitude of 259 m for the period 1927-50 (Weather Bureau, 1954).

5. Relative humidity

The average monthly relative humidity as at 0800 hours and 1400 hours has been determined from readings made at Silver Sands over the period 1969 to 1971 by Mr. G. Affleck (table 2.5). The monthly average is characteristically higher in the morning than in the evening, being an average of 77,4% in the morning and 67,7% in the afternoon.

TABLE 2.5 Average relative humidity (in percentage)

Month	0800 hrs.	1400 hrs.
January	75,9	67,4
February	78,8	69,6
March	81,8	70,8
April	81,7	71,7
May	80,0	69,3
June	76,0	67,0
July	79,3	68,6
August	76,6	66,3
September	76,3	65,8
October	77,0	67,9
November	70,5	63,8
December	75,1	66,1
Average	77,4	67,7

2.5 F i r e

Fire, as a factor influencing vegetation, must be considered along with the prevailing climatic conditions which determine its influence on the vegetation and its duration and extent. It is generally held that fires result from a number of sources such as: lightning strikes, spontaneous combustion of rotting organic material, friction from rolling rocks and stones such as those dislodged by earth quakes or other means and accidental or deliberate ignition by man.

Man made fires are not thought to be of very recent introduction because "the earliest evidence of the use of fire by primitive man in Africa south of the Sahara is associated with the Chelles-Acheul and perhaps the Fauresmith industries which flourished at the very end of the Earlier Stone Age, more than 53 000 years ago" (West, 1965). Fires caused by other factors (such as some of those mentioned above) undoubtedly occurred before this time. According to Phillips (1931), the log-books of Bartholomew Diaz and Vasco da Gama recorded the presence of fires on the Cape coast in the late 15th century. The Cape farmers probably learnt the practice of burning to obtain grazing for their stock from the Hottentots until, "in 1687 a law was passed imposing the severest penalties for contravention, namely, a severe scourging for the first offence, and death by hanging for the second" (Botha, 1924), if anyone was found guilty of causing the veld to be burned. These laws were only very occasionally enforced and fell into disuse although protests about the destruction of the veld because of fires were made during the 18th century.

During the beginning of the 20th century campaigns were started calling for the control of fires by such well-known botanists as Bews (1918), Levyns (1924), Marloth (1924), Pillans (1924), Adamson (1927) and Phillips (1930). In the thirties a wave of increasing antagonism started against fires and total bans on burning were advocated by Compton (1934), for instance. Phillips (1938) regarded climax plant communities as having lost their beauty in many places because of fire. The knowledge of community development at this stage was scanty, resultantly views were inclined towards sentimentality. The result from total protection from fire was a succession of large devastating "wild fires" in the mountains of the South-Western Cape between the 1940's and the 1960's. In 1942, 17 130 ha of veld was burnt in the Nuweberg, Franschhoek and Jonkershoek Mountains. In 1945, 10 280 ha of veld was burnt in the Kogelberg State Forest. A number of other large fires, such as these, occurred during this period.

A change in views about the value of fire in the fynbos started occurring between 1950 and 1960 and in 1956 Prof. C.L. Wicht, in a radio talk, said that controlled fires were permissible under certain circumstances (Le Roux, 1966). Wicht and Banks (1963) considered that the total protection of the fynbos created an unnatural condition because the fynbos had already been exposed to and survived centuries of fire, to such an extent that it had become a natural factor.

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In Southern Australia experiments with heath vegetation on poor sandy soil showed that with complete protection from fire, a species reduction took place in composition. "Of 36 species recorded after a fire only 20 persisted after 25 years, five of these 20 contributing less than 1 kg dry weight per acre. Only ten of these species persist after 50 years and most are greatly depleted in numbers." "It was only as the heath aged that numbers markedly decreased, mostly owing to the competition for water during the first 20 years of the succession. After that, certain nutrients may become limiting and reduce the uptake of others." "Regular firing is essential to maintain many elements of the flora" (Specht, Rayson & Jackman, 1958).

Recently the idea of controlled burns to manage the vegetation, has been advocated by the Department of Forestry in some of the mountain catchment areas, particularly of the South-Western Cape. The Kogelberg State Forest was one area where degeneration of the veld appeared to be occurring and particularly in the case of certain very rare endemic species, such as certain members of the Proteaceae. Some of the members of this latter family appear to be particularly sensitive to the general condition of the veld. The marsh rose, Orothamnus zeyheri, for instance did not appear to be capable of maintaining their numbers, or healthy condition, in veld which had been left unburnt for a number of years. The degeneration of the stands of Orothamnus zeyheri reached such alarmingly low proportions that drastic measures had to be taken to attempt to rescue this species from extinction. On the 10th July, 1968, the Department of Forestry undertook the largest controlled burn attempted to date in the South-Western Cape mountains. The whole of the Platberg mountain massif, on the summit of which a colony of marsh rose had grown, was set alight. This mountain, like a number of others in the vicinity, had been protected from fire since a devastating "wild fire" had swept through the area in 1945. Notwithstanding this being a "winter fire", the veld burnt fiercely developing its own cloud high above the mountain in an otherwise clear sky. The members of the Restionaceae proved particularly inflammable and were favoured when igniting the fire. The vegetation not burnt during the two days that the July fire lasted was subsequently burnt on the 3rd and 4th February, 1969. Seedling regeneration of Orothamnus took place at the site where the species had previously been recorded.

The same pattern was followed with subsequent controlled burns in the Kogelberg State Forest. The Voorberg and Buffelstalberg complex was set alight on the 14th October, 1969 and the remaining unburnt portions of the Voorberg on the 15th December, 1970, a portion of the Perdeberg was burnt in September, 1970 and August, 1971, the remainder being burnt by an accidental fire on the 23rd September, 1971. This latter fire occured simultaneously to one in the Dwarsrivier Mountain after it was struck by lightning. The previously burnt areas of the Kogelberg State Forest limited the disastrous fire which struck Betty's Bay on the 18th February, 1970 and destroyed 22 houses. This fire destroyed the vegetation on the Elephant Rock Mountain damaging the forest patches in the vicinity to varying degrees.

The Betty's Bay fire indicated the dependance of various elements of the fynbos vegetation on fire when large numbers of Cyrtanthus angustifolius, Haemanthus canaliculatus, Kniphofia uvaria, Disa racemosa, Gladiolus carneus, Geissorrhiza wrightii, Watsonia pyramidata, W. comptonii, Danthonia cincta, Elegia thyrsifera, Senecio rigidus, Indigofera filiformis and many more species appeared in one blaze of colour after another, where their existance was previously often unknown because of the tangled mass of rank vegetation.

A considerable amount of experimentation and study is required in the fynbos vegetation before the intricacies of the balance between the communities and fire will reach some degree of clarity. The much discussed questions of time of burning, period between burning, where to burn and where not to burn, etc., are but a few of the many problems which will have to solved. No attempt was made during this survey to study the development of the communities after burning. In all cases the vegetation sampled had not been subjected to burning during at least the last eight to ten years.

2.6 Historical factors

The Quaternary history of the Hangklip area is unfortunately

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relatively unknown. The earliest records of man's activities here can be found on the seaward side of Groot Hangklip Mountain. A Palaeolithic or Early Stone Age site has been excavated here, which consists of "a layer of consolidated black sandy peat, three or four feet thick, in and on which occurred implements, that from a typological point of view, cover the whole range of the Stellenbosch or African Chelles-Acheul Culture" (Mabbutt, 1955).

The Stone Age periods have been listed as follows for South Africa (Goodwin, 1952):

Later Stone Age:	Middens with pottery, rare polished axes, etc.
	Middens with Wilton tools.
	Middens with late Smithfield tools.
Middle Stone Age:	Howieson's Poort Culture.
	Still Bay Culture.
Earlier Stone Age:	Final Chelles-Acheul Culture.
	Chelles-Acheul (Stellenbosch) Culture.
	Pre-Chellean (Pre-Stellenbosch) Culture.

Above the peat layer is a layer containing "four to five feet of less consolidated black earth, matted with grass roots, on which lay a Still Bay assemblage" (Mabbutt, 1955). The early Stellenbosch Culture implements formed a small proportion of those found at the site, the major portion belonging to the later Stellenbosch IV and V cultures. The conclusion is drawn (Mabbutt, 1955) that this site was mostly habited at the close of the Earlier Stone Age and during the Middle Stone Age. Archaeological evidence suggests that a further major period of sand invasion separated the Earlier and Middle Stone Age industries of Cape Hangklip from the Neanthropic midden culture, where iron nails in the middens testifies to their extension into "European" times.

It has been suggested (Gatehouse, 1955) that men had lived at Hangklip without a break throughout the period of cultural development. What is the extent of their influence on the vegetation? From these archaeological sites various deductions have been made concerning variations in the local climate. "Two periods of maximum peat formation seemed to have occurred, one before and one after the late Stellenbosch industry" (Mabbutt, 1955). A palynological analysis of the peat by Dr. E.M. van Zinderen Bakker has shown it to have been derived from an oligotrophic bog vegetation. The peat accumulated in undrained hollows behind the Table Mountain Sandstone ridges.

The following sequence of events have been suggested (Sampson, 1962) for the formation of the Palaeolithic site:

"(1) World-wide rise in sea level in response to the Last Interglacial. Sandstone bench and pebble layers formed sixty feet (18,3 m) above present sea level.

(2) Marine regression in response to first stage of Last Glaciation. Longshore dunes derived from exposed sea bed.

(3) Seaward drainage is restricted. A narrow coastal marsh-lagoon permits deposition of iron oxides. Upper Chelles-Acheul occupation and further deposition of iron oxides.

(4) Southward drift of lagoon. Exposed beds subjected to severe leaching during occupation. Formation of hard ironpans with superposed leached, loose, buff sands. Frequent longshore drift of marsh-lagoon.

(5) Silting up to peak of barrier dunes. Grey sands possibly derived from exposed beds of the second or final advance of the Last Glaciation. Sands cap the silted area. Brief Middle Stone Age occupation.

(6) Drainage eats back through barrier dunes and continues headward erosion through the ferruginised deposits. Cultural horizon deflated and lowered to sixty foot (18,3 m) bench. Formation of vertical ferruginised sheets."

The Hangklip stone industry appears to have commenced and ended during the Third Interglacial, and probably during the last half of that period. According to the absolute calculation (using the potassium-argon dating method) this would be about 120 000 to 140 000 years ago (Gatehouse, 1955).

Possibly, the main source of raw material for the tools of the Early Stone Age hunters, who occupied the area was from the quartzite boulders which split and exfoliate as the result of fire (Sampson, 1962). Such fires would provide fresh grazing for the game which could be driven down the natural funnel bounded by the sea and the vertical coastal peaks, where their passage was slowed by the swampland so that they could be easily stoned.

From the Later Stone Age onwards, or about 100 000 years ago, people who appeared to be related to the surviving Bushmen and Hottentots, lived along the whole coast. They are associated with the deposits of fish-shell remains known as kitchen-middens. Van Riebeeck applied the term "strand-loper" to them which describes their beach-combing way of life. This is a sudden development in the Later Stone Age man because previously "no form of fish, either molluscan or vertebrate, was eaten in caves" and "whatever knowledge man may have had of fire, little evidence can be obtained from these deposits." With the appearance of the strandloper, "cave deposits changed abruptly from the dark lime-free earth below to layers with an abundance of recognizable shell and shell-lime. Frequent evidence of fire can now be seen." (Goodwin, 1952).

It would be of particular interest to determine when fire emerged as an ecological factor in the historical development of the fynbos vegetation.

In 1503 the Portuguese navigator Antonio da Saldanha anchored in Table Bay. He later climbed Table Mountain and from it saw the end of the Cape and the sea beyond, on the eastern side, where it formed a deep bay (False Bay), into which two ridges of high rocks protruded (Cape Point and Cape Hangklip) (Botha, 1926). This is the first recorded view of Cape Hangklip by a European.

On Germanus' map of 1489, False Bay is marked as "golfo dentro das Serras", the gulf within the mountain ranges. "The 16th and 17th century charts show Cape Falso, and the 17th and 18th century maps mark Hangklip as Falso" (Botha, 1926). The map in Sparrman's travels marks Hangklip about where Danger Point is, he has marked False Hangklip at the present Hangklip. The Rev. Francois Valentyn says it is called the Hang Lip because it resembles a pendulous lip attached to the range of mountains (Heap, 1970). Thompson, in his "Travels in Southern Africa" of 1827, says that False Bay was so called from ships having been deceived in coming in from the eastward. "After rounding Hangklip in dark weather, imagining they had passed the real Cape of Good Hope, they stand to the north, when in a short time they find

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themselves on the Muizenberg beach at the bottom of False Bay" (Botha, 1926). And, "if we look at the chart of the South African coast made by Perestrello in 1576 we find Cabo Falso marked about where Danger Point is. Cape Hangklip, Hanging Rock, was marked according to Ravenstein, by the Portuguese as Ponta Espinhosa, Thorny Point, or, as one map marked it on the west, it might be Bok Point."

There now followed the period of overland exploration usually in search of cattle, butter and milk for the garrison at Cape Town. The general routes from Cape Town "eastwards" followed either the coast line, crossing the Eersterivier and the Tweederivier (now Lourens River) at their mouths, or past de Kuilen (Kuilsrivier) to the Hottentots Holland area and then following the Elands Pad (called Gantouw by the Hottentots and later Hottentots Holland Kloof and now Sir Lowry's Pass) over the Hottentots Holland Mountains (Heap, 1970). This route generally bypassed the Hangklip area, primarily because of it being a dangerous route with lofty mountains rising steeply out of the sea.

The first farming permit to be issued in the Hangklip area was for an area called "Waai de Gat" and was described as occurring "aan deese kant van de Hangklip" in 1739 (Botha, 1926).

Lieutenant William Paterson in company with Colonel Robert Gordon (then a captain of the troops in the Cape) undertook a journey of exploration in October, 1777. After reaching the Hottentots Holland, via the shores of False Bay from Muizenberg, the party separated from their baggage which was taken over Sir Lowry's Pass, while they "pursued our journey, on the 12th, round the Hang Lip." They took scanty provisions with them, probably expecting to complete the journey in one day. They spent their first night at a place which Captain Gordon called Van Pletenbey's Bay (this bay was called Colebrooke Bay for a time after the boat of that name ran aground here but the older Dutch name of Kogel Bay survives today. Both of the latter names are given on Colonel Robert Gordon's map of 1780 (Botha, 1926)). Paterson comments that "from Hottentot Holland, to this place, the country is quite uninhabited; the whole tract consisting of precipes and rugged mountains" (Paterson, 1789). They called the present Rooi Els, Gordon's Bay and Pringle Bay, Paterson's Bay. (Gordon's map of 1780 shows Rooi Els to be "Paterson's Baaytje" and Pringle Bay to be Gordon's Bay (Botha, 1926)). Subsequently Pringle Bay (probably after Rear-Admiral Thomas Pringle who was in charge of the naval station at the Cape in 1796) has been called Buffels Bay, McKellar's Bay (Porter, 1967) and recently Beryl's Bay.

Paterson in his journey through the Hangklip area (Paterson, 1789) found "lakes of fresh water, and plenty of wood" between Pringle Bay and Rooi Els. (A small patch of Sideroxylon inerme dune scrub at Pringle Bay and a small lake, which dries out in summer, are all that remain today).

Paterson's description of the Betty's Bay flats is a good illustration of the way man has influenced the balance of nature: ".... we passed Cape False; to the south-east of which is a large plain, covered with many different species of grass; but all of them bad for cattle"(probably Restionaceae and Cyperaceae). "Here I found a species of Erica, which was quite new, with a spike of long tubular yellow flowers, the most beautiful I have ever seen." This Erica has been called Erica patersonia in his honour. "There are some wild buffaloes about this place, of which we saw several; but they were so very shy that we could not approach them. There is also a species of antelope, which the Dutch call Eland" (Paterson, 1789). Today buffalo and Eland are absent. What did they eat? What other effects did they have on the ecology of the area?

In April 1747, Matzain le Roux was grazing his stock at a loan farm on "'d'Aries Craal over Palmeet Rivier" (Burman, 1970). The stock would probably have crossed the Palmiet River during the dry season to graze in the vicinity of or in the Kogelberg State Forest.

Little information is available about the Betty's Bay area between Paterson's journey in 1777 and 1912 when whaling operations were started there, except that stock were grazed in the area and professional fisherman lived near Cape Hangklip at the turn of the century. This absence of reports can probably be attributed to the completion of Sir Lowry's Pass (opened officially on the 6th July, 1830) and shortly after, Houw Hoek Pass. This easier route provided an effective bypass around the rugged rocks and lofty mountains rising straight out of the sea between Gordon's Bay and Rooi Els.

The buildings and machinery of the Southern Cross Whaling Company Limited were erected at Stony Point, Betty's Bay in 1912, with whaling operations starting in 1913. This land was taken on a lease of R600 for 60 acres from a Mr. John G. Walsh (Krohn, 1970), a farmer from the Caledon district. Supplies for the whalers was brought by boat from Cape Town, although a cart track to the Palmiet River existed; the latter could later be crossed by pontoon which remained in use till after 1939 (Porter, 1967). Cattle, horse and sheep were grazed in the area during this period. The name given to the Sideroxylon inerme dune scrub patch, Dawidskraal, refers to the shelter it provided for one of these shepherds and his flock (Bulpin, 1970). The area was sparsely populated at this stage with one family living near the Blesberg and another at the Blomhuis (Krohn, 1970); the latter is situated on the present Elephant Rock Estates (which owes its name to the effigy of an elephant in stone on the mountain above the estate) and is still used for its original function of drying and the storage of wild flowers. Camping was popular then, as now, at the Palmiet River mouth. "Wild, white ever-lasting flowers, particularly Helichrysum vestitum, grew in profusion. These flowers created a profitable trade, being used for funeral tributes, non-white gaities as well as good filling for pillows and mattresses" (Porter, 1967).

During the period, 1936-38, Jack Clarence and Arthur Youldon appointed Harold N. Porter, together with a lawyer and surveyor, to inspect the area between the Rooi Els River and the Palmiet River, which was offered for sale, with a view to purchasing it. A company of promoters was eventually formed, the land was purchased and Hangklip Beach Estate Company was started (Porter, 1967). Betty's Bay was named after A. Youldon's daughter, Betty.

The Hangklip area was threatened with invasion by the Japanese during the Second World War. Barracks were hastily erected at the base of Groot Hangklip Mountain (called

Skilpad Camp) and at Stony Point (also known as Cook's Harbour, Clareport and the Four Seasons) as a precautionary measure. Roads were speedily constructed from Gordon's Bay and from the Palmiet River by the Hangklip Beach Estate Company, with aid from the government and military authorities. The road from Gordon's Bay to Rooi Els has been called Clarence Drive after G.J.V. Clarence "whose vision, faith and determination helped to bring it into being" (inscription on a roadside memorial dated 1st January, 1950).

In 1945 a road was constructed by the Hangklip Beach Estate Company to Oudebosch, to start a market garden there. This venture never proved successful and Oudebosch was eventually purchased by the Department of Forestry in 1961 for the conservation of water and protection of rare species of indigenous flora. Flower picking was practiced there until this time. It was declared a demarcated forest in the Government Gazette of 28th October, 1962. Prior to this purchase, Oudebosch had been state owned but had been exchanged for a lot called Dwarsrivier in 1937, which was considered a "nuisance island" in the middle of the then Kogelberg Reserve. The Kogelberg State Forest included the mountainous areas between the Elgin Basin, Kogel Bay and almost to Kleinmond where it abutted onto the Highlands State Forest. The arable portions of the Oudebosch lot have, subsequently been developed into a research station by Dr. M. Vogts for the study and cultivation of various Protea species. Particular attention has been paid to the variations occurring in Protea cynaroides. The management and control of the Kogelberg State Forest is effected from the adjoining Highlands State Forest although a foreman was stationed at Oudebosch for a number of years.

In 1957, on the death of H.N. Porter, his property, Shangri-la, was ceded to the National Botanic Gardens of South Africa while the Disa Kloof was donated by the Hangklip Beach Estate Company. This all forms part of what is now called the Harold Porter Botanic Reserve (Porter, 1967) instigated for the cultivation and preservation of the indigenous flora of the area.

A large dam is now envisaged near the mouth of the

Palmiet River to augment the water supply to Cape Town. Surveying for this dam has been undertaken up to the 137 m contour and will extend back along 19 km of the Palmiet River Valley.

CHAPTER 3

METHODS: THEIR APPLICATION AND PERFORMANCE

3.1 Object

The primary object of this survey was to determine whether any relationships could be detected between the vegetation and the habitat in the Hangklip area. Statistical methods were employed for data comparison purposes and to eliminate as much subjectivity as possible. The suitability of statistical methods as an aid to the enumeration of the vegetation on an extensive scale, required testing in the fynbos of the South-Western Cape Province.

Taylor (1969b) tested the association-analysis methods of Williams and Lambert (1959, 1960 and 1961) while undertaking a survey of the vegetation of the Cape of Good Hope Nature Reserve by conventional methods. He also applied phytosociological methods, which proved fairly successful, in contrast to the association-analysis methods, which he found to be unsuitable in this fynbos vegetation. The reasons he gives for this latter method's unsuitability will be discussed later as will certain variations in technique which have been employed in the reapplication of these methods.

Hall (1970) successfully applied a method, developed by himself, which used a homogeneity function to demonstrate the similarities between sampling points in a transect through fynbos vegetation of limited extent. This method was applied to data obtained from a more extensive area to determine its potential suitability as a tool in the survey of the fynbos vegetation of the mountainous areas of the winter rainfall region.

The determination of the vegetation and its relationship with the habitat were required as part of a programme for the assessment of the natural resources of South Africa and for the management of the mountain catchment areas. Information about the numbers and condition of endemic and rare species and a comprehensive collection of botanical specimens were also required.

3.2 The sampling unit

Standard phytosociological practice, as advocated by the Braun-Blanquet school of methodology (Küchler, 1967), requires that sampling quadrats should be relatively uniform in floristics and size. This does not, however, imply a fixed quadrat size, but one which should be large enough to encompass all the species which belong to the particular community which is being analysed. The minimum size would, therefore, vary with the type of vegetation involved i.e. herbaceous, woody or forest vegetation.

In this study use has been made of statistical methods which require that all the sampling sites be of equal size and shape to be strictly comparable. Taylor (1969b) undertook a pilot survey to determine the size of plot to be used in the survey of the fynbos vegetation of South Africa. The vegetation of the Cape Peninsula was used as a typical example. The present study forms part of this master programme. Twenty sampling sites were located randomly over an area of the Cape Peninsula. At each site a quadrat of 10 x 10 square metres was constructed which was subdivided into ten sub-plots of 2 x 5 square metres each. Separate species lists were made for each sub-plot. Regression equations for plot sizes of $20m^2$, $50m^2$ and $100m^2$, were derived and species-number expectancies for each plot size were calculated. From these calculations a quadrat of rectangular shape having a size of 10 x 5 square metres was chosen as being the most efficient.

To determine the performance and suitability of this quadrat size in the present study, data were collected from ten local randomly located sampling quadrats, situated in the various major physiographic-physiognomic vegetation units which were delimited on the aerial photographs (described under the distribution of sampling sites). Species-area curves were constructed and compared. The species-area curves all had levelled off considerably by the $120m^2$ stage. This was taken as the maximum quadrat size necessary to include most of the species in a particular community. This was checked by studying the same community outside the limits of the quadrat at each site. The limits of each community were taken as that zone where a significant change in the vegetation, usually indicated by a sudden increase in additional species, occurred. The increase in different species appears to produce a step-wise graph with an increase in area. This pattern should theoretically increase until the major vegetation groups of the world are included. The decision on the scale of vegetation analysis which is being undertaken will therefore have a great influence on the concept of a homogeneous community and therefore the applicable quadrat size.

TABLE 3.1 A comparison of the results from the average species-area curve for the ten sample quadrats of $120m^2$ size for the determination of optimum quadrat size assuming $120m^2$ to be the maximum area.

Quadrat area	Species content as a % of the maximum	Reduction in area as a % of the maximum
$120m^2$	100%	0%
$110m^2$	97%	9%
$100m^2$	94%	17%
$90m^2$	91%	25%
$80m^2$	88%	33%
$70m^2$	85%	42%
$60m^2$	82%	50%
$50m^2$	79%	58%
$40m^2$	75%	66%
$30m^2$	71%	75%
$20m^2$	64%	83%
$10m^2$	54%	92%

If an area of $50m^2$ was therefore intensively studied, then 79% of the species would, on average, be encountered. Those species occurring outside the sample quadrat could be included within a separate list of species occurring in the surroundings. A 50% reduction in plot size from $100m^2$ would result in a 12% reduction in the number of species present, in contrast to the equivalent 15% reduction on the Cape Peninsula (Taylor, 1969b). A fixed quadrat size of 10 x 5 square metres would, therefore, give adequate data for the analysis of the vegetation in the Hangklip area, while at the same time making the quadrat data comparable, statistically, to that collected by Taylor on the Cape of Good Hope Nature Reserve (Taylor, 1969b). The smaller sampling area of $50m^2$ is more practical as a quadrat size in the vegetation of the Hangklip area because the terrain is often very rugged and then it is sometimes impossible to use a larger quadrat. The very dense tall shrubby vegetation found in some of the kloofs which haven't been subjected to fire for 26 years and more, would also be particularly difficult to sample accurately with a larger quadrat. On the other hand a $50m^2$ sample plot would not be adequate to sample the forest vegetation because of the spatial arrangement of the component species. A larger sized quadrat would be necessary here, but could not be used generally because difficulties would arise in the sampling of some of the smaller fynbos communities. The data would have to be treated separately in any statistical analysis if two sample sizes were used and the results would not be comparable. The forest vegetation is of limited extent in the survey area, yet is quite distinctive physiognomically and floristically, on the ground and on aerial photographs. It was, therefore, decided not to sample them for statistical analysis but rather to restrict the limited number of sampling quadrats allowed to the more complex fynbos vegetation.

In a survey of the fynbos vegetation in Swartboskloof, Jonkershoek, undertaken by Werger, Kruger & Taylor (1972), strictly phytosociological practices were applied. A quadrat size of $100m^2$ was selected for use in the majority of relevés but on two occasions, out of 44, quadrats of $50m^2$ had to be used to avoid obvious heterogeneity. This latter survey therefore supports the general use of a quadrat of $50m^2$ maximum size, if heterogeneity is to be avoided in most instances when a primary level of survey is intended. The scale of pattern reflected appears, therefore, in most cases, to be most suitable for the mapping of communities at a primary level for veld management and subsequent information retrieval purposes.

To ensure that all the species in the community being sampled were recorded, during the actual survey, a list of species occurring in the surroundings of the sample quadrat

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was also made. These additional lists were found to be useful in a few cases where sites appeared to be wrongly grouped in the association-analysis, which was based on the $50m^2$ plot lists, and could then be reclassified on the basis of a dividing species being recorded in the surround list.

Distribution of sampling units

In his survey of the vegetation of the Cape of Good Hope Nature Reserve, Taylor (1969b) distributed 100 sampling sites systematically along the grid-line intersections on a 1:18 000 topographical map of that area. He found, when interpreting the association-analysis, that the results could not be effectively correlated to ecological factors because of different levels of heterogeneity in the final groups or those at higher levels. A subjective element would be introduced if selective regrouping was undertaken and there were, in some cases, too few plots to provide a picture of communities and they could not be accurately mapped, because natural boundaries did not occur intermediately between the sampling sites, where different communities were represented by adjacent sites. And, finally, the use of systematically placed sampling sites resulted in transitions being sampled in a number of instances which confused the interpretation, particularly when so few quadrats had been distributed (100 sampling sites over 7 680 ha).

To improve the efficiency of the sampling method so as to avoid some of the problems encountered by Taylor (1969b), as have been outlined above, the method of stratified random sampling was used (Brown, 1954 & Scheepers, 1969). The stratification is based on physiography and vegetation physiognomy. Entities of uniform physiography and physiognomy being delimited on aerial photographs. Physiographic features such as landscape type (river bank, mountain plateau, etc.) or geological formation (shale band, etc.) or physiognomic features of the vegetation (forests, etc.), where they are readily distinguishable, are delimited. The sampling efficiency would be improved because, theoretically, sufficient sampling sites could be located in each unit (by random means) to characterize it adequately by varying the sampling intensity according to the area occupied by each physiographic-physiognomic entity. This would in effect provide an objective means of limiting the oversampling of a common unit or the undersampling of a rare unit and is termed restricted randomization.

The distribution of the sampling sites, at random, on the aerial photographs ensures that sampling sites occurring on the boundaries of the physiographic-physiognomic units can be recognized and discarded without having to undertake field investigations, which are time-consuming and avoiding the possibility that transitions might not, on occasion, be recognized in the field. The pertinent 1:36 000 scale aerial photographs, from Job 461 of the Trigonometrical Survey series of aerial photographs flown between October, 1961 and January, 1962, were used in this study. Additional information was obtained from 1:25 000 scale photographs forming Job 126 of February and March, 1938.

When collecting the field data, care was taken that the location of the sampling site was objectively established but that the vegetation appeared homogenous. The reason for requiring that the vegetation sampled is of as homogenous a composition as possible, is because of the limitation on the amount of data which can be analyzed with available computer facilities where the vegetation is very complex and the confused classifications of transitionary samples would represent wasted effort.

Taylor (1969b) distributed 100 sampling sites over the 7 680 ha (30 square miles) of his study area whereas 150 sites were distributed over the 11 506 ha involved in this study. This is a slightly more intensive ratio but is counteracted by the evident greater variety of habitats in the Hangklip area.

The mapping of the recognized communities was done from the aerial photographs to ensure that the boundaries were as natural and as accurate as possible. This eliminated the objection raised by Taylor (1969b) of unnatural boundaries, where the boundaries of each grid-square were regarded as the boundaries of the respective community.

The aerial photographs could be successfully interpreted to pin-point the location of the sampling sites fairly accurately in the field. The south-west corner of each quadrat was finally located by throwing a peg over a shoulder so as to keep any subjective choice to a minimum. The quadrats were in each case laid out along with the north-south axis (magnetic) forming the longest sides of the rectangle. To assist in the actual listing of the species, each quadrat was subdivided into ten parts. The disadvantage of randomly distributed sampling sites with quadrats of fixed size became evident when a phytosociological analysis of these data was attempted.

3.3 The data collected at each site

Although the area under investigation falls into the winter rainfall region of the Cape Province, precipitation is not restricted to the winter months, certain portions receiving considerable precipitation during the summer months. The flora is therefore not restricted to a specific period during which the majority of species flower but is extended over the whole year. A peak flowering period is however generally found to occur during spring (van der Merwe, 1966). Before any study of the vegetation can be undertaken, a fairly complete collection of the flora is necessary, particularly when so many species having a restricted distribution occur.

While collecting herbarium specimens, large portions of the survey area were examined which were previously relatively poorly known botanically. Scraps of specimens were mounted on index cards to serve as a field herbarium when collecting quadrat data to aid in the identification of vegetative specimens. In spite of this aid a few misidentifications were made during the 1970-71 drought conditions. This is unavoidable when the number of different species occurring in the area are taken into account. More than 1 380 different taxa have been collected in the area since starting this survey.

The sociability and degree of cover abundance of all the species encountered in each quadrat was listed according to the scales devised by Braun-Blanquet (Becking, 1957). Hawson's scale of abundance (Brown, 1954) was used in a slightly modified form by estimating the number of individuals occurring in each sample quadrat instead of considering the number of stalks or plants per square metre quadrat. This scale was required for evaluation using the homogeneity function of Hall (1970) which is frequency modulated. Raunkiaer's classification of growth forms (Odum, 1959) was recorded for each species to facilitate the description of the communities.

The collection of plot data could not be confined to any particular season, consequently the problem arose of species such as annuals and geophytes which were not permanently recognizable. It was decided to list only those species which are permanently recognizable for analysis but nevertheless recording the presence of the annuals and geophytes when they did occur in a recognizable form, for distribution purposes. Communities would therefore be characterized by species which could be recognized with equal facility throughout the year.

To enable description and comparison of the sites, the following data were recorded for each plot:

(1) Ball's definition of soil class (Peterken, 1967), the depth of the soil and the soil series as described in chapter 2.4 were noted in each instance.

(2) An indication of the type of stoniness was estimated according to an arbitrary range similar to that used by Taylor (1969b):

0 = not stony with only small fragmentary material.
1 = pebbly with material averaging about 2,5 cm in diameter.
2 = small stones averaging about 15 cm in diameter.
3 = large rocks averaging about 60 cm in diameter.
4 = boulders averaging about 2,2 m in diameter.
5 = bedrock near the surface, partly protruding.

The degree of stoniness was estimated according to the following scale:

0 = no "stones".
1 = slightly "stony", generally less than 10% stones.
2 = moderately "stony", approximately 11%-30% stones.
3 = very "stony", generally more than 30% stones.

(3) The soil moisture was estimated according to the following index:

1 = dry (usually deep sand or steep slopes with coarse sand).
2 = temporarily moist (such as steep south- or east-facing slopes).
3 = seasonally moist (such as depressions or plateau flats).
4 = seasonally wet (such as vleis or marshy flats).
5 = permanently wet (such as stream verges, bogs or seepages).

(4) Data about each quadrat's altitude, aspect and slope were measured and any additional features affecting the local climate.

(5) A pH reading of the soils acidity or alkalinity was taken at each site using a Lovibond 1000 comparator with a B.D.H. pH indicator of range 4,0 to 8,0.

(6) A coloured slide and a black and white photograph were taken of each sampling site to record specific vegetational and topographic features.

(7) Sketches were made of each site to indicate the general topographic and vegetational features showing the dominant species and their relative proportional contributions to the vegetation.

(8) The formation was recorded using Fosberg's classification (Peterken, 1967).

(9) The post-burn age of the vegetation was assessed by counting the branching of the Proteaceous shrubs (van der Merwe, 1969) and by determining the number of annual zones of rapid growth on members of the Proteaceae (Hall, 1959). In a number of cases the dates and extent of earlier fires could be obtained from the literature or records kept by the Department of Forestry.

The relevé data for the 150 sampling sites were collected over a period of approximately 60 field days at an average of 2,54 sites per field day. This low rate of data collection can be attributed to the inaccessibility of many sites. On occasions it took a day to reach and record data from a single relevé.

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The species list compiled from the relevés alone totalled 518 species of which 170 species were only recorded once or were not permanently recognizable. Sixty-seven species were recorded in not more than two relevés each while 281 species were found in three or more sampling sites and were coded for the comparison of the data. The maximum number of permanently recognizable species recorded in one relevé was 57 species in quadrat number 77 with an additional seven recorded in the surround list. The average number of species coded per plot was 27,18. This average number might conceivably be much higher if most of the vegetation had not been in an advanced state of maturity due to protection from fire for at least 26 years (see comments in chapter 2.4 on fire).

The classification

The use of an ordination technique has not been tested in the fynbos vegetation of the South-Western Cape. The use of a technique of this nature is however immediately excluded in a survey of the scale undertaken here because the data-set would be too large to be handled by any available computer facilities. One of the reasons for undertaking this survey is to divide the vegetation into mappable units which can also be used in its management.

Hall (1969c) has discussed some of the shortcomings of various functions and methods in common use in vegetation analysis, referring particularly to the following:

(1) The product-moment correlation coefficient.

(2) The mean Euclidean distance.

(3) Jaccard's similarity coefficient.

(4) The Czekanowski similarity coefficient.

(5) Showing group structure using principal components analysis.

(6) The nature of the item array and clustering methods in use.

Field (1969) has demonstrated that the use of the association-analysis (Williams & Lambert, 1959, 1960 and 1961), similarity-analysis (Lance & Williams, 1966) and information-analysis (Macnaughton-Smith, 1965) methods are inappropriate in the classification of heterogeneous systems.

The association-analysis techniques of Williams & Lambert (1959, 1960 and 1961) and Lambert & Williams (1962) had been successfully applied variously in South Africa and elsewhere to correlate ecological factors to vegetational differences. Notwithstanding the reservations voiced against the techniques by the above authors, and others, it was decided again to apply the method, with certain modifications, because of the advantage of being able to use large sets of species data with these methods due to additional performance data not being used. Each species occurs naturally under specific conditions (whether these are physiological, geographical or ecological) and the very reference to each taxon implies certain conditions in an area. In the fynbos vegetation a large specific complement is typically found (2 622 species have been recorded on the Cape Peninsula alone (Adamson & Salter, 1950)). To reject a number of species to reduce the size of the data-set for computational purposes would in actual fact constitute a considerable loss of implied information. To reject a number of species in favour of additional aspects such as frequency data would require considerable statistical adjustment to reduce the resultant bias towards this additional information, unless a bias towards these factors is required. The final test of a method's suitability would in any event be the applicability of the resultant classification.

Hall (1967b and 1969c) has developed a classificatory technique which avoids most informational distortions by treating the data consistently and most exactly thereby making most use of the accurate facilities provided by electronic computers. This is an agglomerative technique which makes use of a relative homogeneity function to compare data sets and uses average member linkage while at the same time provides the additional facility of space conservation (Hall, 1969c) for the suitable placing of rare or poorly sampled communities. The final size of the data-set from this survey was, however, found to be too large to be accomodated on available computer facilities using this technique, without prior treatment of the data to reduce its size.

The Braun-Blanquet phytosociological methods are widely accepted as suitable in the grouping of data sets based on vegetational features. Although being largely subjective this latter method is dependant on similar vegetational features for classification as those required by the frequency modulated homogeneity function. For example, the actual species present at each location and their performance. Primary grouping of the simpler vegetation groups could therefore be effected by phytosociological methods and the more complex types could then be analyzed using Hall's (1969c) methods.

3.4 The Braun-Blanquet phytosociological method and its performance

The Braun-Blanquet phytosociological methodology which developed out of the approaches of the Zurich-Montpellier traditions and remained largely unused by the English-speaking world, according to Whittaker (1962), because the only source of information was Fuller & Conard's (1932) authorized translation which omitted certain important details of the technique. Braun-Blanquet himself, even in the third edition of his book, failed to say anything about the method of establishing associations,etc., and how to map them. "Tüxen & Preising (1951, p.9) even go so far as to state that a phytocenologist must have special talents (besondere Begabung) to master the principles and techniques of the tables, and that a knowledge of the manipulation of the tables is to be gained by oral instruction rather than by the printed word", according to Küchler (1967) and that "Ellenberg (1956) showed how the tables are first prepared and then manipulated in order to identify the plant communities and their divisions in the Braun-Blanquet's classification of vegetation."

Attention was focussed on this system by Poore (1955 & 1956) when he critically evaluated it in English but many of his criticisms were shown to be largely unfounded by Moore (1962). Becking (1957) reviewed the method and gave a few practical aids. The results, according to Kershaw (1964), was that "the vegetation of the Scottish Highlands has been comprehensively treated by McVean & Ratcliffe (1962) on this basis".

Some of the most impressive achievements of the school, especially in Germany, are in the field of applied vegetation study and the use of vegetation maps in relation to management. The two main centres of vegetation mapping using the Braun-Blanquet methodology are situated at Montpellier in France under the direction of L. Emberger and at Rinteln in Germany under the direction of R. Tüxen. Whittaker (1962) discusses the spread of the use of the Braun-Blanquet methodology outside its European homeland where it usually received considerable dilution with concepts from other ecological traditions. In Europe and overseas it is, however, by far the most extensively used single approach to intensive study of vegetation and has produced a literature of rather overwhelming extent.

Although van Donselaar (1965), in a classification of the Northern Surinam savannas, stated that "to successfully use the Braun-Blanquet method the number of species must be moderate", Taylor (1969b) successfully applied this method in the fynbos vegetation of the Western Cape, which is an area recognized for its species diversity. The 47 138 ha of the Cape Peninsula has 2 622 recorded species according to Adamson & Salter (1950). (More than 1 380 taxa have been collected during the present survey where 11 506 ha are involved). A study of a smaller area (373 ha) in the Swartboskloof-Sosyskloof Nature Reserve in the Jonkershoek State Forest near Stellenbosch (Werger, et al, 1972) has revealed the potential of the Braun-Blanquet method in the fynbos vegetation of the South-Western Cape.

The use of the Braun-Blanquet table method was necessitated in this survey because of the large amount of data involved which prohibited the direct application of Hall's (1969c) homogeneity function. Once the data were divided into a few acceptable vegetation groups then the interrelationships between the sampling quadrats in these groups could be studied and the larger groups could then also be related and evaluated by this latter method. The use of statistical comparisons involves the requirement of consistent quadrat size at all times for any valid results. In the accepted Braun-Blanquet tradition, "the size of a quadrat should be large enough to encompass all species which belong to the particular community that is being analyzed" (Küchler, 1967) and need therefore not be of consistent size in different vegetation types.

Statistical methods require that the sampling sites should be distributed randomly (restricted randomization, as discussed under the paragraph on the distribution of sampling sites, was used during this survey) to give valid results which is in direct contrast to the method of distribution used in the Braun-Blanquet methodology where "care should be taken that they (the sampling sites) are located well within the area of a community" (Küchler, 1967). A stipulation during this survey to ensure most efficient sampling was that quadrats situated on obvious transitions, visible either on aerial photographs or in the field, should be relocated. Notwithstanding this limitation, a few quadrats were badly placed, primarily because of the complex nature of the vegetation and the surveyors inexperience in observing such transitions.

Notwithstanding the difficulty that the sampling techniques were not exactly as required by phytosociological techniques, a raw table was constructed using the 150 sampling quadrats and the 348 species occurring in two or more quadrats. The number of species was reduced to 273 by excluding geophytes, annuals and species only occurring in two quadrats. By rearranging the site and species orders, the data were ordered to show the following groups:

(1) A coastal community.
(2) A riverine community.
(3) The marsh community on the coastal plain.
(4) A transitional community between coastal sand vegetation and fynbos.
(5) A transitional group associated with yellow plinthic soils.
(6) A large "fynbos matrix" which was found to be of an intergrading nature with too few sites in each community to be extractable into groups, using visual means.

The table method had successfully shown a number of distinct groups to be present and the "fynbos matrix" which required further analysis was now compiled of 108 sites having 185 species, which was of nearly acceptable size for analysis, using the frequency modulated homogeneity functions. By discarding those species which were not of frequent occurrence in the "fynbos matrix", the number of species were reduced to 86 species, which formed the largest data-set which could be analyzed, because of limitations in computer facilities available.

Interpretation of the Braun-Blanquet tables

(1) Coastal dune group

The differential species are Restio eleocharis, Passerina paleaceae and Carpobrotus acinaciformis.

The sampling plots included within this group are: 43, 29, 35, 32, 45, 44, 2, 58, 33, 36, 37, 34 and 16. These sites are virtually all included within groups 23 and 24 of the vegetation classification according to the association-analysis hierarchy, namely, the Arctotheca-Myrica strand pioneer and the Colpoon-Rhus dune scrub communities. Plots 16, 43 and 58 have not been included in the latter two communities in the vegetation classification. Plot 43 occurs on limestone and the vegetation is of a transitional nature between coastal dune vegetation and fynbos and has been called Leucadendron coniferum limestone fynbos. Plots 16 and 58 are also in transitional zones having elements of both coastal dune and fynbos vegetation. The grouping of these latter two sites in the objective association-analysis hierarchy, based on the evaluation of the total of each's floristic composition, resulted in their grouping in the mixed coastal fynbos of the acid sands. Plots 25, 30 and 31 also contain a few elements of the coastal dune vegetation but not enough to justify their inclusion in this group.

(2) The seepage group

The differential species of this group are: Erica perspicua, Osmitopsis asteriscoides and Danthonia cincta. The relevés included within this group are: 14, 19, 18, 17, 40, 41, 83 and 56. These sites have mostly been included within two communities in the proposed vegetation classification namely the Brunia-Erica seepage fynbos and the Restio-

Chondropetalum tussock marsh. Relevé 41 is included within the coastal mixed fynbos of the acid sands although it contains the differential species of this group. This is a badly selected site with representatives of both communities.

This seepage group shows close floristic resemblance to the Berzelia lanuginosa-Osmitopsis asteriscoides community found in Swartboskloof, Jonkershoek (Werger, et al, 1972). The differences are largely to be found in the Brunia-Erica seepage fynbos where Osmitopsis asteriscoides is not always so common and Berzelia lanuginosa is not as common as the ecologically similar Brunia alopecuroides. The Restio-Chondropetalum tussock marsh shows much greater similarity but the defining species, Berzelia lanuginosa and Osmitopsis asteriscoides, are not specific to this community.

(3) The riverine scrub group

The differential species of this group are Halleria elliptica, Rhus tomentosa and Brabeium stellatifolium. The relevés included within this group accord exactly with those of the Brabeium-Rhus scrub on alluvium of the vegetation classification. Werger, et al (1972) recognize a Brabeium stellatifolium community on the lower less steep parts of the streams in the Swartboskloof at Jonkershoek. Not all the character species found by them occur in the similar community recognized in this survey.

(4) The coastal dune vegetation to fynbos transitional group

(a) This subgroup has Lightfootia tenella as differential species. The relevés involved in this transition are: 1, 25, 31, 30 and 28. These relevés are grouped into the Brunia-Erica seepage fynbos (plot 1), the mixed coastal fynbos of the acid sands (plot 25) and the Leucadendron coniferum limestone fynbos (plots 28, 30 and 31). Each of these sampling sites have a transitional type of vegetation but are included within the communities indicated on the basis of their total floristics and therefore closest resemblance. This transition results from dune sand of shallow depth occurring on sandstone mountain slopes or on limestone. Site 28 shows an additional transition to the yellow plinthic soil group. The soil at the site actually being of the duplex type with shallow dune sand overlying a soft yellow plinthic soil.

This transition together with that of the following subgroup are linked by the three species, Cymbopogon marginatus, Ficinia albicans and Myrica quercifolia which appear to be characteristic of these two groups.

(b) No species can be considered as being differential to this subgroup which includes the plots: 27, 26, 24 and 6. These have been grouped into the following communities in the classification of the vegetation: Mixed ericoid and restioid fynbos of the inland facing slopes of the coastal mountains (plot 27), the mixed ericoid and restioid fynbos of the xeric seaward slopes of the coastal mountains (plots 6 and 26) and the mixed coastal fynbos of the acid sands (plot 24). All the sites are near the lower boundaries of their respective communities on dry sandstone outcrops on the lower slopes of coastal mountains and it is only the common species with the previous subgroup (i.e. Cymbopogon marginatus, Ficinia albicans and Myrica serrata) which are the reason for their separation from the general fynbos matrix.

(5) The transitional group occurring on both white sandstone and yellow plinthic soils

The differential species of this group is Peucedanum sieberianum. The relevés included within this group are: 72, 10, 69, 102, 104 and 7. These are grouped into the following communities: The mixed ericoid and restioid fynbos of xeric seaward slopes of the coastal mountains (plots 10 and 72), the mixed fynbos of the lower southerly slopes (plot 104), the mixed proteoid and restioid fynbos of the mesic southerly shale-sandstone transitions (plot 69) and the Protea-Gerbera short dry fynbos of the soft yellow plinthic soils (plots 7 and 102).

These sites are transitional because they are located on duplex type soils having a surface sand horizon over a yellow plinthic soil. The depth of the surface horizon determines the community into which the site is classed. If the surface horizon is shallow then the majority of the species will show affinities to the underlying horizon and conversely, a deeper surface horizon would have only the deeper rooted species indicating its presence. Site 28 shows the same transition but has already been discussed above.

(6) The fynbos matrix

The differential species of this group is Chondropetalum hookerianum which characterizes the majority of the upland relevés, being absent in only 23 of the remaining 108 plots. This group could not be arranged into any reasonable phyto-sociological groups. This illustrates the complex nature of the upland fynbos vegetation, where one community merges almost imperceptibly into the next, requiring an objective measure to delimit communities or alternatively, a greater sampling intensity which will in turn increase the problem of evaluating the data.

3.5 The frequency modulated relative homogeneity function and its performance

In contrast to the association-analysis techniques Williams & Lambert (1959, 1960 and 1961) and Lambert & Williams (1962) which use monothetic divisive methods to form groups, the frequency modulated relative homogeneity function (Hall, 1969b, 1969c and 1970) is agglomerative. This survey would therefore serve as a test of these two very different techniques' performances, on an extensive scale, in the fynbos vegetation. This particular agglomerative group forming system has been developed by Dr. A.V. Hall of the Bolus Herbarium, University of Cape Town, because he found certain informational distortions to be present in a number of statistical systems in common usage in vegetation analysis, namely that:

(1) The product-moment correlation coefficient is not consistent in the treatment of the data in all parts of the data range.

(2) The mean Euclidean distance shows a distorted picture of informational relationships in their geometrical representation (e.g. in scatter diagrams where the informational differences taken along, say vertical and

horizontal "directions" are about 29 per cent smaller than those at 45^o to the axes) (Hall, 1969c).

(3) The Jaccard's similarity coefficient has the anomaly of excluding total species absences (0,0 matches), but gives equal weight to the presence of one species (0,1 matches) and total species presence (1,1 matches), in the denominators.

(4) The Czekanowski similarity coefficient is unstable, falling off progressively more sharply as the lower part of the data scale is approached, therefore quite similar items with small property values would be strongly discouraged from linking with each other.

(5) The group structures shown by the principal components analysis (in addition to the distortions shown in the scatter diagrams) must be intuitively grouped in the final stage and there "does not seem to be a way of altering the weightings of properties for either the facies-type classification or for the case where some are homologically near-duplicates" (Hall, 1969c).

(6) Sampling is rarely so complete as to include the entire range of variation. Classifications are generally intended to be as permanent as possible. Where the sampling has obviously been poor, the items are arranged in a loosely packed way so that future additions can be accommodated without drastic changes. Space is conserved in such arrangements. This matter has often been overlooked in studies of numerical aids for classification. Group average linkage is informationally distorting where the values of properties overlap and therefore have greater affinity to each other, but this is obscured when the link levels are averaged.

(7) The use of special purpose clustering systems where single linkage methods are used and all other link levels are disregarded. This results in a serious loss of information. In median linkage the last-added member, or subcluster, contributes as much to further link levels as the set to which it has been joined. This leads to distortions when few-item and many-item clusters are joined together (Hall, 1969b and c).

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The basis of group forming is the grouping together of items which are informationally somewhat homogeneous, to be used for generalizations, predictions and information retrieval. With each subdivision of the set of sites, groups become homogeneous over more properties till a final maximally homogeneous group (a single site) results. The use of relative homogeneity and relative heterogeneity functions (Hall, 1970) are designed to avoid the informational distortions such as have been listed above.

The heterogeneity of an item's values for a property is related to that of a maximally heterogeneous group which acts as a dummy standard against which the heterogeneity of the property row is compared. The contributions by the various item properties to the overall ("average") relative heterogeneity may be adjusted by weighting. In ecology, for instance, higher abundances would contribute more to group formation than the rarer abundances. The groupings are then formed on the basis of their overall facies. These functions therefore use frequency modulated relative homogeneity and are unusual because it is usually the similarity between two items or clusters that is measured and not the homogeneity of a trial fusion-set. The information statistic is similar in this respect but has the flaw of giving favour to the formation of few-item groups before any others. The frequency modulated relative homogeneity function is very nearly stable in the consistent treatment of the data in any part of the possible data range (about 2% drop was found in the test range).

Where the sampling has obviously been poor, the items are arranged in a loosely packed way so that future additions can be accommodated without drastic changes. In other words space is conserved in such arrangements because classifications are intended to be as permanent as possible. When sampling is complete there is no need to conserve space and the data-set forms a closed array. Here a single unusual member is given less prominence among the groupings than a subset of several. The essential requirement of a fully space-conserving algorithm is that each item or cluster must be treated as the possible starting point of a new class, until this has been disproved by the demonstration of a close relationship with established groups.

At each stage during the clustering, the homogeneity values for every possible pair-combination of unlinked members or of clusters, are calculated. The linkage chosen, is the one with the highest homogeneity value. The process is repeated until all the members are linked. Where an overlap occurs in the values between one cluster and another, the greater affinity this reflects will be obscured if the link levels themselves are averaged. The solution to this is to find the average of the values of every property in each cluster, to give two imaginary "average members" which are then compared. This method is termed average member linkage (Hall, 1969a).

The homogeneity function for grouping sites or vegetation types has a modulation system for giving greater emphasis to the values from the more common taxa. A rare species at the same abundance at two sites contributes less to the overall homogeneity value than a common species.

This function is written for a subset of k plots as follows:

$$H_{qm} = \sum_{j=1}^{p} \left[\left(\sum_{t=1}^{k} a_{jt} \right) \left(\sum_{j=1}^{p} \sum_{t=1}^{k} a_{jt} \right)^{-1} \right] \left(1 - \frac{S_{ajk}}{S_{hjk}} \right) \text{...Equation 1}$$

H_{qm} = Frequency modulated relative homogeneity function for ecology (equation 1).

p = Number of species.

k = Number of sample plots.

(j and t are counters).

A_{jt} = Value for the jth species of sample plot t, s_{ajk} and s_{hjk} are the standard deviations of the subset's actual data row for the jth species and the dummy maximally heterogeneous row respectively. The expression in the squared brackets above serves for the frequency modulation, while the expression in the last rounded brackets gives the measure of heterogeneity (Hall, 1969a and 1970).

The treatment of the data

The fynbos matrix of 108 sites (items) and 87 species (properties) delimited previously in the phytosociological table was coded for computation using a programme written by Dr. A.V. Hall of the Bolus Herbarium, University of Cape Town which uses the frequency modulated relative homogeneity function, with space conservation (based on array-scaling), for average member linkage.

The highest linkage level was calculated to have a homogeneity value of 0,869 (on the scale 0 to 1) and occurred between sites 11 and 64. The majority of the sites are grouped fairly regularly until approximately the 0,60 homogeneity level, after which the last 15 sites show a rapid decrease in level of homogeneity with the lowest value of linkage occurring between sites 75 and 108 at the 0,331 level.

Hall (1970) gives an interpretation of a dendrogram constructed for the comparison of a small number of sampling sites in fynbos vegetation in the Bains Kloof area of the South-Western Cape. In the interpretation of the data, three major groups were recognized while certain sites, considered as either rapidly transitional or as almost entirely distinct floristically, were held to form separate groups which link at much lower levels of homogeneity because of their distinctness. Under certain conditions the dendrogram produced can indicate floristic distinctness, in the form of a continuum, and therefore not result in a classification which can be adapted for practical use such as management proposals where definite groups are more suitable.
The dendrogram which was constructed from the comparison of the data in this survey showed a step-wise addition of sites with virtually no distinct clusters being produced (table II). A possible explanation must be considered in the light of the great species diversity of the area, with the added factor of frequency variation. If each site is found on comparison to represent a distinct community (frequency variation would tend to emphasize this distinctness) which resembles the average member more closely than any other site, then each must be added individually, the distinctness of each being indicated by the level of homogeneity at which linkage occurs. Any sampling site located

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in transitionary vegetation would be linked intermediately between the distinct communities. The level of linkage in the latter case could be very similar to the linkage level of another entirely distinct community. These latter two conditions would then be indicated as being apparently very similar although little similarity in actual fact exists. A seemingly meaningless gradient of sites, being linked at decreasing levels of homogeneity, would then characterize the dendrogram. By taking chiefly the more commonly encountered species into consideration, as was done during this analysis to reduce the amount of data, the floristic distinctness of each site would be reduced because the more sensitive indicator species of the more specialized habitats would be excluded. This would be neutralized to a certain extent by including the frequency performance of these commoner species although such data is based on subjective estimates. An alternative explanation for the step-wise addition of sites which is the general character of the dendrogram produced using this method could be sought in the very richness of the fynbos flora with many distinct communities and innumerable intermediate zones which prevents the actual arrangement of the sites into groups without a much greater sampling intensity, or the study of smaller areas which could then be compared at a later stage, once suitable computer facilities were available.

A study of the dendrogram, keeping the above possibilities in mind, indicated the presence of a broadly arranged moisture gradient which consisted of the drier sites being linked at the higher homogeneity levels on the left-hand side of the dendrogram, to the more individually distinct and more specialized moister sites linking at the lower homogeneity levels on the right-hand side of the dendrogram.

The dendrogram can roughly be divided up into sections. The first 27 sites are roughly located in the warmer drier northerly facing areas where the vegetation is mainly of the short mixed ericoid and restioid type. Occasionally a sampling site on a dry lower altitude southerly facing slope occurs intermingled with those on the northerly slopes, generally increasing in number with an increase in number of wetter northerly facing slopes. The next ten or so sites are generally cooler and moister with a prevalence of rocky terrain. The coastal fynbos elements (excluding those belonging to the broad leaved scrub group) generally appear to be slightly moister occurring near the middle of the dendrogram. The deep coastal sand vegetation types occur near the end of the dendrogram suggesting an entirely distinct flora because of the low homogeneity level at which linkage occurs. This would be equivalent to the broad leaved scrub community. Next follows a series of about 16 sites which are generally moist but not wet presenting cooler conditions either because of their southerly aspect or because of the higher altitudes or the presence of large boulders causing shade and less water loss. A taller fynbos vegetation occurs in these sites (in the region of 1,5 m tall) generally because of the moister conditions. The last section of the dendrogram is characterized by an increase in the number of transitional sites and vegetation samples occurring at higher altitudes or in wet seepage areas.

Individual species often show clines between low and high altitude and over varying distance from the sea, in the area e.g. Leucospermum oleifolium and Saltera sarcocolla. This could in fact be a similar relationship which is being indicated in the dendrogram. Unfortunately this does not lend itself to a detailed description of the vegetation, in this form, particularly when the data is required to produce a map of the vegetation or for management purposes.

3.6 Testing of group similarities

This method was developed by Hall (1970) to demonstrate the degree of similarity between recognized groups. The groups obtained from the homogeneity function comparisons and the phytosociological tables were compared in this instance. When an even grading from a compact subset to a more diverse member, such as was obtained in the fynbos matrix, occurs, then a "core" is arbitrarily delimited, usually by the exclusion of certain items linking at generally lower homogeneity levels.

Average members are computed for each major group, subgroup, sibling-group (Hall, 1969d) or core and are taken as the representative of a putative community. The similarity between this average member and each site is then determined using the following simplified homogeneity function (equation no. 2) (Hall, 1970):

$$H_{qm} \quad \sum_{j=1}^{p} M_j \left(1- \left| a'_{jt} - a'_{jk} \right| \right) \text{ ..... Equation 2.}$$

The similarity between the two average members, t and k, would be given with this function, where a'_{jt} and other symbols are the same as in equation 1 (see previously). M_j is the modulating factor.

The similarity values can be plotted at the site localities on a map, either as numbers or as glyphs of appropriate sizes or as histograms as in this case (table III), where columns having lengths proportional to respective similarity values, are used. The longer the columns, the greater the similarity between each site and the average member with which it is being compared. Therefore, as in the case of Run 5 (see below for explanation) in table III , where only one site was compared to determine the average member, there is an exact similarity and the columns attains maximum length. The types of conclusions which can be drawn from such diagrams have been listed by Hall (1970).

Performance of the data

Comparisons were made using the full total of 150 sites but only over 175 of the species. The average member is computed for each group or core separately and then compared to that group or core's members and to the remainder of the 150 sites. Each group of comparisons is termed a "Run".

Run 1 (table III): The average member for this run was determined from the members of the broad leaved coastal sand vegetation. The highest similarity, namely 0,339 is shown between site 45 and the average member. The 14 sites from which this average member was computed (i.e. sites 2, 16, 21, 29, 32, 33, 34, 35, 36, 37, 43, 44, 45 and 58) show themselves to be reasonably distinct from the rest of the sampling sites. One other plot (site 25) shows close resemblance to this group but is more closely related to the coastal fynbos of run 4. Other sites showing slight affinities to this community are sites 19, 30, 31, 38, 39 and 68. The only members of this group, from which the average member was determined, which have not been classed into the broad leaved coastal sand vegetation in the vegetation classification, are sites 16, 21, 43 and 58. These latter sites all have fynbos elements and are either transitional between the fynbos and the broad leaved scrub or occur on limestone.

Run 2 (table III): The average member was determined from sites 14, 17, 18, 19, 40, 41, 56 and 83 which represent the Brunia-Erica seepage fynbos community of the coastal plain and, in the case of the last two sites, the Restio-Chondropetalum tussock marshes of the inland fynbos. Site 13 which consists mainly of riverine vegetation also has a few elements of the seepage fynbos. A number of the inland mountain plots such as sites 135, 144, 147 and 150, also show a slight resemblance to this community. These latter sites include the wetter shale band vegetation, sites occurring at higher altitudes facing a southerly direction and some near seepage sites facing a northerly direction. Site 14 of this group shows a slight similarity to the average member of run 6 and to a lesser extent with the other drier fynbos communities. This latter site occurs near the boundary of the community and of a disturbed area. In this run, site 17, with a value of 0,475, is the most similar to the average member of the group.

Run 3 (table III): This group consisting of sites 13, 89, 91, 100 and 101, represents the Brabeium-Rhus scrub community found on alluvium. Because this community forms a narrow belt along the river banks, a certain amount of the adjacent fynbos communities were sampled at the same time which explains why this very distinct community appears to show resemblance to the fynbos communities but is apparently only an artifact of sampling.

Run 4 (table III): The average member of this group was determined from sites 1, 25, 30 and 31. These sites represent the transitional vegetation between the coastal mountain fynbos and the dune sands and are located in areas where drift sand has been blown onto the mountain sandstones but has not sufficient depth to exclude all the fynbos elements and therefore shows a certain amount of similarity to runs 1 and 6 and to a lesser extent with runs 9, 10 and 11. Site 8, which is located on coastal sandstone rocks in the spray zone, has fynbos elements because of the sandstone substrate but, nevertheless, shows strong affinities to the dune sand vegetation because of the close proximity to the sea and small pockets of sand between the rocks, the result is a transitional type flora most similar to this group where it would be more suitably located.

Run 5 (table III): The average member for this run was restricted to site 28. This site was particularly badly located although this was not so obvious in the field. Three types of vegetation are represented in this group namely: (1) the coastal dune scrub, (2) the coastal mountain sandstone fynbos and (3) the vegetation on yellow plinthic soils. Floristically this site is of particular interest because the more tolerant species to the various habitat conditions are indicated. Affinities are shown between this run and runs 4 and 6 and to a lesser extent with the fynbos matrix of runs 7 and 11.

Run 6 (table III): The average member for this run was determined over the following four sites: 6, 24, 26 and 27, which are representative of the lower dry sandstone outcrops of the coastal mountains, in the vicinity of Cape Hangklip itself, near areas where dune sand occurs. These sites appear to be close to the lower boundaries of the communities in which they occur, therefore affinities with sites having coastal dune vegetation can be expected. Further sites occurring in very similar situations in the rest of the area show close resemblance and it appears that they could rather have been arranged with this group in the phytosociological table. The classification by homogeneity function does not group these sites together.

Run 7 (table III): The following six sites: 7, 10, 69, 72, 102 and 104, were used in computing an average member. They form a relatively poor group in the phytosociological tables being characterized by five species of which only one is differential (Peucedanum sieberianum). These sites occur in transitional zones having duplex type soils with a surface sand horizon over yellow plinthic soils. The vegetation shows variation from one community to the other according to the depth of the surface horizon. Closest affinities, which are not particularly marked, are with the fynbos matrix sites in general, these sites not being particularly representative of any community according to their performance and those of the remainder of sites with the average member.

Run 8 (table III): Thirty two sites were used here in computing an average member, namely sites 118 to 93. These form the core of the dendrogram constructed using the homogeneity function to show the structure of the fynbos matrix. The average member comparison shows that those sites having low similarity values are either related to coastal dune vegetation or are particularly moist sites which have a very different, specialized fynbos vegetation. Comparisons with this core produced the highest similarity values over all the data. This core would therefore represent the type of fynbos vegetation most commonly encountered in this survey i.e. which is not particularly moist and which occurs on a sandstone substrate.

Run 9 (table III): The average member for this run was calculated over the middle order sites in the dendrogram, which were arbitrarily delimited. Thirty six sites, from site 127 to site 105 in the dendrogram were compared. The comparison of each site, over the whole range of the data, with the average member, appears to show the least variation in similarity value over the greatest number of sites indicating that this average member is nearest to the total average for all the sites. The wetter sites still show the least similarity in the fynbos matrix but this is not so marked as in the case of run 8.

Run 10 (table III): The average member, in this case, was computed over the combined cores used in runs 8 and 9, namely from site 118 to site 105 in the dendrogram. The similarity values from comparisons with the average member seems to indicate the same ecological factors as run 8, but the unusual sites do not have such low values.

Run 11 (table III): The average member was computed over the whole range of the fynbos matrix, including all the

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sites in the dendrogram from site 118 to site 108. It is particularly interesting to note that five sites were completely dissimilar to the average member, namely 33, 34, 37, 44 and 45, having similarity values of 0,00. These sites are all located in the coastal scrub vegetation grouped into run 1 above. This confirms that the coastal dune vegetation represents a completely distinct vegetation type to the fynbos.

Discussion

This above method for the evaluation of continua by determining the similarity between the average member and each site, is particularly useful in ecology to indicate the "goodness of fit" of each site in each vegetation group which has been delimited. This is particularly valuable in the case of the inevitable transitionary sites.

3.7 The association-analysis method and its performance

The reason for using the association-analysis techniques of Williams & Lambert (1959 and 1960) for the study and classification of the vegetation in the Hangklip area, in spite of Taylor (1969b) finding the method to be unsuitable in the fynbos vegetation of the Cape of Good Hope Nature Reserve, can be given as follows. Of primary importance is the large amount of data which it is necessary to compare in a survey of the scale undertaken. This limits the use of multifactorial methods, such as ordination, considerably. When Taylor (1969b) applied the association-analysis technique, he made use of a limited amount of data, collected systematically over a large area at the grid intersection points on a map. He found that a large number of the sampling sites were located on transitions between communities. The hierarchy produced from the association-analysis was, therefore, not constructed from a sufficient range of information, particularly from homogeneous communities, to give ecologically meaningful groups. Some communities had been oversampled and others had not been sampled at all because they were not located on the grid intersections. In the present survey it was proposed to distribute the sampling sites within physiographic-physiognomic units which would be delimited on aerial photographs, to ensure that all the obvious major communities were sampled. This would mean that the samples were still being distributed randomly to satisfy statistical requirements, but the randomness would have the restriction that at least eight sampling sites were to be located in each physiographic-physiognomic unit because of the limitation in the association-analysis programme requiring at least eight samples of a particular community for it to be subdivided. A fixed sampling intensity need not be adhered to in the case of a particularly distinct but localized physiographic-physiognomic unit where the sampling sites would still be distributed randomly but on a more intensive scale. The sampling sites would be located as accurately as possible in the field by the interpretation of the aerial photographs which would serve as maps. The final location of the site was found by throwing a marker over a shoulder. If the sampling site included an obvious transition between communities, then it would be relocated, using similar methods. Aerial photographs would be used to interpret and map the groups obtained from the association-analysis hierarchy. This would give a more realistic reflection of the community boundaries than their construction midway between two sampling points as was done by Miller & Booysen (1968) and Taylor (1969). In addition to groups being formed in the hierarchy which are easier to define and map than abstract units, a dichotomous key can be readily constructed for the identification of the communities. This is particularly useful in the management of the vegetation when only the dividing species need be known to the officers concerned. A computer programme and the necessary facilities for the analysis of the data by this method are readily available because it is being extensively applied in the Transvaal Highveld Region by the Botanical Research Institute.

The association-analysis technique was first proposed by Williams & Lambert, in 1959, in the form which became known as the "normal analysis". This is an extention and modification of the initial methodology of Goodall (1953). It is a method which is designed to divide the population as efficiently as possible by selecting the greatest possible discontinuity in the first centroid axis of the association matrix under scrutiny. It was suggested by the authors to be of most use where primary surveys of the vegetation of an area are required rather than in later more detailed investigations. "The homogeneous groups which result may be used in their own right for phytosociological study" (Williams & Lambert, 1959). This method was tested in the United Kingdom on comparatively small areas with intensive degrees of sampling and ecologically significant subdivisions of the vegetation were obtained.

The method is based on the construction of 2 x 2 contingency tables to test for association between the individual species, for all combinations of pairs. In the present case with 281 species, 39 340 contingency tables were constructed. The $\sqrt{\chi^2/N}$ values or correlation coefficients obtained from the contingency tables (where χ^2 is significant at $p = 0,05$ and N is the total number of sampling units, in this case 150), are summed for each species, regardless of the sign. Each division of the vegetation is based on that species which shows, through the $\sum \sqrt{\chi^2/N}$ values, the greatest degree of association in the respective group. The association-analysis programme available at the Botanical Research Institute, Pretoria also allows the use of $\sum \chi^2$ or $\sum \frac{\chi^2}{N}$ as the subdivision parameter, if desired, but Williams & Lambert (1959 and 1960) consider that the use of the greatest $\sum \sqrt{\chi^2/N}$ as a subdivision criterion would result in the most efficient subdivision or subdivision on that species which, in the two resulting subclasses, would produce the smallest total number of residual significant associations. Each successive group in the subdivision is more homogeneous than the last, in contrast to the homogeneity function which links the most homogeneous groups first. The criterion used to test for association is χ^2 (with Yates' correction). In this case subdivision was terminated at below either the 3,841 significance level of association (this corresponds to the $p = 0,05$ level for the highest single χ^2) or when there were less than eight sites to be subdivided because the significance test used is too crude to detect any but the most intense associations with a smaller number of sites. The association-analysis method has been described in great detail by Grunow (1965), Miller & Booysen (1968) and Taylor (1969) amongst many others.

The method of normal association-analysis has been variously applied in studies of the South African Veld Types as delimited by Acocks (1953), by the following:

(1) Van der Walt (1962) in a study of the Karroid Danthonia Mountain Veld (Veld Type 42).

(2) Grunow (1965) in the Sourish Mixed Bushveld (Veld Type 19).

(3) Downing (1966) in the Highland Sourveld (Veld Type 44).

(4) Roberts (1966) in the Cymbopogon-Themeda Veld (Veld Type 48).

(5) Woods & Moll (1967) in the Coastal Forest (Veld Type 1), the 'Ngongoni Veld (Veld Type 5), the Valley Bushveld (Veld Type 23), the Southern Tall Grassveld (Veld Type 65), the Natal Mist Belt 'Ngongoni Veld (Veld Type 45) and the Highland Sourveld (Veld Type 44(a)).

(6) Miller & Booysen (1968) in the Highland Sourveld (Veld Type 44).

(7) Scheepers (1969) in Transitional Cymbopogon-Themeda Veld (Veld Type 49).

(8) Taylor (1969b) in the Fynbos or Macchia (Veld Type 69).

Only two of the above authors i.e. Roberts (1966) and Scheepers (1969) have published the results of the "inverse" association-analysis of their data (Williams & Lambert, 1961). In the "inverse" association-analysis the quadrats are correlated in all possible pairs and the properties of the resulting quadrat-correlation matrix are used to divide the species into groups. The fundamental postulate being that the species can then be regarded as being defined by underlying physiological propensities related to their ecological distribution and the quadrats are now used as tests to identify major discontinuities between the groups of species. Scheepers (1969) found that the "inverse" association-analysis produced a stepwise arrangement of species grouping which was difficult to interpret. Mr. J.W. Morris (personal communication), who is responsible for the computation of botanical survey data for the Botanical Research Institute, considers this stepwise arrangement as a fairly regular feature of the "inverse" association-analysis, when large numbers of species are involved, such as in this case, and that it would be advisable to restrict the treatment of the data to the "normal" association-analysis. The information gained from such "inverse" association-analyses does not warrant the extra expenditure on computer time, in most instances. A programme for nodal analysis (Lambert & Williams, 1962) was not available.

The treatment of the data

The computer programme AANAL written by J.W. Morris of the Botanical Research Institute was used to compute a "normal" association-analysis of the data collected in this survey. A Burroughs 3600 machine was used but the Central Processing Unit time was not recorded, therefore no indication can be given of the computational period.

The hierarchy produced showed fairly uniform divisions with only a very small tendency to stepwise division (also known as chaining) in the final negatively associated region of the hierarchy. It is particularly interesting to note that the more distinctive communities such as the coastal dune vegetation or wet seepage vegetation occur in this negatively defined portion of the hierarchy.

Another interesting occurrence in the hierarchy is a reversal or increase in the level of the subdivision of a subsequent group instead of the normal decrease in level corresponding to a decrease in the χ^2 value after group 12 has been delimited. A reversal indicates an increase in heterogeneity of the subsequent group following the "removal" of a more homogeneous group.

In certain instances, such as in the subdivision of groups 6 and 7, two species could equally well have been used to effect the subdivision, both resulting in the smallest total of residual significant associations in the two resulting subclasses. The computer programme used selects the species with the lowest code number in the event of the ambiguity of two or more species effecting subdivision.

The hierarchy has been constructed according to the conventional manner where the positively defined quadrats,

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at each division, are grouped on the left-hand limbs of the hierarchy and the negatively defined species on the right-hand limbs.

The termination of subdivision at a level equal to or higher than $\chi^2 = 3.841$ or if more than eight plots were considered as the minimum number, would in effect be equivalent to regrouping certain of the final groups in the hierarchy. In the evaluation of the hierarchy it was found that the recombination of closely related final groups would only result in ecologically valid larger groups in a limited number of cases because, in the majority of cases, undersampling rather than oversampling was the norm. The ecological and floristic interpretations of the final groups are discussed under the chapter dealing with the description of the vegetation.

The major problem encountered in the association-analysis method was one inherent in any monothetic divisive technique where apparent misclassifications occur. This misclassification can result in the first major divisions when division occurs over all the sites, separating the biggest discontinuities, or when a species is frequent in the region of the sample site but happens to be absent within it by some chance circumstances. A number of plots were successfully reclassified during this survey after the list of species occurring in the surroundings were consulted. In the event of the "surroundings list" not solving the problem, the site locality was revisited. This latter case was necessary in a few instances of obvious misclassification and, on revisiting, was found to be the result of the misidentification of a species during the drought conditions of 1970-71 when these plots had been studied. This is an actual problem when a monothetic divisive method is applied in fynbos vegetation. The great diversity of species often results in flowering material being required for positive identification of certain members. (A field herbarium of small specimens mounted on index cards proved very useful during the survey and reduced misidentifications to a minimum). The isolation of particular species and their subsequent evolution such as could occur on high mountain tops, for instance, has been suggested as a possible contributing factor towards the diversity of the species encountered in the area. These floristically different but related species could nevertheless be growing in place of their forbears in a particular community. A sample plot in such a community would then not be grouped along with others which are essentially similar if this species was the dividing species.

The final groups in the hierarchy were found to vary in their extent of floristic and ecological homogeneity. This could in most cases be attributed to insufficient numbers of sampling sites distributed in some communities. To obtain a fairly uniform level of homogeneity in the classification, certain final groups had to be further subdivided while others had to be recombined. The subdivision and recombination was subjectively done on the grounds of ecological factors in combination with the respective floristics (see table V).

A certain percentage of the sampling plots were located on transitions, notwithstanding efforts to avoid them, mainly because of the inexperience of the surveyor and because of the rapid variation in topography and therefore communities. Such transitions are often grouped in that community which is delimited first in the hierarchy and might not therefore be the best grouping. Site 41 is such a case. These plots have in most cases been left in their original groups although comparisons with an average member would demonstrate their best location.

Aerial photographs present some difficulties in the location of sites, observance of transitions and mapping of communities because of one or more of the following reasons:

(1) The high altitude and therefore small scale of photography (1:40 000) from which present day photographs are taken.

(2) The poor quality of the prints received and because black and white prints only being available.

(3) After fires in the fynbos vegetation, the aerial photographs show very white patches, where little detail can be discerned. This condition remains for a number of

years after a fire, the wetter sites recovering first. Fire is a common occurrence in fynbos vegetation.

(4) The occurrence of cloud from the prevailing south-east or north-west winds during certain times of the year, particularly on the higher mountains which obscures the vegetation differences.

The sampling sites could nevertheless be fairly accurately located during this survey, after the careful study, comparison and evaluation of the available aerial photographs which were taken during 1938 and 1961.

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CHAPTER 4

THE VEGETATION

...erg State ...getation ...sudden, ...ly into the ...defined, ...of species ...r that the ...local ...mposition. ...species, ...all area. ...red amongst ...mmunities ...tline, where virtually ...rely in ...on had been ...st cases, ...regeneration. ...en to the ...litter had ...gst the main ...ng a programme ...on, indepen- ...is would ...rmulation ...t has been ...hich, at ...sible.

... the classification of so diverse a vegetation. Any completely subjective approach must, by virtue of the nature of the vegetation and the large area involved, be very general. For instance, Rycroft (1953) divided the vegetation in the

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Kogelberg State Forest into:

(1) High altitude flora.

(2) Flora of the lower mountain slopes.

(3) Forests.

(4) Flora of the stream banks.

Grobler (1964) undertook an intensive study of 72 ha of vegetation in the Kogelberg State Forest near Oudebosch over a period of a year. He also made use of a subjective approach but provided additional statistical information. He recognized 16 communities which were grouped into the following stands:

(1) Leucadendron xanthoconus (= L. salignum R.Br.) stands.

   (a) Leucadendron gandogeri (= L. guthriae) stands.
   (b) Phaenocoma prolifera stands.
   (c) Protea repens (= P. mellifera) stands.
   (d) Berzelia-Leucadendron-Danthonia stands.

(2) Prionium-Brachylaena stands.

(3) Osmitopsis-Cliffortia stands.

(4) Acacia mearnsii (A. mollissima) stands.

Taylor (1969b), when studying the vegetation of the Cape of Good Hope Nature Reserve, found that phytosociological methods were more suitable for the delimitation and description of the fynbos communities occurring in the Reserve than the quantitative association-analysis techniques of Williams & Lambert (1959, 1960 and 1961). (See discussion in chapter three). Phytosociological tables were constructed from the data collected during this present study, but only to facilitate further analysis of the data using frequency modulated homogeneity functions (Hall, 1967, 1969a and 1970). A description of these latter two techniques and an evaluation of the results obtained are given in chapter three.

The objections raised by Taylor (1969b) to the application of the association-analysis techniques, as discussed in chapter three, and the proposed variations in method to overcome these difficulties, were applied. Notwithstanding the distribution of sampling sites within physiographic-physiognomic units, certain sites were found, on location in the field to be unsuitable because they were located on transitions and were therefore repositioned as provided for (see chapter three). The location of the 150 sampling sites are shown in the vegetation map (fig. V).

A detailed study of the data collected at each sampling site showed a degree of correlation between the habitat and the final groups of the association-analysis hierarchy (table IV in the appendix). The description of the vegetation has therefore, where possible, been based on the association-analysis final groups. This required the regrouping of certain sites, as listed in table V in the appendix. In certain instances some final groups have been recombined where the variation indicated by the final group was not considered to be sufficient to justify subdivision at the scale of survey involved or because the monothetic divisive nature of the algorithm resulted in the separation of similar sampling sites during the initial divisions. The communities have mostly been named according to floristics, physiognomy and habitat factors. The lack of widespread dominance and the mixed nature of the vegetation has prevented the use of floristics in the titles in all cases. The defining species of the communities are obtained from the association-analysis hierarchy, in which case a "+" sign indicates the presence of that species while a "-" sign indicates that that species is absent.

Additional information on the floristics of certain communities have been given in the form of tables of characteristic species. Character species are those having significant levels of distribution at the p = 0,05 level of freedom using an exact chi-square test (after Goodall, 1953) according to the programme CFREQ of the Botanical Research Institute, which calculates the species frequencies for the sets of data forming each community and gives the following information for each species:

(1) Presence (P.), which is the degree of occurrence of a species in the stands of a community.

(2) Constancy (const.), which is the percentage occurrence of that species in the total number of plots of uniform area located in that community.

(3) Significance (Signif.) or level of frequency, where four arbitrary levels are used as markers to show whether the percentage frequency is equal to or greater than each respective level.

The levels are:

(i) a blank indicating a level < 40%.
(ii) "*" indicating a level 40% to < 60%.
(iii) "**" indicating a level 60% to 80%.
(iv) "***" indicating a level > 80%.

(4) Continuity (Cont.) which is the faithfulness of species to a group as a percentage of the total species occurrence.

(5) Indicator value (I.V.), which expresses the frequency (constancy or "presence") of a species to a particular community in comparison to all the other communities. The index of Goodall's indicator value is $\frac{(a-\frac{1}{2})(b+d)}{(b+\frac{1}{2})(a+c)} - 1$, where a, b, c and d represent the number of stands in each category of a 2 x 2 contingency table. Yates' correction is applied in the programme in certain cases to correct the anomaly of a species having infinite fidelity when a single record only existed. The index values take on a value of zero when the species has equal frequency in two communities and ranges up to indefinitely high values where it is strictly confined to the one community, to negative values if the species is more frequent in the rest of the communities and rare in the community under consideration.

4.2 The proposed vegetation classification

The basis of these proposals are given in section 4.3. Further, more detailed, study of particular groups might indicate that merging of some and further subdivision of other groups are necessary. The following classification is proposed on the grounds of the available information.

1. Broad leaved scrub

1.1 Coastal dune vegetation

1.1.1 *Arctotheca-Myrica* strand pioneers.
1.1.2 *Colpoon-Rhus* dune scrub.
1.1.3 *Sideroxylon inerme* dune scrub.

1.2 Inland vegetation

1.2.1 *Cussonia-Rapanea* scree forest.
1.2.2 *Cunonia-Cyathea* kloof forest.
1.2.3 *Podocarpus-Olinia* shale forest.

2. F y n b o s

2.1 Coastal plain vegetation

2.1.1 *Coleonema album* short coastal fynbos.
2.1.2 Mixed coastal fynbos of acid sands.
2.1.3 *Leucadendron coniferum* limestone fynbos.
2.1.4 *Brunia-Erica* seepage fynbos.
2.1.5 *Chondropetalum-Juncus* vlei-fringing tussock.
2.1.6 *Phragmites*, *Scirpus* or *Typha* reedswamp.

2.2 Coastal mountain fynbos

2.2.1 Mixed ericoid and restioid fynbos of xeric seaward slopes.
2.2.2 Mixed ericoid and restioid fynbos of mesic seaward slopes.
2.2.3 Mixed ericoid and restioid fynbos of inland facing slopes.

2.3 Fynbos on soft yellow plinthic soils

2.3.1 *Protea-Gerbera* dry short fynbos.
2.3.2 *Berzelia-Leucadendron* dense tall moist fynbos.
2.3.3 Mixed dry fynbos on shale-sandstone transitions or areas with sand on shales.
2.3.4 Mixed ericoid and restioid fynbos of the rocky ridges on the flats bordering the Elgin basin.
2.3.5 Mixed proteoid and restioid fynbos of the mesic southerly shale-sandstone transitions.

2.4 Fynbos on inland white sandstone soils

2.4.1 Mixed short ericoid and restioid fynbos of xeric shallow sandy flats.
2.4.2 Mixed short ericoid and restioid fynbos of lower slope drainage lines.
2.4.3 Mixed ericoid and restioid fynbos of lower northerly rocky slopes.
2.4.4 Mixed short ericoid and restioid fynbos of xeric upper drainage lines.

2.4.5 Mixed ericoid and restioid fynbos of mesic upper drainage lines.
2.4.6 Mixed open fynbos of summit ridge rocky outcrops.
2.4.7 Mixed fynbos of the lower southerly slopes.
2.4.8 Mixed fynbos of the hygric upper southerly slopes.
2.4.9 Restio-Chondropetalum tussock marsh.

2.5 Riparian vegetation

2.5.1 Brabeium-Rhus riverine scrub.
2.5.2 Berzelia-Pseudobaeckea tall fynbos of rocky streams.
2.5.3 Prionium-Wachendorfia swamp.

3. Alien vegetation

3.1 Acacia cyclops thicket.
3.2 Pinus pinaster tree clump.
3.3 Other alien communities.

4.3 Description of the vegetation

The vegetation can very broadly be divided up into two types which can be compared to formations, namely the broad leaved scrub and the fynbos.

1. THE BROAD LEAVED SCRUB

Certain communities are characterized by the absence of both the sclerophyllous ericoid type of leaves and the restionaceous complement, which are typical of the fynbos. Broader leaves and a tree-like growth form in moister conditions or broader leaves with a covering wax layer or other xerophytic characteristics can be found in these communities.

1.1 The coastal dune vegetation

The broad leaved coastal scrub and associated littoral dune communities or psammoseres occupy a small portion of the total area being investigated, being confined to those portions of the coastal plain which border immediately onto the sea. This area has been subjected to large scale, but localized, dune formation during the recent past. The 1938 aerial photographs (Trigonometrical Survey Job no. 126/38), for instance, show two main areas of active dune formation. The largest reaches far up the Blesberg into Hangklip kloof, from the Silver Sands-Doringbaai area. The other occurs along the coast on the seaward side of Malkopvlei (also known as Bass Lake). The open, uncolonized portions of these dunes have undergone considerable reduction in area since 1938. This can be attributed to stricter fire control measures, absence of grazing by domestic animals and stricter control of trespassing and other denuding activities of man by the present owners. The strong south-east winds which are a common and prominent climatic feature of this coastline (to such an extent that the first farming rights to be granted in this area in 1739 were for a farm called "Waai-de-Gat") soon cause dune movement if the vegetation cover is disturbed. The open uncolonized portions of these dunes have also been reduced considerably by recent colonizations of the exotic species, Acacia cyclops, which has proved extremely hardy and a good sand binder. Unfortunately it has assumed plague proportions, leading to extensive replacement of the indigenous vegetation.

The vegetation on these alkaline sandy soils is much more complex than is shown by the broad groups recognized in this account. The coastal dune vegetation is subject to the salt spray carried inland by inshore winds. Plants frequently show evidence of deformation from the effects of the salt spray and wind.

1.1.1 The Arctotheca-Myrica strand pioneers

Under strand is understood that area of bare beach above high water level subject to the action of wind and sand blasts.

Group 24 in the association-analysis hierarchy (table IV) includes both the strand pioneers and the Colpoon-Rhus scrub (1.1.2). There are nine sampling sites in this group (sites 2, 32, 33, 34, 35, 36, 37, 44 and 45) (see fig. V) which are defined by the following species:

- Chondropetalum hookerianum
+ Metalasia muricata
- Struthiola ciliata subsp. schlechteri
- Aspalathus biflora
- Hypodiscus aristatus
- Aspalathus forbesii
+ Passerina paleacea

The closely related group 23 (Colpoon-Rhus dune scrub) differs from the above group in definition by having Aspalathus biflora present.

The Arctotheca-Myrica community includes all the vegetation growing on the unstable littoral sands (alkaline), from the initial or early colonizers forming open scattered patches of Arctotheca populifolia and Stipagrostis zeyheri, to the more continuous colonies of Agropyron distichum, Ammophila arenaria, Ehrharta villosa, Felicia amelloides, Ficinia lateralis, Silene crassifolia, Sporobolus africanus, Stenotaphrum secundatum, Tetragonia spicata, T. decumbens, etc., on the upper beaches, to the taller shrubbier zone where Metalasia muricata, Myrica cordifolia, Passerina rigida, P. paleacea, P. vulgaris, Psoralea repens, Restio eleocharis, Thesidium fragile, etc., can be found.

A variation of the strand pioneers occurs on the inland extremities of the partially mobile dunes. Here fynbos elements occur in conjunction with littoral elements such as Metalasia muricata, Passerina paleacea, Olea exasperata, Restio eleocharis, Ficinia lateralis, etc. This variation is only represented by the single sampling site (no. 29) of group 23.

The strand pioneer vegetation is closely related to Taylor's (1969b) Pioneer Dune Mixed Fynbos Sub-Association and Littoral Dune Mixed Fynbos Sub-Association.

The characteristic species and their indicator values have been listed along with those of the Colpoon-Rhus scrub community (1.1.2).

1.1.2 The Colpoon-Rhus dune scrub

The Colpoon-Rhus scrub is included with the strand pioneer community (1.1.1) in the association-analysis hierarchy and has the same defining species.

This community can be found on the fixed or stabilized dunes where organic material has started to accumulate in the sandy soil giving it a greyish colour. No limestone deposits occur.

The Colpoon-Rhus scrub is closely related to the Sideroxylon inerme scrub (1.1.3), which appears to represent

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the climax form of this community where freedom from climatic (e.g. fires) and edaphic disturbance has been experienced for longer periods.

This community has been subjected to extensive invasions by the exotic plant, Acacia cyclops, which grows more vigorously than the natural vegetation after disturbance.

The colonization of stabilized dunes by the Colpoon-Rhus scrub begins in the dune slacks particularly on the leeward side of the dunes away from the inshore seabreezes. Progressive colonization by this community takes place with the dune crests forming the last portions of the dune still under the strand pioneer community.

Local water accumulation sometimes occurs in the dune slacks where reedswamp and vlei fringing communities develope (2.1.5 and 2.1.6).

Rhus lucida, Olea exasperata, Colpoon compressum, Cassine maritima, Maytenus lucidus, Euclea racemosa, etc., are found in the drier portions with Chrysanthemoides monilifera, Salvia africana-lutea, Senecio halimifolius, Metalasia muricata, etc., are found in the moister areas particularly in the dune slacks.

The characteristic species of the Arctotheca-Myrica strand pioneers and the Colpoon-Rhus dune scrub, forming groups 23 and 24 in the association-analysis hierarchy are:

TABLE 4.1

Species	P.	Const.	Signif.	Cont.	I.V.
Anaxeton nycthemerum	3	30		50	0,9
Carpobrotus acinaciformis	5	50	*	71	24,2
Chironia baccifera	4	40	*	66	18,6
Chrysocoma coma-aurea	2	20		66	13,0
Ehrharta villosa	4	40	*	100	97,0
Euclea racemosa	5	50	*	83	41,0
Ficinia lateralis	7	70	**	87	59,7
Helichrysum crispum	3	30		60	13,0
H. ericaefolium	3	30		100	69,0
H. maritimum	2	20		50	1,0
Lasiochloa longifolia	2	20		66	13,0

contin. 85/...

Species	P.	Const.	Signif.	Cont.	I.V.
Leontonyx spathulatus	5	50	*	55	13,0
Metalasia muricata	10	100	***	40	0,9
Myrica cordifolia	4	40	*	100	97,0
Passerina paleaceae	9	90	***	90	78,3
Phylica ericoides	3	30		60	13,0
Psoralea fruticans	6	60	**	75	29,8
Restio eleocharis	8	80	**	80	41,0
Rhus lucida	3	30		60	13,0
R. laevigata	3	30		42	0,9
Senecio elegans	2	20		66	13,0
S. halimifolius	4	40	*	66	18,6
Sporobolus africanus	3	30		75	22,3
Thesidium fragile	2	20		66	13,0
Zantedeschia aethiopica	2	20		66	13,0

A characteristic of these two communities is the large number of species having a high fidelity value notably Ehrharta villosa, Helichrysum ericaefolium and Myrica cordifolia, although they are not constant to all the sampling sites.

1.1.3 Sideroxylon inerme dune scrub

The Sideroxylon inerme scrub or melkhoutbos was not sampled during this survey because it is easily recognizable on aerial photographs and on the ground by its distinctive physiognomy.

The Sideroxylon scrub appears to represent the climax community of the vegetation found on the deep stabilized littoral sands.

Well developed Sideroxylon scrub patches can be found at Dawidskraal, Boskop, Pringle Bay and on the Elephant Rock Estates near the mouth of the Palmiet River. Verbal reports from older inhabitants of this area indicate that this community was much more extensive during the end of the last century (Prof. C.M. Muller, pers. comm.). The frequent fires and accompanying movement of sand appears to have been the cause of the reduction in extent of this community while the exotic Acacia cyclops has encroached and become dominant in many of these areas.

A very interesting patch of dune scrub can be found on

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the seaward slopes of the Klein Hangklip Range, where an isolated dune, having no present connection to any sandy beach, for the addition of more dune sand, shows some of the various stages in the apparent coastal dune sand vegetation succession. On the lower portion, loose, unstable sand with scattered Metalasia muricata individuals can be found, while the upper central portion has developed a dense Colpoon-Rhus scrub in the centre of which a lone large Sideroxylon inerme individual, with Cussonia thyrsiflora intertwined, can be found.

In its best developed form, this community has a compact and continuous upper canopy, from two to four metres high, formed mainly by Sideroxylon inerme, Cussonia thyrsiflora, Euclea racemosa and Olea exasperata. The margin of this scrub is usually composed of stunted and wind shorn individuals, from the effects of the salt laden inshore sea breezes. Sideroxylon inerme appears to grow best where there is a degree of protection from these winds. This is actually effected by the hardier Olea exasperata, Euclea racemosa, Rhus undulata and members of the Colpoon-Rhus scrub. Tarchonanthus camphoratus and Olea exasperata often form dense stands of their own, but usually in close proximity to a Sideroxylon patch. Possibly they could develope into Sideroxylon scrub with time, or even into a community such as the Maurocenia-Linociera tall scrub of the Cape of Good Hope Nature Reserve (Taylor, 1969b) because young individuals of Maurocenia frangularia and Linociera foveolata have been recorded in these patches. One well-developed patch of scrub dominated by Maurocenia frangularia and Linociera foveolata occurs to the south of Hangklip Kloof. Other dominants are Euclea racemosa, Olea exasperata, Cassine maritima and Cussonia thyrsiflora, amongst others. This patch has been regarded here as a form of Sideroxylon scrub.

A number of climbers can usually be found in this scrub. Examples are: Cynanchum africanum, Kedrostis nana, Asparagus asparagoides and Solanum quadrangulare, amongst others. Cussonia thyrsiflora, usually found in coastal scrub patches, often forms a semi-climber, becoming self-supporting when larger. The herbaceous layer in these scrub patches usually consists of Asparagus scandens, Australina lanceolata, Cineraria geifolia and Knowltonia capensis, amongst others.

Because the Sideroxylon scrub offers shade from the sun and protection from the wind, it is very popular amongst the general public for picnicking and camping purposes. The result is that the marginal species, which protect it from the salt-laden seabreezes, are often removed which is not beneficial to the natural enlargement of these scrub patches or to their general existence and might eventually lead to their destruction.

1.2 Inland broad leaved scrub

This category would include all the forest patches, which are those communities dominated by trees with interlocking crowns and at least a well developed strata consisting of trees perhaps with shrubs. The forest found in this area are generally much less tall than those of the Knysna region possibly because of the greater climatic extremes in the South-Western Cape. Taylor (1955) found, when investigating the Grootvadersbosch Forest (Heidelberg Division), that some of the characteristic species of certain of the Knysna types of forest, as described by Phillips (1928) and Laughton (1935), were either absent or rare in that forest. A similar case was found to be true of the forest patches in the Hangklip area where a much poorer species composition exists than in the Knysna types.

The forest patches were not sampled because they formed a distinctive physiognomic unit which could be readily delimited on aerial photographs. To have sampled this community would have meant that a larger sample-area would have had used and this data would then not be statistically comparable to the other data. In addition, the increase in number of samples and species would have presented more computing difficulties.

The different types of inland broad leaved scrub have not been distinguished in the vegetation map (fig. V) because of the limited extent of this vegetation type.

1.2.1 The Cussonia-Rapanea scree forest

On the southerly slopes of the Elephant Rock Mountain above Sunny Seas, two patches of scree forest can be found while another smaller one is situated on its northern slopes.

These scree forests, which are locally known as "dasbosse", probably after the hyrax or dassies which inhabit some of them, contain, characteristically, large boulders in close proximity to one another. The rôle of these boulders in the ecology of the scree forests could be to create a suitable habitat for the initial colonization by tree species. The habitat does not appear to be particularly moist when compared to the surrounding slopes, although a reasonable supply of water would be available to deeper rooted species through seepage water in the shallower upper talus areas and could therefore also be a contributing factor. The presence of boulders results in large bare areas devoid of undergrowth and detritus and might, therefore, exclude all but the fiercest fires. The 1970 fire which devastated portion of the village of Betty's Bay, also swept through the scree forest patches and appeared to have destroyed them. Some months later, however, most of the component tree species were found to be regenerating by coppicing, while Haemanthus coccineus growing in the centres of the forest patches was found to be flowering profusely. A possible deduction from this observation is that fire is a normal climatic phenomenon of fairly regular occurrence in these scree forest patches, as appears to be the case with the fynbos vegetation.

The conspicuous species occurring in the scree forests are: Cassine barbara, Cunonia capensis, Cussonia thyrsiflora, Halleria lucida, Knowltonia capensis, Olea africana and Rapanea melanophloeos, amongst others. Helichrysum crispum, Laurophyllus capensis, Myrsine africana, Glia gummifera, Solanum nigrum and others can be found growing in the forest margin.

The Cussonia-Rapanea forests differ from the Podocarpus-Olinia forests in that they occur on sandstone and not on shale and from the Cunonia-Cyathea forests because they are drier and are subject to occasional fires. The shale in the Podocarpus-Olinia forests, occasionally becomes covered by some sandstone scree, in which case similarities between the two types of forests can be encountered (for example the forest patch in Leopard's Gorge).

1.2.2 The Cunonia-Cyathea kloof forest

The Cunonia-Cyathea forests are rare in the survey area, only being able to develope completely in a deep gorge in the upper sandstones of the Table Mountain Series in the Dwarsrivier Mountains. (This type of forest is also found at the head of the Spinnekopneskloof which is outside this survey area). Large old individuals of Cunonia capensis (10 to 15 m tall), covered with thick growths of an Usnea sp. can be found.

The walls of the kloof are steep and wet while in the kloof, Cyathea capensis can be found growing in profusion. The steep rock walls and wet kloof conditions have excluded fire for a long period. A notable feature of the kloof forest is the paucity of other tree species, Cunonia capensis is the only species reaching tree proportions.

Access to this forest is particularly difficult because of the terrain.

The kloof forest patch on the southerly slopes of the Voorberg mountain near the Betty's Bay Post Office is most similar to the Cunonia-Cyathea forests but the presence of Cussonia thyrsiflora, for instance, indicates this forest's closer proximity to the sea and accompanying slightly richer species complement.

The absence of fire and a shale substrate distinguishes the Cunonia-Cyathea forest type from the other two types mentioned.

1.2.3 The Podocarpus-Olinia shale forest

The shale forests are the most common type of forest in this area, and because they cover the largest areas and are the most developed, are the best known. All of the shale forests occur in the Kogelberg State Forest. Prior to the declaration of this reserve, a certain amount of exploitation occurred. The Disa Kloof, Leopard Gorge and Oudebosch Forests and to a lesser extent the Wynand Louwsbosch Forest were the most accessible and therefore subject to the most disturbance. Ocotea bullata, the black stinkwood can still be found in some of these forests.

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The remoter Platbos and another patch up the Spinnekopneskloof have not been subjected to this exploitation.

The role of fires in the ecology of the shale forests appears to differ from that in scree forests. During the 1970 wild-fire, the marginal shale forest vegetation was burnt. The fire did not spread into the true forest vegetation. This accorded with earlier observations that vegetation showing signs of previous fires was only encountered along the forest margin, except where man had apparently been extracting honey from hollow trees in the forest itself. The forest margin consists of fynbos species which are adapted to regenerate after fires.

The forest margin usually has dense stands of Pteridium aquilinum forming the ground cover. This species builds up a fair amount of dead material which is highly inflammable, while Rumohra adiantiformis, which is a common species forming the ground cover in the forests, does not appear to build up this fire staple. The distinction between the true forest and the forest margin is indicated by these two species.

The shale provides a deeper soil than the sandstone because it weathers more readily and it is usually moist because of seepage. The tendency for the shale to weather more readily than the underlying tillites or sandstones often results in steep sided ravines being found near the forest patches.

Scattered young trees of Rapanea melanophloeos, Cunonia capensis, Olinia cymosa, etc., can be found in the Spinnekopneskloof on the shale band but periodic fires appear to limit their development of the closed canopies found in the true forest patches.

The forest margins are formed by the Berzelia-Leucadendron tall fynbos (2.3.2) with Protea mundii present, which reaches tree proportions, often attaining heights of up to 10 m. Cliffortia heterophylla and Podalyria calyptrata are conspicuous elements while Brachylaena neriifolia and Laurophyllus capensis occur nearer the limits of the true forest.

The conspicuous tree species which form a continuous canopy in the shale forests are Podocarpus latifolius, Cunonia capensis, Curtisia dentata, Apodytes dimidiata, Platylophus trifoliatus, Hartogia schinoides, Pterocelastrus rostratus, etc. Creepers are not prevalent although Secamone alpini can, on occasion, be commonly found. Saplings of Rapanea melanophloeos , Curtisia dentata and particularly of Podocarpus latifolius are commonly found, even under the densest canopy.

Pteridophytes form a major portion of the herbaceous covering of the forest floor. Species often encountered are: Cyathea capensis, Rumohra adiantiformis, Blechnum capensis, B. attenuatum and Elaphoglossum acrostichoides, while Asparagus scandens, Droguetia ambigua and Knowltonia capensis are also commonly found.

2. FYNBOS

The term "fynbos" has been used here to signify the bushy, sclerophyllous, evergreen, indigenous vegetation of the winter rainfall region of the South-Western Cape Province. This vegetation mainly consists of ericoid-leaved shrubs and species having a tussocky growth form belonging to the families Cyperaceae and Restionaceae.

Adamson (1938), in his discussion of the Sclerophyllous Bush (the fynbos is variously known as: Heath (Martin, 1965), Macchia (Phillips, 1931; Acocks, 1953; Roberts, 1966), Maqui (Warming, 1909), Sclerophyllous Bush (Schimper, 1903; Pole Evans, 1936; Adamson, 1938) and Sclerophyllous Scrub (Riley & Young, 1966)) recognizes it as having three layers in its most developed form. The upper layer would be represented by emergent dominants which vary according to locality but consist mainly of members of the family Proteaceae, especially in the area under consideration, where the following species can be mentioned: Leucadendron gandogeri (= L. guthriae), L. microcephalum (= L. glabrum), L. salignum Berg. (= L. adscendens), L. spissifolium (= L. glabrum), L. xanthoconus (= L. salignum R.Br.), Leucospermum conocarpodendron, Mimetes argenteus, M. capitulatus, M. cuculatus (= M. lyrigera), M. hirtus, Orothamnus zeyheri, Protea arborea, P. lepidocarpodendron, P. longifolia, P. mundii, P. repens and P. stokoei. The members of the Proteaceae generally have broad leathery sclerophyllous leaves. Tree proportions are sometimes attained especially in the cases of Leucospermum conocarpodendron, Protea arborea and P. mundii. The middle layer is generally composed of wiry shrubs and dwarf shrubs with ericoid leaves which generally represent the following families: Bruniaceae, Compositae, Ericaceae, Rosaceae, Rutaceae and Thymelaeaceae.

The lower layer consists of tufted or tussocky Restionaceae and Cyperaceae and smaller herbaceous plants and geophytes.

Not all of the layers recognized by Adamson (1938) develope under all habitat conditions. Fires might prevent the development of the upper or middle layers, or the physical or climatic nature of a particular area might be such that the development of all three the layers cannot take place.

The fynbos in the studied area is recognized as being amongst the richest florally in the South-Western Cape. Many endemic species may be found in the area, some of which are particularly showy e.g.: Erica pillansii, E. macowanii, E. foliacea, E. leucotrachela, Mimetes hottentoticus, Sonderothamnus patraeus, etc., to name but a few. A possible factor contributing towards the great species diversity in the area could be the great variety of habitats produced by the many topographic variations. Climatically, the Hottentots Holland range appears to form the dividing line between the area receiving its rainfall predominantly in winter to the north and that receiving a greater proportion during the summer which increases in a south-easterly direction. The mountains in the Hangklip area appear to be located on this dividing line. Because the species diversity is so great, the study of the vegetation becomes difficult, especially in the search for typifying species for particular habitats.

The tussocky Restionaceae and Cyperaceae coppice or sprout rapidly after fire and persist throughout the life of the fynbos communities. This makes them extremely valuable in the study of the vegetation. The first division in the association-analysis hierarchy, on Chondropetalum hookerianum, testifies to their value. Furthermore Taylor (1969b) regards the Restionaceae as being more restricted to specific habitats than the shrubby elements of the flora. The moister areas, particularly the southern mountain slopes, are generally richer in Ericaceae species while the yellow plinthic soils appear to support the most Protea species.

2.1 Coastal plain vegetation

The Hangklip area has a fairly broad coastal plain between the mountains and the sea which mainly originates from earlier sea-level fluctuations. The 18 m (60 ft.) sea abrasion platform (Taljaard, 1948) is well developed along the whole coastline. The flats between the foothills of Buffelstalberg and the Klein Hangklip range would be included under the category of coastal plain although higher altitudes than 18 m are reached here. The coastal plain often has a substrate of a deep sandy soil which is mainly of marine origin (Tertiary to Recent) but includes sands from the surrounding mountains. These sands differ from the coastal dune sand by virtue of their acid nature. Boggy seepage areas with dense seepage fynbos, limestone deposits or rocky sandstone outcrops are also common features of the coastal plain. Various vlei's (permanent or temporary expanses of standing water, closed to the sea) occur in the coastal plain. Some of these dry out completely during summer while others have permanent water. The natural beauty of these vlei's is conveyed by the picturesque names they have been given, i.e.: Lovers Lake, Malkopvlei (Bass Lake) or Skilpadvlei, etc.

2.2.1 Coleonema album short coastal fynbos

The coastal plain affronts the sea with a short steepish rocky sandstone step along much of the rocky coastline where dune formation does not occur.

The vegetation shows strong xerophytic characteristics with succulents such as Tetragonia spicata, Aizoon sarmentosum, Drosanthemum floribundum, Lampranthus austricolus and L. aurantiacus, amongst others, because the high salt content from the sea spray makes the soil physiologically dry. Heavy dew falls during the nights help to compensate for the lack of available moisture in the soil. A deep soil seldom developes excepting for local sand pockets. The sandstone substrate is not rich in plant nutrients (see chapter 2.3).

In the association-analysis hierarchy this community is grouped with the mixed coastal fynbos of the acid sands

(2.1.2) because insufficient sampling sites were located in it to result in separation. The short fynbos can be distinguished, however, by the alkaline substrate and the poorer species complement particularly of Restionaceae. Coastal dune scrub or strand pioneers might sometimes be encountered in the local sand pockets between the sandstone rock outcrops.

The conspicuous species are: Aizoon sarmentosum, Carpobrotus acinaciformis, Coleonema album, Drosanthemum floribundum, Metalasia muricata, Orphium frutescens, Passerina ericoides, P. vulgaris, Phylica ericoides, P. stipularis, Senecio elegans and Tetragonia spicata.

2.1.2 Mixed coastal fynbos of acid sands

The Coleonema album short coastal fynbos (2.1.1) and this mixed fynbos were included in one end group of the association-analysis hierarchy. The misidentification of Chondropetalum nudum as C. hookerianum during a drought resulted in some of the sampling sites being separated from the rest during the first subdivision of the hierarchy. There were therefore too few sites remaining for the subdivision of this combined group because of the limitations incorporated into the computer programme (see chapter 3).

The defining species for these two communities of group 25 are:

-Chondropetalum hookerianum
+Metalasia muricata
-Struthiola ciliata subsp. schlechteri
-Hypodiscus aristatus
-Aspalathus forbesii
-Passerina paleacea

The following sampling sites are included within group 25: 8, 15, 16, 21, 24, 25, 38, 39, 41 and 58.

The coastal plain has extensive deposits of Tertiary to Recent marine sands. Those marine sands which have lost their alkaline nature through rain and seepage waters from the surrounding mountains, which contain organic acids, have developed a mixed fynbos plant cover. The soil is composed of a deep fine textured sand (in contrast to the coarse sand originating from weathered sandstone) which is not rich in mineral nutrients.

The mixed fynbos described here is characteristic of the drier sites through good drainage in contrast to the areas where seepage fynbos, vlei-fringing tussock or reed-swamps are found.

The slope of the sampling sites was found to be between 0^o and 3^o although 8^o was recorded in one instance (site 25) where wind had transported marine sand up a mountain side.

The characteristic species of the Coleonema album short fynbos and the mixed coastal fynbos of the acid sands, comprising group 25 in the association-analysis hierarchy are:

TABLE 4.2

Species	P.	Const.	Signif.	Cont.	I.V.
Berzelia abrotanoides	5	50	*	71	24,2
Cliffortia hirsuta	2	20		66	13,0
C. subsetacea	3	30		42	0,9
Cymbopogon marginatus	3	30		21	0,8
Erica multumbellifera	3	30		100	69,0
E. patersonia	2	20		40	0,9
Helichrysum cymosum	2	20		50	1,0
Metalasia muricata	8	80	**	32	0,9
Myrica quercifolia	4	40	*	44	0,9
Passerina vulgaris	5	50	*	45	0,9
Pelargonium capitatum	4	40	*	100	97,0
Pterocelastrus tricuspidatus	2	20		66	13,0
Rhus africana	2	20		66	13,0
R. scytophylla	3	30		23	0,8
Scirpus nodosus	4	40	*	30	0,9
Serruria elongatum	2	20		33	0,9
Staberoha cernua	1	10		1	-1,9
Tetraria fasciata	1	10		1	-2,9
T. fimbriolata	1	10		1	-2,2
Thamnochortus dichotomus	4	40	*	17	0,7

Erica multumbellifera and Pelargonium capitatum are the only two species which are completely faithful to this group but neither is of constant occurrence throughout the stands.

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2.1.3 Leucadendron coniferum limestone fynbos

In the association-analysis hierarchy, group 22 includes the limestone fynbos and is defined by the following species:

-Chondropetalum hookerianum
+Metalasia muricata
+Struthiola ciliata subsp. schlechteri
-Hypodiscus aristatus
+Aspalathus forbesii

Group 22 consists of the following sampling sites: 28, 30, 31 and 43.

The limestone deposits found in the area have been formed by dune calcification. They have been exposed, subsequently, by the removal of the loose surface sands. Where the exposed limestone deposits are found, such as in the vicinity of the Groot Vleie, a short limestone vegetation with sparse cover occurs in the shallow lime soil found in pockets between the exposed rocks. Dry conditions are prevalent in summer. Here species found in the Coleonema album fynbos and in the Arctotheca-Myrica strand communities can be encountered. Where the loose sand covering over the limestone still occurs, a more luxuriant form of limestone vegetation may be encountered. The soil is deeper, has a higher organic matter content and generally moister conditions are found. Some dune scrub elements occur with the limestone fynbos.

On the south-eastern slopes of Hangklip and the southern slopes of Blesberg, wind blown marine sand has accumulated on the mountain side to an altitude of about 180 m. Here dune calcification has also taken place. The vegetation here is predominantly that of the limestone type yet elements of mountain fynbos and fynbos of yellow plinthic soils are found where the sands of marine origin are shallower or mixed with the weathered products of sandstone from higher up the mountain slopes. The deep rooted Leucospermum conocarpodendron, for instance, can be found growing in what appears to be dune sand at first glance but is in fact of a duplex type with the yellow plinthic soils beneath.

The characteristic species of the Leucadendron coniferum limestone fynbos representing group 22 in the association-analysis hierarchy are:

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TABLE 4.3

Species	P.	Const.	Signif.	Cont.	I.V.
Anaxeton nycthemerum	2	50	*	33	1,0
Anthospermum ciliare	4	100	***	11	0,8
Aspalathus ciliaris	2	50	*	50	1,0
A. forbesii	3	75	**	100	181,5
Cassytha filiformis	2	50	*	20	0,9
Centella restioides	3	75	**	25	0,9
Cymbopogon marginatus	3	75	**	21	0,9
Ficinia albicans	2	50	*	28	1,0
Knowltonia capensis	2	50	*	50	1,0
Leucadendron xanthoconus	3	75	**	9	0,8
Lightfootia tenella	3	75	**	60	35,5
Linum africanum	2	50	*	28	1,0
Metalasia muricata	4	100	***	16	0,9
Mimetes cucullatus	2	50	*	33	1,0
Myrica quercifolia	3	75	**	33	1,0
Olea capensis subsp. capensis	3	75	**	50	1,0
Osteospermum polygaloides	2	50	*	66	35,5
Othonna quinquedentata	3	75	**	60	35,5
Pelargonium betulinum	2	50	*	66	35,5
Protea scabra	2	50	*	14	0,9
Roella compacta	2	50	*	66	35,5
Senecio arnicaeflorus	2	50	*	66	35,5
Stoebe cinerea	2	50	*	28	1,0
Struthiola ciliata subsp. schlechteri	3	75	**	100	181,5
Thesium virgatum	2	50	*	28	1,0

The two dividing species in the association-analysis hierarchy, Aspalathus forbesii and Struthiola ciliata subsp. schlechteri, are both completely faithful to this group. Eight species show some importance according to Goodall's Indicator Values.

2.1.4 Brunia-Erica seepage fynbos

The seepage fynbos comprising groups 31 and 32 in the association-analysis hierarchy, are negatively defined by the absence of the following species:

-*Chondropetalum hookerianum*
-*Metalasia muricata*
-*Montinia caryophyllacea*
-*Leucadendron xanthoconus*
-*Restio purpurascens*
-*Hypodiscus aristatus*
-*Erica pulchella*
-*Osmites parvifolia*
-*Erica intervallaris*

Danthonia cincta is present in the case of group 31 and is represented by the following sampling sites: 14, 17, 18, 19 and 40. In the case of group 32, represented by sampling sites 1 and 3, *Danthonia cincta* is also absent.

Danthonia cincta is characteristic of the wet seepage areas where it may, on occasion, become dominant although the normal vegetation is a tall fynbos dominated by *Brunia alopecuroides* and *Erica perspicua*. Other lower growing species do also attain the same type of local dominance. The following might be mentioned in this respect: *Cliffortia ferruginea*, *C. hirsuta*, *Epischoenus gracilis* and others.

Group 32 represents the tall fynbos in a rudimentary form, found where the soil is shallower and consequently becomes drier in summer although it is just as waterlogged as the seepage fynbos proper in winter.

This tall seepage fynbos forms a dense community of erect but straggly stems which becomes difficult to penetrate when left unburnt for a reasonable period, reaching heights of 1 m to 2 m and over. When walking through this community, the unpleasant characteristic odour of hydrogen sulphide from *Carpococe spermacocea* can often be smelt. The water table is high but standing or surface water does not normally occur. The soil has a high organic content and resembles peat.

The Buffels River flats seepage fynbos is mainly dominated by *Erica perspicua*, *Berzelia lanuginosa*, *Brunia alopecuroides* and occasionally by large *Psoralea affinis* individuals while *Cliffortia graminea*, *Carpococe spermacocea*, *Epischoenus gracilis*, *Neesenbeckia punctoria* and others represent the herbaceous layer. The above seepage area has a much greater depth of soil than is found on the rocky coastal plain such as occurs to the west of the Klein Hangklip range, where similar seepage fynbos

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is found, but which is shorter (approximately 1 m tall) and has less of an ericoid appearance. Berzelia abrotanoides, Erica perspicua, Leucadendron spissifolium and Osmitopsis asteriscoides occur as dominants while herbaceous species like Anaxeton asperum, Cliffortia hirsuta and Danthonia macrantha are more prevalent.

In areas nearer the streams where the movement of seepage water is faster, scattered tall Psoralea pinnata individuals occur giving a savanna-like appearance.

The upland seepage areas occasionally have a similar species content but are distinguished by the presence of Erica intervallaris and Restio purpurascens.

The Brunia-Erica seepage fynbos gives a rather drab and uniform impression during the year excepting when the Brunia alopecuroides, Berzelia lanuginosa and Erica perspicua individuals are flowering. The rare, showy Proteaceae, Mimetes hirtus, can be found in this community, especially when it is in flower. This community, however, is at its most beautiful during the first year or two after a fire. After the February 1971 fire at Betty's Bay masses of Haemanthus canaliculatus gave the appearance of a fiery red field of tulips between the month old burnt out remains of the seepage fynbos. Various other species, especially geophytes, have been found flowering profusely since the fire. Amongst the showy geophytes, the following can be mentioned: Kniphofia uvaria, Geissorrhiza wrightii, Gladiolus carneus, Disa racemosa and Watsonia comptonii. Some of these species have only been collected in this area after fires. Haemanthus canaliculatus, for instance, was described for the first time after a fire in 1960 (Levyns, 1966).

Danthonia cincta, Elegia thyrsifera, Senecio subcanescens, Pelargonium cucullatum all flowered prolifically and occurred as dominants during various stages in the post fire succession.

This Brunia-Erica seepage fynbos is similar to Taylor's (1969b) Berzelia-Osmitopsis Seepage Scrub Association. This community would be included under Adamson's (1938) Wet Sclerophyll Bush, which he describes as having a denser less xerophytic growth form, where there is a prevalence of soft small leaves and an absence of hard leathery leaves and which

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he has called "Hygrophilous Macchia".

The characteristic species of the Brunia-Erica seepage fynbos representing groups 31 and 32 in the association-analysis hierarchy, are:

TABLE 4.4

Species	P.	Const.	Signif.	Cont.	I.V.
Carpococe spermacocea	2	28		33	0,9
Cliffortia graminea	2	28		66	19,4
Danthonia cincta	4	57	*	57	19,4
Epischoenus gracilis	3	42	*	100	101,1
Erica perspicua	4	57	*	66	27,6
Linum africanum	2	28		28	0,9
Osmitopsis asteriscoides	4	57	*	57	19,4
Polygala garcini	2	28		66	19,4
Senecio halimifolius	2	28		33	0,9

Epischoenus gracilis, which is faithful to this community, was considered for the naming of this seepage fynbos but it is rather inconspicuous and, although not well known ecologically, appears to be indicative of a more specialized habitat than that occupied by the more general community described here.

2.1.5 The Chondropetalum-Juncus vlei-fringing tussock vegetation

Under the term vlei is understood a moist or marshy area with permanent or temporary standing water not open to the sea. Tussock vegetation would include the members of the families Restionaceae and Cyperaceae which have a tufted growth form.

This community was not sampled, mainly because it is found in a zone around areas where expanses of open water are found and is too narrow to be sampled by the regular 10 m x 5 m quadrat size used during this survey. The surrounding communities would also be included. In addition this vlei-fringing tussock vegetation is distinctive and easily distinguished on aerial photographs but are generally too narrow to be mapped separately.

The dominant species are Chondropetalum tectorum and Juncus kraussii which are from 50 cm to 1 m tall. The latter species, although occurring amongst the Chondropetalum tectorum individuals, appears to prefer those portions of the vleis' fringe which are innundated for slightly longer periods. The following species often form a mat which can completely cover the ground: Centella calliodus, Lobelia anceps, Plantago carnosa and Sporobolus virginicus.

This community is particularly well developed around the Groot Vleie, Bass Lake and in the smaller vlei's amongst the limestone outcrops.

2.1.6 The Phragmites, Scirpus or Typha reedswamp

Those areas which have relatively permanent surface water are often colonized by 2 m to 3 m tall patches of Phragmites australis, Scirpus littoralis or Typha latifolia subsp. capensis.

Phragmites australis is most often found in those areas where flowing water is found. These conditions occur in drainage channels from the vleis or in the rivers.

Scirpus littoralis and Typha latifolia do not appear to be restricted to areas where flowing water is found and can usually be found growing in the vlei's and bogs which can become completely overgrown by these species.

In the vlei's and rivers the reeds are usually restricted to the shallower water where Crassula natans and Scirpus fluitans can also be found.

Cyperus thunbergii can occur in fairly dense stands in the slightly drier bog areas along with Typha latifolia or on its own.

2.2 The coastal mountain fynbos

This fynbos vegetation is found on the white sandstone soils on the rocky coastal mountains. In contrast to the inland vegetation, this fynbos appears to be influenced to a marked degree by its close proximity to the sea. Climatic influences associated with the sea such as salt laden onshore sea breezes blow against the 150 m to 600 m coastal mountain barrier. The vegetation in collaboration with the sudden increase in altitude, appear to effectively "filter out" much of the salt and moisture load from these breezes and appear to be influenced by these factors. Where these coastal barriers are interrupted, the influence of these maritime breezes extends considerably further inland. The vegetation at the junction of the Palmiet, Louw and Dwars Rivers, for instance, shows similarities in composition to that closer to the sea, although being located approximately 7 km inland.

Groot Hangklip Mountain is an inselberg of Table Mountain Sandstone surrounded by Tertiary and Recent deposits of marine sands on the coastal plain. This mountain is surrounded by sea on three sides and maritime influences are therefore important.

The mountains of these coastal ranges generally affront onto the coastal plains with steep, virtually perpendicular rock faces. The more inland mountains show similar tendencies. These mountain faces are regarded as being amongst the most steeply vegetated slopes in the South-Western Cape.

2.2.1 Mixed ericoid and restioid fynbos of the xeric seaward slopes

This community is predominantly composed of various members of the family Ericaceae and other species having a tussock growth form. Various Proteaceae can also be found but they do not appear to play a major rôle in this community. No constant species could be found to describe this community which is represented by three end groups in the association-analysis hierarchy.

Group 2 which consists of stands 11, 48, 55, 59, 61, 64, 65, 66 and 68 is defined by the following species:

+*Chondropetalum hookerianum*
+ *Anthospermum ciliare*
+*Restio egregius*
-*Leucadendron xanthoconus*
+*Lanaria lanata*

Group 19 consists of stands 5, 6, 23 and 26 and is defined by the following species:

-*Chondropetalum hookerianum*
+*Hypodiscus aristatus*
+*Phaenocoma prolifera*

Group 8 consists of stands 10, 20, 22, 46, 47, 54, 71 and 72 and is characterized by the following species:

+*Chondropetalum hookerianum*
-*Anthospermum ciliare*
+*Erica hispidula*
-*Erica fastigiata*
+*Erica placentaeflora*

Group 2 represents the seaward facing scree slopes of Elephant Rock Mountain with a maximum recorded altitude of 200 m. Drainage is good in all cases in the coarse sandy soil.

Aspect appears to be a distinguishing feature between this group and the sites in group 19 which, instead of facing in a southerly direction as is the case with group 2, have a westerly exposition.

The south-easterly winds are often rain bearing to the Elephant Rock Mountain area whereas the sites in group 19 occur mainly on the leeward slopes and are subject to drier summers through rain-shadow effects.

The sites in group 19 receive moisture almost exclusively from the north-west winds.

During the hotter summer months, the sites in group 19 are subject to the incident rays of the sun during the afternoons in contrast to the sites in group 2 which are cooler by virtue of their aspect and the higher mountains to northwards.

Group 8 represents the remainder of the drier sites occurring at low altitudes on these seaward facing coastal mountains. In the west the yellow plinthic soils are found in close proximity to the sampling sites. Sites 46 and 47 are located on very dry well-drained portions of a southerly facing scree slope. Sites 71 and 72 are situated on dry sandy lower scree slopes of a slightly more inland mountain but which is still exposed to the direct influence of sea breezes.

The possibility that group 8 represents intermediate and transitional forms of the coastal mountain mixed ericoid and restioid fynbos of the xeric seaward slopes, cannot be excluded, additional sampling is required to determine the ecological status of the vegetation represented in this group.

The vegetation of the western form, as represented by group 19, is dominated by plants giving an ericoid appearance, with species having a tussock growth form being common. The latter are particularly visible for the first few years after fire has swept through the vegetation. The younger vegetation is particularly attractive for a few years after a fire when Elegia parviflora is in flower, forming extensive golden carpets while either the white or yellow flowering forms of Helichrysum sesamoides, an everlasting, are particularly conspicious. Leucadendron xanthoconus forms the upper canopy of this vegetation (1 m to 2 m high) in the mature form with Leucadendron gandogeri and L. microcephalum occasionally interspersed.

The eastern form of this community, as represented by group 2, gives a taller impression than the western form and a greater variety of tussocky species can be found.

The eastern form of this community is similar to the communities found on the drier, low altitude, southern inland slopes (2.4.7) while the western form has affinities to the drier fynbos of the coastal plain.

The characteristic species of the mixed ericoid and restioid fynbos of the xeric seaward slopes as represented by groups 2, 8 and 19, are:

TABLE 4.5

Species	P.	Const.	Signif.	Cont.	I.V.
Adenandra brachyphyla	2	10		66	5,5
Agathelpis dubia	6	30		75	13,3
Anthospermum aethiopicum	5	25		35	0,8
A. ciliare	12	60	**	33	0,7
Aspalathus aspalathoides	5	25		100	57,5
Centella triloba	4	20		36	0,8
Chondropetalum ebracteatum	4	20		36	0,8
Corymbium africanum	8	40	*	36	0,8
Dilatris pillansii	9	45	*	37	0,8
Diosma oppositifolia	3	15		42	0,8
Elegia juncea	10	50	*	37	0,8
E. parviflora	17	85	***	27	0,6
E. spathacea	2	10		5	-1,3

Species	P.	Const.	Signif.	Cont.	I.V.
Erica coriifolia	12	60	**	24	0,5
E. gysbertii	3	15		42	0,8
E. placentaeflora	8	40	*	44	0,8
Euphorbia silenifolia	2	10		66	5,5
Ficinia filiformis	15	75	**	34	0,7
F. monticola	2	10		66	5,5
F. ramossissima	14	70	**	29	0,6
Gnidia anomala	5	25		41	0,8
G. pinifolia	4	20		50	0,9
Helichrysum sesamoides	8	40	*	34	0,7
Hypodiscus aristatus	15	75	**	22	0,5
Indigofera mauritanica	4	20		44	0,8
Lanaria lanata	14	70	**	34	0,7
Leptocarpus hyalinus	13	65	**	37	0,8
Leucadendron salignum Berg.	7	35		36	0,8
Lobelia capillifolia	5	25		62	7,4
L. coronopifolia	4	20		33	0,7
Merciera brevifolia	7	35		63	8,4
M. tenuifolia	3	15		75	9,8
Nagelocarpus serratus	8	40	*	25	0,6
Pentaschistis juncifolia	11	55	*	25	0,6
P. steudelii	4	20		50	0,9
Phaenocoma prolifera	12	60	**	34	0,7
Phylica imberbis	12	60	**	41	0,8
Restio bifarius	1	5		2	-3,1
R. bifurcus	2	10		66	5,5
R. cuspidatus	7	35		50	0,9
R. egregius	12	60	**	24	0,6
Roella ciliata	6	30		60	6,9
Rochea subulata	4	20		50	0,9
Serruria adscendens	3	15		60	5,5
Staberoha cernua	15	75	**	24	0,5
Sympieza articulata	6	30		37	0,8
S. pallescens	15	75	**	25	0,6
Tetraria fimbriolata	16	80	**	23	0,5
Thamnochortus dichotomus	8	40	*	34	0,7
T. pulcher	16	80	**	22	0,5
Ursinia crithmoides	7	35		36	0,8

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In the description, this community was considered as being composed of two variations with a third which appears to intergrade but for comparison with other communities they were all considered as one unit. Aspalathus aspalathoides proved to be the only species faithful to this community yet only occurring in five of the twenty sampling sites. Elegia parviflora occurred in 85% of the stands.

2.2.2 Mixed ericoid and restioid fynbos of mesic seaward facing slopes

This community is not common in the area. In the association-analysis hierarchy three sites, 50, 51 and 53, form group 21 and are defined by the following species:

-Chondropetalum hookerianum
+Hypodiscus aristatus
-Phaenocoma prolifera
-Erica coriifolia

The sites in question are all located on a moderately steep, south-west facing, sandstone hillside. Slope measurements of between 25^{o} and 35^{o} were recorded. This hillside is characterized by steps resulting from the sandstone layers weathering unevenly and dipping at an angle of 40^{o} to the north-east. Local seepage zones alternate with drier areas in the short steps but no great depth of soil developes.

This community does not have the species-richness of the upper southerly slope communities (2.4.8 and 2.4.9) because the lower altitudes involved here result in less exposure to south-east mists so drier conditions exist in summer. The sites are located in a wind funnel for south-east and south-west winds formed between the Elephant Rock and Voorberg Mountains. The influence of salt laden sea breezes is marked.

Physiognomically the vegetation is composed of ericoid and tussock species with scattered proteoid emergents. The large Cyperaceae Tetraria thermalis and Leucadendron gandogeri are often conspicuous.

The characteristic species of the mesic seaward facing mountain slope mixed ericoid and restioid fynbos representing group 21 in the association-analysis hierarchy, are:

TABLE 4.6

Species	P.	Const.	Signif.	Cont.	I.V.
Danthonia macrantha	3	100	***	8	0,8
Diosma oppositifolia	2	66	**	28	1,0
Lobelia coronopifolia	2	66	**	16	0,9
L. pinifolia	2	66	**	13	0,9
Nivenia stokoei	2	66	**	10	0,9
Protea cynaroides	2	66	**	13	0,9
Restio occultus	3	100	***	5	0,7
Schizaea pectinata	3	100	***	11	0,9

Although three species (Danthonia macrantha, Restio occultus and Schizaea pectinata) occur in all the sites none are particularly faithful to this community as is shown by the low indicator values. This reflects the mixed nature of the fynbos in this community.

2.2.3 Mixed ericoid and restioid fynbos of inland facing slopes

Two association-analysis end groups have been combined to represent this community. Group 1 consists of sampling sites 27 and 62 and group 3 consists of sites 4 and 57.

The defining species for group 1 are entirely positive (i.e. defined by the presence of species only) and are:

+Chondropetalum hookerianum
+Anthospermum ciliare
+Restio egregius
+Leucadendron xanthoconus

Group 3 is defined by the following species:

+Chondropetalum hookerianum
+Anthospermum ciliare
+Restio egregius
-Leucadendron xanthoconus
-Lanaria lanata

The sampling sites in this community are located on the drier less steep sandstone outcrops of the coastal mountains facing away from the sea. Higher day temperatures would develope in these sites than on the seaward facing slopes

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because of the greater angle of incidence of the sun's rays. The higher temperatures, in most cases, are accompanied by drier conditions.

Group 1 appears to be subject to more exposure to the direct force of sea breezes, with their accompanying cooler conditions and higher salt load, than group 3. Stand 13 recognized by Grobler (1964) appears to be similar to this community.

The characteristic species of the mixed ericoid and restioid fynbos of the inland facing slopes representing groups 1 and 3 in the association-analysis hierarchy are:

TABLE 4.7

Species	P.	Const.	Signif.	Cont.	I.V.
Adenandra umbellata	3	75	**	18	0,9
Anthospermum ciliare	4	100	***	11	0,8
Centella triloba	2	50	*	18	0,9
Elegia juncea	4	100	***	14	0,9
Erica imbricata	3	75	**	7	0,7
Gnidia pinifolia	2	50	*	25	0,9
Leptocarpus hyalinus	3	75	**	8	0,8
Lobelia pinifolia	3	75	**	20	0,9
Restio egregius	4	100	***	8	0,7
Willdenowia cf. humilis	3	75	**	37	1,0

This community has no species which can be used to typify it as is shown by the low indicator values. Three species occur in all the sampling sites but they all have wider distributions.

2.3 Fynbos on yellow plinthic soils

Soils belonging to the following four forms which are found in the Hangklip are classed within this group (see Chapter 2.3): Longlands form, Estcourt form, Clovelly form and Glencoe form.

These soils, or plinthites, are generally found in areas where an accumulation of particularly iron and manganese oxides, amongst other things, has occurred through impeded drainage or in association with the upper Klipheuwel beds, the Cedarberg formation, or the Bokkeveld beds (see chapter 2.2).

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In the drier areas, these plinthites can often be recognized by the occurrence of concretions of ironpan fragments and ferruginized grit, on the surface. In the wetter areas, the accumulation of organic material from the dense vegetation cover conceals the substrate, in many cases. The drier plinthites, in the area, have and are being subjected to extensive open cast mining for gravel. The vegetation on these soils could become rare because of the economic importance of the substrate.

2.3.1 The Protea-Gerbera dry short fynbos

This community is represented by group 26 in the association-analysis hierarchy and includes the following four sampling sites: 7, 42, 67 and 102 and are defined by the following species:

-Chondropetalum hookerianum
-Hypodiscus aristatus
-Metalasia muricata
+Erica pulchella

The yellow plinthic soils show numerous intergradations between dry and moist conditions, particularly in the case of the shale band of the Cedarberg formation. The vegetation varies in accordance with the change in moisture conditions with numerous intergradations occurring. Altitudinal variation was found to be between 60 m and 200 m and the aspect northerly to westerly.

This survey showed that there was close resemblance between the vegetation occurring on the yellow plinthic soils of sandstone origin and those of shale band origin with Protea scabra, Gerbera asplenifolia, Willdenowia teres and Tetraria bromoides being good indicator species. Tetraria bromoides can tolerate a fairly wide range of moisture conditions but only grows where surface deposits of yellow plinthic soils occur. Dense localized stands of various members of the Proteaceae are often encountered and the following can be mentioned: Protea repens, P. lepidocarpodendron, Aulax umbellata and Leucadendron xanthoconus. The Cyperaceae form a major constituent of this community giving it a tussocky appearance particularly during the first few years after a fire e.g. Tetraria fasciata, T. flexuosa and T. cuspidata, etc.

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Stands 6 and 11 recognized by Grobler (1964) appear to be represented by this community.

The characteristic species of the Protea-Gerbera dry short fynbos are:

TABLE 4.8

Species	P.	Const.	Signif.	Cont.	I.V.
Centella restioides	3	75	**	25	0,9
Elegia parviflora	4	100	***	6	0,7
Erica coriifolia	4	100	***	8	0,7
E. pulchella	4	100	***	5	0,6
Helipterum gnaphaloides	2	50	*	66	35,5
Lanaria lanata	4	100	***	9	0,8
Merciera brevifolia	2	50	*	18	0,9
Protea scabra	3	75	**	21	0,9
Restio cuspidatus	3	75	**	21	0,9
Stilbe ericoides	2	50	*	50	1,0
Thesium virgatum	2	50	*	28	1,0
Ursinia crithmoides	3	75	**	15	0,9

Four species occurred in all the stands but only one species, which occurs in 50% of the sampling sites, Helipterum gnaphaloides, has a high indicator value.

2.3.2 The Berzelia-Leucadendron dense tall moist fynbos

This community is represented by four sampling sites in the association-analysis hierarchy forming group 29 namely 128, 130, 135 and 136. The defining species are:

-Chondropetalum hookerianum
-Hypodiscus aristatus
-Metalasia muricata
-Erica pulchella
-Montinia caryophyllacea
-Osmites parvifolia
+Leucadendron xanthoconus

This community occurs on the shale band, called the Cedarberg formation, where wetter conditions, usually through seepage, prevail. The moister conditions have resulted in a dense tangled mass of plants which have resulted in a highly organic soil developing which often shows tendencies towards bogs. The moistest conditions are found at the contact between the shale and the tillite.

This community is very similar in physiognomic appearance to the Brunia-Erica seepage fynbos (2.1.4) found in the coastal plain but differs physiognomically and floristically, for instance, by having the broader leaved Leucadendron xanthoconus as dominant.

As is the case with the drier Protea-Gerbera short fynbos (2.3.1), Tetraria bromoides can be found on the exposed shales. The shale band up the Spinnekopneskloof carried a particularly dense cover of 2 m to 4 m tall Berzelia-Leucadendron fynbos. Fire protection had been practised for at least 26 years and the vegetation had become particularly moribund and virtually impenetrable. Recently a fire caused by lightning (September, 1971) has burnt this vegetation.

Tall dense stands of Protea lepidocarpodendron and P. mundii can be encountered. The latter species forms an important constituent of the forest margins where 4 m to 10 m tall individuals can be found. Another fynbos species which is commonly encountered in these forest margins and becomes quite tall, is Cliffortia heterophylla. The boundary between the tall moist fynbos forming the forest margin and the broad leaved shale forests proper (1.2.3) is indicated by Pteridium aquilinum growing in the fynbos and Rumohra adiantiformis in the forest. This fynbos differs from the shale forest in that it is periodically burnt.

Stands 9 and 10 recognized by Grobler (1964) appear to be represented by this community.

The characteristic species of the Berzelia-Leucadendron dense tall moist fynbos represented by group 29 in the association-analysis hierarchy are:

TABLE 4.9

Species	P.	Const.	Signif.	Cont.	I.V.
Anthospermum ciliare	3	75	**	8	0,7
Berzelia lanuginosa	3	75	**	16	0,9
Clutia polygonoides	4	100	***	25	0,9
Epischoenus quadrangularis	2	50	*	100	108,5
Erica hispidula	4	100	***	5	0,6
Leucadendron xanthoconus	4	100	***	12	0,8
Restio stokoei	2	50	*	40	1,0
Tetraria bromoides	4	100	***	40	1,0
Widdringtonia cupressoides	2	50	*	25	0,9

The sedge Epischoenus quadrangularis was found in 50% of the sampling sites in this community to which it is restricted. It only occurred in the particularly wet sites.

2.3.3 Mixed dry fynbos on shale-sandstone transitions or areas with sand on shale

This is a complex community which might require further subdivision in a more detailed study. Four sites were located in this community, namely 97, 99, 105 and 122 comprising group 14 in the association-analysis hierarchy, are the only representatives. The defining species are:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
-Indigofera mauritanica
+Dilatris pillansii

The very arable and extensive Bokkeveld shales which are found in the Elgin Basin are only of very limited occurrence in the surveyed area, where they occur in transitional zones to the upper sandstones of the Table Mountain Sandstones. In addition this zone has undergone considerable faulting and a mosaic occurs of shallow pockets of yellow plinthic soils overlying the sandstones. These plinthites can sometimes be concealed by recent deposits of sand but the vegetation often reflects their presence. The Bokkeveld shale shows the characteristic development of iron and manganese concretions in the yellow plinthic soils. These are very similar to those found in the shale band of the Table Mountain Sandstones.

Physiognomically the vegetation is chiefly restioid with interspersed ericoids and local patches of emergent proteoids. This is a dryer type of fynbos.

The characteristic species of the mixed dry fynbos on shale-sandstone transitions or areas with sand on shales forming group 14 in the association-analysis hierarchy (table IV) are:

TABLE 4.10

Species	P.	Const.	Signif.	Cont.	I.V.
Bobartia indica	2	40	*	22	0,9
Dilatris pillansii	5	100	***	20	0,9
Elegia parviflora	5	100	***	8	0,7
Hypodiscus alternans	3	60	**	60	28,0
Hypolaena digitata	3	60	**	11	0,8
Leptocarpus asper	3	60	**	11	0,8
L. membranaceus	4	80	**	10	0,8
Staberoha cernua	5	100	***	8	0,6
Willdenowia teres	3	60	**	27	0,9

Hypodiscus alternans, although not being entirely restricted to this community type or occurring in all the sampling sites, has, nevertheless, a high indicator value which a more detailed study might prove to be significant of particular habitat conditions.

Although not reaching any significance Aulax umbellata can usually be found in association with Hypolaena digitata under these drier conditions. Tetraria bromoides and Protea scabra can also be found on the exposed yellow plinthic soils. These latter four species are indicative of yellow plinthic soils but have wider ecological tolerance than is represented by this community.

2.3.4 Mixed ericoid and restioid fynbos of the rocky ridges on the flats bordering the Elgin basin

Two final association-analysis groups have been combined to form this community. Group 11 consists of sampling sites 98, 103, 120, 123 and 140 and group 13 consists of stand 119 alone.

The defining species of group 11 are:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
-Erica fastigiata
-Erica placentaeflora
-Tetraria fasciata

The defining species of group 13 are:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
+Indigofera mauritanica

This community has been included under the yellow plinthic soils vegetation although it is only represented by few of the indicator species of this group. Hypolaena digitata, for instance, is often encountered which is one of the more tolerant species found on the yellow plinthic soils. The species composition of this community indicates that although it is more closely related to the white sandstone soils vegetation group, there is influence from the yellow plinthic soils through close proximity.

This community is of a drier type of fynbos because the Elgin basin, in the surveyed area, is situated in the rain-shadow of both the north-west and south-east rain-bearing winds.

The vegetation reflects this lack of moisture by the greater restioid and wiry ericoid complement.

The characteristic species of this community are:

TABLE 4.11

Species	P.	Const.	Signif.	Cont.	I.V.
Blaeria ericoides	3	50	*	13	0,8
Chondropetalum hookerianum	6	100	***	6	0,5
Coleonema juniperinum	2	33		50	1,0
Leptocarpus membranaceus	4	66	**	10	0,7
Metalasia cepubifolia	2	33		33	0,9
M. lichtensteinii	3	50	*	15	0,8
Phaenocoma prolifera	4	66	**	11	0,7

No species has a high indicator value which demonstrates the mixed nature of the community. Chondropetalum hookerianum which occurs in all the sampling sites often reaches dominance.

2.3.5 Mixed proteoid and tussock fynbos of the mesic southerly shale-sandstone transitions

This community is represented by five stands, namely 49, 69, 70, 86 and 134 which form group 4 in the association-analysis hierarchy.

The defining species for this community are:

+Chondropetalum hookerianum
+Anthospermum ciliare
-Restio egregius

The representative sites of this community are all located on the transitional zones between the shale band of the Cedarberg formation and the tillites of the Pakhuis formation, below or between the Cedarberg formation shale band and the upper sandstones of the Nardouw formation.

The shale band is often covered by a layer of sandstone detritus from the upper sandstones. Plants having deeper root systems but which grow mainly on shales can therefore survive on these areas which appear to be entirely sandstone. Widdringtonia cupressoides therefore often forms the upper limits of the shale vegetation. Species normally occurring on shales but having shallower root systems can conversely survive on the tillites below the shale band where weathered material from the shale bands collect.

Recently exposed (geologically) harder tillites below the softer shales often form exposed sheets of rock which have undergone little weathering and have very little soil covering. Species commonly encountered here are: Blaeria ericoides, Coleonema junipermum, Drosera hilaris, Erica parvula, Macrochaetium dregei, Othonna dentata, Rochea jasminea and numerous small geophytes such as Disa vaginata, D. uncinata, Penthea patens and Urginea dregei.

Those tillite areas which have been subjected to longer periods of weathering support a flora which shows similarity to that immediately above the shale band. This community varies according to the moisture conditions of the habitat but is generally composed of a mixture of one metre to two metre tall Proteaceae and Ericaceae and tussocky Cyperaceae and Restionaceae.

Stand 5, recognized by Grobler (1964) appears to be located on the lower tillite transitionary zone with stand 4 representing the upper shale transitionary area.

The characteristic species of the mixed proteoid and restioid fynbos of the moister southerly shale to sandstone transitions are:

TABLE 4.12

Species	P.	Const.	Signif.	Cont.	I.V.
Anthospermum ciliare	5	100	***	13	0,8
Clutia polygonoides	3	60	**	18	0,9
Gnidia anomala	2	40	*	16	0,9
Hermas villosa	2	40	*	40	1,0
Phylica humilis	2	40	*	33	1,0
P. imberbis	3	60	**	10	0,7
Restio occultus	4	80	**	7	0,6
R. purpurascens	2	40	*	18	0,9
Schizaea pectinata	4	80	**	14	0,8
Stoebe spiralis	2	40	*	50	1,0

No species has a high indicator value and the only species to occur in all the sampling sites, Anthospermum ciliare, is a defining species.

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2.4 The fynbos on inland white sandstone soils

The major part of the area surveyed is mountainous, being composed of sandstones of the Table Mountain Series. The soils which develope in these mountainous areas are basically a well-leached white sandy soil which might on occasion have a high organic content but a low clay fraction is characteristic. The soil is poor in mineral nutrients and drainage is good.

During the summer months, the mountains are often covered by south-east clouds, which often results in rain, particularly in the southern portions. The flora at higher altitudes obtains a supply of moisture during the summer months which is not available to the drier fynbos of the lower altitude northerly areas. The higher the mountains, the greater is the effectivity of the south-east mists and the steeper are the slopes which can be colonized by the vegetation. Taylor (pers. comm.) regards some of the southerly slopes as being amongst the most steeply vegetated he has seen in the South-Western Cape.

2.4.1 Mixed short ericoid and restioid fynbos of shallow sandy xeric flats

This community is represented by seven sampling sites which have been classed into two final groups in the association-analysis hierarchy.

Group 16 consists of sites 111, 113, 116, 124, 125 and 126.

Group 20 consists of site 121.

The defining species for group 16 are:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
-Indigofera mauritanica
-Dilatris pillansii
+Staberoha cernua
-Hypolaena digitata

The defining species for group 20 are:

-Chondropetalum hookerianum

+Hypodiscus aristatus
-Phaenocoma prolifera
+Erica coriifolia

This community can typically be found on a coarse pebbly sandy soil of the Grovedale Series which is well-drained and becomes very hot and dry in summer. The slope is generally 2^{o} to 3^{o} although on occasion 8^{o} has been recorded. Small low rock outcrops are also found scattered through these shallow sandy flats. The altitudes which were recorded at the sampling sites varied between 260 m and 400 m. The sites were all located on flat areas in the Elgin Basin where drier conditions are found, particularly during summer.

The community shows many xerophytic characters particularly in the form of short Restionaceae, which are common, and wiry ericoids. Chondropetalum hookerianum and Erica cristata often become dominants. Site 121 has a deposit of coarse sand over yellow plinthic soil and the vegetation shows certain characteristics of the mixed dry fynbos on the shale-sandstone transitions (2.3.3) but because of the depth of soil and coarseness of the sand is most closely related to this group.

The characteristic species of this group are:

TABLE 4.13

Species	P.	Const.	Signif.	Cont.	I.V.
Erica coriifolia	6	85	***	12	0,7
E. placentaeflora	4	57	*	22	0,9
Hypodiscus argenteus	4	57	*	16	0,8
H. aristatus	7	100	***	10	0,6
Leptocarpus asper	7	100	***	26	0,9
L. membranaceus	6	85	***	16	0,8
Restio debilis	5	71	**	16	0,8
R. egregius	5	71	**	10	0,6
Tetraria fimbriolata	6	85	***	8	0,5
Thamnochortus gracilis	4	57	*	16	0,8
Willdenowia teres	3	42	*	27	0,9

Although none of the characteristic species have high indicator values, a number of species occur in most of the sampling sites.

2.4.2 Mixed short ericoid and restioid fynbos of lower slope drainage lines

This mixed short ericoid and restioid fynbos is represented by six sampling sites in the association-analysis hierarchy, constituting group 18 namely: 94, 95, 109, 110, 114 and 141.

This community is defined by the following species:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
-Indigofera mauritanica
-Dilatris pillansii
-Staberoha cernua
-Chondropetalum deustum

This community constitutes the negatively defined leg of the group having Chondropetalum hookerianum present, in the association-analysis hierarchy.

In contrast to the mixed fynbos of the xeric sandy flats (2.4.1), this community occurs on the lower, gently sloping (3^o to 8^o), hillsides near or on the edge of the Elgin Basin, where drainage lines occur between rocky slopes and rock outcrops. The coarse pebbly sand is shallower, being between 10 cm to 15 cm deep at altitudes varying between 120 m and 440 m.

The vegetation is generally taller than that found in the dry sandy flats and Restio bifarius can often be found as a dominant with the shorter Elegia parviflora. The Restionaceae and Cyperaceae which form the major part of this community have Ericaceae such as Erica pulchella and Nagelocarpus serratus commonly interspersed.

The characteristic species are:

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TABLE 4.14

Species	P.	Const.	Signif.	Cont.	I.V.
Elegia parviflora	6	100	***	8	0,7
Erica cristata	3	60	**	18	0,9
Hypodiscus argenteus	5	83	***	16	0,8
Hypolaena cf. crinalis	2	40	*	16	0,9
Leptocarpus asper	4	66	**	11	0,8
Restio bifarius	5	83	***	9	0,7
R. subverticellatus	2	40	*	25	0,9

Elegia parviflora, which often reaches dominance, is the only species occurring in all the sampling sites in this community. The mixed nature of this community is shown by the low indicator values.

2.4.3 Mixed ericoid and restioid fynbos of the lower northerly rocky slopes

The following six sampling sites: 92, 96, 107, 115, 118 and 127, were grouped into group 15 in the association-analysis hierarchy and are defined by the following species:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
-Indigofera mauritanica
-Dilatris pillansii
+Staberoha cernua
+Hypolaena digitata

This community was recorded on the lower northerly facing slopes of the more inland mountains between altitudes of 120 m to 500 m. The slope at the recording sites was found to vary between 19° and 29°. A rudimentary coarse shallow sand originating from sandstone supports this community in rocky areas. The habitat is exposed to the incident rays of the sun and is in the rain-shadow from the south-easters and is consequently warm and dry in summer.

The large member of the Cyperaceae, Tetraria thermalis, forms a conspicuous element in this community, but its pattern of distribution is clumped and it was resultantly not recorded

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in every sample plot in this community, although, when not recorded in the sampling sites, it was found to have been recorded in the list of other species found in the surroundings.

Restionaceae are the conspicuous elements of this community although the ericoid leaved Erica massoni, Nagelocarpus serratus, Phaenocoma prolifera and Sympieza pallescens might also be commonly encountered.

The characteristic species of group 15 are:

TABLE 4.15

Species	P.	Const.	Signif.	Cont.	I.V.
Chondropetalum hookerianum	6	100	***	7	0,5
Elegia racemosa	4	66	**	50	1,0
E. spathacea	4	66	**	12	0,7
Hypolaena digitata	6	100	***	25	0,9
Leptocarpus asper	4	66	**	19	0,8
Restio bifarius	6	100	***	14	0,7
R. debilis	4	66	**	16	0,8
R. similis	6	100	***	10	0,6
Staberoha cernua	6	100	***	9	0,6
Thamnochortus pulcher	5	83	***	8	0,5

Chondropetalum hookerianum and Restio bifarius are often the dominant species in this community which is otherwise of a mixed nature.

2.4.4 Mixed short ericoid and restioid fynbos of the xeric upper drainage lines

Seven sampling sites have been arranged into group 17, namely 78, 79, 80, 81, 85, 93 and 138, which constitutes the mixed short ericoid and restioid fynbos of the xeric upper drainage lines. The defining species are:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
-Blaeria dumosa
-Indigofera mauritanica
-Dilatris pillansii
-Staberoha cernua
+Chondropetalum deustum

The sampling sites are all located at altitudes of between 300 m and 600 m in areas which are not very steep (maximum measured slope is 13°) and face in a northerly direction. A shallow coarse sand such as occurs in the lower altitude drainage line fynbos community (2.4.2) can be found but the higher altitude results in cooler and moister conditions during summer, because of the south-east winds which often form clouds and sometimes bring rain. This community is nevertheless still subject to periods of dry conditions and there is not the accumulation of organic material in the soil such as takes place under moister conditions (e.g. the fynbos of the mesic upper drainage lines).

Physiognomically the vegetation consists mainly of tussocky restionaceous species with interspersed wiry ericoids. The occurrence of Chondropetalum deustum is associated with higher altitudes and slightly moister conditions and this species eventually appears to replace Chondropetalum hookerianum at higher altitudes. Similarly Restio bifidus appears to be more common than R. bifarius at the higher altitudes while many more species of Ericaceae can be found in the higher altitude drainage lines than at the lower altitudes.

The characteristic species are:

TABLE 4.16

Species	P.	Const.	Signif.	Cont.	I.V.
Blaeria barbigera	2	28		25	0,9
B. ericoides	4	57	*	17	0,8
Chondropetalum deustum	7	100	***	14	0,7
C. hookerianum	7	100	***	7	0,5
Elegia spathacea	6	85	***	15	0,7
Erica cristata	4	57	*	25	0,9
E. imbricata	5	71	**	12	0,7
E. pulchella	7	100	***	9	0,6
Hypolaena cf. crinalis	3	42	*	25	0,9
Nebelia fragaroides	3	42	*	42	1,0
Restio bifarius	6	85	***	14	0,7

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Species	P.	Const.	Signif.	Cont.	I.V.
R. bifidus	5	71	**	17	0,8
R. similis	7	100	***	10	0,6
Sympieza pallescens	6	85	***	10	0,6
Tetraria flexuosa	4	57	*	26	0,9
Thamnochortus insignis	2	28		66	19,4
T. pulcher	7	100	***	9	0,6

Only one species, Thamnochortus insignis, has a high indicator value but only occurred in two of the sampling sites. Chondropetalum deustum, C. hookerianum, Erica pulchella, Restio similis and Thamnochortus pulcher were found to occur in all the sampled stands.

2.4.5 Mixed ericoid and restioid fynbos of mesic upper drainage lines

Five sampling sites were located in this community belonging to group 7 of the association-analysis hierarchy, namely: 84, 142, 143, 144 and 150.

The defining species are:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
+Erica fastigiata
-Sympieza pallescens
-Drosera glabripes
-Protea cynaroides

This community was found between altitudes of 410 m and 850 m in shallow, coarse, sandy soil in moister drainage lines which tended towards the accumulation of organic matter. The maximum slope recorded was 14^{o} which was also found to be at the site having the highest altitude, where the better drainage would be offset by the moister conditions of the location.

The vegetation was found to be predominantly restionaceous although a greater number of ericoid leaved species occurred than in the drier drainage lines. In the wetter zones Brunia alopecuroides and Nebelia fragaroides often occur as dominants although only the latter of the two species has a significant distribution in this community according to Goodall's Indicator

Values (see table 4.17).

The summit floras were found to be amongst the better collected in the area because the summit ridges provide easier access routes through the area.

Grobler (1964) appears to have included this community with the rocky summit ridge community in his stand 1.

The characteristic species of group 7 are:

TABLE 4.17

Species	P.	Const.	Signif.	Cont.	I.V.
Brunia albiflora	3	60	**	15	0,8
B. alopecuroides	2	40	*	40	1,0
Chondropetalum deustum	5	100	***	10	0,7
C. mucronatum	2	40	*	25	0,9
Danthonia lanata	2	40	*	16	0,9
Elegia spathacea	4	80	**	10	0,7
Erica fastigiata	5	100	***	20	0,9
E. hispidula	5	100	***	7	0,6
Nebelia fragaroides	2	40	*	28	0,9
Restio bifidus	3	60	**	10	0,8
R. similis	5	100	***	7	0,6
Villarsia capensis	4	80	**	25	0,9

Chondropetalum deustum, which sometimes occurs as a dominant, occurs in all the sampling sites and replaces C. hookerianum at higher altitudes. Erica hispidula also becomes a dominant in the moister areas at higher altitudes.

2.4.6 Mixed open fynbos of the summit ridge rocky outcrops

This community is represented by group 10 in the association-analysis hierarchy and includes the following sampling sites: 9, 12, 63, 76, 82 and 139. The following are the defining species:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
-Erica fastigiata
-Erica placentaeflora
+Tetraria fasciata
-Osmites parvifolia

This community was found on the rockier areas near or at the summits of the various mountains or hills in the area. The altitudes at which this community was recorded varied between 120 m and 640 m. Between the rocks, a sandy soil of varying depth accumulates, which is cooler than the adjacent drainage lines and sometimes even moister because of the shade afforded by the rocks. At the higher altitudes the south-east winds provide moisture during summer in addition to the winter rains. The drainage lines between the rock outcrops often form mosaics, particularly near the summits, where they have their sources.

Brunia albiflora was found to be a conspicuous emergent attaining heights of between 2 m and 3 m.

Grobler (1964) appears to have included this community with the upper mesic drainage line community in his stand 1.

The characteristic species of group 10 are:

TABLE 4.18

Species	P.	Const.	Signif.	Cont.	I.V.
Adenandra umbellata	3	50	*	18	0,9
Brunia albiflora	5	83	***	26	0,9
Centella difformis	2	33		40	1,0
Chondropetalum deustum	5	83	***	10	0,7
C. hookerianum	6	100	***	6	0,5
Danthonia macrantha	4	66	**	10	0,7
Elegia spathacea	4	66	**	10	0,7
Erica hispidula	6	100	***	8	0,6
E. imbricata	4	66	**	10	0,7
E. thomae	4	66	**	23	0,9
Ficinia ramosissima	5	83	***	10	0,7
Helichrysum sesamoides	3	50	*	13	0,8
Metalasia lichtensteinii	6	100	***	30	0,9
Nebelia paleacea	2	33		33	0,9
Phaenocoma prolifera	4	66	**	11	0,7
Restio bifarius	4	66	**	9	0,7
R. occultus	5	83	***	9	0,6
R. similis	6	100	***	9	0,6

Species	P.	Const.	Signif.	Cont.	I.V.
Sympieza pallescens	6	100	***	10	0,7
Tetraria fasciata	6	100	***	7	0,5
T. thermalis	6	100	***	11	0,7

Seven species occur in all the sampling sites but none have been attributed a high value using Goodall's Indicator Value index. Brunia albiflora and Tetraria thermalis are of common occurrence outside this community yet both form conspicuous elements within it.

2.4.7 Mixed fynbos of the lower southerly slopes

Three final groups in the association-analysis hierarchy have been combined to form this community.

Group 5 consists of stands 60, 75, 131 and 132 and is defined by the following species:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
+Erica fastigiata
+Sympieza pallescens

Group 9 consists of sites 74, 77, 108 and 133 and is defined by the following species:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
-Erica fastigiata
-Erica placentaeflora
+Tetraria fasciata
+Osmites parvifolia

Group 12 consists of stands 73, 87, 88, 90, 104 and 106 and is defined by the following species:

+Chondropetalum hookerianum
-Anthospermum ciliare
-Erica hispidula
+Blaeria dumosa

The general moisture conditions of the soil which was recorded at these sampling sites were classed as being moist; this was mainly because of the exposition resulting in cooler slopes which benefit from south-east clouds. The altitude was found to vary in group 12 between 100 m and 600 m which would include the ranges of both the other groups which were between 180 m and 360 m in group 9 and 230 m to 425 m in group 5. Where sampling sites of the latter two groups were located on the same mountain faces, group 9 sites were generally found to represent the lower altitudes than group 5 sites.

Some of the sampling sites had a vegetation which had affinities to the yellow plinthic soil communities but the specific habitats conditions formed by the southerly aspects resulted in these sites on upper T.M.S. sandstones being grouped together. Steep slopes were generally recorded with slopes of less than 26° being the exception, as in the case of the higher altitude of site 73 where an 8° slope was recorded, rather than the rule. The maximum slope recorded on two occasions in this community was 45°. The soil was a shallow coarse sand with occasional local accumulations of organic materials.

Leucadendron xanthoconus is a common emergent species, particularly at the lower altitudes while L. gandogeri usually replaces it at higher altitudes. A certain amount of intermediate hybrid forms between these two species can be found in the overlapping zones. A gradual change in the species complement particularly of Ericaceae occurs with an increase in moisture or higher altitudes. Erica corydalis is usually found at the higher altitudes where Chondropetalum deustum becomes commoner while C. hookerianum is a dominant at the lower altitudes.

Group 12 was found to contain extreme and intermediate forms of this community, which could explain the increase in the level of subdivision after this group had been split off in the association-analysis hierarchy.

Stands 2 and 3 recognized by Grobler (1964) appear to be representative of this community.

The characteristic species of groups five and nine combined are:

TABLE 4.19a

Species	P.	Const.	Signif.	Cont.	I.V.
Agathosma bifida	2	25		66	16,8
Alciope lanata	3	37		16	0,8
Blaeria dumosa	7	87	***	21	0,8
Bobartia indica	3	37		33	0,9
Brunia stokoei	4	50	*	50	1,0
Chondropetalum deustum	8	100	***	16	0,7
Clutia polygonoides	4	50	*	25	0,9
Danthonia macrantha	7	87	***	18	0,8
Drosera aliciae	3	37		23	0,8
D. glabripes	6	75	**	30	0,9
Elegia spathacea	6	75	**	15	0,7
Erica articularis	2	25		50	1,0
E. coccinea	5	62	**	12	0,6
E. fastigiata	4	50	*	16	0,8
E. hispidula	8	100	***	11	0,6
E. massoni	7	87	***	22	0,8
E. retorta	3	37		50	1,0
E. sitiens	5	62	**	50	1,0
Gerbera tomentosa	5	62	**	50	1,0
Indigofera tetragonoloba	3	37		50	1,0
Leptocarpus membranaceus	5	62	**	13	0,7
Lobelia coronopifolia	3	37		25	0,9
Metalasia lichtensteinii	5	62	**	33	0,9
M. sphaerocephala	2	25		50	1,0
Nivenia levynsiae	4	50	*	28	0,9
Osmites parvifolia	7	87	***	46	0,9
Pentaschistis juncifolia	5	62	**	11	0,6
Protea cynaroides	3	37		20	0,8
Restio obtusissimus	4	50	*	26	0,9
R. occultus	7	87	***	13	0,7
Restio similis	7	87	***	10	0,6
Saltera sarcocolla	7	87	***	17	0,7
Schizaea pectinata	5	62	**	18	0,8
Sympieza pallescens	6	75	**	10	0,6
Tetraria brevicaulis	5	62	**	55	16,8

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Species	P.	Const.	Signif.	Cont.	I.V.
T. cf. exilis	4	50	*	50	1,0
T. fasciata	8	100	***	9	0,5
T. thermalis	7	87	***	13	0,7

High indicator values have been attributed to two species, namely: Tetraria brevicaulis and Agathosma bifida, but their ecological significance is not well known. The numerous other significant species are the main contributors to this mixed community.

Grobler's (1964) stand two would be included within this community.

When the indicator values were computed for this community, it was considered that group 12 might represent another community, but this was not found to be the case and it has therefore been included although the specific comparisons are given separately.

The characteristic species of group 12 are:

TABLE 4.19b

Species	P.	Const.	Signif.	Cont.	I.V.
Blaeria dumosa	6	100	***	18	0,8
Bobartia gladiata	6	100	***	11	0,7
Centella triloba	3	50	*	27	0,9
Chondropetalum hookerianum	6	100	***	6	0,5
Dilatris pillansii	3	50	*	12	0,8
Elegia spathacea	4	66	**	10	0,7
Erica coccinea	4	66	**	10	0,7
E. velitaris	2	33		66	23,0
Metalasia lichtensteinii	3	50	*	15	0,8
Nivenia stokoei	3	50	*	15	0,8
Pentaschistis juncifolia	4	66	**	9	0,6
Restio bifarius	5	83	***	12	0,7
Scyphogyne longistyla	3	50	*	30	0,9
Sympieza articulata	3	50	*	18	0,9
Thamnochortus pellucidus	3	50	*	16	0,8
Willdenowia cf. humilis	2	33		25	0,9

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Erica velitaris, which is found in a third of the stands in this section of the community, has the highest indicator value. The other species have all been attributed values which are less than one.

2.4.8 Mixed fynbos of hygric upper southerly slopes

Two final groups in the association-analysis hierarchy have been combined to represent this community.

Group 6 consists of stands 129, 137, 145, 146, 147 and 149. Group 28 consists of stands 52 and 148.

The defining species for group 6 are:

+Chondropetalum hookerianum
-Anthospermum ciliare
+Erica hispidula
+Erica fastigiata
-Sympieza pallescens
+Drosera glabripes
+ Protea cynaroides

The defining species for group 28 are:

-Chondropetalum hookerianum
-Hypodiscus aristatus
-Metalasia muricata
-Erica pulchella
-Montinia caryophyllacea
+Osmites parvifolia

These sampling sites are located on the wetter steeper southerly slopes of the various mountains. The altitudes at the sampling siteswere recorded as varying between 245 m and 800 m. Group 28 differs from group 6 in habitat by the wetter moisture conditions prevalent through most of the year by virtue of their steeper southerly facing slopes (31^{o} to 45^{o}) with corresponding less exposure to the suns rays and greater extent of local seepage through the geological structure of the sandstones.

Moisture in this community is deposited in the form of rain from the north-west in winter and rain and mist from the south-east in summer.

Notwithstanding the moist conditions found at these sites, drainage is good which distinguishes the habitat from that of the Restio-Chondropetalum marshes (2.4.10).

The upper shrub canopy of the vegetation is mainly composed of various members of the Proteaceae (particularly Leucadendron gandogeri and Protea stokoei), Osmitopsis asteriscoides and Priestleya vestita, amongst others, while the lower shrub layer is a dense growth dominated by various Ericaceae, particularly Erica hispidula.

The moist nature of the habitat results in the vegetation being able to colonize very steep rocky slopes, even to the extent that Taylor (pers. comm.) has commented on them being amongst the most steeply vegetated slopes that he has seen in the South-Western Cape.

Floristically this is a very interesting community and many rare and endemic species can be found here, for instance: Erica leucotrachela, E. serratifolia, Protea stokoei, Mimetes argenteus, Sorocephalus clavigerus, Spatalla longifolia, Berzelia dregeana and many others, some of which are, as yet, undescribed new species. The rare Orothamnus zeyheri was also known to occur in this community. Many of the botanically interesting species are found near the summit ridges where the strong south-east winds are often encountered.

Stand 12 recognized by Grobler (1964) appears to be representative of this community.

The characteristic species of the combined groups 6 and 28 are:

TABLE 4.20

Species	P.	Const.	Signif.	Cont.	I.V.
Bobartia gladiata	8	100	***	15	0,7
Chondropetalum ebracteatum	3	37		27	0,9
Drosera glabripes	6	75	**	30	0,9
Elegia persistens	6	75	**	24	0,8
Erica corydalis	2	25		66	16,8
E. fastigiata	6	75	**	25	0,8
E. hispidula	8	100	***	11	0,6
E. massoni	5	62	**	16	0,7
Grubbia tomentosa	3	37		75	28,6

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Species	P.	Const.	Signif.	Cont.	I.V.
Hypodiscus albo-aristatus	2	25		40	0,9
Indigofera tetragonoloba	2	25		33	0,9
Leucadendron gandogeri	7	87	***	31	0,9
Nivenia levynsiae	4	50	*	28	0,9
Osmites parvifolia	4	50	*	26	0,9
Protea cynaroides	4	50	*	26	0,9
Raspalia microphylla	3	37		75	28,6
Restio dispar	3	37		60	16,8
R. obtussissimus	3	37		20	0,8
R. stokoei	2	25		40	0,9
Schizaea pectinata	4	50	*	14	0,7
Tetraria flexuosa	3	37		20	0,8
Villarsia capensis	3	37		18	0,8

Erica corydalis, Grubbia tomentosa, Raspalia microphylla and Restio dispar all have fairly high indicator values but are indicative of more specialized habitats than is encompassed by this community. Erica hispidula which occurs in all the sampling sites is a regular prominent species in this community.

2.4.9 Restio-Chondropetalum tussock marshes

Four sites have been grouped into final group no. 30 in the association-analysis hierarchy, namely: 56, 83, 112 and 117 and represent this community.

The defining species are:

-Chondropetalum hookerianum
-Hypodiscus aristatus
-Metalasia muricata
-Erica pulchella
-Montinia caryophyllacea
-Osmites parvifolia
-Leucadendron xanthoconus
+Erica intervallaris
+Restio purpurascens

This community can be encountered on all slopes, irrespective of aspect, where wet marshy seepage conditions occur in the mountainous areas. The slope can be gradual such as on the summit plateaus or steep on southerly slopes.

Scattered clumps of Chondropetalum mucronatum are distinct and easily seen while climbing through the area but they are often of very limited size and as such cannot all be mapped, except where extensive marshes occur. They have generally been regarded as an integral part of the community in which they occur.

The vegetation consists of a dense restioid mat, usually of Restio ambiguus, forming a dense ground cover with tall ericoid and restioid emergents. The habitat conditions where this community is found are very specialized and interesting species can sometimes be encountered. Lonchostoma monogynum which is rare in the survey area, is localized to such marshy areas, while Grubbia rosmarinifolia, which belongs to the endemic family Grubbiaceae, can reach heights of 3 m and more.

Stands 14 and 15 recognized by Grobler (1964) appears to show aspects of this community.

The characteristic species of group 30 are:

TABLE 4.21

Species	P.	Const.	Signif.	Cont.	I.V.
Chondropetalum mucronatum	2	50	*	25	0,9
Danthonia cincta	2	50	*	28	1,0
Drosera aliciae	2	50	*	15	0,9
Erica intervallaris	3	75	**	33	1,0
E. macowanii	2	50	*	50	1,0
Osmitopsis asteriscoides	2	50	*	28	1,0
Restio ambiguus	3	75	**	100	181,5
R. obtussissimus	2	50	*	13	0,9
R. purpurascens	3	75	**	27	0,9
Villarsia capensis	4	100	***	25	0,9

Chondropetalum mucronatum often forms very dense stands which can be two to three metres tall. Osmitopsis asteriscoides and Villarsia capensis commonly occur in any wet, marshy conditions throughout the area and are not restricted to this community.

Elements of this community can be found in many of the mountain streams in association with the Berzelia-Pseudobaeckea tall fynbos (2.5.2).

2.5 Riparian vegetation

Distinct communities can be found in or alongside drainage channels which have temporary or permanent movement of surface water.

Two principal substrate habitats can be found:

(1) Rocky stream beds and banks with very little alluvium where the plants are strongly rooted and wedged into cracks and crevices between stones, boulders and rock faces.

(2) The sand, mud and alluvial river banks where the plants have deeper and more extensive root systems.

The main river systems having a permanent flow of water are (1) the Palmiet River with its main tributaries the Klein Palmiet, the Dwars and the Louws Rivers,(2) the Cascades Stream, (3) the Buffels River and (4) the Rooi Els River.

2.5.1 Brabeium-Rhus riverine scrub

Five sampling sites representing group 27 in the association-analysis, 13, 89, 91, 100 and 101, are located in this community and are defined by the following species:

-Chondropetalum hookerianum
-Hypodiscus aristatus
-Metalasia muricata
-Erica pulchella
+Montinia caryophyllacea

This community is found where sand and mud are deposited as alluvial river banks. The rivers only carry a heavy silt load during times of floods, particularly in the case of the Palmiet River, which flows through cultivated lands of the Elgin Basin while the rest of the streams have their sources in the Kogelberg State Forest where farming is not practised.

The undisturbed form of this community is a 3 m to 4 m tall, dense scrub in which a number of forest tree species can be found, such as, Cunonia capensis, Laurophyllus capensis, Podocarpus elongatus, Rapanea melanophloeos, etc., but the species complement is entirely different from the forest communities of the broad leaved scrub with which it must not be confused.

Various zones have been included under this one community of which the main ones are:

(1) The upper zone which fringes the water only during floods and contains many fynbos elements from the adjacent communities. The following species might be mentioned: Asparagus thunbergianus, Arctotis semipapposa, Erica discolor, Halleria elliptica, Leucospermum conocarpodendron, etc. The latter species appears to have been replaced by Protea arborea in the upper Buffels River Valley, where some exceptionally large individuals could be found, before they were destroyed during dam building operations.

(2) The middle zone which is fringed by water during high periods of flow and submerged during times of floods. Here the forest tree species mentioned above can be found with other species such as Brabeium stellatifolium, Halleria elliptica, Montinia caryophyllacea, Rhus tomentosa and others.

(3) The lower zone which fringes the water during normal flow and is submerged during periods of high flows, consists mainly of Cannamois virgata, Phragmites australis and Restio subverticillatus. Nearer the river mouths Phragmites australis can be found growing in the streams while Sporobolus virginicus forms thick mats to the water's edge.

Fires occasionally spread into the riparian scrub particularly where piles of brushwood have accumulated during times of floods.

Stand 7 recognized by Grobler (1964) appears to be representative of this community.

The characteristic species of group 27 are:

TABLE 4.22

Species	P.	Const.	Signif.	Cont.	I.V.
Agathosma imbricata	3	60	**	100	144,0
Anthospermum aethiopicum	3	60	**	21	0,9
Arctotis semipapposa	3	60	**	75	47,3
Brabeium stellatifolium	4	80	**	100	202,0
Cassytha filiformis	3	60	**	30	0,9
Diospyros glabra	4	80	**	66	39,6
Erica discolor	2	40	*	100	86,0
Ficinia ramosissima	4	80	**	8	0,7
Halleria elliptica	3	60	**	100	144,0
Laurophyllus capensis	2	40	*	50	1,0
Montinia caryophyllacea	4	80	**	66	39,6
Myrsine africana	2	40	*	66	28,0
Passerina vulgaris	4	80	**	36	1,0
Pelargonium cucullatum	2	40	*	40	1,0
Pteridium aquilinum	3	60	**	50	1,0
Rhus tomentosa	4	80	**	100	202,0
Rochea subulata	2	40	*	25	0,9
Scyphogyne muscosa	3	60	**	33	0,9
Thamnochortus gracilis	3	60	**	12	0,8
Widdringtonia cupressoides	3	60	**	37	1,0

Brabeium stellatifolium and Rhus tomentosa, which have been used to describe this community, have been attributed the highest indicator values of all the species in all the groups.

2.5.2 The Berzelia-Pseudobaeckea tall fynbos of rocky streams

This community can be found along the rocky streams where very little alluvium has collected. The plants are strongly rooted and are wedged between cracks and crevices.

Because this community occurs as a narrow margin alongside streams it is not suited to sampling using the standard 10 m x 5 m quadrat.

The rocky streams are very numerous and some have a permanent flow of water while others only flow during the wetter months. Elements of the Restio-Chondropetalum tussock marsh community (2.4.10) can sometimes be found growing in

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association with the rocky stream fynbos. The rocky streams are very numerous in this mountainous area and form an integral part of each community through which they flow and they cannot be mapped independantly at the scale involved here.

On the stream banks and sometimes in the streams, the following species may be encountered: Berzelia lanuginosa, Brunia albiflora, Leucadendron salicifolium, L. xanthoconus, Metrosideros angustifolia, Pseudobaeckea africana, Restio dispar and R. purpurascens, amongst many others. In the streams where normal stream flow would keep them moist, the boulders are often covered by a thick mat of Scirpus digitatus which is very strongly rooted to withstand fast flowing streams.

The Scirpus digitatus, particularly in the more permanent portions of the streams, provides a suitable habitat for innumerable individuals of Disa tripetaloides, while at higher altitudes in the cool moist overhangs or otherwise moist sheltered sites, plants of Disa uniflora can be found, which form bright splashes of orange to red during February.

Stand 8 recognized by Grobler (1964) would appear to be included within this community.

2.5.3 Prionium-Wachendorfia swamp

The slower flowing permanent streams in the area are often overgrown by dense stands of Prionium serratum, Blechnum capense, Todea barbara and Wachendorfia thyrsiflora. Occasional trees of Psoralea pinnata, Cunonia capensis, Widdringtonia cupressoides and Brachylaena neriifolia are scattered amongst this dense growth to give a park like effect.

This community colonizes the shallower portions of these streams leaving dark open pools in between, which are too deep for colonization.

Flow through this dense growth is slow and silt deposition eventually results in this community growing on dry land (such as can be seen alongside the Cascades Stream in the Harold Porter Botanic Garden) when sporadic floods then either open new channels or wash this vegetation away.

This community is best seen in the Louws and Buffels Rivers. The sampling of this community is virtually impossible because of the dense growths with deep holes in between. The major river in the area, the Palmiet River, has been attributed the common name for Prionium serratum.

3. ALIEN VEGETATION

The term alien vegetation is used here to denote introduced plants which grow spontaneously and can maintain themselves in the vegetation in their country of adoption and which form a permanent cover.

Taylor (1969) quotes Bews (1916) who remarked that "the vegetation of South Africa, on the whole, is resistant to invaders" yet the pest-plants have now reached serious proportions in all four provinces and in diverse vegetation types. In the winter rainfall region of the Cape Province, nearly half-a-million morgen of wild veld is infested by pest-plants. Pest-plants are the aggressive introduced woody perennial species which form permanent cover and spread unaided by man into natural plant communities.

In the Hangklip area considerable efforts have been made by various local and state authorities to eradicate and control the various pest-plants. A group of Betty's Bay citizens have a regular monthly meeting to eradicate the pest-plants on the local commonages. This gathering have aptly called their activities "The Battle of Betty's Bay" and recently held their 100th "hacking party". The Department of Forestry regularly sends out teams of labourers to clear pest-plants from the department's property.

The alien vegetation establishes itself in disturbed or uncolonized areas and extends into the natural vegetation when fire or some other disturbance destroys the vegetation cover. These hardy species then regenerate more vigorously than the indigenous flora. All the pest-plants regenerate profusely after a veld fire, either because the heat stimulates the germination (Acacia spp.) or because it opens serotinous fruits and cones (Hakea and Pinus spp.), thereby releasing the seed (Taylor, 1969).

3.1 The Acacia cyclops thicket

Acacia cyclops was originally introduced into South Africa to fix the drift sands of the Cape Flats as has been described by Roux (1961). This species appears to have fulfilled its alloted function fairly successfully even to a natural spread to the Hangklip area where the large sand dune, which gives the Blesberg its name, has been considerably reduced in size since aerial photographs were taken of it in 1938 (Job 126). Acacia cyclops has formed dense thickets, along with the Colpoon-Rhus dune scrub (1.1.2) between this dune and the sea, resultantly no new sand from the beaches is being added. Unfortunately areas which have not been subjected to open moving dunes and which were covered with indigenous coastal dune vegetation, have also been colonized, to the detriment of the indigenous vegetation, which is slowly becoming dominated by dense stands of this Acacia species and could eventually completely replace this vegetation. At Cape Hangklip dense stands of Acacia cyclops now occur where Sideroxylon scrub was formerly common according to local inhabitants (Prof. C.M. Muller, pers. comm.).

Acacia cyclops forms the most extensive infestations of any of the alien species in the Hangklip area. The densest thickets occur along the south-east to westerly foot of the Groot Hangklip Mountain. Portions around the Silver Sands Estate Extension and further towards Betty's Bay are being periodically cleared by a group of Betty's Bay residents. Here the indigenous vegetation has not been influenced to the same extent as in the Groot Hangklip area.

Scattered small thickets and individual bushes are found all along the coastal plain and up the slopes of the drier coastal mountains. The main distributing agents are the seed eating wild birds, particularly the redwing starling (Amydrus morio morio) and the pied starling (Spreo bicolor).

The heat from fires is one of the more effective stimulants for the germination of the seeds of this pest-plant. After fires, in particular, this species regenerates much more vigorously than the indigenous vegetation does. Fires or other disturbance should theoretically, therefore, be completely excluded from the drier sandier areas of the coastal plain if the indigenous vegetation is to survive this vigorous intruder.

Acacia cyclops competes most successfully with the *Colpoon-Rhus* dune scrub (1.1.2) and less successfully, but still to a fairly extensive degree, with the limestone fynbos (2.1.3), while scattered individuals only are found in the *Coleonema album* fynbos (2.1.1). Fairly large thickets might be encountered in the mixed coastal fynbos of acid sands (2.1.2) where this community has been disturbed, particularly by clearing.

3.2 The Pinus pinaster tree clumps

Pinus pinaster, or the cluster pine, were originally planted for saw timber (Taylor, 1969) but have since proved to be hardy species capable of surviving and extending their distribution naturally in the veld.

Infestations are the worst in the lower altitudes of the mountains, particularly nearer to established plantations such as in the Highlands State Forest, Steenbras Dam catchment plantations and the plantations in the Elgin Basin. The Kogelberg State Forest has always been managed as a nature reserve since it has been controlled by the Forest Department and active measures are taken to eradicate any *Pinus pinaster* infestations.

Unfortunately the Kogelberg State Forest is very rugged and access paths are few, local dense infestations in inaccessible portions of the area can therefore still be found, particularly along the eastern portions of the Dwarsrivier Mountains and up the Spinnekopneskloof. Access to the latter has been considerably improved recently.

The coastal plain supports cluster pine infestations in the rockier areas. A plantation can be found on the roadside between Pringle Bay and Betty's Bay. This is the only introduced plantation in this area. Various local cluster pine clumps can be found, at the Buffels River mouth on the Rooi Els side, some "escaped" clumps near the plantation mentioned above, on the Elephant Rock Estates, and on a hill near Fairy Glen which is fairly densely infested and has been called Pine Hill.

Scattered *Pinus pinaster* individuals can be found through the rest of the area and can potentially develope into clumps if not destroyed.

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The fynbos shows remarkable ability to regenerate after removal of Pinus pinaster plantations but no study has as yet been undertaken in this respect. The dense litter of pine needles which accumulates under the pine trees and the shade from the trees, suppresses the fynbos vegetation.

Fire provides bare areas and stimulates germination by opening the serotinous fruits and cones and is therefore an important ecological factor governing the spread of this pest-plant. Baboons eat the seeds and appear to be the main distributing agent to isolated areas.

3.3 Other alien species

Only mention will be made here of those alien species which have become pest-plants according to Taylor's (1969) definition. This would exclude a small plantation of Pinus radiata on private property alongside the road to Oudebos Farm and another alongside the road between Pringle Bay and Betty's Bay.

Acacia longifolia is the common pest-plant along the Palmiet River, particularly, and some of the other river banks. Acacia cyanophylla can also be found along the river banks and also on the coastal plain where it becomes the subject for attack during "hacking" operations.

A dense stand of Acacia mearnsii surrounds the old derelict Oudebos farmhouse and provides shade at the popular camping site called Fairy Glen. This species does not appear to spread into the indigenous vegetation to the extent of some of the other pest-plants but maintains itself, once established, in areas of human activity. Eucalyptus lehmannii which has similar tendencies and can be found around the old gaol and at the "cooling stream" or turnoff to the Blesberg area. In the latter locality, Albizia lophantha has occurred but is on occasion removed by the local residents.

Hakea sericea occurs in fair quantities at one locality only which is near the Buffels River source above the dam. The rest of the area only supports scattered individuals but which can become dense stands if left to be subjected to fires when the serotinous fruits open releasing the seeds. The Mountain Club of South Africa in association with some of the Betty's Bay residents, recently destroyed a colony

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on the eastern slopes of the Klein Hangklip Range. Regular patrols are undertaken by Forest Department staff to destroy the scattered Hakea plants which periodically appear in the Kogelberg State Forest.

Leptospermum laevigatum, which was introduced from Australia for hedges and windbreaks and for combating drift sands on the Cape Flats (Taylor, 1969), is a pest-plant which is spreading rapidly because of its ability to regenerate from coppice shoots in addition to having serotinous fruits. This species can be found near the mouth of the Palmiet River in the vicinity of Fairy Glen and the Oudebos turnoff and at the roadside between the Klein Hangklip Range and the sea.

A few individuals of Populus canescens, of which only male trees are known in South Africa (Adamson and Salter, 1950), occur along the lower course of the Buffels River. This species spreads freely from suckers and, therefore, could be regarded as a potential danger to the indigenous vegetation.

Various of these pest-plants are found in local residents' gardens but have not been included in this study.

CHAPTER 5

CONCLUSIONS

The large number of species in the fynbos vegetation is one of the major difficulties to overcome in a survey of this type of vegetation. The collection of flowering specimens for identification generally requires a period of a full year prior to the actual collection of vegetation data. Recognition of these taxa in the vegetative state, once the actual survey is being undertaken, presents the biggest problem, primarily because of the similar appearance of many species (more than 110 species of Ericaceae, which are characterized by "ericoid" leaves, have been collected in the area, to date). This problem was largely overcome by making use of a field herbarium consisting of specimen scraps mounted on index cards. Identification by comparison of vegetative material could in most cases be successfully accomplished in the absence of flowering material.

The stratification of the vegetation into physiographic-physiognomic units on aerial photographs, improved the distribution of sampling sites considerably, although further refinements could be made. The major units, for instance, should preferably be evaluated by entirely separate surveys to ensure their successful analysis. The number of sampling sites in each unit could then be increased without creating the problem of some of the data having to be rejected prior to analysis so that it can be accommodated by the available computer facilities. Variations within each of the obviously different physiographic-physiognomic units could be analysed more efficiently if each was treated as a separate entity, because sampling sites could then be located in each. The evaluation, which must necessarily be subjectively assessed, would then be considerably less difficult because less data would be involved. Some suggested major units which could be delimited and treated as separate entities in the Hangklip area are:

(1) Forests - these were in actual fact treated separately, but were not sampled, only subjectively described.

Their quantitative assessment might confirm the subdivisions suggested in the classification.

(2) The riverine scrub.

(3) The coastal communities on dune sand.

(4) The fynbos communities.

Division of the fynbos into that found on yellow plinthic soils and on white sandstone soils cannot be accomplished into indisputably distinct entities on conventional panchromatic aerial photographs. The use of false colour or conventional colour photographs might make this a feasible division for separate analysis. These subdivisions would result in an enormous reduction in the computational load, when comparing the data, because of the almost entirely different flora found in each subdivision. Each subdivision could be thoroughly sampled and investigated objectively, while the subjective initial divisions would be indisputably distinct and natural, making objective separation unnecessary in any event. If the sampling of a particular major unit proved to be inadequate, by proving to be more complex than the others, for instance, then more sampling sites could be established and recomputation of the data would be more feasible because less data were involved than if the total of the data collected were to be reanalyzed.

In instances where obviously different vegetation units have a distribution pattern which cannot be adequately accommodated within the standard shape or size of quadrat, it would be more practical to vary these factors for more efficient sampling and therefore eventual evaluation of that particular unit. The riverine scrub, for instance, often forms a narrow belt alongside the river and the standard sampling quadrat used during the present survey sometimes resulted in elements of the adjacent but entirely different fynbos vegetation being included within the sample. The construction of the sampling site in the field having its long axis placed on a fixed north-south line sometimes accentuated this difficulty. A less rigid system, "fitting" the quadrat into the pattern of the community, would solve this problem. Accepted phytosociological techniques do

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not have such rigid requirements for sample size, shape, number or location and have thereby largely solved the above problems. The subjective location of sampling sites is, however, not statistically acceptable and can therefore not be applied within a quantitative survey because the sampling would then, in effect, reflect the analyst's subjective assessment of the vegetation. The sampling intensity can be increased in any vegetation unit recognized, ad lib, according to its complexity as assessed subjectively during the initial collection of field data or, if found necessary, after the construction of the initial tables, when the data are found to be insufficient or even when more data become available from new areas. These additions to the tables can be effected without excessive reorganization. This is the same principle which is being striven for in the frequency modulated homogeneity functions. The latter method requires the recalculation of the total data to accommodate the additional information, but without disturbing the grouping already effected.

The stratification of aerial photographs according to the major physiographic-physiognomic units and the distribution of sampling sites randomly within these units, appear to result in less sampling of transitionary areas, than Taylor (1969) found using sampling units located on the intersections of a uniform grid distributed over the whole area.

The location, in the field, of the sampling sites was found to be easily and fairly accurately determinable from the 1961-62 aerial photographs. Occasionally an area had been burnt prior to the aerial photographs being taken, in which case the topographic features became rather obscured by the whiteness of the substrate. Reference to the older 1938 aerial photographs of these areas generally solved this problem. The most recent aerial photographs available for this study were those of the 1961-62 series (Job 461). The mapping of relatively unstable communities such as those occurring in the coastal areas could not be accomplished exactly because of sand movement and stabilization subsequent to 1961-62. More recent panchromatic photographs would probably have increased the accuracy of the vegetation map in these areas. The quality of the aerial photographs used and their scale of photography (1:36 000 for Job 461) were also limiting factors in this study.

The most practical classification for mapping and describing the vegetation is based on the results obtained from the association-analysis of the data. The difficulty of misplaced plots through the chance absence of the dividing species was largely overcome by reference to the list of species occurring in the surroundings of the sampling quadrat, but within the same community. These species were used to relocate apparently misclassified plots. The groupings obtained from the association-analysis hierarchy proved particularly useful in understanding the mountain fynbos communities which showed the greatest variations. The classification presented, 32 communities are recognized and described, is intended to be of a semi-detailed nature providing the reference framework from which extrapolation and predictions, provided by more detailed surveys, can be made. More detailed surveys or surveys of adjacent areas might prove that certain categories need further subdivision while others might require "lumping" together.

The broad leaved scrub has been recognized as a distinct vegetation type from the fynbos vegetation and has been subdivided into six coastal dune and forest communities. The 26 types of fynbos vegetation recognized, basically fall into five major categories based on the following habitat factors: whether they occur on (1) the coastal plain, (2) on the coastal mountains, (3) on yellow plinthic soils, (4) on inland white sandstone soils or (5) if they are associated with the rivers and streams in the area.

The homogeneity functions demonstrated the degree of variability and individuality of the various stands in the vegetation. The added information on abundance used in these functions appears to emphasize this character. No distinctive groups could be detected in the dendrogram produced using this function. The agglomerative technique used to construct the dendrogram generally resulted in the step-wise addition of quadrats. The use of abundance data should theoretically therefore be more suitable in a simpler flora such as is found in the Karoo, for instance, where abundances are the more distinctive feature distinguishing the communities.

The monothetic divisive nature of the association-analysis hierarchy appears to result in an artificial classification but the final groups do reflect ecological similarities and the classification can be of practical application, after a certain amount of subjective interpretation.

A larger number of sampling quadrats would probably have resulted in termination of subdivision taking place at the limiting level of heterogeneity, in most instances (χ^2 = 3,841 in this case), instead of being limited by the occurrence of less than eight plots in a group. The final groups in this case might be capable of further subdivision except for this limiting factor. Various levels of heterogeneity are therefore reflected in the final groups.

The application of phytosociological techniques to the data collected during this survey, did not prove entirely satisfactory, although they fulfilled their purpose, for the following reasons: (1) The data were collected from sites which were located on random grid intersects instead of being subjectively chosen. (2) The sampling sites were located along fixed axes and were not, therefore, "fitted" into the pattern of the communities. (3) The sample size was fixed. (4) The species list proved to be rather large for visual organization. The refinement of the table would, in all probability, prove much more successful if the association-analysis groupings were now applied. A re-assessment of the groups recognized in this study might then prove necessary. The further refinement of the table has not been undertaken because the data had been successfully reduced to enable further comparison using the homogeneity functions.

Additional floristic data on the composition of the communities recognized in the association-analysis hierarchy were given in the form of tables of the characteristic species found in each group. These tables indicate the relative rôle played by each of the more important species in the community as a whole. These species lists are considered to be more valuable than lists of dominant species because of the apparent general lack of widespread single species dominance in the fynbos vegetation.

CHAPTER 6

SUMMARY

The primary object of this survey was the determination of the vegetation communities and their relationships with the habitat, at a semi-detailed level of investigation, in the Hangklip area of the South-Western Cape Province, South Africa.

The complex vegetation and the large area involved required that statistical aids be used. This study would serve as a test of two of these methods in the fynbos vegetation.

Data were collected from 150 sampling sites located randomly within physiographic-physiognomic units delimited by the stratification of aerial photographs of the area. A total of 518 taxa were recorded in the sampling lists. Certain habitats' data were measured simultaneously. The data matrix proved to be too large to be accommodated within the available computer facilities. The data were therefore arranged into a number of separate units by phytosociological means prior to analysis using frequency modulated homogeneity functions. The standardized manipulations of the tables revealed six blocks of plots represented by character species. These were excluded from the data compared by the homogeneity functions. Species of less frequent occurrence were also excluded. The main body of data which was, for convenience, termed the "fynbos matrix", was then compared. No distinct groups could be distinguished in the dendrogram. The groups distinguished by phytosociological means were compared with each other and with various portions of the dendrogram, for distinctness, by computing the average members of each group.

The association-analysis of the data resulted in 32 end groups which were then used as the basis for the proposed vegetation classification where 32 natural communities and a number dominated by exotic introduced species, were recognized. The broad leaved scrub was subdivided into the coastal dune vegetation and the inland forest vegetation.

The fynbos was subdivided into that found on the coastal plain, on the coastal mountains, on the yellow plinthic soils, on the inland white sandstone soils and the riparian communities.

It is concluded that the association-analysis provided units which could be correlated with certain habitat factors and a classification of practical application could be developed from the groupings obtained from this method.

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Fig. I

Geographical location of the study area

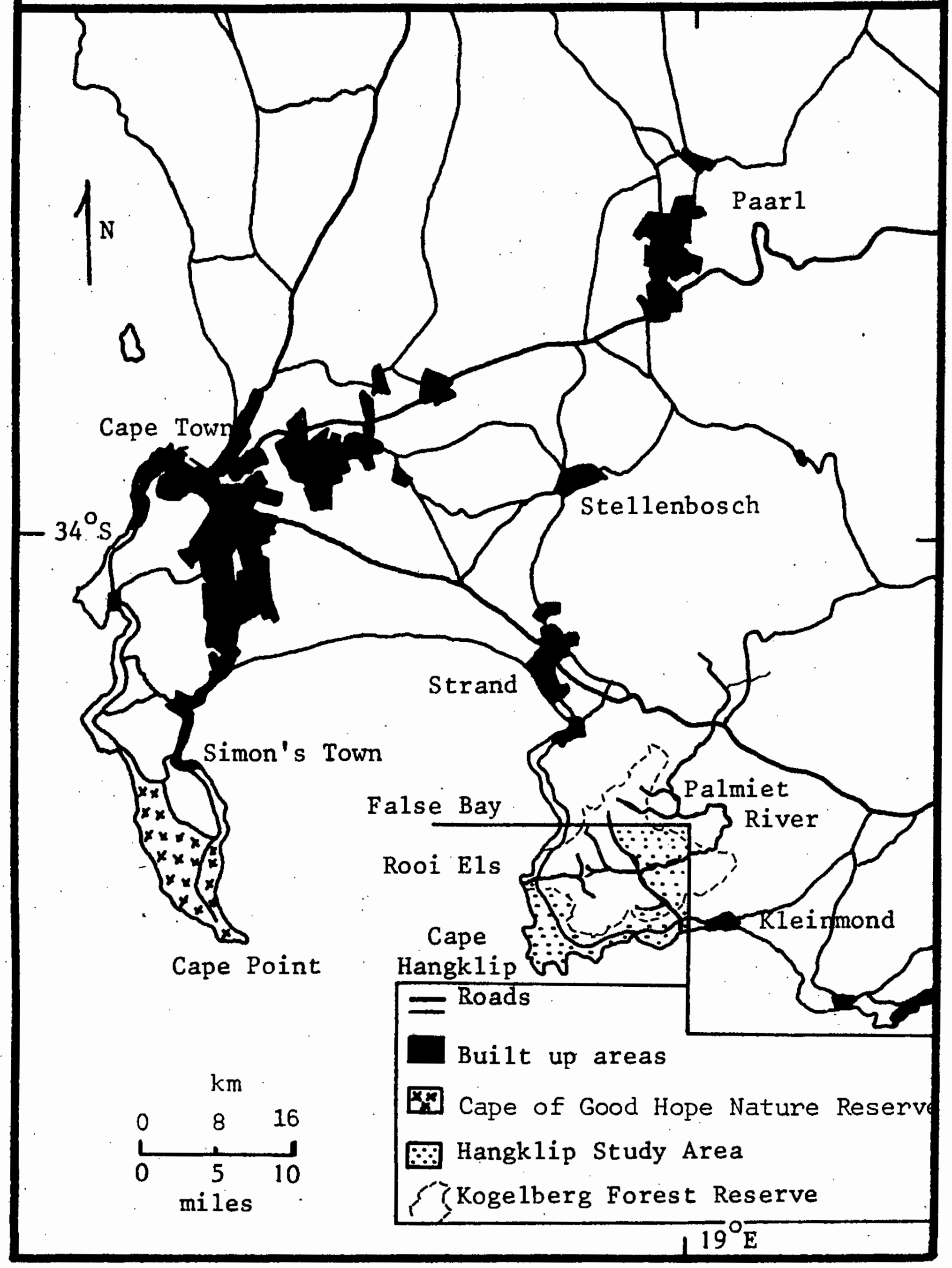


Fig. III GEOLOGY

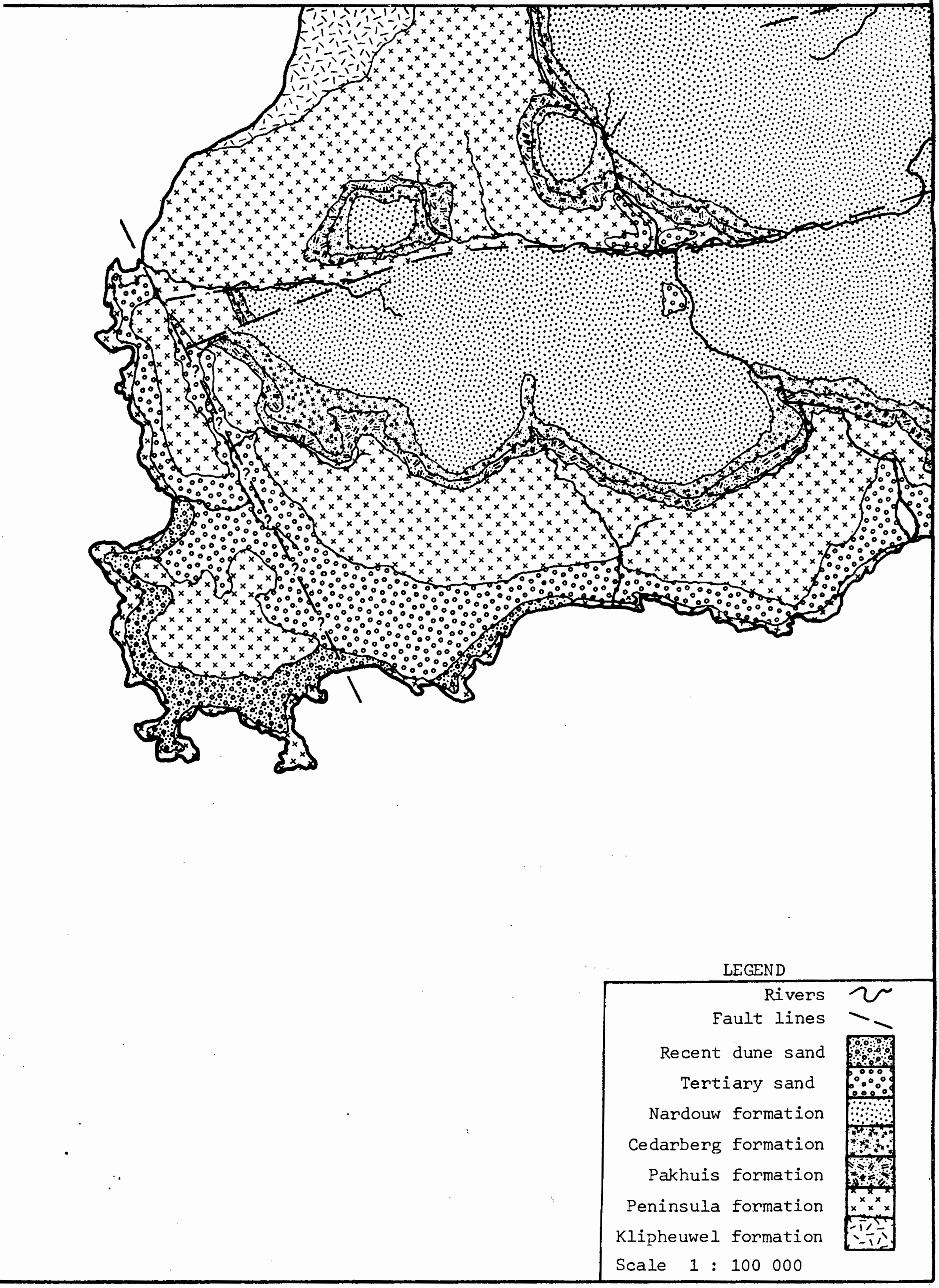
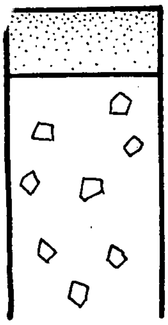


Figure IV

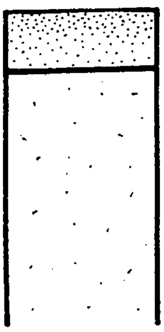
SOIL CLASSIFICATION

. MISPAH FORM



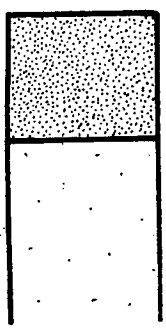
	Mispah series	Muden series
Orthic A C or R or hard plinthic B	Non calcareous	Calcareous

2. FERNWOOD FORM



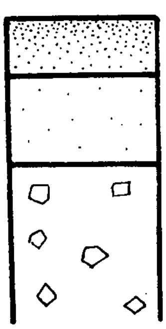
	Sandveld series	Langebaan series	Warrington series
Orthic A Regic sand	Coarse grade sand Acid Without abnormal organic matter accumulations	Medium grade sand Neutral to alkaline Without abnormal organic matter accumulations	Medium grade sand Acid With abnormal organic matter accumulations but <10% C

3. CHAMPAGNE FORM



	Champagne series	Mposa series
Organic O Firm gley or regic sand	pH >4 < 20% clay	pH < 4 ≮ 20% clay

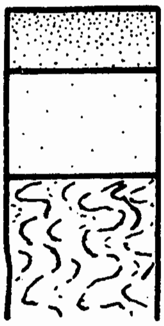
4. CARTREF FORM



	Waterridge series	Grovedale series	Cartref series
Orthic A Perched gley (P) C or R	0-6% clay medium grade sand	0-6% clay coarse grade sand	6-15% clay medium grade sand

Fig. IV

5. LONGLANDS FORM



Orthic A

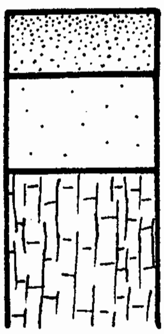
Perched gley (P)

Soft plinthic B

Longlands series

6-15% clay
medium grade sand

6. ESTCOURT FORM



Orthic A

Perched gley (P)

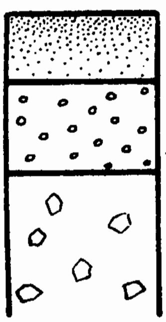
Prismatic textural B

Soldaatskraal series

0-6% clay
coarse grade sand

< 25% clay

7. CLOVELLY FORM



Orthic A

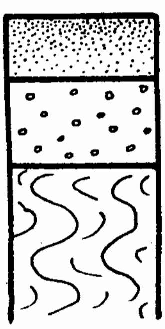
Yellow apedal B

C or R

Mossdale series

6-15% clay
medium grade sand

8. GLENCOE FORM



Orthic A

Yellow apedal B

Hard plinthic B

Weltevrede series

6-15% clay
medium grade sand
highly leached

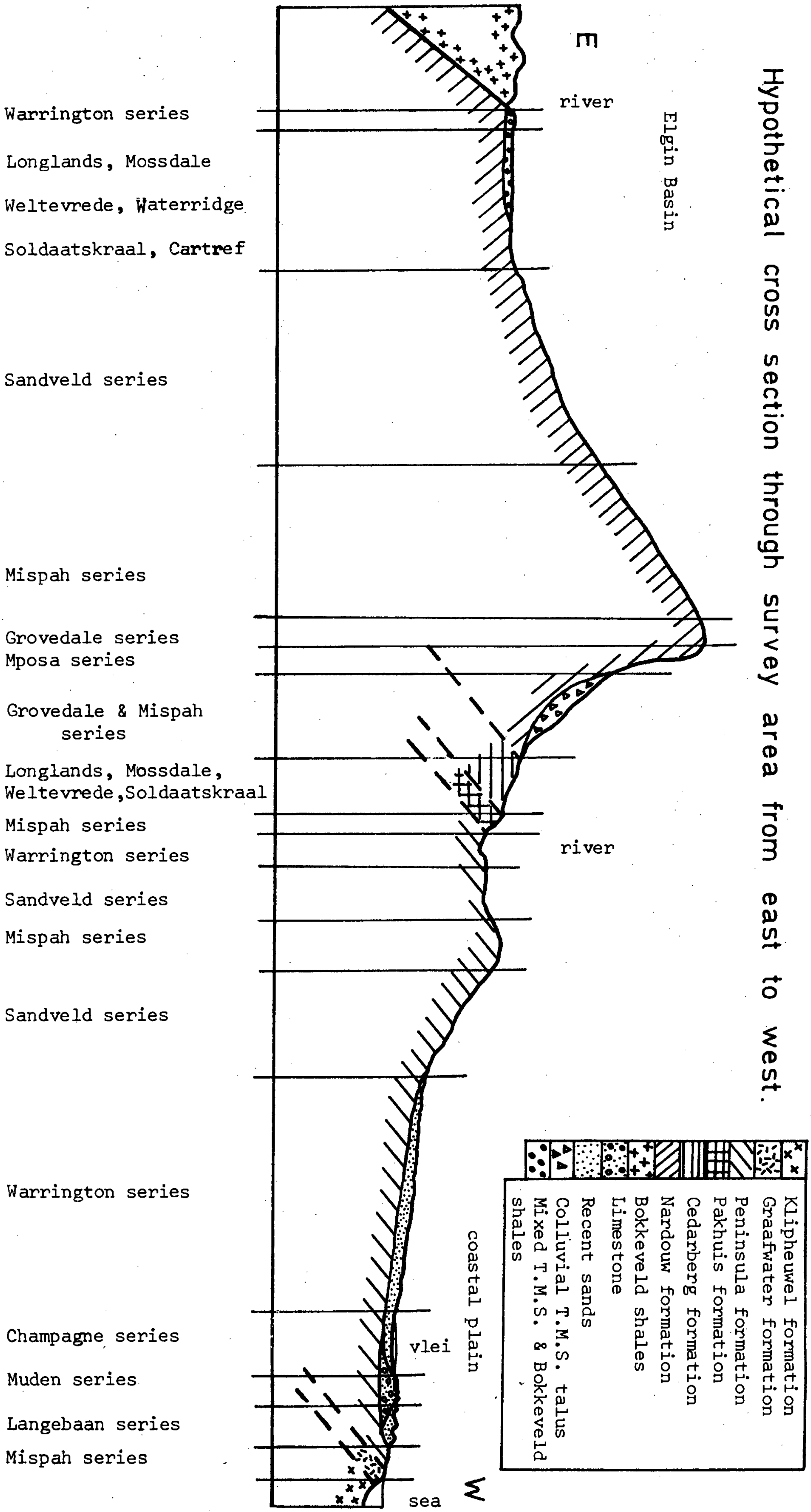


Fig. IV.9 GENERAL RELATIONSHIP BETWEEN GEOLOGY AND PEDOLOGY

Hypothetical cross section through survey area from east to west.

Fig IV · 10 **GENERAL RELATIONSHIP BETWEEN GEOLOGY AND PEDOLOGY**

Hypothetical cross section on the boundary of the Elgin Basin.

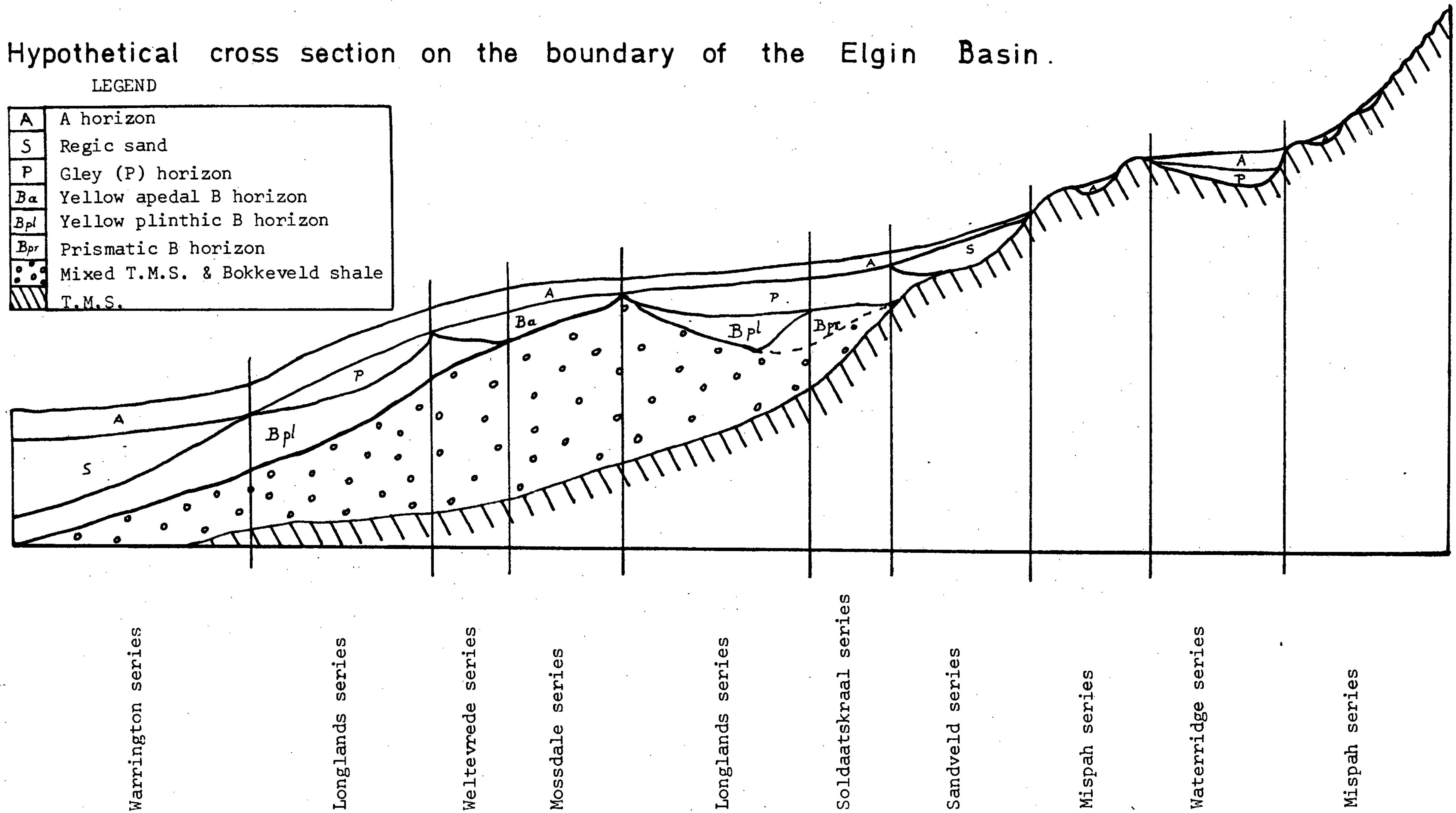


TABLE I(1) PHYTOSOCIOLOGICAL TABLE - PART 1

Plot number	16	43	29	35	44	45	32	21	2	58	33	37	36	34	14	19	18	17	40	41	83	56	91	101	89	100	13	1	25	31	30	28	27	26	24	6	72	10	69	102	104	7
No. of species	10	15	21	15	12	9	18	18	14	37	21	17	19	6	20	11	11	14	11	12	15	17	10	28	32	26	27	12	21	31	37	49	45	38	75	50	47	50	39	34	37	37
Altitude (m)	9	9	46	8	6	6	15	18	6	91	18	6	6	6	46	18	30	30	15	18	427	366	46	91	46	91	172	15	122	152	165	61	134	122	43	168	193	91	46	61	244	213
Aspect	-	-	-	NW	-	W	-	N	S	-	S	SE	N	-	SW	NW	SW	-	-	-	-	N	-	SE	NE	SE	-	-	E	S	SW	NW	SE	N	E	W	S	S	SE	-	SE	SW
Slope (degrees)	0	0	0	3	0	2	0	2	3	0	5	12	14	0	2	1	2	0	0	0	0	16	0	25	14	7	0	0	8	23	23	10	14	25	2	35	27	22	16	0	33	12
Soil type	SR	LI	S	S	S	S	S	S	S	LS	S	S	S	S	PS	PS	PS	PS	PS	PS	PS	P	LS	LS	LS	LS	LS	LS	SR	FS	FS	FC	SR	S	S	S	S	S	LS	FC	FC	FC
Soil depth	↓	→	↓	→	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	10	↓	→	→	↓	→	15	→	↓	↓	15	↓
Helich. cymos.				2															1	1									1													
Eragros. sabu.			2	1			1																																	2		
Phylica eric.		4	2	4							1																		2													
Restio eleoch.		1	2	3	1	2	4				5	3	4																													
Passer. palea.		1	2	2		2	1		3		2	1	3	1																												
Carpob. acina.	1		1	1					1	1		2	2																1	1	3	1		1								
Metal. muric.	1	2	1	1	1	2	1	1	1	2	4	3	2	2						1									1	3												
Psoral. fruti.				2		3					2	1	1	1																												
Picinia lat.				2	2	2	2				2	2	1																													
Euclea racemo.				1	1		2			2	3		3																													
Myrica cordif.					3		2		4			2																														
Senecio halim.					2				1			1		1		2														1												
Leonton. spat.						2	1				1	2	1																													
Butera hispida							1			2																													1			
Chironia bac.							1	2	1		1	2																	1	1							1					
Rhus laevig.							3		1	1	1																															
Chrysoc. coma-.								1	1		2														1																	
Helich. crisp.						1		1	4		2																															
Helich. marit.		2							2	2		2																						1								
Acacia cyclops										1		2																														
Thesid. frag.									1	1		1																														
Pentasch. ang.										1	1																															
Leptocar. fru.										1	1																															
Salvia afric.										1			1																													
Solanum quadr.					3								2			1														1	2		1									
Anaxeton nyc.					2							1	1																													
Helich. eric.			1									1	2																													
Rhus lucida			3								1		3																		1											
Ehrharta vill.											1	2	2	2																												
Colpoon comp.	1												2																													
Senecio eleg.						1								2																									1			
Restio ambig.																					3	4																				
Erica perspic.															2		4	3	4	4	2																					
Osmitop. ast.															3		2	3	3	1	1	2																				
Danthonia cin.																2	1	2	1	2	1	1																				
Carpoco. sper.																		1	3	2	2																					
Pterydium aqu.																									1	1	1															
Crassula cap.																								1		3																
Myrsine afric.										1														1	1																	
Halleria elli.																								2	1	1	1															
Agathosma imb.																								1	1	1																
Diospyr. glab.																							3		1	1																
Rhus tomentosa																							1	1	1		1															
Brabeium stel.																							2	1	1	2																
Arctotis semi.										1														1	1	1																
Montinia cary.																								2	2	3													1	1		
Scyphog. musc.																								3	3	3															1	
Widdring. cup.																								1	1	1																
Muraltia pauc.																								1																1		
Erica discolor																								3	1	2																
Asparag. comp.																								1																		
Asparag. thun.																								1	1																	
Cannamois virg.																								1		2																
Cassytha fili.		1																			1			1	1							1										
Passerina vul.	2									2														1	1	1		1	2													
Othonna quinq.												1																		1	1	1										
Struthiola cil.																														3	2	2										
Indigof. ang.																															2	1										
Osteosp. poly.																															1	1										
Aspalath. for.																															1	1										
Knowlton. cap.										1	1																			2	1											
Nemesia versi.																														1	1											
Pelargon. mul.																														2	1											
Senecio arnic.				1																										2	2											
Olea capensis										2															1					1	1	1	1									
Cassine barb.										3	1														1						1											
Pterocel. tri.										2														1					1													
Roella comp.																														3	2											
Pelargon. bet.																													2		1	1										
Mimetes cucul.																											2				1	1			1							
Lightfoot. ten							1																						1	2	2	1										
Stoebe cinerea																														2		2								1		
Linum african.							1										1											3		2	1											
Cymbopo. marg.			1					2																				1	3	1	2	1	3	2	3	2						
Picinia albi.																													1		1	1	1			1						
Myrica querci.		2																										4	3		2	2	2		3							
Erica paterson																																2			3		1					
Roella ciliata																																2	1			2		1				
Aspalath. cil.																															1	1	1			1						
Eroeda imbric.			1																													1	1	1								1
Thesium epic.																																1	1									
Erepsia anceps																																1				1						
Serruria burm.																																2	3							1		
Protea scabra																															2	2					2	1	1	2	2	3
Elegia stipul.																																3						3	3	2		
Diosma oppo.																																2		1			1		2			
Willdeno. hum.																																2	1				1				1	
Peucedan. sieb																																1					1	1				1
Leucaden. gan.																																							1			
Erica retorta																																										
Nivenia levyn.																																							1			
Erica massoni																																										
Brunia albi.																																										
Erica fastig.																																										
Villarsia cap.																					2	2																				
Erica inter.																						1																				
Restio obtus.																						1																				
Drosera alic.															1			1			2	2																				
Restio purpur.																						2																				
Osmitopsis par																																									1	
Protea cynar.																																										
Drosera glab.																																									1	
Erica sitiens																																										
Schizaea pect.																									1		1														1	
Alciope lanata																					1																					
Clutia polyg.																																										
Erica sessili.																																										
Tetraria exil.																																										
Brunia stokoei																		1																							1	
Indigof. tet.																																										
Tetraria brevi																																										
Lobelia coron.															1																											
Erica articul.																																										
Grubbia tomen.																																										
Drosera trin.																								1	1																	
Agathosma cili																																										

continued overleaf ...

TABLE I(1) continued

Species	A	B	C	D	E	F
Scyphoc. longi.						
Nivenia stokoei						1 1
Leucaden. xan.	1 3	2	1 2		1 2 2 1 4	2 1 2
Thamnoch. dich.	3 1				3	2 3
Phylica imberb.	1		3		2 2 2 1	1 2
Lobelia pinifol.					1	
Hypolaena digi.					1 1	1
Helich. sesam.					1 1	1
Elegia juncea		3 2			2	2
Restio debilis	4					1
Phaenocoma prol.		1			1	
Erica imbricata			1 3		2 1 1 2 1	2 1 2
Leptocar. hyal.		1	2		3	1 1
Nagelocarp. ser.					1	
Anthosper. cili.	1 1		1 1	3	2 1 2 1 1 1 1	1
Hypodiscus arg.						
Sympieza artic.						1
Ursinia crith.					1	1 1
Leucaden. salig.	1				1 2 1 1	3 2 1
Thamnoch. pell.					2	
Leptocarp. asp.		2			2	
Picinia ramos.	2 2 3 3	1 2 2	3 1 1 2	3	2 2	1 2
Picinia filif.	1 4		1		2 2 2 2	1
Blaeria eric.			1			1
Metalasia ceph.					2	1
Blaeria dumosa		1				2 2 1 3
Erica coccinea	2	1			3 1 1 1	1 3 1 1
Erica corifolia			2		1	1 3 2 1
Elegia spathacea		1			3	
Staberoha cern.			1 1 2		3	2 1 2 2
Restio bifarius	1					
Elegia parvifl.	3	2			2 2 3	2 4 1 2
Erica pulchella					1 1	2 1 2 1 1
Tetraria therm.			2			1 1
Thamnoch. pulch.	1	2 1	2		1 1 1 2	2 2
Restio egregius					1	1
Sympieza pall.		2	1		2 1	1 1 1 3
Saltera sarco.					1 1	2 1
Tetraria fimbri.					2	1 2 2 1
Restio occultus		1	1			2 2 1
Hypodiscus aris.					2 3 2	2
Danthonia macra.						1
Restio similis						1 2
Chondrop. deus.		1				2
Tetraria fasc.	2	1 1 2			1 1 1 2	1 1 1
Erica hispidula		3 1 3 2	1		1 1 1	2 2 1 1 1
Chondrop. hook.					1	1 1 3
Tetraria cuspi.	2 1	2 1 1	1 1 1	1 1	3 2 1 2 1 2 2	1 2 1 1 1 4
Pentasch. junci.			1		1 2 1	1 2
Leptocarp. mem.						2 1
Penaea mucron.		2			2 1 4	2 2 1 2 2
Restio bifidus		1				
Elegia persis.	1	2				
Gnidia viridis		2 1 1 1	1 1		1 1 1	1 1
Danthonia lan.	5				2	1
Scirpus nodos.	2 2	1 2 1			1 1 1	1
Corymbium afric.					2 2 2	2 5
Dilatris pill.					1	1 1 2
Erica thomae		1	1		2 1	
Centella rest.				1	1	1
Pentasch. curv.	3 2 2 1 2		1		1	1
Rhus africana	2 1 2	1		1		
Brunia alopec.	1	4 3 1	1			
Cliffortia sub.	1 1				1	
Thamnoch. grac.			1 1 1			2
Gerbera tomen.						1
Hypolaena diff.		3			1	1
Restio dispar		3	3			
Erica cristata						
Nebelia fragar.						
Aniserica grac.						
Elegia racemosa						
Chondrop. mucr.		2				
Tetraria flex.						1
Thesium carin.					1 1 1	
Adenandra umbel.					1 1 1 2	
Rochea subulata			1 1		1 1	1
Pentasch. steud.						
Lobelia capil.					2 1	
Thesium commut.					1	
Merciera brevi.					1	1 1
Indigof. mauri.						
Serruria elong.						1
Chondrop. ebrac.		1			1	1
Tetraria brom.			3		1 1	1 3
Restio filif.			1		1	2 1
Pentasch. ampla			1			
Blaeria barbig.			1			1 3
Bobartia indica					1 1 1	
Thesium virgat.		1			1 1 1	2
Centella tril.						2
Picinia bract.			1		1	2
Ursinia dentata				1	1	
Anthosper. aet.	1 1		2 3	2	1 1	
Erica placen.						1 1
Gnidia anomala					1	1
Aspalath. asp.					1	2
Hypodisc. alt.						2
Aulax umbellata						1 1
Metalasia lich.					1	1
Phylica humilis						
Nebelia palea.						2
Restio cuspid.			1		2	1 1 2
Erica gysbertii						3
Gnidia pinif.		1			1	
Hypolaena crin.	2					
Centella diff.					3 1	
Erica longif.					2 3	1
Agathelpis dub.						
Serruria adsc.					2	2 1
Diastella bry.					1	1
Restio subvert.						
Willden. teres					2	1

PHYTOSOCIOLOGICAL TABLE - PART 2 FYNBOS MATRIX

TABLE II(2)

Plot number	[illegible]
No. of species	[illegible]
Altitude (m)	[illegible]
Aspect	[illegible]
Slope (degrees)	[illegible]
Soil type	[illegible]
Soil depth	[illegible]
Leucaden. gand.	[illegible]
Erica retorta	[illegible]
Nivenia levyn.	[illegible]
Erica massoni	[illegible]
Brunia albi.	[illegible]
Erica fastig.	[illegible]
Villarsia cap.	[illegible]
Erica interval.	[illegible]
Restio obtus.	[illegible]
Drosera alic.	[illegible]
Restio purpur.	[illegible]
Osmitop. parvi.	[illegible]
Protea cynar.	[illegible]
Drosera glab.	[illegible]
Erica sitiens	[illegible]
Schizaea pect.	[illegible]
Alciope lanata	[illegible]
Clutia polyg.	[illegible]
Erica sessili.	[illegible]
Tetraria exil.	[illegible]
Brunia stokoei	[illegible]
Indigof. tet.	[illegible]
Tetraria brevi.	[illegible]
Lobelia corono.	[illegible]
Erica articul.	[illegible]
Grubbia tomen.	[illegible]
Drosera trin.	[illegible]
Agathosma cili.	[illegible]
Scyphog. longi.	[illegible]
Nivenia stoko.	[illegible]
Leucaden. xan.	[illegible]
Thamnoch. dich.	[illegible]
Phylica imber.	[illegible]
Lobelia pinif.	[illegible]
Hypolaena dig.	[illegible]
Helich. sesam.	[illegible]
Elegia juncea	[illegible]
Restio debilis	[illegible]
Phaenocoma pro.	[illegible]
Erica imbric.	[illegible]
Leptocar. hyal.	[illegible]
Nagelocar. ser.	[illegible]
Anthosper. cil.	[illegible]
Hypodiscus arg.	[illegible]
Sympieza artic.	[illegible]
Ursinia crith.	[illegible]
Leucaden. sal.	[illegible]
Thamnoch. pel.	[illegible]
Leptocar. asp.	[illegible]
Ficinia ramos.	[illegible]
Ficinia fili.	[illegible]
Blaeria erio.	[illegible]
Metalasia cep.	[illegible]
Blaeria dumosa	[illegible]
Erica coccinea	[illegible]
Erica corifoli.	[illegible]
Elegia spath.	[illegible]
Staberoha cer.	[illegible]
Restio bifar.	[illegible]
Elegia parvi.	[illegible]
Erica pulchel.	[illegible]
Tetraria ther.	[illegible]
Thamnoch. pul.	[illegible]
Restio egreg.	[illegible]
Sympieza pal.	[illegible]
Saltera sarco.	[illegible]
Tetraria fimb.	[illegible]
Restio occul.	[illegible]
Hypodiscus ari.	[illegible]
Danthonia mac.	[illegible]
Restio similis	[illegible]
Chondrop. deus.	[illegible]
Tetraria fas.	[illegible]
Erica hispid.	[illegible]
Chondrop. hook.	[illegible]
Tetraria cusp.	[illegible]
Pentasch. junc.	[illegible]
Leptocarp. sem.	[illegible]
Penaea mucron.	[illegible]
Restio bifidus	[illegible]
Elegia persis.	[illegible]
Cnidia viridis	[illegible]
Danthonia lan.	[illegible]
Scirpus nodos.	[illegible]
Corymbium afr.	[illegible]
Dilatris pill.	[illegible]
Erica thomae	[illegible]
Centella rest.	[illegible]
Pentasch. cur.	[illegible]
Rhus africana	[illegible]
Brunia alopec.	[illegible]
Cliffortia sub.	[illegible]
Thamnoch. gra.	[illegible]
Gerbera tomen.	[illegible]
Hypolaena dif.	[illegible]
Restio dispar	[illegible]
Erica cristata	[illegible]
Nebelia frag.	[illegible]
Anisarica afr.	[illegible]
Elegia racem.	[illegible]
Chondrop. euo.	[illegible]
Tetraria flex.	[illegible]
Thesium carin.	[illegible]
Adenandra umb.	[illegible]
Rochea subul.	[illegible]
Pentasch. steud.	[illegible]
Lobelia capil.	[illegible]
Thesium comm.	[illegible]
Ferciera brev.	[illegible]
Indigof. saur.	[illegible]
Serruria elon.	[illegible]
Chondrop. obr.	[illegible]
Tetraria brom.	[illegible]
Restio fili.	[illegible]
Pentasch. asp.	[illegible]
Blaeria barb.	[illegible]
Robertia ind.	[illegible]
Thesium virg.	[illegible]
Centella tril.	[illegible]
Ficinia bract.	[illegible]
Ursinia dent.	[illegible]
Anthosper. aet.	[illegible]
Erica placent.	[illegible]
Cnidia anomala	[illegible]
Aspalath. asp.	[illegible]
Hypodiscus alt.	[illegible]
Aulax umbell.	[illegible]
Metalasia lio.	[illegible]
Phylica humil.	[illegible]
Nebelia palea.	[illegible]
Restio cuspid.	[illegible]
Erica grabert.	[illegible]
Cnidia pinif.	[illegible]
Hypolaena ork.	[illegible]
Centella diff.	[illegible]
Erica longif.	[illegible]
Agathelpis dub.	[illegible]
Serruria adsc.	[illegible]
Dieatelia bry.	[illegible]
Restio subvert.	[illegible]
Willdenow. ter.	[illegible]

TABLE II

HOMOGENEITY - FUNCTION DENDROGRAM

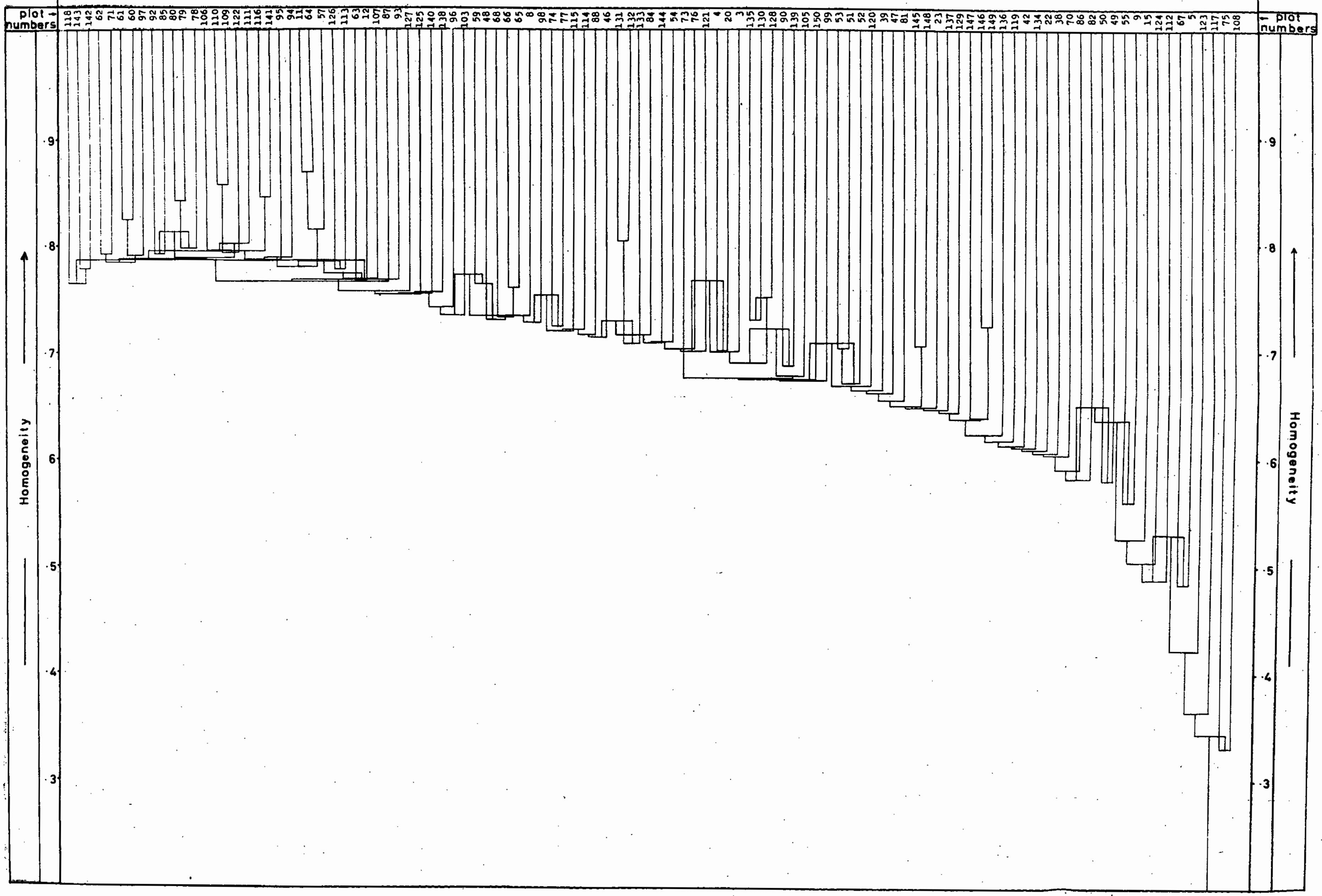


TABLE III

GROUP SIMILARITY ANALYSIS

RUNS 1-11

The following set of 11 tables (runs 1-11) indicates the similarity between each individual site and either a phytosociological group or a set of sites arbitrarily delimited from the homogeneity function dendrogram, as underlined in each of the 11 runs. The arrangement of the sites in each run is in the same order as in run 1. The performance of the data is discussed in chapter 3.6.

Table 111 RUN 1.

145	-	114	-	116	-	30	—	16	—
148	·	88	-	141	-	28	-	43	———
23	-	46	—	95	-	27	-	29	———
137	-	131	-	94	-	26	-	35	———
129	-	132	-	11	-	24	-	44	———
147	-	133	-	64	-	6	-	45	———
146	-	84	-	57	-	72	-	32	———
149	-	144	-	126	-	10	-	21	—
136	-	54	-	113	-	69	-	2	———
119	-	76	-	63	-	102	-	58	———
42	-	121	-	12	-	104	-	33	———
134	·	4	-	107	-	7	-	37	———
22	-	20	-	87	-	118	-	36	———
38	—	3	—	93	-	143	-	34	———
70	·	135	·	127	-	142	-	14	-
86	-	130	-	125	-	62	—	19	—
82	·	128	-	140	-	71	—	18	-
50	·	90	-	138	-	61	·	17	·
49	·	139	-	96	-	60	-	40	·
55	-	105	-	103	-	97	-	41	-
9	-	73	-	59	—	92	-	83	·
15	-	150	-	48	—	85	-	56	-
124	-	99	-	68	—	80	-	91	-
112	·	53	-	66	-	79	-	101	-
67	-	51	-	65	-	78	-	89	-
5	—	52	-	8	—	106	-	100	-
123	-	120	-	98	·	110	-	13	-
117	-	39	—	74	-	109	-	1	-
75	·	47	-	77	-	122	-	25	———
108	·	81	-	115	-	111	-	31	—

Table III RUN 2.

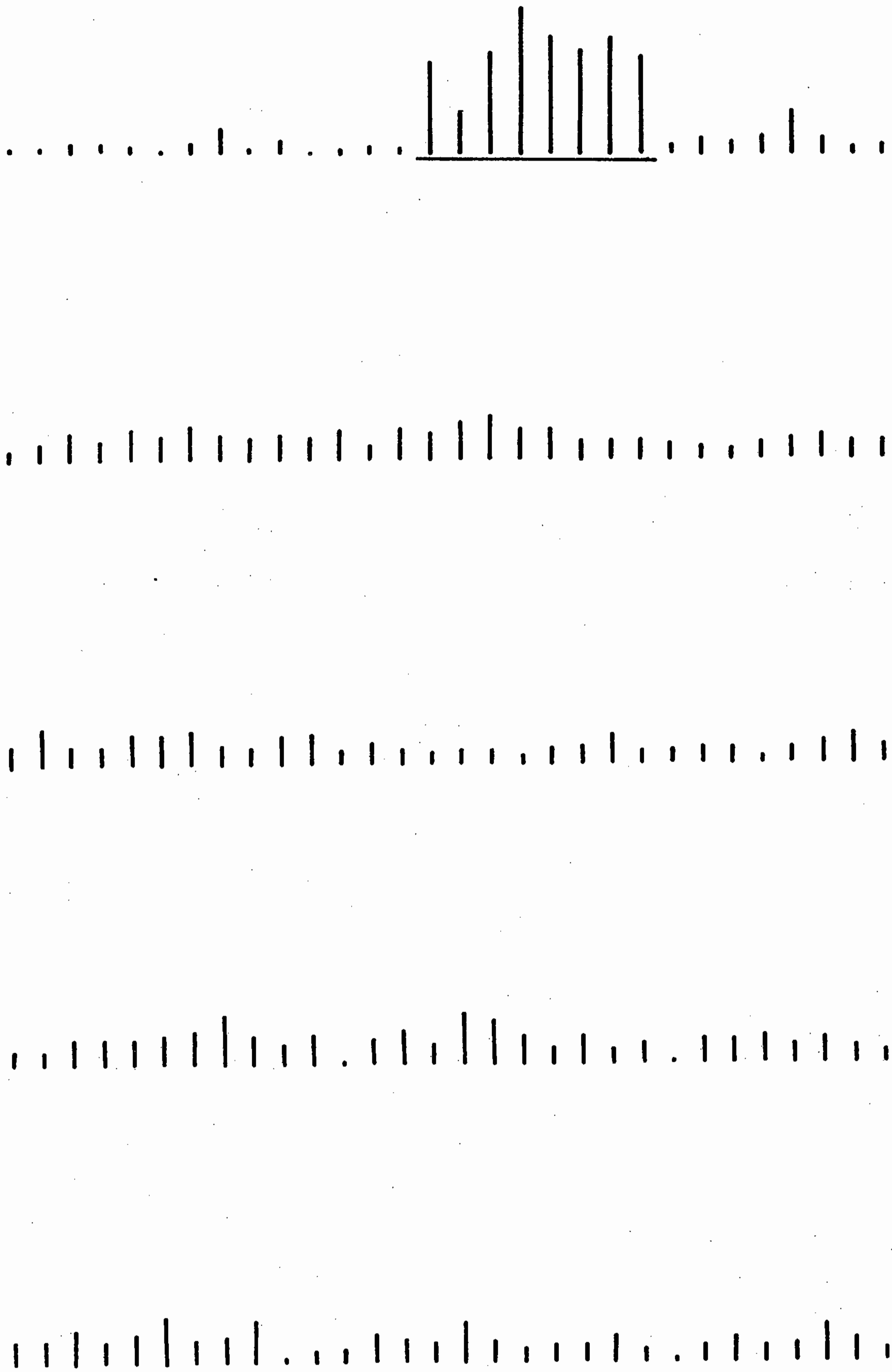


Table $\overline{\underline{111}}$ RUN 3.

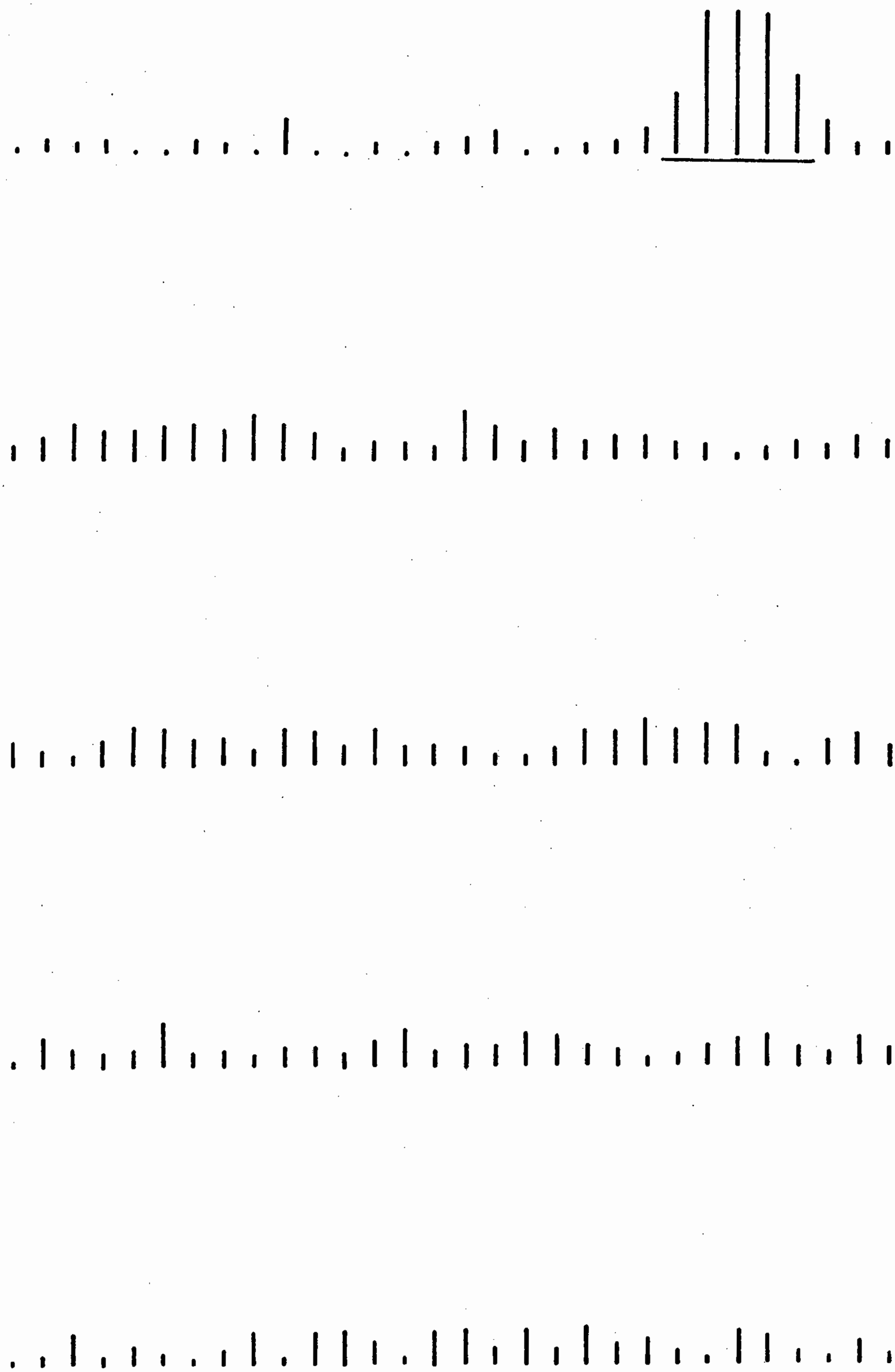


Table III   RUN 4.

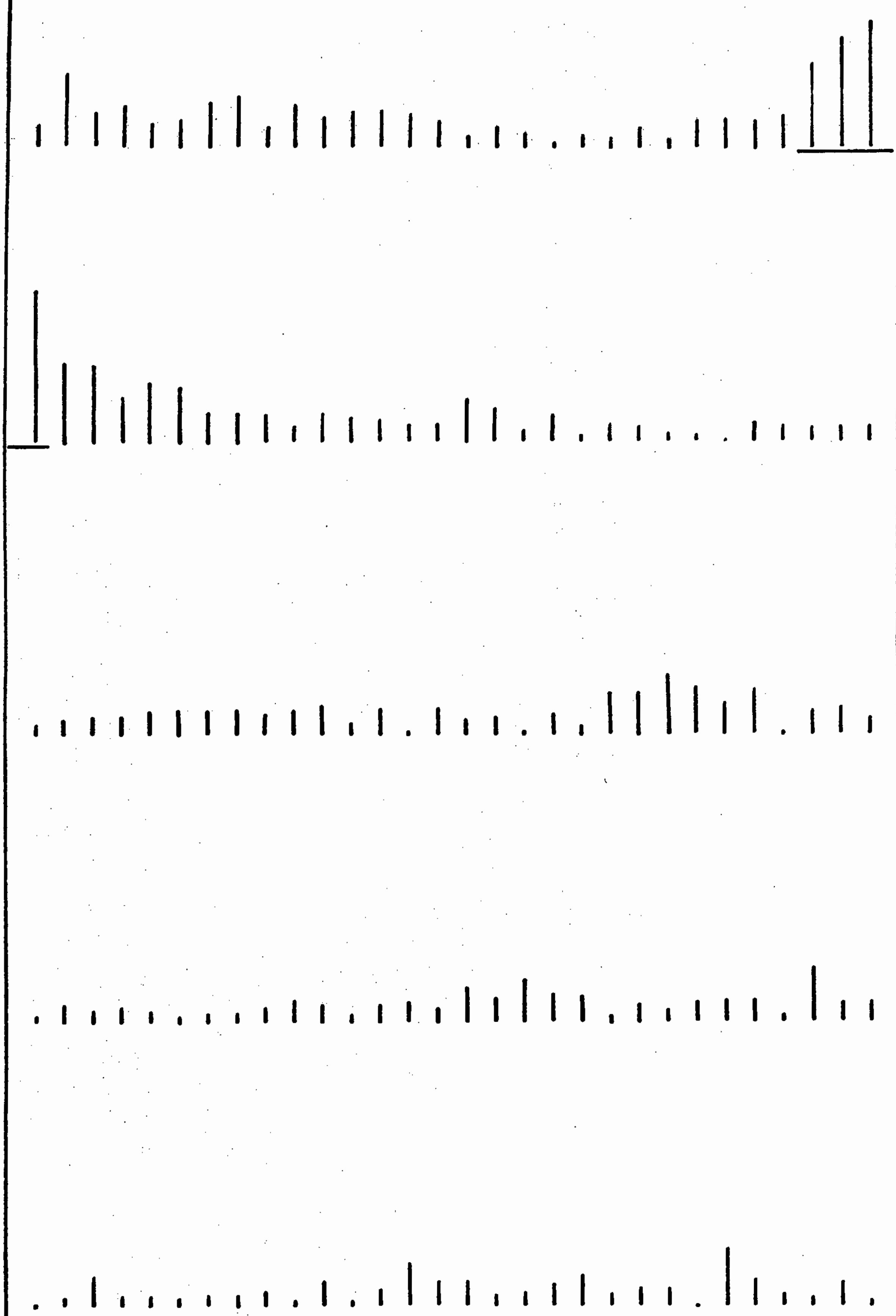


Table III | RUN 5.

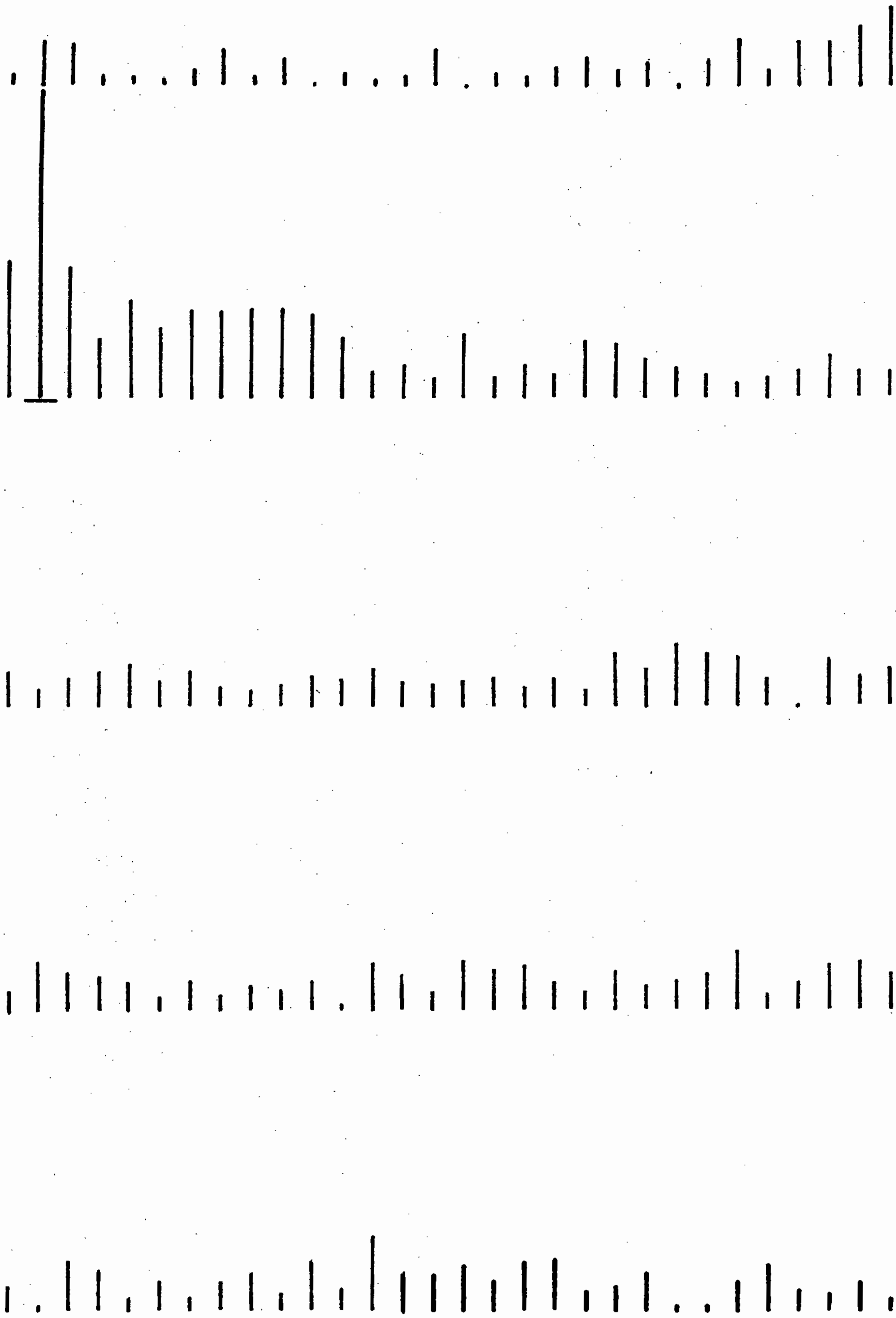


Table III RUN 6.

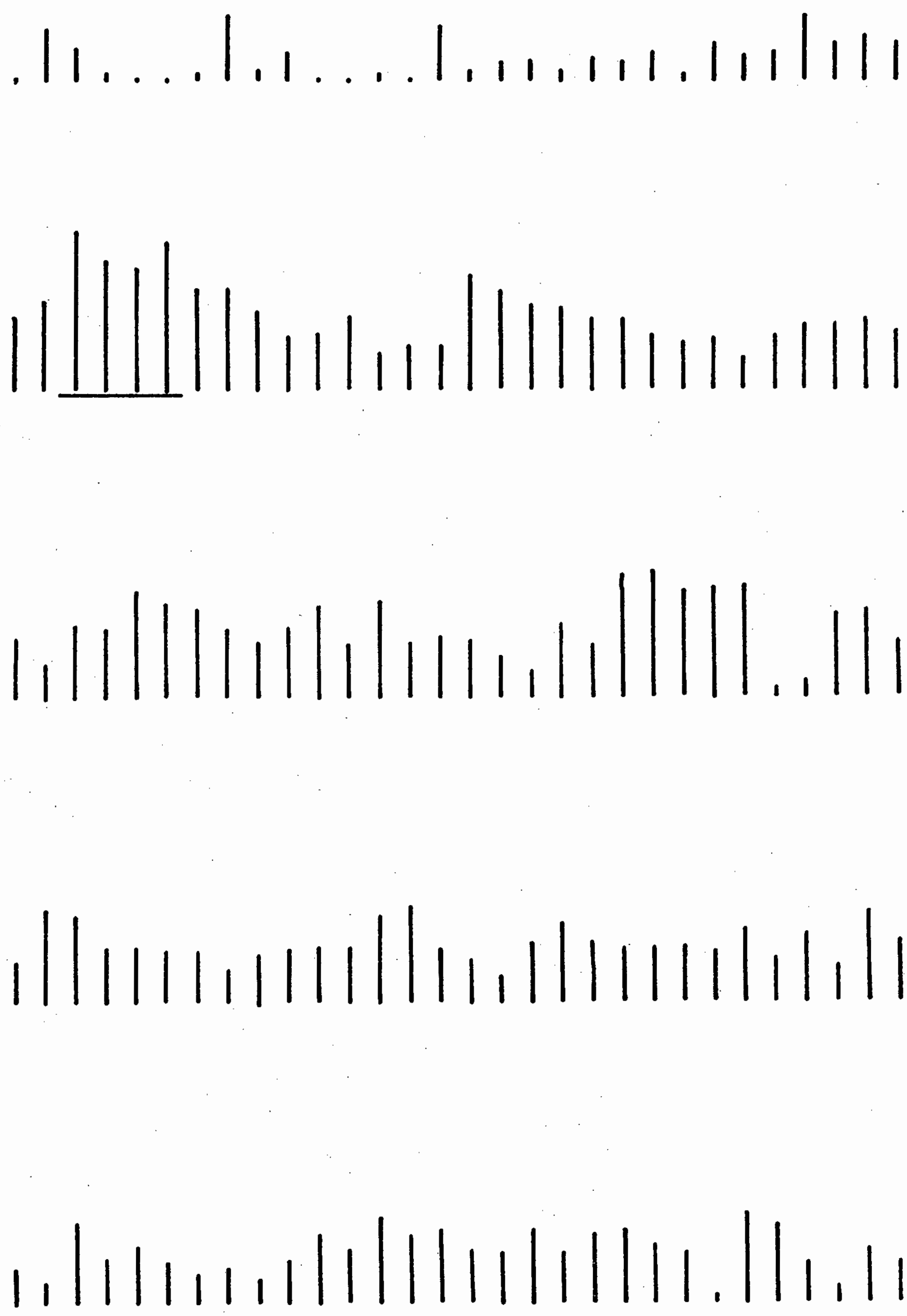


Table III RUN 7.

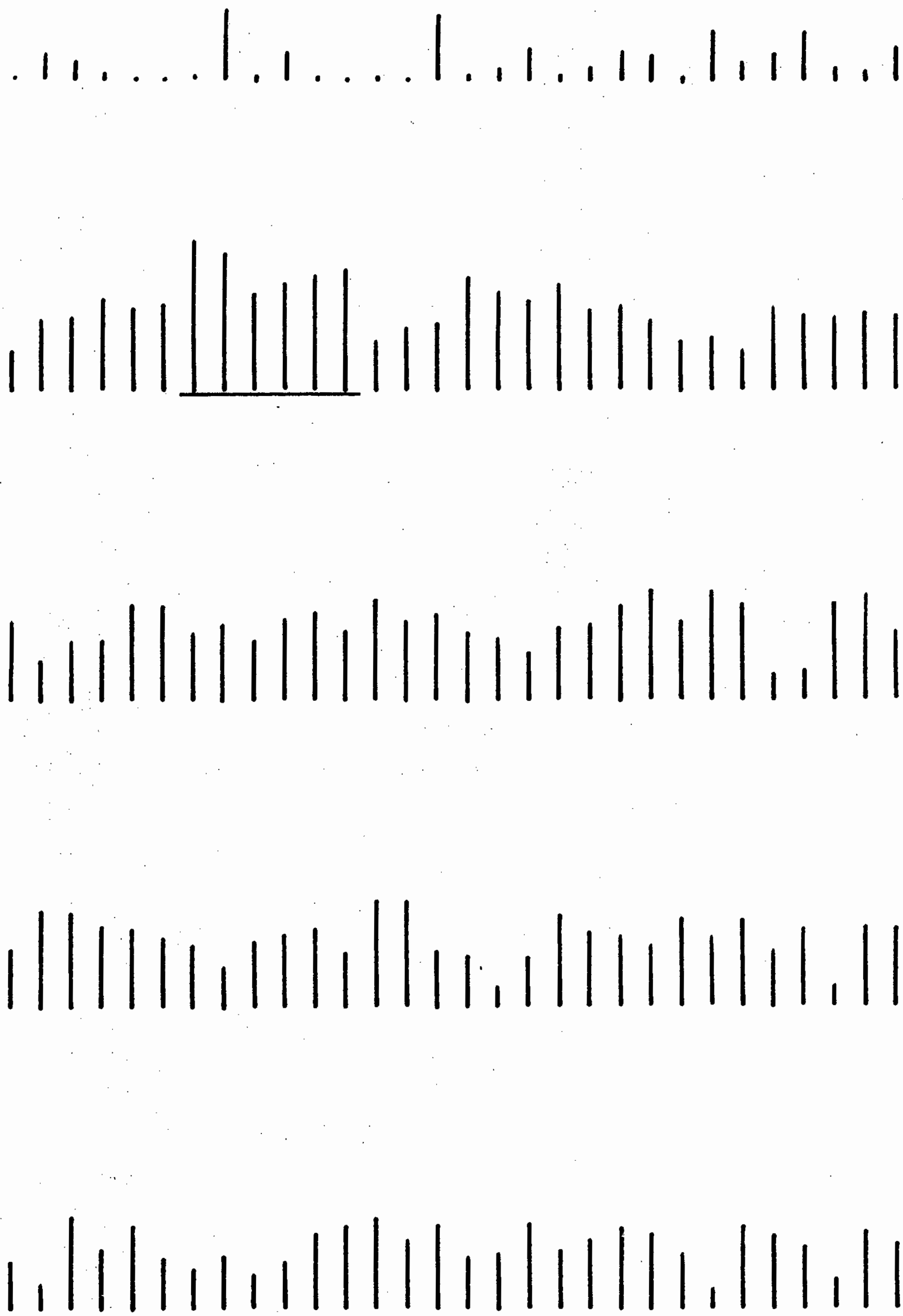


Table III RUN 8.

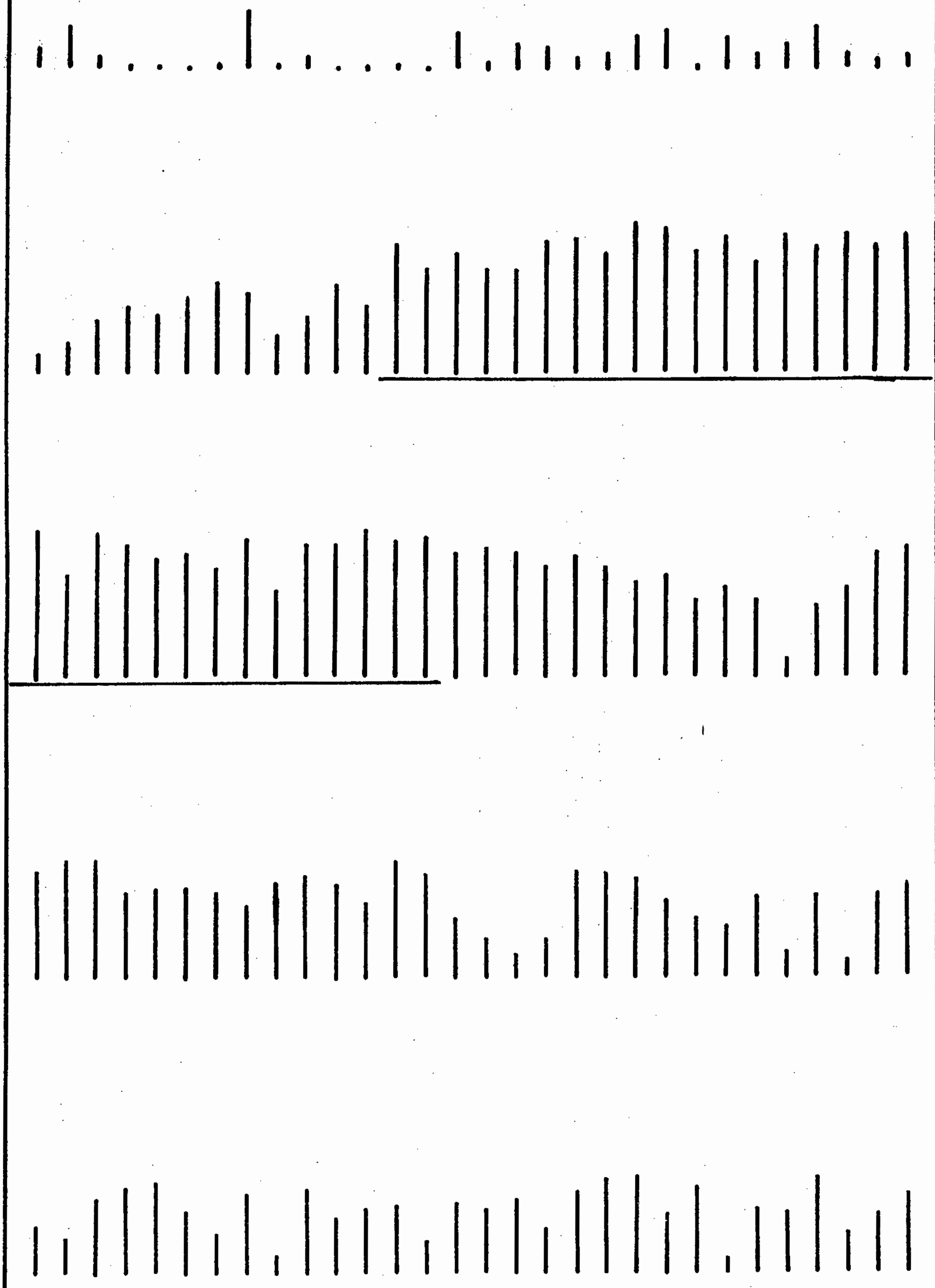


Table 111 RUN 9.

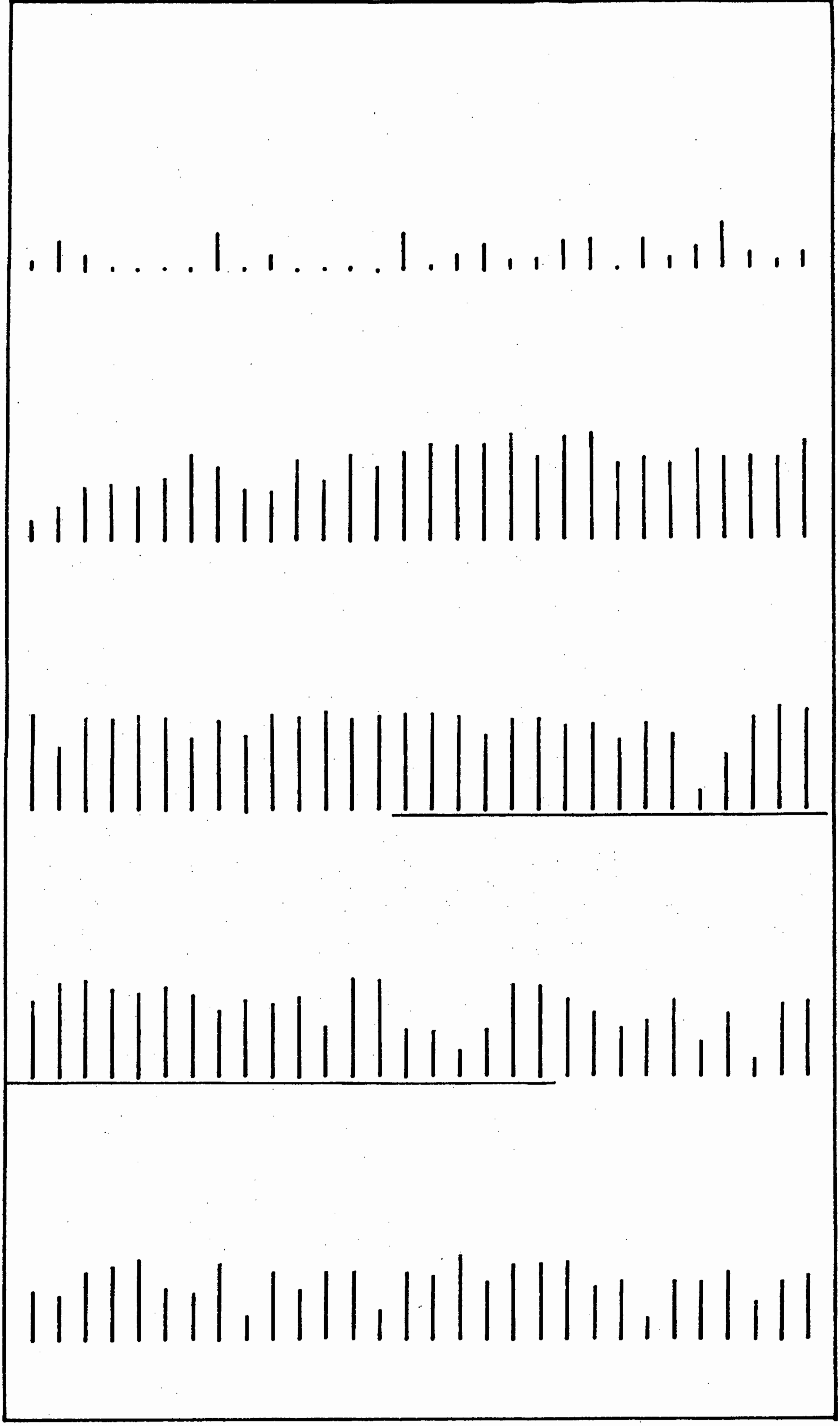


Table III RUN 10.

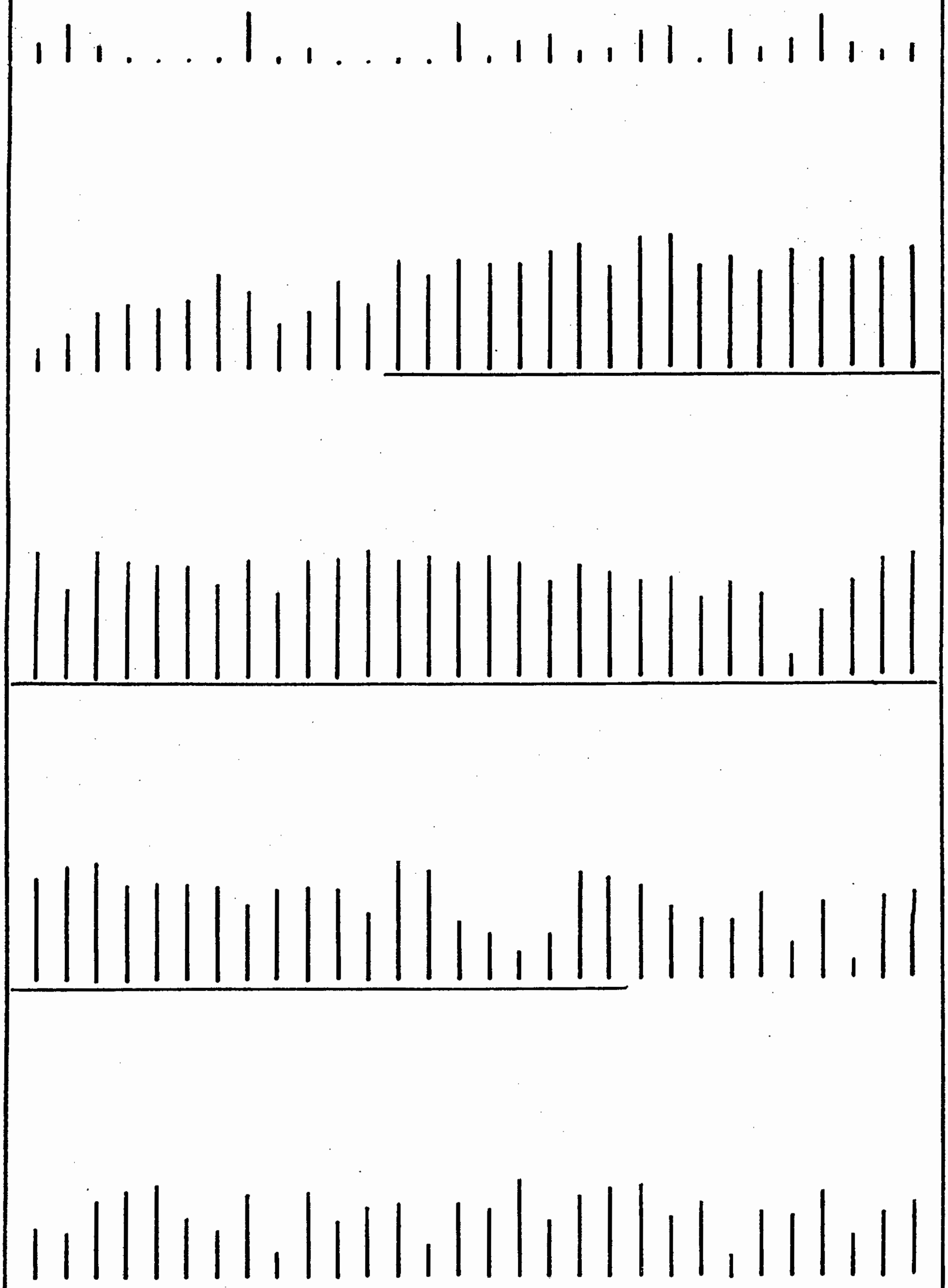
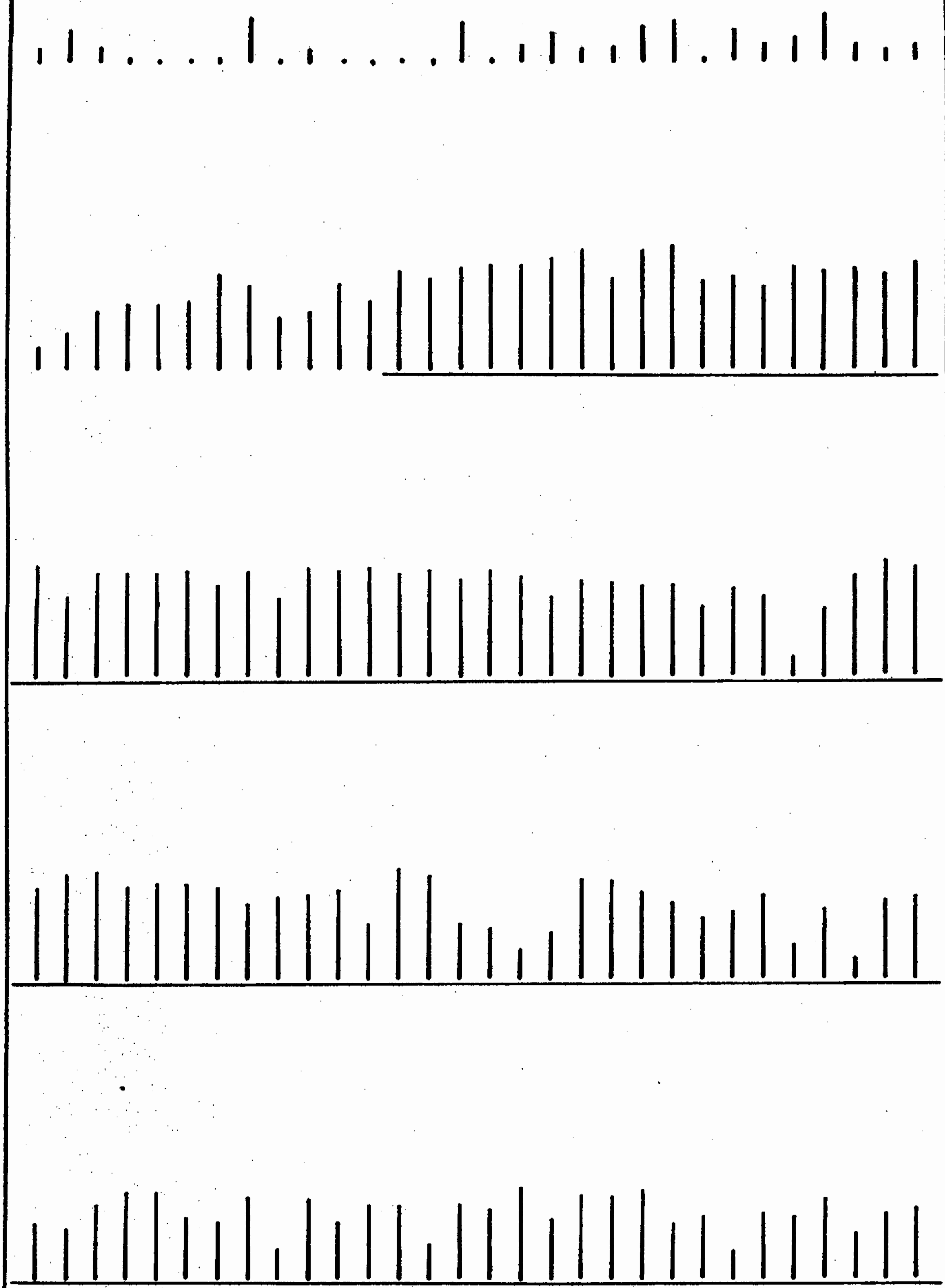


Table 111 RUN 11.



ASSOCIATION-ANALYSIS HIERARCHY

TABLE IV

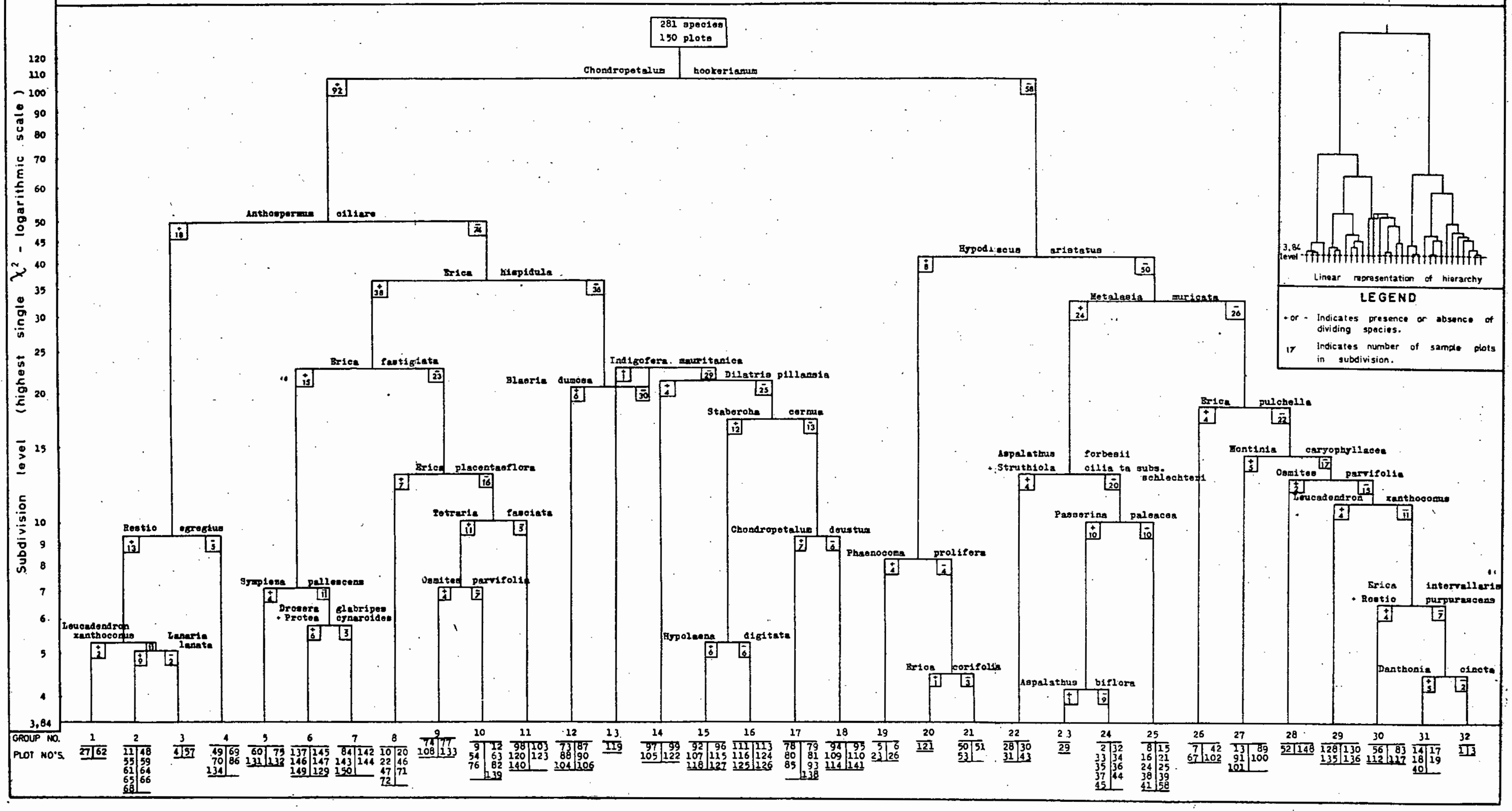


TABLE V. Regrouping of sampling sites

Explanation:

Each end group of plots in the association-analysis hierarchy was studied to determine the habitat and floristic similarities. If no, or very few, similarities could be found, then the list of species occurring in the immediate surroundings of the plot, but within the same community, were consulted to determine whether the absence of another dividing species, in the plot, was a chance occurrence. If another dividing species was present then the plot was regrouped accordingly. If, however, the possibility existed of a dividing species having been overlooked through it not being in the flowering state during the drought conditions prevailing when the field work was undertaken and misidentification resulting, then such plots had to be revisited for further investigation.

In one instance, the subdivision in the hierarchy could have taken place on two species which had identical values for the highest sum of chi-squared. In this instance the alternative species was used to reposition an apparently wrongly grouped plot and a better grouping resulted (site 147).

A total of 21 out of the 150 sampling sites were repositioned in the final groups to more suitable groups (on the basis of habitat and floristics). This is not a particularly high percentage if it is considered that approximately 10% of the sampling lists used in phytosociological tables have generally to be discarded for one or more reasons (M.A. Werger, pers. comm.)

List of regrouped sampling sites:

Site No.	New final group	Original final group	Reason for regrouping
5	19	20	Phaenocoma prolifera in plot surround.
14	31	29	Sample plot located on edge of cultivated area, almost on boundary between two communities. Vegetationally most similar to negatively defined group.
15	25	12	Chondropetalum nudum was wrongly identified as C. hookerianum during drought.
21	25	4	Same reason as site 15.

Site No.	New final group	Original final group	Reason for regrouping
22	8	19	*Chondropetalum hookerianum* found in plot surround.
23	19	26	*Hypodiscus aristatus* and *Phaenocoma prolifera* found in plot surround.
24	25	4	Same reason as site 15.
26	19	20	Same reason as site 15.
43	22	4	Same reason as site 15.
44	24	25	*Passerina paleacea* found in plot surround.
46	8	13	*Erica hispidula* found in plot surround.
47	8	26	Same reason as site 22.
54	8	10	Habitat and floristics indicate a greater similarity to group 8. The vegetation was destroyed by a fire before the site could te re-visited.
65	2	19	Same reason as site 22.
68	2	19	Same reason as site 22.
69	4	21	Same reason as site 22.
83	30	31	Habitat and floristics indicate a greater similarity to group 30. Vegetation destroyed by fire before site could be revisited.
91	27	32	*Montinia caryophyllacea* found in plot surround.
113	16	21	Same reason as site 22.
129	6	14	On transition including a *Restio-Chondropetalum* tussock marsh patch and is most similar to the hygric upper southerly slope mixed fynbos.

TABLE VI. Preliminary list of larger fauna

Compiled from a list by J. le Roux and R. Mayer for the Kogelberg State Forest with additions by the author of fauna observed in the rest of the Hangklip area.

Carnivores

Leopard	Lynx
Small spotted Genet	Ratel Honey Badger
Cape grey Mongoose	Striped Polecat
Otter	

Omnivores

Hyrax or Rock Dassie	Cape Porcupine
Chacma Baboon	

Ungulates

Grey Duiker	Grey or Vaal Rhebuck
Grysbuck	Klipspringer
Steenbuck	Grey Squirrel

Birds (seen on land)

Cape Eagle Owl	Rock Kestrel
Secretary Bird	Cape Sea Eagle
Black-shouldered Kite	Cape Cormorant
Bank Cormorant	Jackass Penquin
Southern Black-backed Gull	Hartlaub's Gull
Common Tern	Yellowbill Duck
Black Duck	Spurwing Goose
Egyptian Goose	Hammerhead
Common Sandpiper	Little Stint
Ethiopian Snipe	Malachite Kingfisher
Giant Kingfisher	Greywing Partridge
Brown-hooded Kingfisher	Guineafowl
Quail (Hottentot Button?)	Crowned Plover
Cape Dikkop	Red-eyed Turtle Dove
Rock Pigeon	Laughing Dove
Cape Turtle Dove	Fiery-necked Nightjar
African Hoopoe	Cape Raven
Red-chested Cuckoo	Various Swallows
Cape Coly	Fiscal Shrike
Boubou Shrike	Red-winged Starling
Bokmakiri	Malachite Sunbird
Cape Sugar Bird	Cape White-eye

Lesser Double-collared Sunbird	Common Waxbill
Cape Sparrow	Cape Thrush
Cape Canary	Cape Rock-jumper
Cape Rock-thrush	Clapper Lark
Cape Robin	Woodpecker (Cardinal?)

<u>Snakes</u>

Puff-adder	Mountain Adder
Boomslang	Cobra
Mole Snake	Skaapsteker

No record has been kept of fish, frogs, lizards and insects etc.

TABLE VII. List of flowering plants and ferns found in plots or mentioned in the text as occurring in the investigated area. Arranged according to families.

Original specimens are housed in the herbarium of the Botanical Research Unit, Stellenbosch (STE) and first duplicates in the National Herbarium, Pretoria (PRE). Other duplicates were forwarded to the Forestry Herbarium, Jonkershoek and the Compton Herbarium, Kirstenbosch.

Specimens were mainly identified by STE and PRE, except in certain specialist cases.

The latest accepted names have been used.

PTERYDOPHYTA

Aspidiaceae
Rumohra adiantiformis (Forst.) Ching

Blechnaceae
Blechnum attenuatum (Sw.) Mett.
B. capense (L.) Schlechtd.

Cyatheaceae
Cyathea capensis (L.f.) Smith

Dennstaedtiaceae
Pteridium aquilinum (L.) Kuhn

Gleicheniaceae
Gleichenia polypodioides (L.) Sm.

Lomariopsidaceae
Elaphoglossum acrostichoides (Hook.) Schelpe

Osmundaceae
Todea barbara (L.) Moore
Schizaea pectinata (L.) Sw.

GYMNOSPERMAE

Cupressaceae
Widdringtonia cupressoides (L.) Endl.

Pinaceae
Pinus pinaster Ait.
P. radiata D. Don

Podocarpaceae

Podocarpus elongatus (Ait.) L.'Hérit. ex Pers.

P. latifolius (Thunb.) R.Br. ex Mirb.

ANGIOSPERMAE: MONOCOTYLEDONEAE

Amaryllidaceae

Haemanthus canaliculatus Levyns

H. coccineus L.

H. rotundifolius Ker-Gawl

Cyperaceae

Carpha glomerata Nees

Chrysithrix capensis L.

Cyperus sphaerospermus Schrad.

C. thunbergii Vahl

Epischoenus gracilis Levyns

E. quadrangularis C.B.Cl.

Ficinia albicans Nees

F. anceps Nees

F. bracteata Boeck.

F. bulbosa (L.) Nees

F. capitella (Thunb.) Nees

F. deusta (Berg.) Levyns

F. filiformis (Lam.) Schrad.

F. indica (Lam.) Pfeiffer

F. lateralis (Vahl) Kunth

F. monticola Kunth

F. ramosissima Kunth

F. zeyheri Boeck.

Macrochaetium hexandrum (Lam.) Pfeiffer

Schoenus nigricans L.

Scirpus digitatus (Schrad.) Boeck.

S. membranaceus Thunb.

S. nodosus Rottb.

Sickmannia radiata (L.f.) Nees

Tetraria brevicaulis C.B.Cl.

T. bromoides (Lam.) Pfeiffer

T. capillacea (Thunb.) C.B.Cl.

T. compar (L.) Lestib.

T. cuspidata (Rottb.) C.B.Cl.

T. exilis Levyns

T. fasciata (Rottb.) C.B.Cl.

T. fimbriolata C.B.Cl.

T. flexuosa (Thunb.) C.B.Cl.

T. thermalis (L.) C.B.Cl.

Gramineae

Agropyron distichum (Thunb.) Beauv.

Ammophila arenaria (L.) Link

Cymbopogon marginatus (Steud.) Stapf

Danthonia cincta Nees

D. lanata Schrad.

D. macrantha Schrad.

Ehrharta ramosa Thunb.

E. villosa Schult.f.

Eragrostis sabulosa (Steud.) Schweick.

Lasiochloa longifolia (Schrad.) Kunth

Pentaschistis ampla (Nees) McClean

P. angustifolia (Nees) Stapf var. albescens Stapf

P. curvifolia (Schrad.) Stapf

P. juncifolia Stapf

P. steudelii (Nees) McClean

Phragmites australis (Cav.) Trin. ex Steud.

Sporobolus africanus (Poir.) Robyns & Tournay

S. virginicus (L.) Kunth

Stenotaphrum secundatum (Walt.) Kuntze

Stipagrostis zeyheri (Nees) de Winter

Themeda triandra Forsk.

Haemoderaceae

Dilatris pillansii Barker

Lanaria lanata Dur. & Schinz

Wachendorfia thyrsiflora L.

Hypoxidaceae

Spiloxene monophylla (Schltr.)

Iridaceae

Anapalina pulchra (Bak.) N.E.Br.

Aristea africana (L.) Hoffmg.

A. oligocephala Bak.

Bobartia gladiata (L.f.) Ker-Gawl.

B. indica L.

Geissorrhiza wrightii Bak.

Gladiolus carneus de la Roche

Melasphaerula ramosa (L.) N.E.Br.

Nivenia levynsiae Weim.

N. stokoei (Guthrie) N.E.Br.
Pillansia templemannii (Bak.) L.Bol.
Tritoniopsis pulchella Lewis
Watsonia comptonii L.Bol.

Juncaceae

Juncus kraussii Hochst.
Prionium serratum (L.f.) Drége

Liliaceae

Agapanthus africanus (L.) Hoffmg.
Asparagus aethiopicus L. var. aethiopicus
A. asparagoides (L.) Wight
A. capensis L. var. capensis
A. compactus Salter
A crispus Lam.
A. scandens Thunb.
A. thunbergianus Schult.
Kniphofia uvaria (L.) Hook.
Ornithogalum graminifolium Thunb.
Trachyandra divaricata (Jacq.) Kunth
T. esterhuysenae Oberm.
Urginea dregei Bak.

Orchidaceae

Disa racemosa L.f.
D. tripetaloides (L.f.) N.E.Br.
D. uncinata Bol.
D. uniflora Berg.
D. vaginata Harv.
Penthea patens (L.f.) Swartz

Restionaceae

Cannamois virgata Steud.
Chondropetalum deustum Rottb.
C. ebracteatum Pillans
C. hookerianum Pillans
C. mucronatum Pillans
C. nudum Rottb.
C. tectorum Pillans
Elegia asperiflora Kunth
E. asperiflora Kunth var. lacerata Pillans
E. fistulosa Kunth
E. juncea L.
E. parviflora Kunth

E. persistens Mast.

E. racemosa Pers.

E. spathacea Mast.

E. stipularis Mast.

Elegia species Boucher 1303

E. thyrsifera Pers.

Hypodiscus albo-aristatus Mast.

H. alternans Pillans

H. argenteus Mast.

H. aristatus Nees

H. willdenowia Mast.

Hypolaena crinalis Pillans

H. diffusa Mast.

H. digitata Pillans

Leptocarpus asper Pillans

L. ejuncidus Pillans

L. fruticosus Mast.

L. hyalinus (Mast.) Pillans

L. membranaceus Pillans

L. species Boucher 1233

Restio ambiguus Mast.

R. bifarius Mast.

R. bifidus Thunb.

R. bifurcus Nees

R. brachiatus Pillans

R. curviramis Kunth

R. cuspidatus Thunb.

R. debilis Nees

R. dispar Mast.

R. egregius Hochst.

R. eleocharis Nees ex Mast.

R. filiformis Poir.

R. obtussissimus Steud.

R. occultus Pillans

R. species near R. fusiformis Pillans

R. purpurascens Nees ex Mast.

R. similis Pillans

R. stokoei Pillans

R. subverticellatus Mast.

Staberoha cernua Dur. & Schinz

Thamnochortus dichotomus R.Br.

T. fruticosus Berg.

T. gracilis Mast.
T. insignis Mast.
T. pellucidus Pillans
T. pulcher Pillans
Willdenowia argentea Hieron.
W. humilis Mast.
W. lucaeana Kunth
W. teres Thunb.

Typhaceae

Typha latifolia L. subsp. capensis Rohrb.

ANGIOSPERMAE: DICOTYLEDONEAE

Aizoaceae

Aizoon sarmentosum L.f.
Carpobrotus acinaciformis (L.) L.Bol.
Drosanthemum floribundum (Haw.) Schwant.
Erepsia anceps (Harv.) L.Bol.
Kensitia pillansii (Kensit) Fedde
Lampranthus aurantiacus (DC.) Schwant.
L. austricolus (L. Bol.) L. Bol.
Ruschia sarmentosa (Haw.) Schwant.
Tetragonia spicata L.f.

Anacardiaceae

Laurophyllus capensis Thunb.
Rhus africana Mill.
R. crenata Thunb.
R. laevigata L.
R. lucida L.
R. tomentosa L.
R. undulata Jacq.

Araliaceae

Cussonia thyrsiflora Thunb.

Asclepiadaceae

Astephanus neglectus Schltr.
A. triflorus (L.f.) Schult.
Cynanchum africanum R.Br.
Oncinema lineare (L.f.) Bullock
Secamone alpini Schult.

Bruniaceae

Berzelia abrotanoides (L.) Brongn.

B. dregeana Colozza

B. lanuginosa (L.) Brongn.

Brunia albiflora Phill.

B. alopecuroides Thunb.

B. neglecta Schltr.

B. stokoei Phill.

Lonchostoma monogynum (Vahl) Pillans

Nebelia fragaroides (Willd.) Kuntze

N. paleacea (Berg.) Sweet

Pseudobaeckea africana (Burm. f.) Pillans

Raspalia microphylla (Thunb.) Brongn.

Campanulaceae

Lightfootia axillaris Sond.

L. subulata L'Hérit.

L. tenella Lodd.

Lobelia anceps L.f.

L. capillifolia (Presl) A.DC.

L. coronopifolia L.

Merciera brevifolia A.DC.

M. tenuifolia (L.f.) A.DC.

Prismatocarpus sessilis Eckl. ex A.DC.

Roella ciliata L.

R. compacta Schltr.

Caryophyllaceae

Silene crassifolia L.

Celastraceae

Cassine barbara L.

C. maritima L.Bol.

Hartogia schinoides C.A.Sm.

Maurocenia frangularia (L.) Mill.

Maytenus lucida (L.) Loes.

M. oleoides (Lam.) Loes.

Pterocelastrus rostratus (Thunb.) Walp.

P. tricuspidatus (Lam.) Sond.

Compositae

Alciope lanata DC.

A. tabularis (Thunb.) DC.

Anaxeton asperum (Thunb.) DC.

A. nycthemerum Less.
A. recurvum (Lem.) DC.
Arctotheca populifolia (Berg.) Norl.
Arctotis semipapposa (DC.) Lewin
Athrixia heterophylla (Thunb.) Less.
Berkheya barbata (L.f.) Hutch.
Brachylaena neriifolia (L.) R.Br.
Chrysanthemoides monilifera (L.) Norl.
Chrysocoma coma-aurea L.
Cineraria geifolia L.
Conyza pinnatifida (Thunb.) Less.
Corymbium africanum L.
C. latifolium Harv.
Cullumia setosa (L.) R.Br.
C. squarossa (Thunb.) R.Br.
Disparago ericoides Gaertn.
Erigeron canadense L.
Eroeda imbricata (Lam.) Levyns
Euryops abrotanifolius (L.) DC.
Felicia amelloides (L.) Voss
Gazania pinnata (Thunb.) Less.
Gerbera asplenifolia (Lam.) Spreng.
G. crocea (L.) Kuntze
G. tomentosa DC.
Gibbaria ilicifolia (L.) Norl.
Helichrysum crispum (L.) D.Don
H. cymosum (L.) D.Don
H. ericaefolium Less.
H. maritimum (L.) D.Don ex G.Don
H. metalasioides DC.
H. orbiculare (Thunb.) Druce
H. retortum (L.) Willd.
H. sesamoides (L.) Willd.
H. vestitum (L.) Schrank
Helipterum canescens (L.) DC.
H. gnaphaloides (L.) DC.
Heterolepis aliena (L.f.) Druce
Lachnospermum umbellatum (D.Don) Pillans
Leontonyx glomeratus (L.) DC.
L. spathulatus (Thunb.) Less.
Osmitopsis asteriscoides (Berg.) Less.
O. parvifolia (DC.) Hofmeyr

Osteospermum polygaloides L.
O. rotundifolium (DC.) Norl.
Othonna amplexifolia DC.
O. dentata L.
O. quinquedentata Thunb.
Phaenocoma prolifera (L.) D.Don
Mairea coriacea H.Bol.
M. microcephala (Less.) DC.
Metalasia brevifolia (Lam.) Levyns
M. cephalotes Less.
M. lichtensteinii Less.
M. muricata (L.) R.Br.
Senecio arnicaeflorus DC.
S. elegans L.
S. halimifolius L.
S. maritimus L.f.
S. subcanescens Compton
Stoebe capitata Berg.
S. cinerea Thunb.
S. plumosa (L.) Thunb.
S. sphaerocephala Schltr.
S. spiralis Less.
Tarchonanthus camphoratus L.
Ursinia crithmoides (Berg.) Poir.
U. dentata (L.) Poir.
U. quinquepartita (DC.) N.E.Br.

Cornaceae

Curtisia dentata (Burm.f.) C.A.Sm.

Crassulaceae

Crassula capensis (L.) Baill.
C. rupestris Thunb.
Rochea coccinea (L.) DC.
R. jasminea (Sims) DC.
R. subulata (L.) Adamson

Cruciferae

Heliophila africana (L.) Marais
H. scoparia Burch. ex DC.

Cunoniaceae

Cunonia capensis L.

Curcurbitaceae

Kedrostis nana (Lam.)Cogn.

Droseraceae

Drosera aliciae Hamet

D. glabripes (Harv.) Stein

D. hilaris Cham. & Schlechtd.

D. trinervia Spreng.

Ebenaceae

Diospyros glabra (L.) De Wint.

Euclea racemosa Murr.

Ericaceae

Aniserica gracilis (Bartl.) N.E.Br.

Blaeria barbigera (Salisb.) G.Don

B. dumosa Wendl.

B. ericoides L.

B. species nova Boucher 874

Erica amphigena Guth. & Bol.

E. articularis L.

E. azalaefolia Salisb.

E. brachialis Salisb.

E. cerinthoides L.

E. coccinea L.

E. corifolia L.

E. corydalis Salisb.

E. cristata Dulfer

E. desmantha Benth.

E. discolor Andr.

E. extrusa Compton

E. fascicularis L.f.

E. fastigiata L.

E. filiformis Salisb.

E. foliacea Andr.

E. gysbertii Guth. & Bol.

E. hispidula L.

E. imbricata L.

E. intervallaris Salisb.

E. laeta Bartl.

E. lananthera L. Bol.

E. leucotrachela H.A.Baker

E. longifolia Ait.

E. macowanii Cufino

E. massoni L.f.

E. monadelphia Willd.

Erica multumbellifera Berg.
E. nudiflora L.
E. obliqua Thunb.
E. parvula Guth. & Bol.
E. patersonia Andr.
E. perspicua Wendl.
E. pillansii H.Bol.
E. placentaeflora Salisb.
E. plukenetii L.
E. pulchella Houtt.
E. quadrangularis Salisb.
E. retorta Montin
E. rhopolantha Dulfer
E. serratifolia Andr. var. subnuda Bol.
E. sessiliflora L.f.
E. sitiens Klotzsch
E. species nova Boucher 714
E. thomae L. Bol.
E. velitaris Salisb.
Nagelocarpus serratus (Thunb.) Bullock
Scyphogyne longistyla N.E.Br.
S. muscosa (Ait.) Steud.
Sympieza articulata (Thunb.) N.E.Br.
S. labialis (Salisb.) Druce
S. pallescens N.E.Br.
Syndesmanthus elimensis N.E.Br.

Euphorbiaceae
Clutia alaternoides L.
C. polygonoides L.
Euphorbia silenifolia (Haw.) Sweet

Gentianaceae
Chironia baccifera L.
C. linioides L. subsp. nana Verdoorn
Orphium frutescens (L.) E.Mey.
Villarsia capensis (Houtt.) Merrill

Geraniaceae
Pelargonium angulosum (Mill.) Ait.
P. betulinum (L.) Ait.
P. capitatum (L.) Ait.
P. cucullatum (L.) Ait.
P. multicaule Jacq.
P. triste (L.) Ait.

Grubbiaceae

Grubbia rosmarinifolia Berg.

G. tomentosa (Thunb.) Harms

Icacinaceae

Apodytes dimidiata E.Mey ex Arn.

Labiatae

Salvia africana-lutea L.

Lauraceae

Cassytha filiformis L.

Ocotea bullata (Burch.) Baill.

Leguminosae

Subf. Mimosoideae

Acacia cyanophylla Lindl.

A. cyclops A. Cunn.

A. longifolia Willd.

A. mearnsii De Wild.

Albizia lophantha (Willd.) Benth.

Subf. Papilionatae

Argyrolobium filiforme (Thunb.) Eckl. & Zeyh.

x A. lunaris (L.) Druce

Aspalathus aspalathoides (L.) R. Dahlgr.

A. biflora E.Mey. subsp. biflora

x A. callosa L.

A. ciliaris L.

x A. forbesii Harv.

A. lactea Thunb. subsp. adelphea (Eckl. & Zeyh.) R. Dahlgr.

A. linearis (Burm.f.) R.Dahlgr.

A. stenophylla Eckl. & Zeyh.

Bolusafra bituminosa (L.) Kuntze

Cyclopia genistoides (L.) R.Br.

Indigofera angustifolia L.

I. brachystachya E.Mey.

I. filicaulis Eckl. & Zeyh.

x I. mauritanica (L.) Thunb.

x I. sarmentosa L.f.

I. tetragonoloba E.Mey.

Podalyria calyptrata Willd.

Priestleya vestita DC.

Psoralea affinis Eckl. & Zeyh.

P. aphylla L.

Psoralea asarina (Berg.) Salter
P. cordata (L.) Salter
P. fruticans (L.) Druce
P. laxa Salter
P. pinnata L.
x P. repens L.
x P. zeyheri Harv.
Rafnia perfoliata E.Mey.

Linaceae

Linum africanum L.

Menispermaceae

Antizoma capensis (Thunb.) Diels

Myoporaceae

Oftia africana (L.) Bocq.

Myricaceae

Myrica cordifolia L.
M. diversifolia Adamson
M. quercifolia L.
M. serrata Lam.

Myrsinaceae

Myrsine africana L.
Rapanea melanophloeos (L.) Mez

Myrtaceae

Eucalyptus lehmannii Preiss.
Leptospermum laevigatum F. Muell.
Metrosideros angustifolia (L.) J.E.Sm.

Oleaceae

Olea africana Mill.
O. capensis L. subsp. capensis L.
O. exasperata Jacq.

Oliniaceae

Olinia cymosa Thunb.

Oxalidaceae

Oxalis commutata Sond.
O. luteola Jacq.

Penaeaceae

Penaea mucronata L.
Sonderothamnus petraeus (Barker) R.Dahlgr.

Saltera sarcocolla (L.) Bullock

Plantaginaceae

Plantago carnosa Lam.

Plumbaginaceae

Limonium scabrum (Thunb.) Kuntze

Polygalaceae

Muraltia pauciflora (Thunb.) DC.
M. satureioides DC.
Polygala garcini DC.

Proteaceae

Aulax pallasia Stapf
A. umbellata (Thunb.) R.Br.
Brabeium stellatifolium L.
Diastella bryiflora Salisb. ex Knight
Hakea sericea Schrad.
Leucadendron gandogeri Schinz ex Gand.
L. laureolum (Lam.) Fourcade
L. microcephalum Gand.
L. coniferum (L.) Meisn.
L. salicifolium (Salisb.) Williams
L. salignum Berg.
L. spissifolium (Salisb. ex Knight) Williams
L. xanthoconus (Kuntze) K. Schum.
Leucospermum conocarpodendron (L.) Buek subsp. viridum Rourke
L. oleifolium (Berg.) R.Br.
L. prostratum (Thunb.) Stapf
Mimetes argenteus Salisb. ex Knight
M. capitulatus R.Br.
M. cucullatus (L.) R.Br.
M. hirtus Knight
M. hottentoticus Phill. & Hutch.
Orothamnus zeyheri (Meisn.) Pappe
Protea acaulos (L.) Reichard
P. angustata R.Br.
P. arborea Houtt.
P. cordata Thunb.
P. cynaroides (L.) L.
P. lepidocarpodendron (L.) L.
P. longifolia Andr.
P. mundii Klotzsch

Protea repens (L.) L.
P. scabra R.Br.
P. stokoei Phill.
Serruria adscendens R.Br.
S. burmanii R.Br.
S. elongata R.Br.
Sorocephalus clavigerus (Salisb. ex Knight) Hutch.
Spatalla longifolia Salisb. ex Knight

Ranunculaceae

Anemone capensis (L.) Lam.
Knowltonia capensis (L.) Hutch.

Retziaceae

Retzia capensis Thunb.

Rhamnaceae

Phylica atrata Licht. ex Roem. & Schultes
P. buxifolia L.
P. ericoides L.
P. humilis Sond.
P. imberbis Berg.
P. lasiocarpa Sond.
P. spicata L.f.
P. stipularis L.
P. strigulosa Sond.

Rosaceae

Cliffortia apiculata Weim.
C. atrata Weim.
C. complanata E.Mey.
C. cuneata Ait.
C. ferruginea L.f.
C. graminea L.f.
C. heterophylla Weim.
C. hirsuta Eckl. & Zeyh.
C. ruscifolia L.
C. subsetacea (Eckl. & Zeyh.) Diels ex Bol. & W.Dod.
C. tenuis Weim.

Rubiaceae

Anthospermum aethiopicum L.
A. ciliare L.
A. lichtensteinii Crüse
A. prostratum Sond.

Carpococe spermacocea (Reichb.) Sond.
Calium tomentosum Thunb.

Rutaceae
Adenandra brachyphylla Schlechtd.
A. umbellata Willd.
A. uniflora Willd.
Agathosma anomala E.Mey. ex Sond.
A. bifida (Jacq.) Bartl. & Wendl.
A. ciliaris (L.) Druce
A. imbricata (L.) Willd.
Coleonema album Bartl. & Wendl.
C. juniperinum Sond.
C. nubigenum Esterhuysen
Diosma hirsuta L.
D. oppositifolia L.

Salicaceae
Populus canescens Sm.

Santalaceae
Thesidium fragile Sond.
Thesium capituliflorum Sond.
T. carinatum A.DC.
T. commutatum Sond.
T. ericaefolium A.DC.
T. micropogon A.DC.
T. spicatum L.
T. virgatum Lam.

Sapotaceae
Sideroxylon inerme L.

Saxifragaceae
Montinia caryophyllacea Thunb.

Scrophulariaceae
Halleria elliptica Thunb.
H. lucida L.
Manulea rubra (Berg.) L.f.
Nemesia versicolor E.Mey. ex Benth.
Selago serrata Berg.
S. spuria L.
Sutera hispida (Thunb.) Druce
Zaluzianskya dentata (Benth.) Walp.

Selaginaceae

Agathelpis dubia (L.) Hutch.
A. species cf. A. parviflora Choisy

Sterculiaceae

Hermannia ternifolia Presl

Solanaceae

Solanum nigrum L.
S. quadrangulare Thunb.

Thymelaeaceae

Gnidia anomala Meisn.
G. flanaganii C.H.Wr.
G. juniperifolia Lam.
G. oppositifolia L.
G. pinifolia L.
G. scabra Thunb.
G. viridis Berg.
Lachnaea densiflora Meisn.
Passerina ericoides L.
P. paleacea Wikstrom
P. rigida Wikstrom
P. vulgaris (Meisn.) Thoday
Struthiola ciliata (L.) Lam.
S. ciliata (L.) Lam. subsp. schlechteri (Gilg) Peterson
S. leptranthera Bol.
S. tomentosa Andr.

Umbelliferae

Centella affinis (Eckl. & Zeyh.) Adamson
C. calliodus (Cham. & Schlechtd.) Drude
C. coriacea Nannfd.
C. difformis (Eckl.& Zeyh.) Adamson
C. restioides Adamson
C. triloba (Thunb.) Drude
Glia gummifera (L.) Sond.
Hermas villosa (L.) Thunb.
Lichtensteinia lacera Cham. & Schlechtd.
Peucedanum sieberianum Sond.

Urticaceae

Australina lanceolata (Thunb.) N.E.Br.
Droguetia ambigua Wedd.

Verbenaceae

Campylostachys cernua (L.f.) Kunth

Stilbe ericoides L.

Plate 9. Sunny Seas Estate: mixed coastal fynbos of the acid sands. The Klein Hangklip Mountains are visible in the centre distance.

Plate 10. Sunny Seas Estate: Brunia-Erica seepage fynbos. The tall shrub on the right is Psoralea pinnata.

Plate 1. Silver Sands Bay: Colpoon-Rhus scrub. The Arctotheca-Myrica strand pioneer community found on unstable sand can be distinguished beyond the figure. The Voorberg Mountain in the background dominates the scenery.

Plate 2. Dawidskraal: Sideroxylon inerme dune scrub interior.

Plate 7. Pringle Bay: _Coleonema album_ short coastal fynbos. Note the typical rocky habitat. The highest mountain in the background is Buffelstalberg.

Plate 8. Silver Sands Estate: _Leucadendron coniferum_ limestone fynbos.

Plate 5. Wynand Louw's Forest: *Podocarpus-Olinia* shale forest.

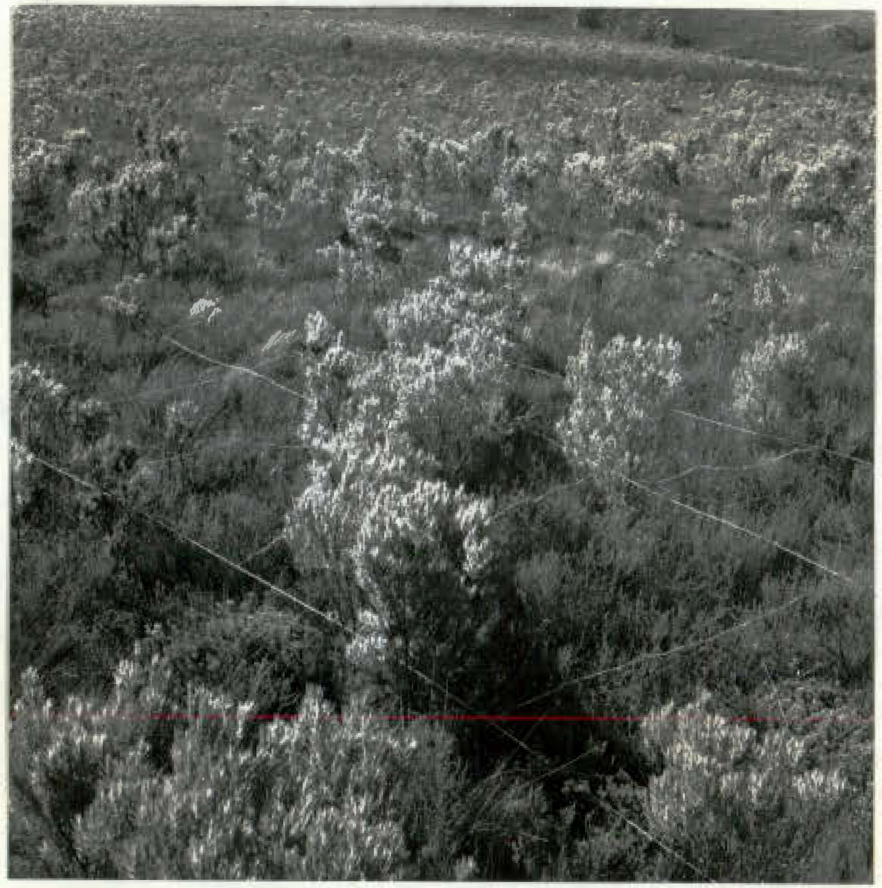
Plate 6. Oudebosch Forest: *Podocarpus-Olinia* shale forest interior. An initialled *Rapanea melanophloeos* trunk can be seen on the left as well as a large *Olinia cymosa* tree behind the figure. *Rumohra adiantiformis* is the common ferm.

Plate 3. Elephant Rock Mountain after fire. The Cussonia-Rapanea scree forest patches are just visible at the foot of the mountain. This photo, taken three months after the 1970 Betty's Bay fire, shows the habitat of the mixed ericoid and restioid fynbos of the xeric seaward slopes, in the foreground.

Plate 4. Spinnekopneskloof: Cunonia-Cyathea kloof forest.

Plate 17. Palmiet Valley: mixed dry fynbos on shale-sandstone transitions or areas with sand on shale. This vegetation was considered to be in a moribund state.

Plate 18. Dwarsrivier Mountains: mixed proteoid and restioid fynbos of the mesic southerly shale-sandstone transitions. Platberg Mountain in the background was burnt three years before the photograph was taken.



<u>Plate 15</u>. Palmiet River Valley: <u>Protea-Gerbera</u> dry short fynbos. <u>Leucadendron</u> <u>xanthoconus</u> is the common shrub.

<u>Plate 16</u>. Conical Hill: <u>Berzelia-Leucadendron</u> dense <u>tall moist fynbos beyond the figure</u>. The shale-sandstone contact is very marked. The <u>Berzelia-Pseudobaeckea</u> tall fynbos of the rocky streams occurs in the left foreground.

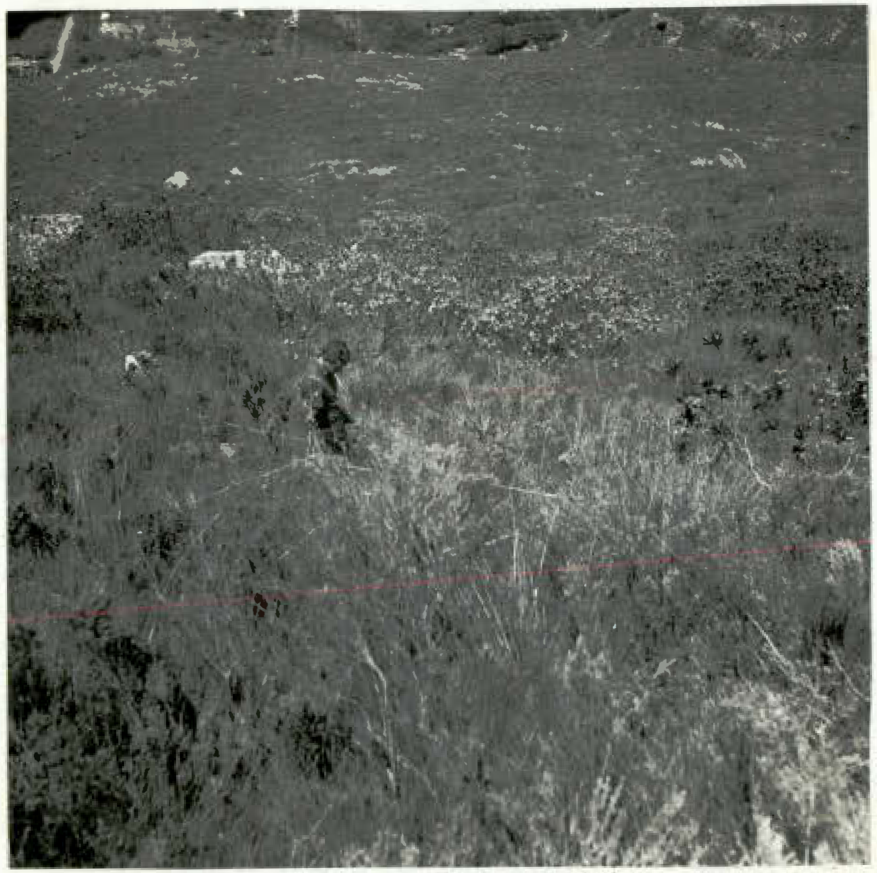


Plate 13. Harold Porter Botanic Gardens: mixed ericoid and restioid fynbos of the mesic seaward slopes.

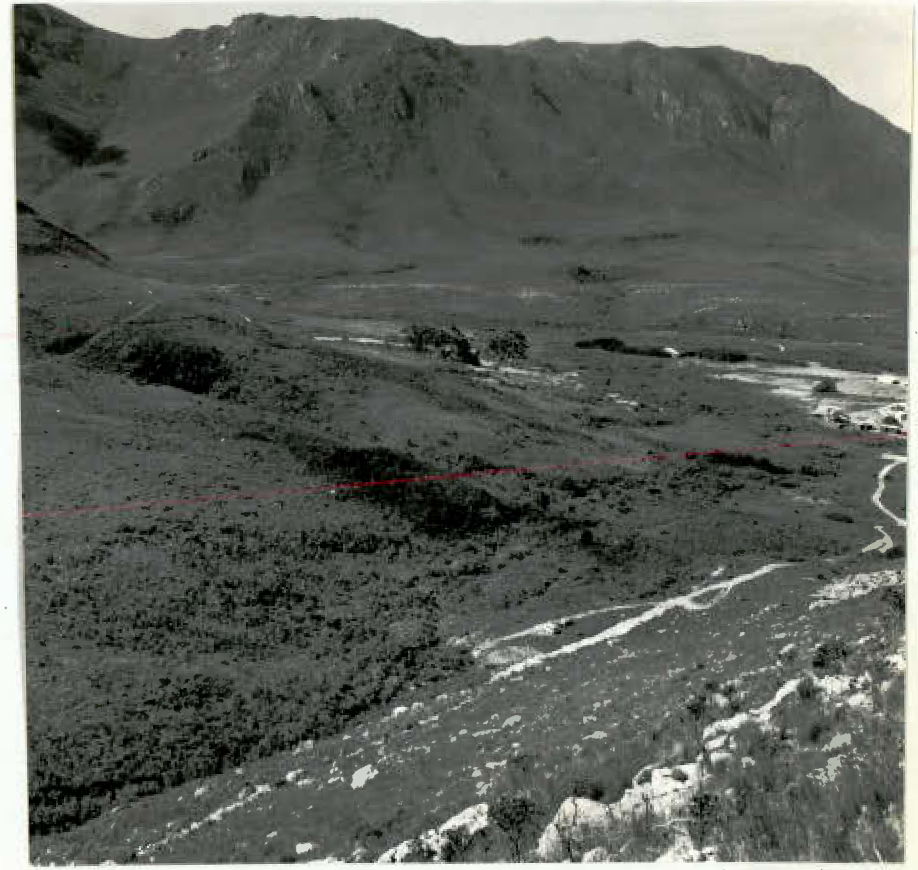


Plate 14. Oudebos Farm: mixed ericoid and restioid fynbos of the inland facing slopes in the right foreground. Paardeberg Mountain on the opposite side of the Palmiet River Valley is the location of the area studied by Grobler (1964).

Plate 11. Groot Vleie: Chondropetalum-Juncus vlei-fringing tussock. A Phragmites australis clump can be seen in the distance.

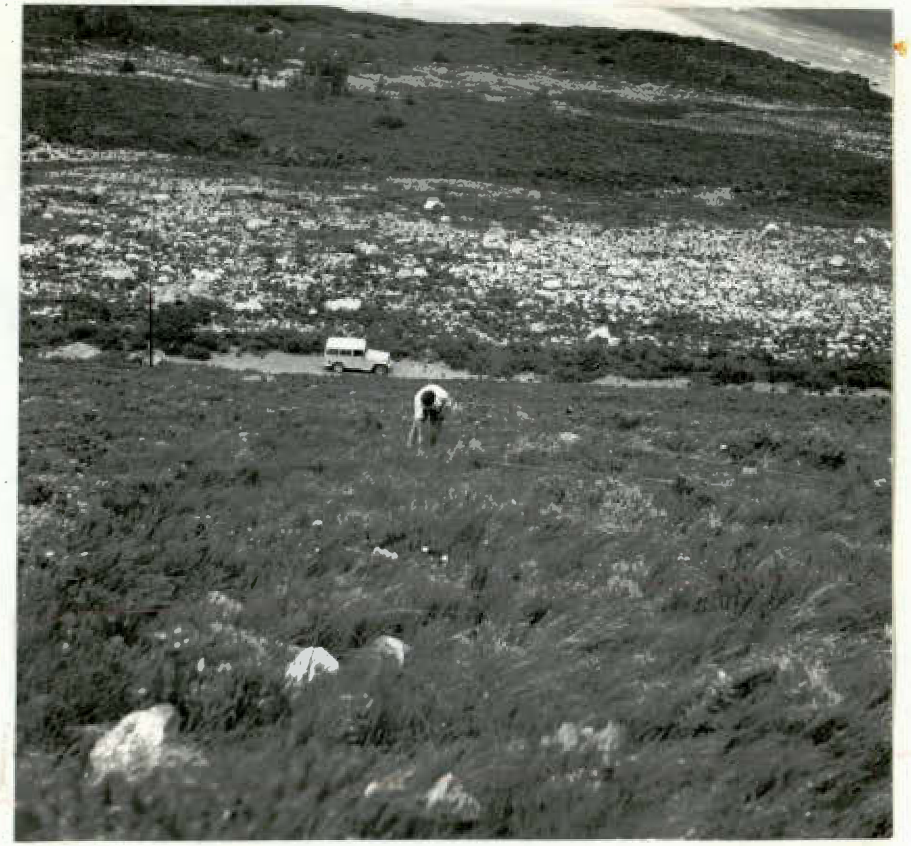


Plate 12. Klein Hangklip and Pringle Bay: mixed ericoid and restioid fynbos of the xeric seaward slopes.

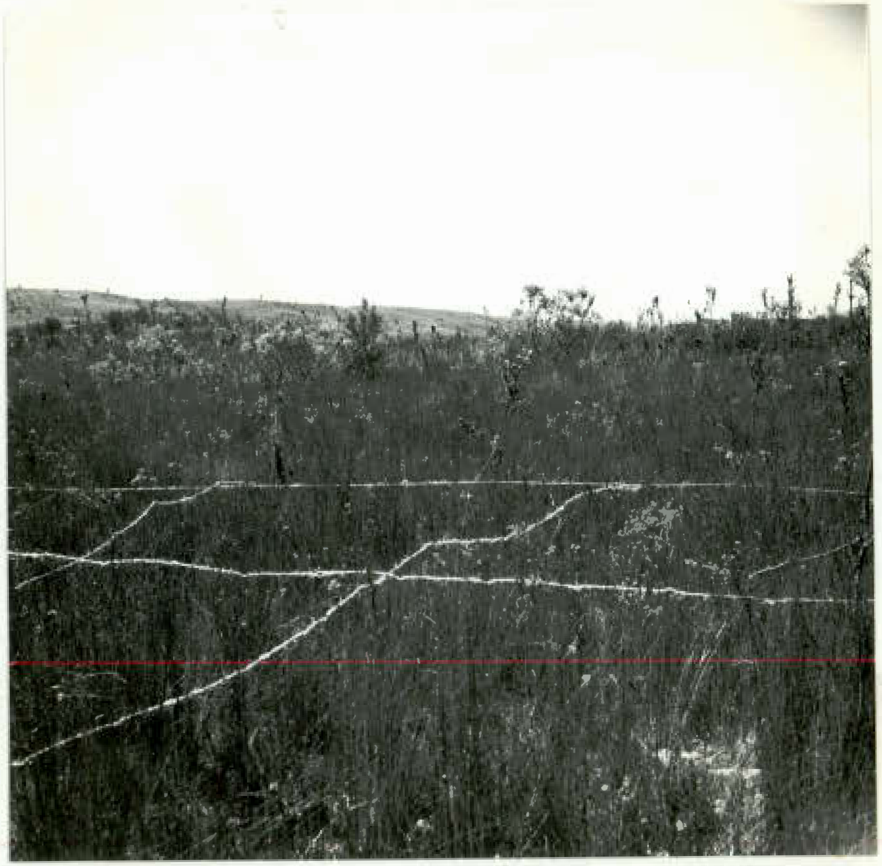


Plate 19. Edge of the Elgin Basin: mixed short ericoid and restioid fynbos of the shallow sandy, xeric flats. Note the young *Pinus pinaster*, an encroaching alien species, amongst the indigenous proteoids.

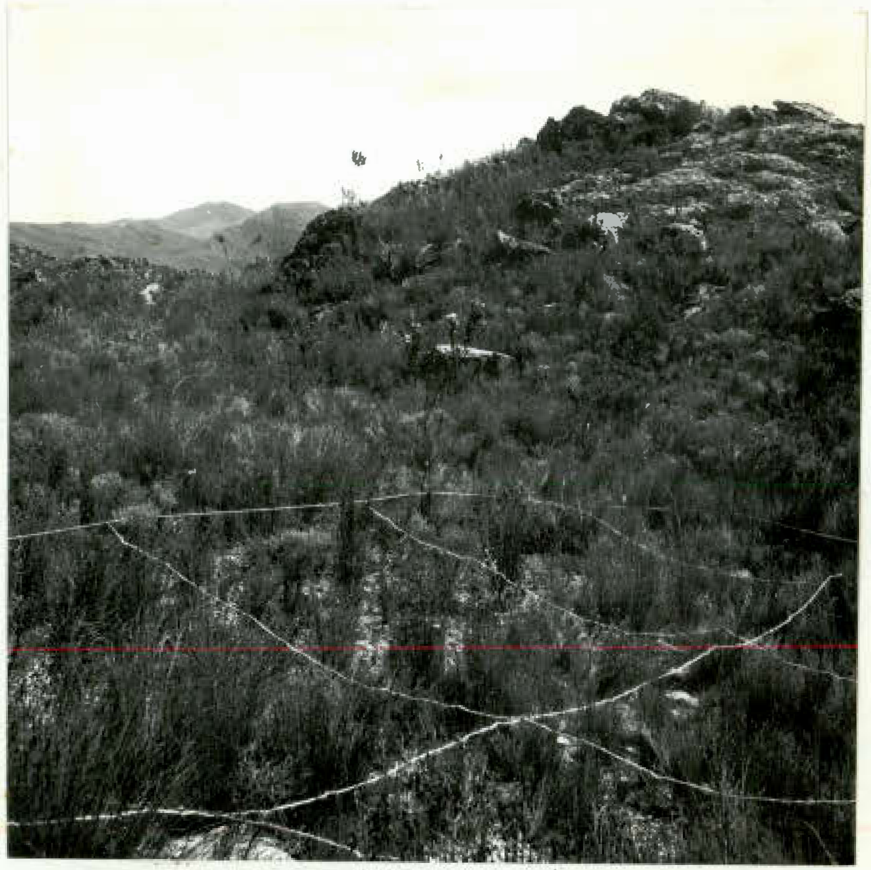


Plate 20. Dwarsrivier Mountain: mixed short ericoid and restioid fynbos of the lower slope drainage lines. The taller shrub in the centre is *Phaenocoma prolifera*.

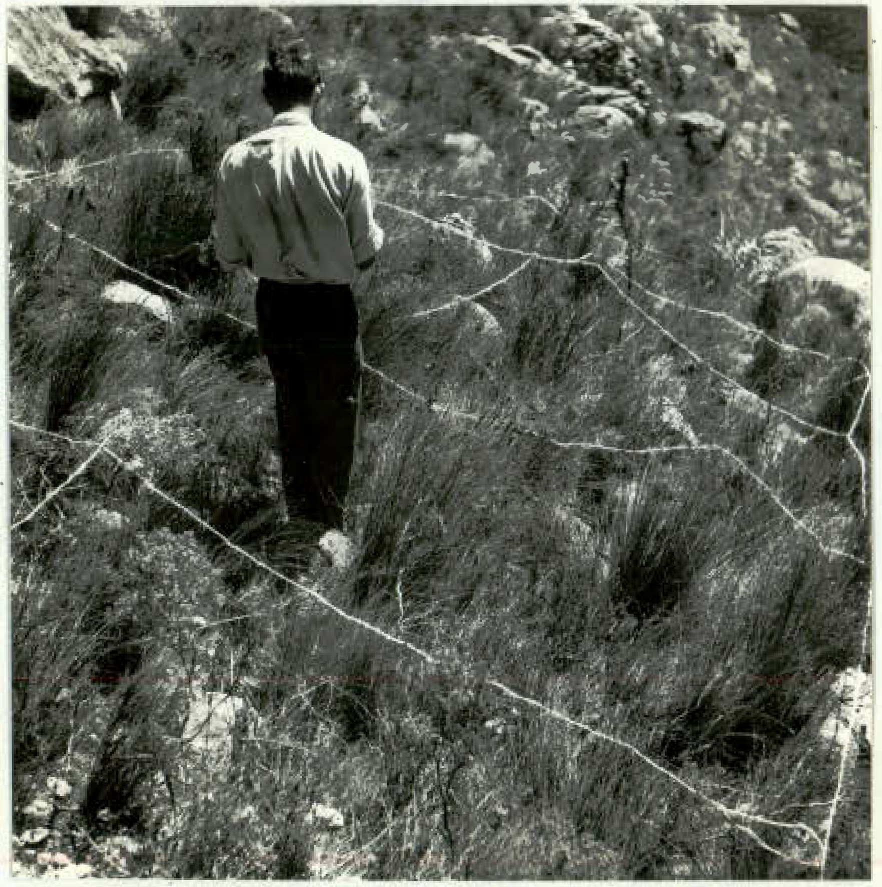


Plate 21. Paardeberg Mountain: mixed short ericoid and restioid fynbos of the lower northerly rocky slopes. The Restio on the right alongside the figure is R. bifarius

Plate 22. Dwarsrivier Mountains: mixed short ericoid and restioid fynbos of the xeric upper drainage lines.

Plate 23. Edge of the Elgin Basin: mixed ericoid and restioid fynbos of the rocky ridges on the flats bordering the Elgin Basin. Tetraria thermalis, a Cyperaceae, is clearly visible in the right foreground. Note the encroaching alien, Pinus pinaster, on the Bokkeveld shales of the Elgin Basin in the distance.

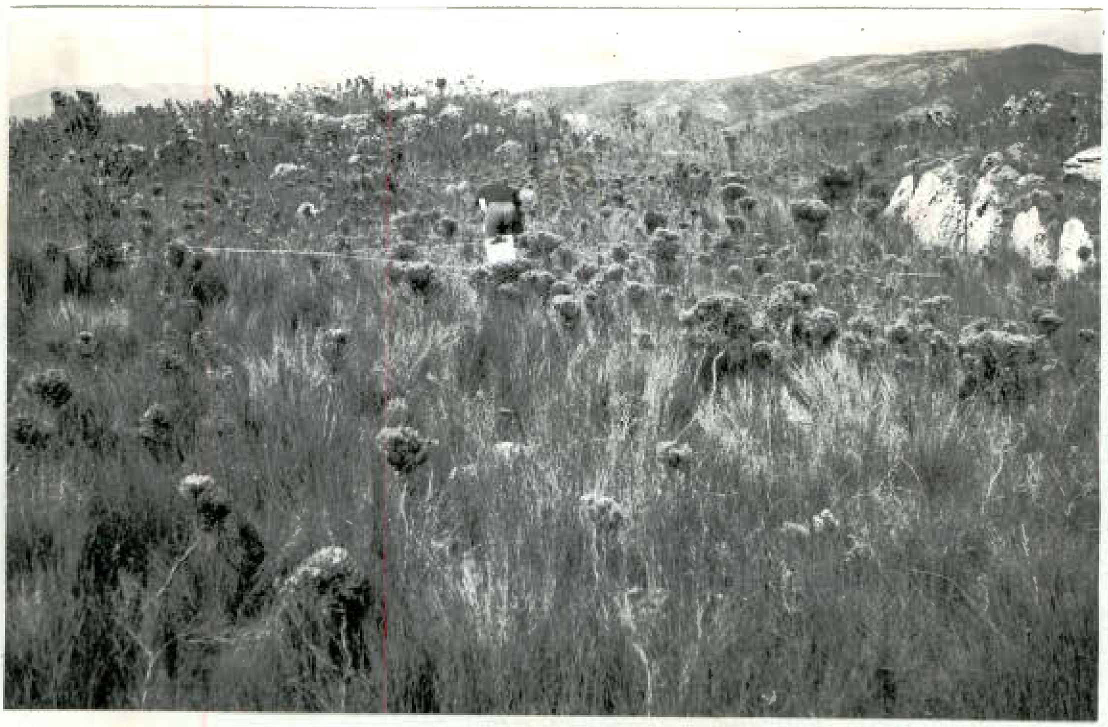


Plate 24. Paardeberg Mountain: mixed ericoid and restioid fynbos of the mesic upper drainage lines. The common rounded shrub is Nebelia fragaroides.

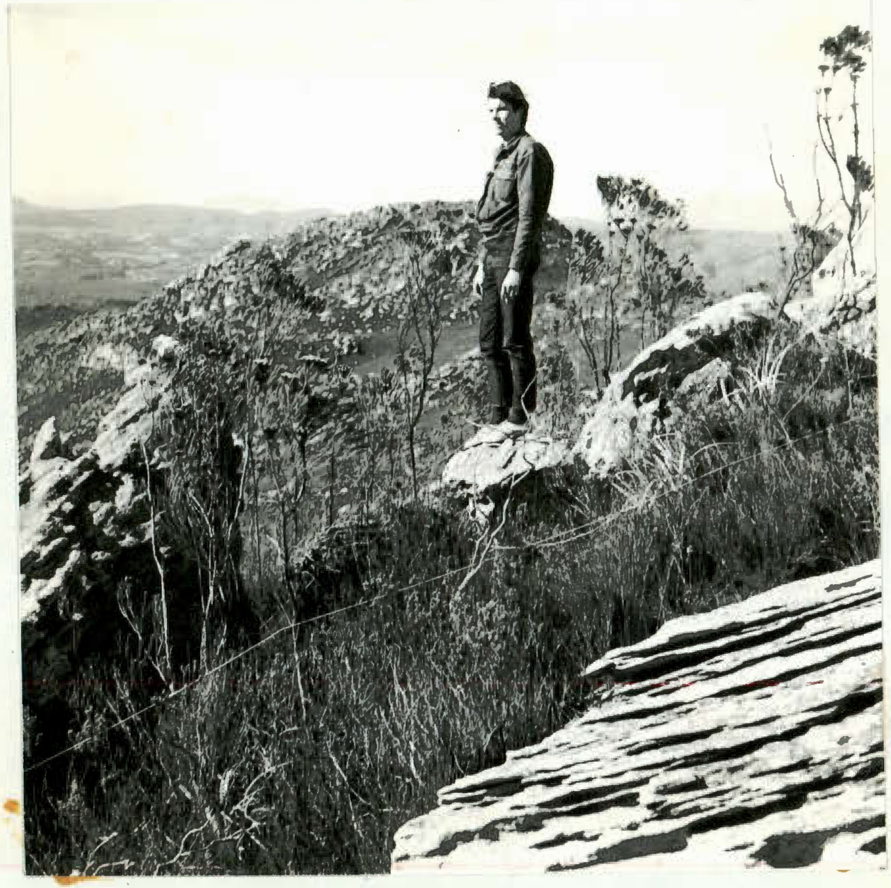


Plate 25. Dwarsrivier Mountains: mixed open fynbos of the summit ridge rocky outcrops. The tall shrub is *Brunia albiflora*.

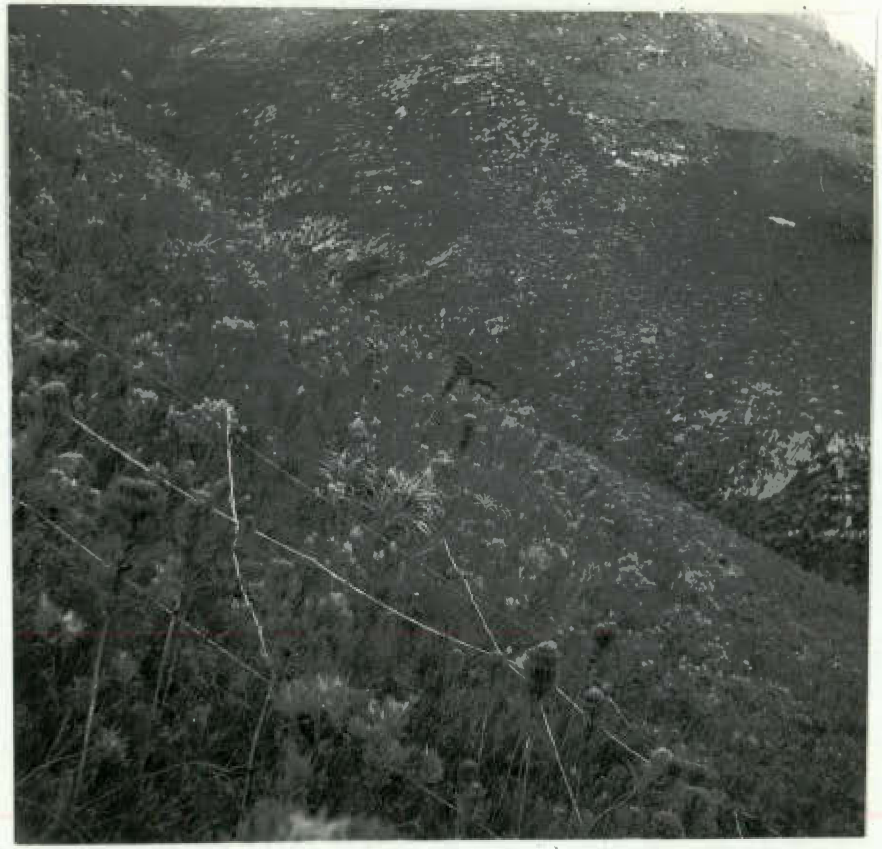
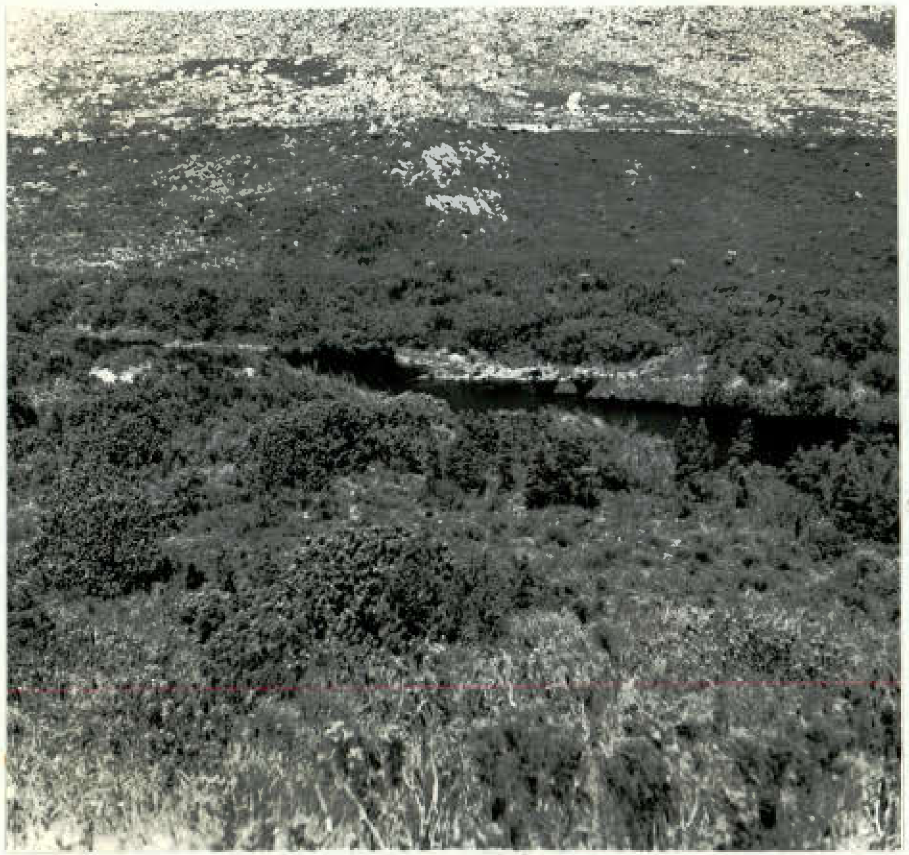


Plate 26. Dwarsrivier Mountains: mixed fynbos of the lower southerly slopes. The single stemmed mop-like shrub is *Brunia alopecuroides*.

<u>Plate 27</u>. Platberg Mountain: mixed fynbos of the hygric upper southerly slopes. The tall rounded shrub is <u>Berzelia dregeana</u>, an endemic species. Photo by H.C. Taylor.

<u>Plate 28</u>. Pringle East Peak: <u>Restio-Chondropetalum</u> tussock marsh. The tall shrub in the background is <u>Leucadendron gandogeri</u>. <u>Chondropetalum mucronatum</u> is the common tall restioid.



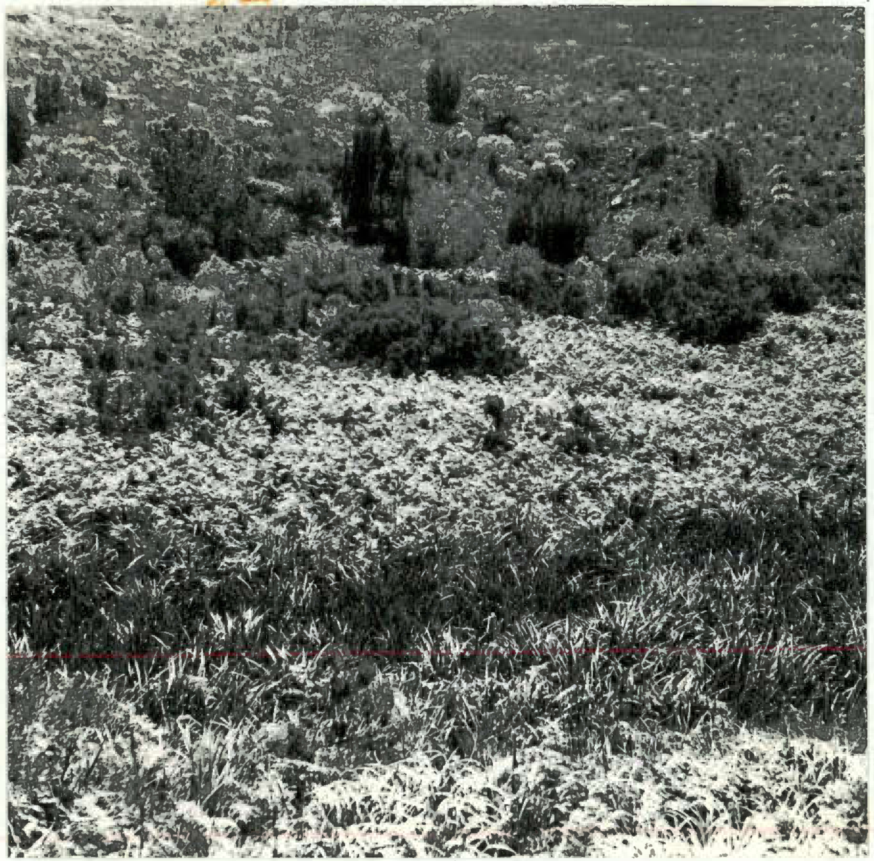


Plate 29. Palmiet River: *Brabeium-Rhus* riverine scrub. The tall lighter coloured shrubs on the left are *Leucospermum conocarpodendron* individuals.

Plate 30. Louw's River: *Prionum-Wachendorfia* swamp. The darker band of vegetation in the foreground mainly consists of *Prionium serratum*, while *Todea barbara* and *Blechnum capense* become dominant in the central area. The darker erect trees are *Widdringtonia cupressoides* individuals.

Plate 31. Platberg Mountain foothills. A wild-fire front, burning against the wind, testifies to the inflammability of the fynbos vegetation. Fires can occur during all seasons of the year. This fire destroyed 22 houses at Betty's Bay during 1970.

Plate 32. Pringle Bay: township development. Certain coastal plain communities, presently of common occurrence, will undoubtedly become very rare in the future.