A VEGETATION SURVEY OF THE CAPE OF GOOD HOPE NATURE RESERVE

by

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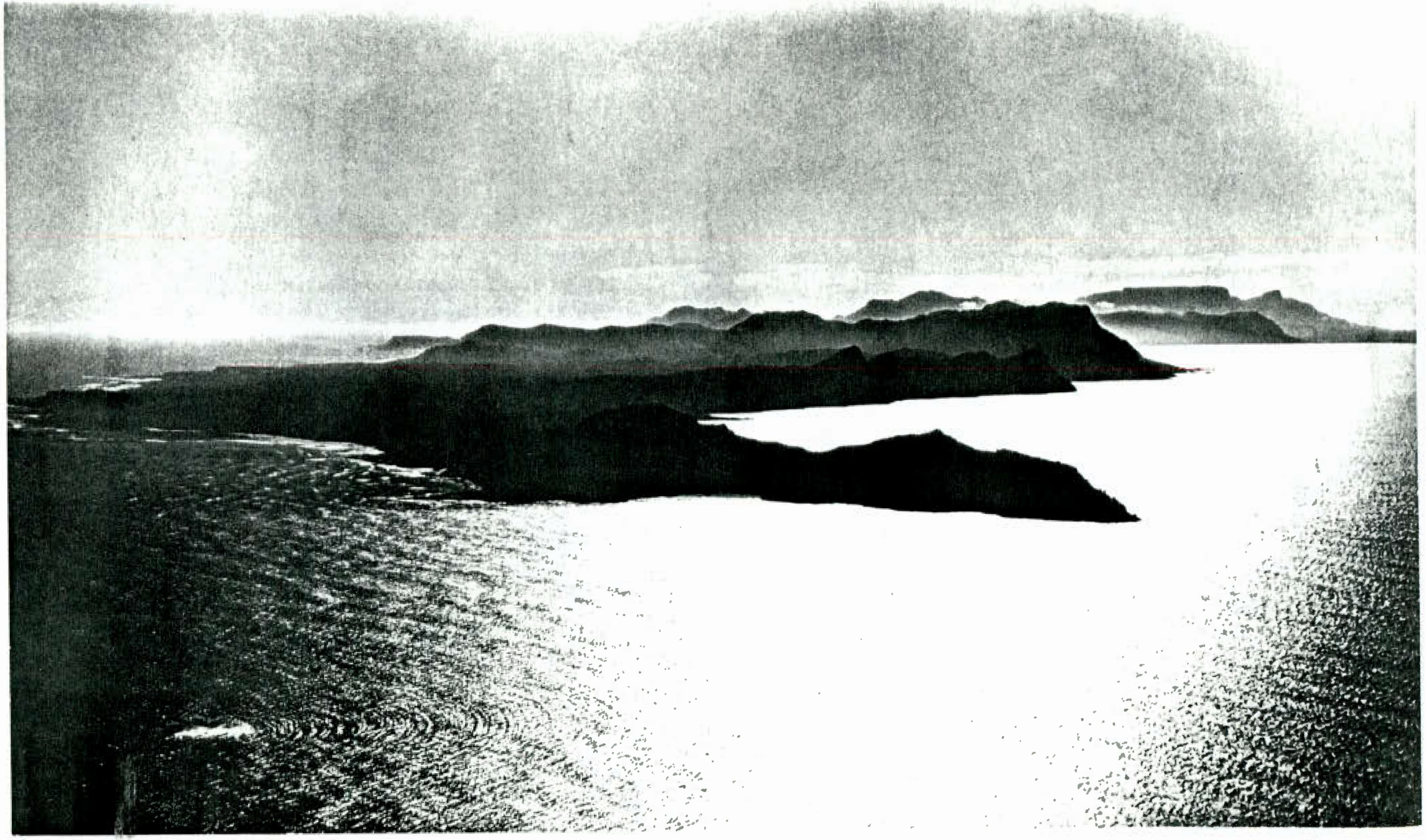

The Cape Peninsula from the south (Photograph by Terence McNally)

ABSTRACT

The survey was undertaken on a 30 square mile (78 square kilometer) area at the southern tip of the Cape Peninsula, in the Cape Province of South Africa. The applicability of association-analysis to the distinctive fynbos vegetation found in the Mediterranean type climate of this region, was tested. Subjectively, two formations, Fynbos and Broad-leaved Scrub, were recognized. Fynbos was subdivided into two alliances, Coast and Inland, and ten individually described associations. The association-analysis, based on 100 grid samples each 5 x 10 metres in extent, revealed 23 final groups. To provide an independent assessment of association-analysis, synthesis tables were constructed from the original plot data. The blocks of species-in-plots, obtained by standardized manipulation of the tabulated data, appear to provide a better correlation with habitat than either the final or recombined groups of the association-analysis.

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INTRODUCTION

According to Cain and Castro (1959), possibly the ideal sequence in the study of vegetation is reconnaissance, progressing to primary survey, to intensive studies, and finally to experimentation and management. Reconnaissance and primary survey, being extensive and general, should precede experimental work.

In his "Veld Types of South Africa" (1953), Acocks writes of the mountain fynbos vegetation of the south-western region of the Cape Province: "It is a complex vegetation, and to divide it simply into Macchia and False Macchia is like dividing the tropical vegetation into grassveld and bushveld, i.e. in this preliminary map and description we are not really subdividing this southern vegetation in the same way as we have subdivided the tropical vegetation." At present we know little about the ways in which different fynbos types react to factors such as fire, partly because we do not know what constitutes the different types or where their boundaries lie. Thus a practice which is beneficial in one area may cause harm in another if the second area bears a different type of fynbos. Because hydrological and veldburning research is to be undertaken in mountain fynbos, a primary survey of this vegetation is needed as a foundation for experimental work. In the meantime, intensive studies may proceed but their results cannot be extrapolated until the primary survey has revealed the boundaries of all fynbos types.

Mountain fynbos vegetation, comprising Acocks' Veld Types 69 and 70, is with few exceptions confined to the rugged mountain complexes of the Winter Rainfall Region where it covers an area of about 10,000 square miles (26,000 square kilometres). Since a survey of this size will take at least 20 years to complete, the area should be subdivided into components and the same approach used in each. The method of survey and analysis should preferably be based upon quantitative data which can be interpreted with statistical aids so that results can be validly compared.

The method of association-analysis, which tests the degree of association between species, has given promising results in Britain (Williams and Lambert, 1959, 1960). It was developed on small areas of relatively simple vegetation, by recording presence of all species on small quadrats closely and systematically spaced in a grid pattern. It would be physically impossible to apply this method with equal intensity on the large area of complex fynbos. The method may, however, be adaptable by using larger plots a mile or two apart. Even on this scale, the time spent in locating, visiting and analyzing plots spaced systematically at predetermined points in rugged mountain terrain would be great, and much interpolation between these widely spaced plots would be needed. To determine whether association-analysis, adapted in this way, would be practicable and efficient, a trial on a smaller sample of fynbos is needed.

The present study, the first of its kind in fynbos, is such a trial. It was undertaken on the Cape of Good Hope Nature Reserve because the flora of the area was well known, thus minimizing identification difficulties. The area was large enough to give the presumed minimum of 100 sampling units if spaced 1,000 yards (914 metres) apart. The Reserve comprises diverse landscape types bearing a rich and heterogeneous flora, and all parts of the area are reasonably accessible.

The initial descriptive account of the vegetation (Chapter 4 and Map 1) was undertaken before the results of the association-analysis became available, thus providing an independent subjective picture of the plant communities. After the association-analysis results were interpreted (Chapter 5), the original plot data were used in a phytosociological analysis (Chapter 6) to provide an independent assessment of the association-analysis.

CHAPTER I

GEOLOGY, TOPOGRAPHY AND SOILS

1.1 Geology and Topography

The Cape of Good Hope Nature Reserve (latitude 34° 15' South, longitude 18° 25' East) occupies the southern end of the Cape Peninsula which is the most south-westerly portion of the African continent, jutting southward some 40 miles (64 km) into the sea. The area of the Reserve is approximately 30 square miles (7680 Ha). In shape it is roughly triangular. The northern boundary extends overland from Schusters Bay south-east to Smitswinkel Bay, a distance of about 8 miles (13 km). The coastline forms the rest of the boundary, with the Atlantic Ocean on the west and False Bay on the east. The coastline is roughly 24 miles (39 km) long, the maximum length of the Reserve from Schusters Bay to Cape Point is about 13 miles (21 km) and the greatest width is some 5½ miles (9 km).

The whole Reserve is composed of level or gently inclined sandstone beds of the Table Mountain Series of the Cape System. These beds are relics of the outer rim of the Folded Belt that forms the long mountain ranges of the South-Western Cape (Rogers, 1922). The beds rest on old granite which, on the Reserve, is visible only at the base of the Cape Point cliffs (Plate 16). The granite had been worn down to an almost flat surface and then submerged before the sandstone sediments were deposited during the Carboniferous period, some 300 million years ago (Walker, 1952). Remains of ripple marks and current bedding show that the sandstone was formed in shallow water by swift currents. Embedded hard white water-worn pebbles are frequently found. On weathering, these are released from the rock and break up to give coarse, white, "sugary" soils.

The Table Mountain Series is a hard, resistant sandstone. When freshly fractured, it is white or pale grey in colour, weathering usually to a darker grey. It may, however, be brown or red due to the leaching of iron that is deposited in the surface layers as brown hydroxide or red oxide. Surface deposits of ferricrete are occasionally found, the two main deposits on the Reserve, at Rooihoogte and near the Rooikrans turn-off, both being quarried for gravel.

Due to differences in hardness, the weathered sandstone surface is often highly irregular, giving rise to typical joint and bedding plane weathering. The block-shaped boulders seen on the summit of Bonteberg (Plate 11) and the escarpment edge above Olifantsbos (Plate 12), have been formed in this way. The lower strata of the Table Mountain Series are softer, the grains smaller and bound together by a bright red or purple muddy sand. These basal shales are seen in places along the foot of the cliffs, as at Cape Maclear (Plate 8).

The diagonal land boundary of the Reserve follows the line of a fault which caused a vertical displacement of several hundred feet (Walker, 1952). South of the broad depression along this fault is a chain of hills in which Bonteberg (745 ft; 227 m) and Rooihoogte (902 ft; 275 m) are prominent points. Eastward these hills merge into the mountain range of the False Bay coast. The summit of Paulsberg (1203 ft; 360 m), the chief peak in this range, is the highest point on the Reserve. The eastern slopes of these mountains have been truncated by wave attack, and drop in almost sheer cliffs to the sea (Plate 7). The coast, too, is steeply shelving, with deep water close inshore. This part of the coastline follows the joints in the Table Mountain Series with a north-east to south-west trend.

The western slopes of the False Bay mountains fall less steeply to a central plateau stretching westward for 3 to 4 miles (5 to 6 km). The plateau drops by a gentle gradient from some 500 ft (152 m) in the east to about 200 ft (61 m) above sea level at its western edge which terminates in a steep sandstone scarp. Since late Cretaceous times the Peninsula has been subjected to spasmodic slow uplift, and the central plateau was formed by planation to

400 ft (122 m) which followed the 600 ft (183 m) uplift of Tertiary times. Further gentle uplift resulted in planation to 200 ft (61 m) after which a pause in uplift gave rise to the shelf forming the plateau's western rim. The plateau forms the most nearly level surface of the Reserve. It is devoid of rocks except for scattered low sandstone outcrops which show that bedrock is generally not far below the surface. It is traversed by a series of shallow seepage steps, usually less than 9 ft (2.7 m) high, formed where a band of tilted sandstone approaches the surface, damming the soil water behind it. Drainage is poor: marshy flats, flooded in winter, are connected by a few small meandering streams.

Sirkelsvlei, a permanent body of water, lies between sandstone ridges on high ground west of the central plateau. Though no streams drain to or from it, Sirkelsvlei is never empty nor stagnant. It appears to be fed from beneath by springs, the overflow through marshy ground to the north-west draining into Die Kloof, a stream which reaches the sea at Olifantsbos. The water of Sirkelsvlei, and of all streams, is dark brown in colour.

Most streams and ridges on the Reserve run roughly north-west or south-east, or at right angles to these directions, following lines of weakness offered by joints or faults. The main drainage system, the Krom River, rises in the Smitswinkel Flats on the northern part of the plateau, and flows north-west in a broad valley to the coast plain where it is joined by the Klaasjagers River which originates outside the Reserve. At the coast these confluent rivers form a lagoon whose outlet is deflected southward by "beach drift" (Mabbutt, 1952, p.20).

The position of the coastline has altered many times, partly on account of world-wide fluctuations in ocean level during the Ice Ages, partly because of local land uplift which lasted into the Early Pleistocene period. There has been a series of sea levels at 100, 60, 30, 20 and 10 ft (30, 18, 9, 6 and 3 m), with intermittent minor fluctuations between these and the present level.

Shingle beaches mark the present limit of the sea's advance but the process of coast retreat is by no means complete. The reefs off the west coast, for example, are relics of a previous land surface.

At times of glacial advance sea-level would fall, exposing extensive sand flats to the dune-building winds. A major sand invasion, starting some 100,000 years ago, coincided with the retreat of the sea after the 20 ft (6 m) Beach period. Probably at this time the inland dunes, an important feature of the Reserve, were formed. These old dunes, now stabilized, originated chiefly in sandy bays along the east coast and were blown inland in a north-westerly direction by the prevailing south-east summer winds. Traces of one such dune extend from Smitswinkel Bay along the fault trough for 5 to 6 miles (8 to 10 km), as far as the nek between Teeberg and Bonteberg (Plate 4). Another more pronounced and continuous dune, filling the whole of the Buffels River valley below the Smith's Farm Homestead, traverses the Reserve diagonally from Buffels Bay to Brightwater, petering out in isolated patches (Plate 3) among the western ridges of the escarpment. North of Buffels Bay, on the coastal shelf between Bordjiesrif and the base of Paulsberg, is a chain of low, rounded, dune-like hills abutting upon but quite separate from the sandstone scarp behind them. These hills, pitted by caves, are built of calcrete (Plate 7). A calcrete dune, starting at the coast below the Meadows, extends nearly as far as the Diaz Beacon, crossing the Platboom road at its highest point (Plate 2). On the Atlantic side, shorter dunes run parallel to the north-west-trending coast, for example from Diaz Beach to Neptune's Dairy (Plate 8); from Platboom towards Rondeheuwel (Plate 5); and from Hestersdam to Olifants Point. Variation in dune structure and in vegetation suggests that the dunes differ quite widely in age. Since the recession of the sea continued for some 80,000 years, this could well be so. The calcrete dunes may be the oldest; certainly their flora is the most distinctive.

1.2 Soils

A reconnaissance survey with Mr. J.J.N. Lambrechts (Senior Lecturer in Soil Science at the University of Stellenbosch) determined the soil types and their distribution in relation to landform. In order to verify the field classification, 16 pre-selected sites were sampled by auger for chemical analysis in the Laboratory of the Department of Soil Science, University of Stellenbosch. Only type profiles were sampled, the many variations being excluded.

The methods of analysis are given in App. I and the analytical data tabulated in App. II.

1.2.1 Classification and definition of soils

From the results of the analyses each sample was classified into a form, group and series according to the system proposed in the soil classification project for the Eastern Transvaal Highveld (A.O.C. Technical Services, 1967). In the following classification, the numbering system used in the above-mentioned project has been adopted.

10 LONGLANDS FORM : Ferruginous grey brown soils, without a yellow chromatic B but with a ferric B horizon; a ferric B is an horizon in which iron accumulation has taken place as evidenced by red mottles, iron concretions or ferricrete (ironstone hardpan).

- 10-1 Witsand Group : Coarse textured ferruginous grey brown soils with less than 20% clay in the horizon above the ferric B.
  - 10-1-0-2 Witsand Series : Medium sand (with less than 10% clay) dominant in horizon above B; mottled ferric B, major part of which is not massive ferricrete.
  - 10-1-0-3 Sandvlei Series : Coarse sand (with less than 10% clay) dominant in horizon above B; ferricrete ferric B, major part of which is massive ferricrete.

12 CARTREF FORM : Grey brown coarse textured A_1-A_2-C profile forms with less than 20% clay in the A_2.

12-0-0-2 Cartref Series : Medium sand (with less than 10% clay) dominant in A_2.

13 MISPAH FORM : Non-margalitic A_1-C/R profile forms.

13-0 Acid, non-humic Group : pH less than 7; surface horizon less than 18 in (45 cm) thick and/or containing less than 2% humified organic carbon.

13-0-0-1 Moeras Series : Less than 10% clay in A_1.

13-0 Alkaline, non-humic Group : pH greater than 7; surface horizon as for Acid, non-humic Group.

13-0-0-1 De Hoop Series : Less than 10% clay in A_1.

14 FERNWOOD FORM : Coarse textured A_1-C profile forms with less than 20% clay in the C_1.

14-1 Maputa Group : Coarse textured soils with S less than 1 in C_1 (pH commonly less than 7).

14-1-0-2 Fernwood Series : Medium sand (with less than 10% clay) dominant in C_1.

14-2 Langebaan Group : Coarse textured soils with S greater than 1 in C_1 (pH commonly more than 7).

14-2-0-2 Langebaan Series : Medium sand (with less than 10% clay) dominant in C_1.

1.2.2 Correlation of soils with topography and vegetation

The plant communities referred to in this section are described in detail in Chapter 4. Landform diagrams depicting the correlations are given in App. III.

The dominant soil on the rocky hills and mountains, bearing the floristically rich and variable Upland Mixed Fynbos, (Association 5, sect. 4.3), is the Moeras Series of the Mispah Form, shown in App. III as site A2. The thin layer of this skeletal soil consists of a mixture of in situ weathered and colluvial materials, the whole mass being continuously subjected to surface erosion and possibly to wind action.

On the lower hill slopes, deep, coarse colluvial layers of the Fernwood Series are formed to a depth of over 7 ft (2 m). Such soils occur where the hills abut on the plateau, the river valleys (site B1) and the coastal plain (B2). Small patches are also formed where blown sand has accumulated locally in hollows (K1). These sites bear a characteristic vegetation, either the _Ifloga-Petalacte_ Dune Fynbos on inland sand-patches (B1, B2), or the _Thamnochortus erectus_ Dune Fynbos on deeper dune pockets (K1).

At least two different soil types are found on the poorly drained plateaus. The Cartref Series, a leached, iron-free soil lacking a B horizon, is found in small, shallow depressions where the simplest Tussock Marsh community, dominated by _Elegia parviflora_, occurs (B5, E2). On sites where iron can accumulate, ferruginized soils of the Witsand Series may develop. The iron accumulation occurs as a softish mottled layer and the horizon above B has a low clay content. This soil, which is more extensive than Cartref, occurs on two distinct landforms, plateaus (E4, F4) and the larger river valleys (C1). The factors causing its formation differ with the position and boundary characteristics of the bedrock but the nature of the soil and vegetation is broadly similar in both cases. Thus, the moister variety of Plateau Fynbos is roughly equivalent to the complex Tussock Marsh of the river valleys where many species of Restionaceae are associated with soft-leaved shrubs.

More strongly ferruginized soils of the Sandvlei Series are found at gravel pits near Rooikrans (L2) and at Rooihoogte. Here, the major part of the ferric B horizon consists of massive ferricrete with a fairly high percentage of clay in the subsoil. Today these sites are dry, but as ferricrete can only develop in alternating saturated and dry conditions, this hardpan must be a remnant that developed during a wetter climatic cycle. Both sites occur near the basal shales of the Table Mountain Series, which usually contain high percentages of clay and iron. The vegetation of these soils is the distinctive Protea lepidocarpodendron Tall Fynbos.

Soils developed on marine surfaces belong to the Mispah and Fernwood Forms. They are consequently morphologically similar to the skeletal soils of rocky hills and to the deeper sand of lower slopes. Where the Table Mountain Sandstone bedrock occurs close to the surface of the coastal shelf, as at Springholsgat (G1), the soil is practically identical with that of the rocky hills, being merely the deeper, almost neutral phase of the non-humic Moeras Series of the Mispah Form. Despite this similarity in soil morphology, the vegetation at Springholsgat is typical Coast-shelf Fynbos, very different from the mixed fynbos of the rocky hills. Base exchange capacity data indicate that the marine soils, although acid, are very close to base saturation (probably due to the accumulation of salt from the sea winds) whereas the skeletal hill soils are base unsaturated. This might explain the difference in vegetation.

The other Mispah soils of the coast are the alkaline, non-humic De Hoop Series. The site at Platboom Point (G3) comprises a shelly marine terrace overlying Table Mountain Sandstone bedrock. The vegetation, a variety of Coast-shelf Fynbos, consists of a low sward of coastal grasses (Sporobolus virginicus, Stenotaphrum secundatum) interspersed with sprawling coastal shrubs (e.g. Exomis microphylla, Geranium incanum, Tetragonia fruticosa) and scattered stunted bushes such as Metalasia muricata and Phylica ericoides. Except for the preponderance of grasses and the absence of Thamnochortus spicigerus, this community is not unlike the Springholsgat Coast-shelf Fynbos. In this case, the De Hoop and coastal Moeras soils are very similar in their base saturation, despite the differences in parent material, which might account for the similarity of the vegetation.

The soil of the sandy coastal dunes near the Krom River Lagoon

(H1), bearing Littoral Dune Mixed Fynbos, also belongs to the De Hoop Series.

The Fernwood soils of marine surfaces are found either on the coastal shelf (K2, G2) or on inland dunes (J3). At the Bloubergstrand site (K2) the coarse-textured soil is of the typical Langebaan Series. The vegetation resembles the Thamnochortus erectus Dune Fynbos on the inland Fernwood Series at Ribboksdam (K1) mentioned previously, with, however, a greater preponderance of the coastal element. The other coastal Fernwood site (G2) occurs on the dunes at Olifants Point where the soil is a humic calcareous variant of the Langebaan Series and the vegetation a rather woody Coast-shelf Fynbos. A less humic, calcareous variant of the Langebaan Series is found over a mile (1800 m) inland on the dune running north-west from Buffels Bay (J3) which bears the floristically rich Thamnochortus erectus Dune Fynbos. This shows that the coastal Fernwood soils are closely related and the plant communities found on them are also very similar to one another.

To summarise, the Inland Fynbos Alliance is found on soils of the Mispah, Longlands and Cartref Forms, while the Coast Fynbos Alliance occurs principally on Fernwood soils. Where coastal communities occur on Mispah soils their base saturation characteristics differ from those of inland Mispah soils. On the whole, the correlation between soil, topography and vegetation is extremely good. This is all the more striking since there are no major differences in parent material of Cape Point soils. Only minor differences exist, due mainly to varying soil climate which in turn is affected by topography. That these minor differences are closely reflected in vegetational changes shows that Cape Point vegetation is a sensitive indicator of edaphic factors.

CHAPTER 2

CLIMATE

2.1 The general climatic cycle

The Cape Peninsula lies at a latitude of 34° South. Being small and almost surrounded by sea, its climate is more equable than that of most land masses at this latitude. The varying relief also modifies the influence of latitude and causes local variations in climate. The general features of this climate are of the Mediterranean type which is characteristically maritime, being confined to the western margin of continents in latitudes comparable to the Cape.

In summer the weather is warm and dry, with frequent strong, south-easterly winds which may last only a few hours or several days. In the southern Peninsula the south-easter is usually stronger and of longer duration than in the northern part. In winter, when cyclones moving eastward over the Southern Ocean affect Cape weather directly, the wind blows from the north-west, bringing in cool, moist air off the Atlantic, this air condensing as rain which may last for several days, the rainfall being heavier near the mountains. As the depression passes, the wind backs to south-westerly and later to southerly, with clearing showers and a drop in temperature. Fine weather following a depression may last for over a week.

The gradual transition between summer and winter gives rise to prolonged spring and autumn seasons, in contrast to most parts of continental Africa. Even the so-called summer and winter phenomena - warm, dry, windy summers and cool, wet winters - are not entirely confined to these seasons, a fact which accentuates the equable nature of the climate.

2.2 Climatic influences in the Reserve

2.2.1 Temperature

The equable temperatures are most marked at Cape Point itself which has the lowest average annual range in mean daily maxima and minima (4.2°C) of all weather stations in the Republic (Weather Bureau, 1954). By comparison, the average annual range for Simon's Town is 8.5°C and for Cape Town 10.5°C. At Cape Point the lowest monthly range occurs during summer (December, 3.6°C) while at Simon's Town the highest monthly range occurs during the same season (February, 9.0°C). This is because Cape Point is continually exposed to the cooling south-east winds, making summer temperatures consistently low, while Simon's Town, on the north side of a range of mountains, not only receives greater insolation but is also sheltered from some of the summer winds and consequently experiences some hot days. The exposed weather station at Cape Point is not representative of general conditions in the Reserve but no other temperature data are available. However, the xerophytic vegetation of north slopes in the Reserve suggests that their temperature regimes are more akin to those of Simon's Town than to Cape Point. South-east slopes, in contrast, are cool and moist, not only on account of their shady exposure but also because they face directly into the south-east winds. Indeed, the south-eastern slopes of the mountains overlooking False Bay, which are often enveloped in cloud during a "black" south-east wind, carry dwarf scrub forest despite their inhospitable substratum and precipitous gradient.

Seasonal temperature variation at Cape Point is also small. Average summer and winter temperatures differ by only about 5°C (daily $\frac{\text{max. + min.}}{2}$ for February 18.3°C, for July 13.4°C) while at Simon's Town the corresponding figure is nearly 17°C (March 31.3°C, July 14.6°C). Here again the Cape Point figures would be representative only of exposed bluffs and headlands while many inland parts of the Reserve would be comparable to Simon's Town. Highest summer temperature at Cape Point is only 20.3°C (mean of daily maximum for February) while at Simon's Town it is 27.1°C. The lowest mean daily maximum temperatures are in July: 15.5°C for Cape Point, 18.5°C for Simon's Town. The winter maxima show smaller differences than the summer because the cool south-east winds are rare during winter. Frost was never recorded at Cape Point during the period 1921-1950. It is unlikely that any part of the Reserve ever experiences frost.

The differing ocean temperatures on the east and west coasts may also affect air temperatures near the coast. Ocean temperatures differ most widely during summer when the warm Agulhas current flows more strongly, penetrating westward into False Bay and around Cape Point. The summer south-east winds accentuate the difference by piling up warm surface waters against the False Bay coast and blowing them away from the Atlantic coast where their place is taken by the cold Benguella current welling up from beneath. Thus, summer sea temperatures on the west coast are about 6°C colder than in False Bay and on calm days air temperatures along the western hills are noticeably cooler than on the eastern side. In winter the warm Agulhas current is weaker and the north-west wind blows the surface waters away from the east coast while piling them up on the west coast, thus reducing the temperature difference.

2.2.2 Wind

The dominant climatic factor on the Reserve is wind. Few places are wholly sheltered either from the south-east trades of summer or from the north-west winter winds. The south-easters blow for longer periods than the north-westers - up to a week or more. At Cape Point south-easters of 10 to 25 miles (16-40 km) per hour occur regularly during summer, gusting up to 75 mls (102 km) per hour. The peaks of False Bay, exposed to the full force of these winds, bear a montane vegetation less xerophytic than the lower slopes, because of the cloud-cap occurring above an altitude of about 800 ft (244 m) during strong south-easters. Deformation

- caused by strong winds from a constant direction - is characteristic of the coast vegetation. The wind-sheared scrub at Buffels Bay is an example of this (Plate 26). The south-easters also have an important effect on the habitat. Because these strong persistent winds blow chiefly in the fire season they are instrumental in the formation of dunes, especially in recently-burnt coastal areas. Also, evidence from the vegetation and the soil profile suggests that soil on the rock outcrops north-west of Sirkelsvlei was blown by the south-easter over the plateau rim where it formed deep sand deposits bearing a characteristic vegetation.

The winter winds, by contrast, seldom form dunes but have a greater scorching effect on the vegetation of the coastal shelf. After a severe winter storm, plants on the west coast show marked browning of the growing tips on the north-west side, probably as a result of wind-borne salt spray. Why this phenomenon is more frequently caused by the winter winds of the west coast than by the summer winds of the east coast is a subject for investigation. It might be that the great rollers of the Atlantic provide more salt spray than the lesser waves of False Bay. At all events, a detailed comparison of the structure, life form and composition of the vegetation on the west and east coasts might yield interesting correlations with habitat, especially wind.

2.2.3 Precipitation

In the Mediterranean type climate of the South-Western Cape, about 90% of the rain falls in winter. The rainfall at Smitswinkel Bay, just outside the north-eastern corner of the Reserve, averages 698 mm per annum while Cape Point (on the ridge at an altitude of 217 m) receives only about 333 mm per year (Weather Bureau, 1950). This large discrepancy is remarkable, but no intervening records are available to show whether a gradient exists. The peaks south of Smitswinkel probably receive a higher rainfall than the bay itself while the lowlands south of Smith's Farm, with their modified vegetation, may be drier. The exceptionally low figure for Cape Point may be due partly to inaccurate recording as a result of marked air turbulence on the windy knife-edge. Nevertheless, the rainfall of the whole Reserve is in general lower than that of the northern part of the Peninsula.

Air moving eastward over the Atlantic is relatively humid from its contact with the fairly warm waters far out to sea. When it meets the cold Benguella shore current, the air cools and its moisture condenses as fog. The west coast of the Reserve is subject to fog at all seasons but particularly during autumn. Figures for the Reserve are lacking, but at Cape Town docks, on the Atlantic coast, fog is experienced on about 25 days a year, whereas Simon's Town, on the False Bay coast, has only about five days of fog annually (Schaffer, 1952).

The increased moisture from fog, combined with the cooler temperatures on the west coast, may partly account for the rich and distinctive flora of the western hills.

CHAPTER 3

HISTORICAL AND BIOTIC FACTORS

3.1 Prehistory

From man's earliest days the southern Cape Peninsula has been a rugged land never well suited to large human settlements. Competition for food was intense; shelter from the elements and protection from predators was always necessary. Permanent water was scarce. Nevertheless, evidence from middens, caves and shelters shows that from the earliest Stone Age onwards, primitive man in limited numbers did make his home there, inhabiting mainly caves in the coastal cliffs. Indeed, one of the most interesting sites of the Chelles-Acheul culture is that near Cape Maclear. In this shelter, and in those at Cape Point lighthouse, Rooikrans, Bonteberg, Batsata Cove and other less well-defined middens, the remains of patella shells, fish vertebrae, rodent and ungulate bones, carnivore teeth and ostrich eggshell beads show that a variety of protein foods was available (Beaumont, 1963). These were no doubt supplemented by carbohydrate from fleshy bulbs, roots and corms of the rich geophytic flora and, to a lesser extent, by edible fruits and seeds.

Clear evidence from the analysis of cave soils shows that seafoods and fire were used only relatively late in the history of primitive man. Quite suddenly, coinciding with the dawn of the Later Stone Age, an abundance of shell and shell-lime, together with frequent evidence of fire, appear in the cave deposits.

Since fire has played an important role in the historical development of fynbos vegetation, it would be of great interest to determine when fire emerged as an ecological factor. Because there is no evidence for a major change in type of climate, lightning was probably never a sufficiently frequent component of Peninsula weather to cause extensive veld fires. Accidental fires probably spread easily from Stone Age shelters, especially during arid climatic cycles, so the fire factor in Cape Peninsula vegetation may have started with the first use of fire by man. Archaeologists are reticent about dating this event. The distribution of prehistoric implements in the Fish Hoek valley (north of the Reserve) shows that the Still Bay culture of the Middle Stone Age preceded the 20 Foot (6 m) Beach (Goodwin, 1952, p.134) which took place some 130,000 years ago (Walker, 1952, p.12). The use of fire by Later Stone Age peoples may thus go back not more than 100,000 years.

3.2 European settlement

Though the early Portuguese navigators, in their search for a sea route to India, discovered the Cape of Good Hope in 1487, it was not until 1652 that the Dutch East India Company established a permanent settlement at the present site of Cape Town. Nearly a century later, in 1742, the Company developed Simon's Bay as an anchorage protected from winter storms.

Until this time the indigenous fauna in the southern Peninsula was seldom hunted by Europeans. Duiker, Grysbok, Ribbok, Klipspringer, Red Hartebeest, Bush Buck, Eland, Cape Buffalo, Zebra, Hippopotamus, Chacma Baboon, Ostrich, Silver Fox, Spotted Hyena, Leopard and Lion were all found (Opie, 1967). From the second half of the eighteenth century this game was ruthlessly shot out and by the end of the nineteenth century only a few Grysbok, Ribbok and Baboons remained.

After the founding of Simon's Bay farmers started settling south of the new town. Mapping of the land began as property boundaries had to be fixed. Until early in the nineteenth century most of the area now comprising the Cape of Good Hope Nature Reserve was unoccupied and was consequently classified as Crown Land. From about 1810 this land was granted to farmers on a quitrent basis right down to Cape Point. Each grant was subject to conditions allowing passage of stock to adjoining farms and access of fishermen to the coast. Tracks also led to the lime kilns at Bordjiesrif and Buffels Bay, and to the new lighthouse at Cape Point. With increasing use by heavy wagons these tracks became deeply rutted and were replaced by new ones running parallel to the old. Even today, where they traverse the sandy plateaus, these parallel routes can be traced by the distinctive Restionaceous vegetation which developed in the moister soil of the hollows, closer to the underlying water table. Plants such as Elegia cuspidata and Restio dodii are extremely sensitive to slight changes in soil moisture and a depression of even a foot or two (30-60 cm) results in their dominance.

The early farmers found no wood supply other than Kreupelhout (Leucospermum conocarpondendron) which, though unsuitable for building, provided excellent firewood as well as tannin for curing hides (Adamson and Salter, 1950). Firewood and rough timber for shelters were also obtained from the littoral scrub by fishermen living semi-permanently along the coast.

During these pioneering days of the early nineteenth century, when many more ships were rounding the Cape than ever before, shipwrecks were not uncommon along the poorly charted west coast. The hidden reefs off Olifants Point were especially treacherous, and picturesque names such as Matroosdam, Duitserstent and Mast Bay testify to the frequency of wrecks in these waters. The stranded ships often carried much valuable merchandise which had to be salvaged at all costs. Salvaging operations on such distant coasts were major undertakings, sometimes lasting many months. Temporary hutments were erected and draught animals concentrated in great numbers. The natural vegetation must have been locally destroyed or at least severely trampled and overgrazed. Patches of anomalous secondary vegetation along the coast may date from these events.

Stock farming developed on an extensive scale. The natural veld was frequently burnt to provide young pasturage for horses, cattle and sheep. Conditions proved most suitable for horses and, during the South African War at the turn of this century, 6,000 remounts were grazed on the area (Opie, 1967). Stock concentrated on the better veld in the Schusters and Krom River valleys and the plateau south of Smith's Farm, places which today bear evidence of considerable disturbance to the natural vegetation. Arable land was limited to richer pockets of alluvial soil with a permanent water supply, as at Klaasjagers River and Olifantsbos. Here, crops such as potatoes, tomatoes and green vegetables were grown for the local market along with barley as a supplementary feed for stock. Fresh meat, dairy products and small orchards of fruit helped local farmers to eke out a subsistence livelihood. As communications improved and large-scale commercial agriculture developed in the hinterland, prices became too competitive for the smallholdings of the southern Peninsula to pay their way. In the first decades of this century many of the southern farmers abandoned their land or used it sporadically for seasonal grazing. In the 1930's only a few hundred cattle ranged over the abandoned farms.

During this time the alien *Acacia* species, planted as windbreaks around farmlands, as shade trees near homesteads and as sand-stabilisers near the coast, developed into impenetrable thickets on the denuded lands and then, aided by fire, spread rapidly into the adjoining veld. A survey of alien vegetation conducted concurrently with the present survey revealed that only 10% of the sampling sites on the Reserve, each 200 yd (183 m) radius, were completely free of alien plants (Taylor, 1967). *Acacia cyclops* is the most aggressive of these species (Plates 2, 12 & 26). It is already found on 75% of the sampling sites. It is concentrated on sandy dune soils in the south but because of its highly efficient seed dispersal and wide ecological amplitude it can thrive in a wide variety of habitats and is still spreading insidiously. *A. cyanophylla* occurs in 42% of the samples, mainly on moister soils in the north in areas of early settlement (Plate 4). *A. longifolia* with a 12% infestation occurs in high density on moist flats and streambanks of the Klaasjagers River valley (Plate 15). Outside the Reserve this wattle has spread to drier sites once the specialized moist habitats have been fully occupied.

3.3 Creation of a Nature Reserve

With the decline of agriculture in the southern Peninsula, farming was no longer an economic proposition. In 1938-39 the Divisional Council of the Cape acquired the two southernmost properties, Smith's Farm and Brightwater, by purchase and donation, to form the nucleus of the Cape of Good Hope Nature Reserve. During the ensuing 27 years the Council bought the remaining land south of the so-called Plateau Road between Scarborough and Smitswinkel. The last farm was bought in 1965 to bring the present extent of the Reserve to about 19,100 ac (7,600 Ha).

The Divisional Council aims eventually to re-establish the natural conditions prevailing at the time of the early settlers, while catering for the recreational needs of an increasing number of visitors. It is hoped to resolve these conflicting aims by developing recreation areas and picnic sites in selected localities mainly along the coast, keeping the rest of the Reserve in a wild state. Game is to be concentrated in the southern half while the natural flora is to be encouraged in the northern half.

The intention is to re-introduce only those animals known to have been present before settlement, encouraging them to congregate near roads within easy view of tourists. To this end, areas of level, stone-free ground near the main road have been bush-cut (Plate 28) or ploughed, fertilized and planted with pasture species notably Serradella (Ornithopus sativus Brot.), Yarloop Clover (Trifolium subterraneum L.), Strawberry Clover (T. fragiferum L.), Paspalum (P. dilatatum Poir. and P. urvillei Steud.) and Wimmera Rye (Lolium rigidum Gaud.). Considerable re-stocking of animals has already been done (Plate 29). The present approximate game population is given in Tab. 1.

TABLE 1

APPROXIMATE GAME POPULATION IN THE CAPE OF GOOD HOPE NATURE RESERVE (1969)

Animal	Numbers	
	Adult	Juvenile
Eland	38	5
Blue Wildebeest	27	6
Zebra	11	-
Bontebok	100	20
Springbok	15	8
Grey Ribbok	70 +	7
Duiker	2 +	
Steenbok	Not known, numbers small	
Grysbok		
Ostrich	8	5
Baboon	± 100 in 3 troops, numbers fluctuating as the troops wander beyond the Reserve boundary	

The most serious and urgent problem facing the authorities is the eradication of alien vegetation. A start has been made by removing scattered <u>Pinus pinaster</u> in the northern areas and by bush-cutting some dense wattle stands. The prime need, however, is to prevent the future extensive spread of wattle by eradicating outlying individuals. While this policy has been adopted in principle, more funds are needed to increase the tempo of this operation, if the natural vegetation is to survive.

CHAPTER 4

DESCRIPTIVE ACCOUNT OF THE VEGETATION

4.1 The need and nature of the classification

There has been no previous survey of the vegetation of the Cape of Good Hope Nature Reserve. In order to obtain an independent general picture with which to compare the objective classification given in the following chapter, this descriptive account was undertaken before the results of the quantitative survey became available. It was prepared from a field survey during which habitat factors on the one hand, and vegetation on the other, were examined in representative localities on the Reserve.

Vegetation consists of a complex mixture of species combined in a great many ways. These combinations are determined by the relations between species and site, and of species one with another. Without some simplification it is impossible to determine the underlying significance of these relationships. Simplification can be attained by reducing the vegetation complex to units with common vegetational properties. The units can be grouped in various ways; traditionally the groupings take the form of a hierarchical classification. Classification of vegetation cannot be compared with classification of organisms because vegetation units are not genetically related (Goodall, 1954; Webb, 1954; Hanson, 1958). Indeed, several writers (Gleason, 1926; Cain, 1947; Curtis and McIntosh, 1951; Whittaker, 1951; Goodall, 1954) regard vegetation as a continuum which by its nature is only arbitrarily classifiable. Nevertheless, the conventional hierarchical classification remains the most suitable means of providing the simplified picture for a preliminary account of the vegetation, as long as the limitations of the classificatory method are understood. Communities should be regarded not as distinct units but rather as species-clusters (Poore's "noda") characterized by their centres rather than by their limits, because their limits are vague. In this sense, communities are groupings of convenience justified by their usefulness rather than by their fundamental validity as units.

Most phytosociological schools recognize that communities intergrade extensively and that ecotones do occur. But if units cannot be delimited, this is no reason for saying they do not exist. "Mendelian populations are recognized, although they are not necessarily discrete units; ... youth and old age exist but they cannot be sharply segregated" (Hanson, 1958, quoting Dobzhansky, 1955). Most phytosociological schools also recognize that classifications are to some degree subjective. Classification may be based on the observer's conception of a "typical" stand of the group, the community concept being progressively refined with increased understanding of all the interacting factors and of the deviations, exceptions and relationships between stands. This sort of classification should be regarded not as an aim in itself but rather as the preliminary ordering of data necessary to delimit the basic vegetation pattern. Later, intensive research will reveal the more detailed relationships.

The classification presented in this chapter has not been reached by exact methods and does not pretend to be unalterable. Because our knowledge is limited, a complex ecosystem like the Cape of Good Hope Nature Reserve cannot yet be subdivided except in the most general terms. This classification is therefore done at the extensive, primary, descriptive level. Map 1 delineates types widely represented in the landscape, and those of special local conditions where they are sufficiently distinct, but unites minor variations and intergrading communities which cannot at this stage be accurately separated.

4.2 Criteria for classification

In his map of the Veld Types of South Africa, which delineates the major vegetation units, Acocks (1953) depicts the greater part of the Reserve as Macchia (type 69), with a narrow strip of Strandveld (type 34) running down the west coast. Floristically, the distinction between these two types is clear. Physiognomically, both types contain a mixture of two structural units, fynbos and forest. Fynbos is the indigenous term for the bushy, macchia-like vegetation of the winter rainfall region of the South-Western Cape Province, known variously as Sclerophyllous Bush (Schimper, 1903; Pole Evans, 1936; Adamson, 1938), Sclerophyllous Scrub (Riley and Young, 1966), Maqui (Warming, 1909), Macchia (Phillips, 1931; Acocks, 1953; Roberts, 1966) and Heath (Martin, 1965). The word has a physiognomic connotation, implying both the fine-leaved form of many of the shrubs and the bushy structure of the vegetation. At the same time it circumscribes a phytogeographical unit, the distinctive temperate flora found within the Mediterranean type climate of the South-Western Cape which Good (1964) designates as a separate Floral Kingdom "roughly equivalent in value" to such large and physiographically diverse areas as, for instance, the Boreal Region, comprising over half the land mass of the northern hemisphere.

It is now generally agreed that "vegetation should be described objectively in terms of its floristics and structure without reference to the complex of factors governing it" (Beadle and Costin, 1952). Major units should be defined purely in terms of structure (for example, grassland, savannah, scrub, woodland and forest), while subsidiary units should be defined in terms of floristics. Acocks' major units contain a mixture of structural types and have therefore not been used as a basis for the present classification. Instead, the classification by Beadle and Costin (1952) has been adopted, with modification. These authors divide Australian vegetation firstly into structural Formations, within which Associations, the primary units, are defined by floristic criteria. Associations may be combined into Alliances (groups of floristically related associations of similar structure); or they may be divided into Sub-Alliances, determined by "a variation in the most important subordinate stratum of the association without significant qualitative changes in the dominant stratum."

Using Beadle and Costin's definition, the Fynbos Formation comprises a homogeneous structural unit, the Cape sclerophyll scrub of Mediterranean type climate, whereas if the term were used for Acocks' Macchia (veld type 69) the fynbos element of Strandveld would be excluded. One may object that, since after long protection from fire fynbos may develop into scrub or forest, it does not accord with Beadle and Costin's definition of an association as a climax community. However, one may regard fire in the South-Western Cape as a natural habitat factor which maintains fynbos as a self-perpetuating community, that is, a climax in this particular habitat. Even if fire is artificially excluded, fynbos still retains its distinctive structure and floristic composition for periods exceeding the life-span of its individual members, and thus remains within Beadle and Costin's practical definition of a climax.

The communities distinguished by the above procedure can be correlated with habitat; this correlation is reflected in the hierarchical grouping of units. Thus, the subdivision of the Fynbos Formation into two floristically-defined alliances reflects the two major soil parent materials present. Further subdivisions can be correlated firstly with edaphic factors, secondly with those physiographic factors which determine local climate, and thirdly with the effect of man's activities which result in secondary vegetation units.

4.3 The classification proposed for the descriptive survey

FYNBOS FORMATION

(on sites exposed to fire)

COAST FYNBOS ALLIANCE

(Associations 1-3 on marine sands, Association 4
on coastal Table Mountain Sandstone)

1. *Eriocephalus* Coast-shelf Fynbos Association on well-drained marine sands of the coastal shelf (p. 31)
2. Dune Mixed Fynbos Association on well-drained aeolian dunes of marine origin (p. 32)
    - (a) Pioneer Dune Mixed Fynbos Sub-Association colonizing open dunes (p.32)
    - (b) Littoral Dune Mixed Fynbos Sub-Association on stabilized coastal dunes (P.33)
    - (c) Dwarf Dune Mixed Fynbos Sub-Association on calcrete (p.33)
    - (d) *Thamnochortus erectus* Dune Fynbos Sub-Association on inland dunes (p.34)
    - (e) *Ifloga*-*Petalacte* Dune Fynbos Sub-Association on inland sand-patches (p.35)
3. *Helichrysum*-*Scirpus* Marsh Association on poorly-drained coastal flats of marine origin (p.37)
4. *Coleonema* Fynbos Association on well-drained Table Mountain Sandstone coastal cliffs (p.37)

THAMNOCHORTUS DICHOTOMUS INLAND FYNBOS ALLIANCE
(on Table Mountain Sandstone)

5. Upland Mixed Fynbos Association on well-drained rocky hills and mountains (p.42)
    - (a) *Aspalathus*-*Phylica* Scrub Sub-Association on protected rock outcrops (p.49)
    - (b) *Metalasia*-*Passerina* Fynbos Sub-Association on deep, dry sand (p.50)
    - (c) *Elegia*-*Salaxis* Fynbos Sub-Association on coarse, shallow sand over bedrock (p.52)
6. *Protea lepidocarpodendron* Tall Fynbos Association on well-drained ferricrete slopes (p.53)
7. *Protea arborea* Pseudo-Savannah Association on a steep, well-drained, rocky, northerly slope (p.54)
8. Restionaceous Plateau Fynbos Association on the drained level plateaus (p.56)

⑨ Restionaceous Tussock Marsh Association on seasonally inundated flats of the plateaus (p.58)

⑩ *Berzelia*-*Osmitopsis* Seepage Scrub Association on permanently moist seepage steps demarcating the terraced flats of the plateaus (p.59)

BROAD-LEAVED SCRUB FORMATION

(on sites protected from fire)

⑪ *Sideroxylon* Scrub Association on dunes of marine origin (p.61)

⑫ *Maurocenia*-*Linociera* Tall Scrub Association on Table Mountain Sandstone slopes and screes (p.62)

4.4 General description of the vegetation

The Broad-leaved Scrub Formation occupies perhaps 2 or 3% of the area of the Reserve, being confined to coastal sites and to rocky screes and scarps protected from fire. The scrub is a simplified, impoverished form of the coast forests of the Knysna region described by Phillips (1931).

By far the more widespread of the two formations on the Reserve is fynbos. It agrees closely with the description of Sclerophyll Bush given by Adamson (1938). When fully developed it has three layers. Over large areas *Leucadendron decorum* forms a discontinuous upper layer 4 to 6 ft (1.2 to 1.8 m) in height. This bush, with its broad, yellow-green, leathery leaves and rounded form, characterizes the central plateau and parts of the surrounding rocky hills. On specialized sites it is replaced by other Proteaceae, for example *Protea lepidocarpodendron* on gravels. The middle layer, about 3 ft (0.9 m) high, consists of a rich variety of small wiry shrubs usually with heathlike leaves, among which the families Compositae, Ericaceae, Rutaceae, Thymelaeaceae and Rosaceae (*Cliffortia*) are conspicuous. Generally these shrubs occur evenly mixed, with little single-species dominance. Locally one species may dominate a small area but elsewhere it can be replaced by another, often of the same genus or family. Precisely which species assumes local dominance appears to be determined more by vegetational history, especially frequency, intensity and time of year of past fires, than by habitat. The lower layer of tufted Restionaceae and Cyperaceae is usually not over 2 ft (o.6 m) in height. Sometimes the shrubs of the middle layer merge with the lower, forming a single layer of variable height. The most frequent plant of the lower layer, Thamnochortus dichotomus, is found in a variety of habitats. Low spreading undershrubs like Diastella serpyllifolia, which do not emerge above this layer, are not infrequently found. In some communities on rocky ridges an emergent layer of scattered large Proteaceous shrubs or small trees (Leucospermum conocarpodendron and Mimetes hartogii) gives a picturesque savannah-like appearance characteristic of the southern Cape Peninsula (Plates 11 and 17). Geophytes are common but many only appear above ground when the veld is burnt. Annuals are usually infrequent but may become abundant after a fire, especially in the Coast Alliance.

Adamson's observations that "the height, density and floristic composition of the various layers show great diversity" and that "the greater part is occupied by simpler types of community which are single or two-layered" (loc. cit., p.89), hold very well for the Reserve. The chief factor causing this diversity is fire, which is responsible for a sere ranging from the early regenerative stages of open, low, predominantly Restionaceous vegetation, through the later stages when ericoid shrubs predominate, to the climax of tall Proteaceous shrubs. Often these stages appear very different: it is only from thorough knowledge of the sequences involved and a close examination of the composition - some species being present in the seedling stage, others moribund - that one can recognize the various stages as belonging to the same community. In Adamson's (1927) treatment of Table Mountain communities each stage of the fire sere was described as a separate community. In the present account, the fire sere is treated as a single community.

Soil and drainage factors can give rise to special communities which deviate from the three-layered norm. In much of the Coast Fynbos, for example, tufted Restionaceae are scarce or absent, resulting in a shrubby, clumped community with a relatively open ground layer. Alternatively, impeded drainage may cause the absence of subshrubs, so that a closed Restionaceous community, often dominated by a single species, is formed (e.g. the Elegia parviflora variety of Tussock Marsh).

Tufted Restionaceae and Cyperaceae which sprout rapidly from the base after a fire, persist throughout the life of the community. They are therefore of greater value in characterizing a community than shrubby seed-regenerating elements such as most Proteaceae and Ericaceae which, through repeated burning and grazing, may have disappeared from certain areas, or through prolonged protection become dominant in others. Members of the Restionaceae are apparently more restricted to specific habitats than the shrubby element of the flora. Over large tracts in the central and northern parts of the Reserve, for example, Staberoha banksii is characteristic of dry rocky ridges, Elegia stipularis of well-drained sandy slopes and Elegia parviflora of poorly-drained plateaus. Each of these species is confined to its specific habitat while the Proteaceous shrub Leucadendron decorum ranges freely over the whole area. For these reasons Restionaceae have been widely used as character species for the recognition of plant communities in this study.

4.5 Detailed description of the communities

FYNBOS FORMATION

I. COAST FYNBOS ALLIANCE

(Plates 1 to 8)

This alliance occurs on all the transported sands of marine origin, comprising old raised beaches and wind-formed dunes, some of which extend for miles inland. These marine sands are deep, well-drained, without rocks or stones, with shells and a pH of usually over seven. The substratum is unstable, with a dry surface layer that is easily wind-blown, partly because of its physical nature, partly from the absence of tufted soil-holding Restionaceae and Cyperaceae which are common elsewhere.

Where Table Mountain Sandstone outcrops occur close to the sea, Coleonema Scrub is found. The ultimate development of this is to the Broad-leaved Scrub Formation of the dunes and coastal scarp. Because of their intergrading nature, the communities of the coast-shelf and dunes (Associations 1 & 2) have not been shown separately on Map 1.

1. ERIOCEPHALUS COAST-SHELF FYNBOS ASSOCIATION

The coastal shelf comprises the old, more or less level, raised beaches, occurring at altitudes of 20 and 60 ft (6 and 18 m) (Mabbutt, 1952), chiefly on the west coast. Typical Coast-shelf Fynbos is found on the younger raised beach at the 20-ft (6-m) level (Plate 5).

A site at Springholsgat just south of Olifantsbos Bay has a substratum of coarse white sand of the Moeras Series, with Table Mountain Sandstone pebbles ¼-1 in (6-25 mm) in diameter scattered on the surface. Bare patches of soil 1-3 ft (30-90 cm) in diameter result from the burrowing of moles. The vegetation varies in height, giving an irregular canopy, and comprises: (1) Low scrub 6-12 in (15-30 cm) high with creeping Mesembryanthemae and other succulent shrubs (Cotyledon, Euphorbia, Othonna), and woody shrubs such as Mundia spinosa, Euclea racemosa and Pterocelastrus tricuspidatus (stunted and spreading), with the grass Stenotaphrum secundatum creeping between. Annuals and geophytes seasonally colonize the bare patches. (2) Fine-leaved shrubs shaped by salt-laden winds into domed hummocks about 2 ft (60 cm) high, of Eriocephalus racemosus, Metalasia muricata and Passerina vulgaris and on rocky outcrops Coleonema album. (3) Clumps of the tufted Thamnochortus spicigerus 5 ft (1.5 m) high occurring as pure stands of erratic size.

Coast-shelf Fynbos occurs to the 60-ft (18-m) raised beach level that can be from 100 yards to ¼ mile (90-400 m) inland. With increasing distance from the sea the vegetation becomes richer in species, but the paucity of Restionaceae and the predominance of woody shrubs separates it from Inland Fynbos. At Ribboksdam, about 45 ft (14 m) above sea level and only 200-300 yd (183-274 m) from the sea, a 5x10 metre plot contained 33 species, among which Eriocephalus racemosus was the most abundant plant. Restionaceae were absent. Woody shrubs, principally Cassine maritima and Pterocelastus tricuspidatus, were conspicuous but scarcely exceeded 3 ft (90 cm) in height though they spread to 6 or 8 ft (1.8-2.4 m) in diameter. The canopy was uneven; in places the ground was bare except for spring-flowering annuals and grasses.

Where the coastal shelf is wide, as at Brightwater, the Coast-shelf Fynbos is heterogeneous, being mixed with Inland Fynbos elements on Table Mountain Sandstone soil washed down from the plateau.

2. DUNE MIXED FYNBOS ASSOCIATION

The dunes vary in age from those still in process of formation to those formed since the recession of the sea from the 20-ft (6-m) shore some 20,000 years ago. The soil consists of deep fine sand, often with a high content of broken shells. The crests are built of dry white sand, enriched further inland, especially in the slacks, by quantities of humus which gives the soil a dark grey colour and improves its water-retaining capacity. The vegetation may vary greatly between the youngest and oldest dunes but it intergrades almost imperceptibly between. However, although somewhat over-simplified, five sub-associations may be distinguished.

(a) Pioneer Dune Mixed Fynbos Sub-Association occurs along the edges of a few bare dunes, for example, from Platboom for approximately 100 yd (91 m) in a northwesterly direction. Such dunes, open to the sea at one end, are being constantly blown back and forth by the two prevailing winds. They are not being actively colonized by plants but are also not spreading. Pioneers of the psammosere along the edges are *Agropyrum distichum*, *Ammophila arenaria*, *Ehrharta villosa* and *Myrica cordifolia*.

(b) Littoral Dune Mixed Fynbos Sub-Association (Plate 1) is best developed around the Krom River lagoon, local patches diminishing in extent southwards. On the slopes and crests of the dunes, with their ~~De Hoop~~ Fernwood soils, fine-leaved elements predominate. *Metalasia muricata* is dominant on the littoral dune but more and more species occur at progressively greater distances from the sea. Typical constituents are *Indigofera brachystachya*, *Passerina paleacea*, *Pelargonium betulinum*, *Phylica ericoides* and *Psoralea fruticans*, together forming a rather open canopy about 2 ft (60 cm) high, with *Myrica cordifolia* emerging in sheltered places to 5 ft (1.5 m), and a lower layer of *Restio eleocharis* and *Ficinia ramosissima* about 8 in (20 cm) high.

In sheltered slacks where the sand is moister, woody elements, beginning with *Euclea racemosa*, *Pterocelastrus tricuspidatus* and *Rhus glauca*, develop into a dense scrub 6 to 8 ft (1.8-2.4 m) tall. These are described under the Broad-leaved Scrub Formation.

(c) Dwarf Dune Mixed Fynbos Sub-Association. Calcrete ridges bearing this sub-association are found from Buffels Bay northward along the base of the hills to Paulsberg (Plate 7); from Meadows tapering northwest to near Diaz Beacon (Plate 2); inland of the bare dune at Platboom (Plate 5); and from Diaz Beach north-west to Groendam (Plate 8). At the latter place the strong south-east winds have shorn the plateau of all covering and the exposed limestone is devoid of plants except for dwarf *Myrica cordifolia* occurring in small pockets of soil.

Where the calcrete dune crosses the main road near the 36th milestone, at Meadows, the fine-grained sandy soil up to 1 ft (30 cm) in depth supports a distinctive dwarf duneveld of divaricate shrubs about 12 in (30 cm) high, quite rich in species.

Further inland at the highest point on the Platboom road where the soil is shallower, only the hardiest species survive. According to Professor D.A. Webb (pers. comm.), the vegetation of this ridge (Plate 2) is reminiscent of depauperated garigue in Spain and Southern France. It is similar to the fynbos of the limestone outcrops in the Bredasdorp Division and the dwarf fynbos of the Elim flats which Acocks (1953, p.129) considers should be regarded as distinct veld types.

This interesting community contains many plants absent or rare elsewhere in the Reserve. It is characterized by the conspicuous Thamnochortus fraternus which is confined to this sub-association. Ursinia ciliaris, a rare plant, occurs only on the limestone outcrops. Plants confined to Dwarf Dune Mixed Fynbos and Thamnochortus erectus Dune Fynbos but more common in the former, include Asparagus stipulaceus, Chascanum cernuum, Erica coarctata, E. coccinea (yellow form), Hermannia trifoliata, Senecio arnicaeflorus and Struthiola salteri. Other plants clearly showing its similarity to the rest of the Coast Fynbos include Chondropetalum microcarpum, Ficinia lateralis, Ifloga seriphioides, Indigofera brachystachya, Lightfootia tenella, Passerina paleacea and Pelargonium betulinum.

In the slacks between the limestone ridges the fine soil is much deeper and supports a tall dense stand of Leucadendron sabulosum 3-8 ft (0.9-2.5 m) in height, intermixed in places with Metalasia muricata. The thick leaf litter beneath these bushes breaks down into a rich mull humus some 3 in (7.5 cm) or more in depth. Where the canopy has been opened a thicket of Cullumia squarrosa scrambles over the soil in a tangle to 3 ft (90 cm) high. The vegetation of the ridge where the soil is shallow has a decidedly xerophytic appearance, while that of the slacks is mesophytic.

(d) Thamnochortus erectus Dune Fynbos Sub-Association is very similar to Dwarf Dune Mixed Fynbos. It occurs on dunes of deep white or grey Fernwood sand with no calcrete near the surface. The main dune extends inland from Buffels Bay in a north-westerly direction for some 3½ miles (5.6 km), diminishing to isolated patches where the Brightwater road descends on to the coastal shelf. Smaller examples of this community are found near Ribboksdam (soil of the Fernwood Series) and Bloubergstrand (Langebaan Series).

The vegetation is taller and floristically more diverse than Dwarf Dune Mixed Fynbos from which it is distinguished by the presence of Thamnochortus erectus. This conspicuous tufted thatching reed reaches a height of 4 ft (1.2 m) and dominates patches mainly on level sand along the flanks of the dunes (Plate 3), in much the same way as Thamnochortus spicigerus occurs in Coast-shelf Fynbos. Scirpus membranaceus, a plant with similar physiognomy, is found locally in the same habitat. The greater part of this community, especially on the dune ridges, has a fairly dense canopy about 2 ft (60 cm) high, comprising species of Dwarf Dune Mixed Fynbos plus Diosma hirsuta, Ficinia secunda and the creeping scented Leucospermum hypophyllocarpodendron. Where fire has been excluded, low woody thickets are found. Besides pioneers of the Broad-leaved Scrub Formation these thickets include Myrica quercifolia which is common in similar habitats on the Cape Flats.

(e) Ifloga-Petalacte Dune Fynbos Sub-Association is an anomalous, heterogeneous community placed here because it apparently bears most resemblance to Coast Fynbos. Unlike other dune communities it occurs not only on marine sand but also on Table Mountain Sandstone soil which has apparently been transported by wind, being found piled up on the windward side of rocky ridges or below the escarpment of the central plateau. The Fernwood soil is a medium, white sand, devoid of humus and usually very dry.

Two species characterize this community: Ifloga seriphioides, a straggly rhizomatous shrub, and Petalacte coronata, a compact, grey-leaved sub-shrub about 1 ft (30 cm) in height. Depending on the location, extent and soil-depth of the patch, it contains an admixture of species from other communities, for example, (1) from Sub-Association 2(d): *Ficinia secunda*, *Leucospermum hypophyllocarpodendron*, *Myrica quercifolia*, *Protea scolymocephala*, *Scirpus membranaceus*, *Thamnochortus erectus*; (2) from Association 1: *Eriocephalus racemosus*, *Mundia spinosa*, *Passerina vulgaris*, *Salvia aurea*; (3) from Association 7: *Diosma hirsuta*, *Leucadendron adscendens*, *Montinia caryophyllacea*, *Protea acaulis*; (4) from Association 5: *Anthospermum berg~~er~~ianum*, *Helichrysum vestitum*, *Metalasia brevifolia*, *Phylica stipularis*, *Ruschia sarmentosa*, *Salaxis flexuosa*, *Staavia radiata* (Plate 4).

Vegetation containing elements of this sub-association occurs just within the northern boundary of the Reserve in the upper Klaasjagers River valley (Plate 4), continuing in patches to the gap between Teeberg and Bonteberg. This community occurs in a belt of varying width on undulating, north-west-trending sand, which suggests that a dune has been blown north-westward by the prevailing south-easterly winds. Floristic composition is very mixed. Species typical of both this and the Tall Fynbos Association occur. It is possible that the gravelly sands of the Tall Fynbos habitat have been blown over Rooihoogte Nek and along the foot of the hills. Marine sand blown from Smitswinkel Bay during a past arid cycle may be intermixed.

Due to the mixed nature, ill-defined boundaries and often limited extent of *Ifloga*-*Petalacte* Dune Fynbos, only the largest and most distinct patches can be shown on Map 1. Many others, often less than ¼ acre (0.1 Ha) in extent, occur scattered throughout the Reserve. The presence of these small sand deposits within the Inland Fynbos seems to indicate a period of drier climate, probably during the last interpluvial, when the soil was more easily eroded and transported by wind because of an impoverished vegetal cover. The same process, on miniature scale, can be seen in operation to-day, after a summer fire.

3. *HELICHRYSUM-SCIRPUS* MARSH ASSOCIATION

Small depressions sometimes occur in the thin layer of marine sand overlying the Table Mountain Sandstone bedrock of the coast shelf. Here, drainage is so poor that the soil is permanently moist; during winter it is waterlogged. The coarse marine sand, containing a high percentage of ground-up sea shells, is white on the surface but dark brown beneath.

Helichrysum-Scirpus Marsh, the only community of this habitat, is often fragmentary because of the limited extent of the coast shelf depressions. However, wherever *Helichrysum orbiculare* and *Scirpus nodosus* are both present the marsh community can be said to exist in rudimentary form. Similar vegetation is to be found in marshy areas of the Cape Flats near Strandfontein.

At Potbank between Platboom and Bloubergstrand there is a well-developed marsh (Plate 5). The vegetation consists of low, rounded *Helichrysum orbiculare* about 18 in (45 cm) high, plus the erect *Scirpus nodosus* and *Juncus kraussii* up to 2 ft (60 cm) high, between which semiscandent herbs and moisture-loving shrubs form a dense matted cover. *Apium graveolens*, *Chironia decumbens*, *Conyza pinnatifida* and *Samolus valerandi* are confined to the wettest parts of this community, while *Chondropetalum nudum*, *C. tectorum*, *Danthonia cincta*, *Orpheum frutescens* and *Samolus porosus* are shared with other marshy communities inland.

4. *COLEONEMA* FYNBOS ASSOCIATION

The rocky littoral is the only coastal habitat found on Table Mountain Sandstone. With its substratum of bedrock close to the surface the soil is genetically related to Inland Fynbos habitats. These sites, however, are directly exposed to salt-laden sea breezes and the vegetation shows a close affinity to the Coast Alliance. On the False Bay coast the narrow rock ledges and precipitous slopes are hot and dry, but on the Atlantic side the slopes are gentler, and many, being south-west-facing, are cooler, so that, if protected, the vegetation develops into Broad-leaved Scrub.

The Coleonema Fynbos, occurring on both the east and west coasts, covers a considerable variety of habitats, with a corresponding variation in species composition. The canopy is uneven, consisting of wind-sheared or cushion-shaped shrubs varying in height from about 6 to 30 in (15-75 cm). Coleonema album is common to both warm and cool aspects. It is a rounded, bright green, fine-leaved shrub about 2½ ft (75 cm) high, and is the most characteristic plant of the Association, occurring in almost pure stands on the cooler slopes. Elsewhere it is associated with coastal shrubs such as Eriocephalus umbellulatus, Metalasia muricata, Passerina vulgaris, Phylica ericoides and Thesium viridifolium. Succulents, mainly sprawling Mesembryanthemae (among them Drosanthemum candens and Tetragonia fruticosa) and creeping Carpobrotus spp., are most common on hot, dry aspects (Plate 6). The only Restionaceous plant present is Restio cincinnatus, sprawling from rock crevices.

THAMNOCHORTUS DICHOTOMUS INLAND FYNBOS ALLIANCE

(Plates 9 to 24)

Whereas Coast Fynbos occurs mainly on neutral or alkaline transported soils of marine origin, Inland Fynbos is confined to acid soils formed from the underlying Table Mountain Sandstone. On the hills the sand grains are coarse, white and angular but where they have been washed down on to the plateau the grains are finer, smoother and mixed with humus which gives the soil a grey or black colour near the surface. Soil depth varies from nil on bedrock to many feet on the plateaus. Ferricrete outcrops locally along the eastern slopes.

On the Reserve, Inland Fynbos occupies a far greater area than Coast Fynbos and covers a wider range of habitats. Altitude varies from the summit of Paulsberg (1203 ft : 366 m) to nearly sea level in the Krom River valley. All aspects, and all slopes from perpendicular cliffs to level flats, are represented. The southerly and easterly aspects are cooler than usual because of the effect of the cool, cloud-bearing south-east winds of summer. The considerable variation in rainfall, its markedly seasonal nature and the great differences in soil depth and slope combine to produce soil conditions which vary from permanently waterlogged to almost permanently dry.

Despite this great range in habitats it is seldom possible to draw sharp boundaries between them, especially in the rocky hills and mountains where drainage is relatively uniform throughout. The plant communities are correspondingly ill-defined.

The vegetation of the hills and mountains was subjectively divided into units of varying distinctness often with gradual ecotones between them. These units, though floristically defined, were given provisional "habitat-names" for convenience. To test the validity of the units, species lists were made in 33 sample plots, each 5 x 10 m, specially sited as typical of the tentative "habitat-community" concepts. A rough synthesis table was then drawn up following Braun-Blanquet (Becking, 1957) to ascertain any obvious species groupings which might indicate distinct communities. For comparison, some plots in other closely-related vegetation units were added so that the total number tabulated was:

"Hills and Mountains"

Unit 1 :	Variety "Rocky Hills"	2	plots
Unit 2 :	Variety "Mountains"	5	"
Unit 3 :	"Southern Hills"	7	"
Unit 4 :	"Mixed Southern Veld"	12	"
Unit 5 :	*Ferricrete*	2	"
Unit 6 :	*Waboomveld*	1	"
Unit 7 :	*Plateauveld*	3	"
Unit 8 :	*Sandveld*	1	"

On examining the table it became clear that no additional units could be detected without re-writing the table many times, continually improving the grouping of plots (by vertical rearrangement) and of species (by horizontal rearrangement) to give so-called "blocks" of character and differentiating species. Since a detailed analysis by Braun-Blanquet's methods is outside the scope of this descriptive survey, it was felt that the time which this work would entail was not justified.

The rough synthesis table nevertheless provided a quantitative measure of constancy, a qualitative measure of fidelity and a pointer to character or indicator species.

1. Constancy is the term used for presence of a species in sample plots which are all of the same size. Relative constancy of all species in a community is a measure of the homogeneity of that community. The greater the number of species with high relative constancy, the more homogeneous is that vegetation.

From the synthesis table, constancy of each species was calculated for all samples of (a) units 1-8, and (b) units 1-4. The results are summarised in Table 2.

TABLE 2

SPECIES RICHNESS OF CONSTANCY CLASSES

Constancy Class	% number of species per class	
	Units 1-8	Units 1-4
I (0-20%)	71	66
II (20-40%)	24	23
III (40-60%)	4)	8)
IV (60-80%)	½) 5	2) 11
V (80-100%)	½)	1)

In both cases there is a large discrepancy between the two lowest-constancy and the three highest-constancy classes. When all the samples of units 1-4 are examined together, 11% of the species they contain are seen to fall into the three highest constancy classes. When all the species of units 1-8 are examined together, only 5% of the species fall into these classes. Therefore units 1-4, having a much larger proportion of high-constancy species, form a more homogeneous group than do units 1-8. This justifies splitting off units 1-4 from the others.

During fieldwork it became apparent that Thamnochortus dichotomus was widespread, often common, even locally dominant in the Inland Fynbos but rare or absent in the Coast Fynbos. It was thus felt that this species might prove the best one to distinguish Inland Fynbos from Coast Fynbos but would probably be of no value in characterizing communities within the Inland Fynbos. The synthesis table confirms this view by revealing that Thamnochortus dichotomus has the highest constancy of all species in the sample plots compared. In Braun-Blanquet terminology it is, in fact, the only "constant" species (over 80% constancy) for the Inland Fynbos Alliance and, being practically confined to this Alliance, it becomes the best character species for Inland Fynbos, which could thus be termed the Thamnochortus dichotomus Alliance. This bears out the observation of Becking (1957, p.445) that "only character species of vegetation units of highest classificatory rank ... are the more common and often locally dominant species."

2. Fidelity. An examination of the synthesis table shows that no species are completely faithful to any one of the units 1, 2, 3 and 4 whereas some species are completely faithful to the combined unit (1-4) and to each of the units 5, 6, 7 and 8. This justifies incorporating units 1-4 in one community and retaining units 5, 6, 7 and 8 as separate communities. These units are equivalent to the following associations:

Units 1-4 : Hills & mountains : Assoc. 5 : Mixed Fynbos
Unit 5 : Ferricrete : Assoc. 6 : Tall Fynbos
Unit 6 : Waboomveld : Assoc. 7 : Pseudo-Savannah
Unit 7 : Plateauveld : Assoc. 8 : Restionaceous Fynbos
Unit 8 : Sandveld retained as Sub-association 2(e) of the Coast Fynbos Alliance.

Faithful species will be further discussed in the community descriptions.

3. Character species could not be determined directly from the synthesis table because a sufficiently wide array of different plant communities was not included in the tabulation. Nevertheless the information in the table, used in conjunction with my knowledge of species composition of other communities, did serve to pinpoint some character species which will be dealt with in the community descriptions.

5. UPLAND MIXED FYNBOS ASSOCIATION (Plates 9 to 18)

Habitat

This is the most extensive and variable community on the Reserve. As is usual in hilly or mountainous terrain, habitat varies greatly with slope, aspect and altitude. The skeletal Mispah soil, composed of coarse white sand over bedrock, is usually shallow. In the very few cases where the ground is level, local patches of poor drainage result, but in general the shallow soil, combined with steep slopes, results in rapid drainage. At a more intensive level of description this community could be subdivided further on the basis of these factors but because of intergradation and the lack of dominance, the differences are not sufficiently distinct to warrant subdivision at this stage.

Three main habitat-geographic variations can be distinguished:

(1) The western edge of the central plateau from Krom River southwards to beyond Ribboksdam: a broad, broken, rocky upland, in altitude about 250 ft (76 m) with a maximum of 381 ft (115 m) at

Kommetjieberg (Plate 27), falling steeply to the coastal plain on the west. Outliers of these rocky hills penetrate the plateau around Sirkelsvlei, at Russouwskop and Lean Rock (402 ft : 122 m), not to mention numerous smaller scattered outcrops. The western hills, being close to the Atlantic, are probably cooler than the rest of the Reserve and receive moisture not only from rain but also from the autumn mists which are thickest and of longest duration here.

(2) A line of high hills along the land boundary of the Reserve, following the north-west-trending joint plane of the Table Mountain Sandstone, intersected by the Klaasjagers River valley; detached in the north but uniting progressively south-eastward to form a hummocky ridge ending in its highest point, Rooihoogte, 932 ft (283 m), near the main entrance gate; from where it drops steeply into the sea at Smitswinkel Bay. The central portion of this ridge appears to be hot and dry while the south-eastern end is exposed to the full force of the cool south-easterly winds.

(3) The mountains of the False Bay coast from Judas Peak to Cape Point, rising steeply from their bases at about 600 ft (183 m) along the upper edge of the Smitswinkel Flats on the west, to summits of 1200 ft (366 m) at Paulsberg. These mountains fall sheer into False Bay on the east (Plate 7). They are often covered in south-east cloud in summer, but at other times the western slopes can be hot and dry. Local deposits of ferricrete on the slopes fall under association 6; the distinction, dependant solely on this soil factor, is delicate, so it is not surprising that the plant communities on sandstone and those on ferricrete intergrade where the two soil types adjoin.

Vegetation

In addition to the variability in physical habitat, other factors such as fire, wind and previous grazing by domestic stock have caused great variation in composition and stratification.

Floristically, the community is richest two to five years after fire when annuals, geophytes, sprouting perennials and seed-regenerating shrubs all occur together. In subsequent stages the last-named predominate while the other three classes become moribund and eventually die out. Conversely, stratification is simplest in the early stages and becomes more complex with advancing age. Starting from a single low layer of sprouting and seed-regenerating plants it increases to a three-layered community of (1) emergent shrubs, often Proteaceae with broad leathery leaves, (2) canopy shrubs, usually fine-leaved, mixed with taller Restionaceae, and (3) ground layer of the lower tufted Restionaceae, Cyperaceae, Gramineae and herbs. After some twenty years of protection from fire all three layers become moribund: the emergents and canopy shrubs slowly die out, littering the ground with dead twigs and leaves which decompose slowly, suppressing even the sprouting element of the lower layer. In steep, rocky places the fynbos may give way to <u>Aspalathus</u>-<u>Phylica</u> Scrub. On more level, less rocky ground, fynbos may be self-perpetuating by regeneration of the early stages in openings caused by the death of shrubs in the mature community.

Examples of the early stages in the fire-sere,are, at the time of writing, to be found near Kommetjieberg and in the Bonteberg-Teeberg area. The highest number of species recorded on all the one hundred 5 x 10 metre computer-study plots (vide Chapter 5) occurred on Bonteberg where 83 species were listed in vegetation burnt three years before (Plate 11). The average count of species in vegetation one to three years after burning was 72 per 50 square metres. In the younger area, the vegetation was one-layered and not over 12 in (30 cm) in height; the Restionaceae-Cyperaceae element was regenerating vigorously and annuals and biennials were common; seedlings of the larger bushes were present but not yet contributing much to the ground cover, and over 50% of the surface was still bare. In three-year veld the Restionaceae-Cyperaceae element, especially <u>Elegia stipularis</u>, was becoming dominant, forming a canopy 12-18 in (30-45 cm) high; annuals and biennials, including Selago spuria and creeping Aspalathus species, were disappearing; fine-leaved shrubs were appearing and the larger seed-regenerators (Leucadendron decorum, Serruria vallaris) were beginning to emerge sparingly to a height of 2 or 3 ft (60-90 cm). Cover had increased to about 75% on dry slopes and to more than 85% on sheltered sites.

Intermediate stages in the fire-sere are rare because fire has been effectively excluded from the Reserve for ten years or more. However, examples of vegetation protected from fire for ten to twenty years are to be found in all three of the major habitats.

Along the western edge of the plateau, mature Mixed Fynbos is typically three-layered. In this tall, long-protected community there are only about 25-50 species per 50-square metre plot. Leucospermum conocarpodendron, a rounded, densely-branched shrub, and Mimetes hartogii, a small tree with umbrageous crown, form an erratic savannah-like emergent layer about 10 ft (3 m) high, the individuals about 15-20 ft (4.5-6 m) apart (Plates 11, 17, 18). Below this is a denser layer of Leucadendron decorum, a globose bush 3-4 ft (90-120 cm) high, its broadly oblong leaves giving a characteristic yellow-green tinge to the plateau vegetation, especially during the winter flowering period. In drier areas of greater relief it is but an infrequent component. Only along the western escarpment is it common in Upland Mixed Fynbos. Its distribution and mode of regeneration suggest that it is a site-tolerant species which has spread beyond its natural range (Plateau Fynbos) as a result of repeated burning in the past. The L. decorum layer gives sporadic cover: sometimes dense but more often scattered, it affords less than 50% of the total cover, being quite absent from areas of 100 sq yd (84 sq m) or more. The lowest layer, densely filling these interspaces and extending more sparsely beneath the Leucadendron, is dominated by Restionaceae 12-30 in (30-75 cm) in height, among which Thamnochortus dichotomus, Hypodiscus alboaristatus and Restio cuspidatus are common. Elegia stipularis is less vigorous than in younger veld. Minor Ericaceous genera and other fine-leaved shrubs are present. Tetraria thermalis occurs sparingly but its gross-leaved yellow-green tufts and erect 6-ft (2-m) culms are conspicuous. Further down the escarpment, nearer the coast, the emergent pseudo-savannah bushes are absent and in the lowest layer Restionaceae take second place to a dense mixture of fine-leaved Ericaceous shrubs such as Salaxis flexuosa and other representatives of the minor genera, plus Erica puchella, E. imbricata, E. corifolia and, among rocks, E. mammosa. Where Salaxis flexuosa and Elegia stipularis together dominate, the community resembles sub-association (c) described later.

In "islands" where Mixed Fynbos occurs on rock outcrops within the plateau, the structure is reduced by shallow soil and strong winds to a low heath of divaricate shrubs some 12 in (30 cm) high, in which the minor Ericaceae are dominant. Elegia stipularis is the most frequent of the Restionaceae and Leucadendron decorum is rare and stunted, not exceeding 2 ft (60 cm) in height.

The drier northern hills of the inland boundary have a simpler vegetation. Leucadendron decorum is conspicuous on the lower slopes, less abundant on the intermediate slopes which bear a single-layered Restionaceous mixture. Restio egregius occurs only in this area. The crests and higher slopes where sheltered by boulders are sparsely covered by the pseudo-savannah bushes Leucospermum conocarpodendron and Mimetes hartogii, with Tetraria thermalis occasional to fairly frequent. On screes and warm boulder-slopes Aspalathus capensis and Phylica buxifolia sometimes form dense closed scrub which is described later as sub-association (a).

The hot, rocky hills bordering the eastern mountains (e.g. Kanonkop) bear a coarse vegetation. The pseudo-savannah bushes are almost absent while Tetraria thermalis is common, regularly spaced and conspicuous. The tufted Staberoha banksii is characteristic, interspersed with heathy shrubs. The mountain slopes are cooler, the vegetation becomes lower but denser, *Elegia juncea* is characteristic and *Alciope tabularis* with its glossy, dark leaves and hairy, pulverulent stems is conspicuous in rock outcrops.

Species Composition

The community as a whole is so rich and variable that only the most striking plants have been mentioned above. In the following lists, extracted from the synthesis table, species are given in order of constancy:

(1) *Exclusives* (fidelity V): confined to this association:
(a) *widespread* within the association, occurring in all site variations: *Bobartia gladiata*, *Tetraria compar*, *Corybium glabrum*, *Gnidia imbricata*, *Liparia parva*, *Clutia alaternoides*.
(b) *somewhat restricted* (i) missing from one unit of the synthesis table: *Metalasia cephalotes*, *Erica phylicaefolia*, *Lobelia setacea*, *Saltera sarcocolla*, *Tetraria thermalis*, *Thesium spicatum*, *Osteospermum polygaloides*, *Carpacoce vaginellata*, *Lobelia pinifolia*; (ii) missing from two units: *Roella ciliata*, *Erica corifolia*, *Mimetes hartogii*, *Thesium virgatum*, *Alciope tabularis*, *Aspalathus carnosa*, *Staberoha banksii*.

Most of these are missing from the *Metalasia*-*Passerina* Sub-Association (c). *Thesium spicatum*, *T. virgatum*, *Roella ciliata* and *Aspalathus carnosa* are not usually found at higher altitudes, while *Mimetes hartogii* and *Alciope tabularis* have not been recorded from the lower sites.

(2) *Selectives* (fidelity IV): strongly prefer this association but occur sparingly elsewhere:
(a) *widespread*: *Anaxeton asperum*, *Adenandra umbellata*, Minor Ericaceae, *Rhus lucida*, *Amphithalea ericaefolia*.
(b) *somewhat restricted* (i) missing from one unit: *Corybium africanum* *Danthonia macrantha*, *Leucospermum conocarpodendron*, *Asparagus compactus*, *Erica cerinthoides*, *E. puchella*, *Restio cuspidatus*, *Tetraria eximia*, *Castalis nudicaulis*, *Leptocarpus gracilis*.

(ii) missing from two units: Cliffortia falcata, Serruria vallaris, Thamnochortus fruticosus, Berkheya ilicina, Ficinia deusta, Watsonia tabularis, Anthospermum ciliare. (iii) missing from three units: Ruschia sarmentosa, Petalacte coronata.

Again, most of these are absent from the Metalasia-Passerina community. Plants missing from high altitudes include Leucospermum conocarpodendron, Serruria vallaris and Ficinia deusta. Thamnochortus fruticosus, Ruschia sarmentosa and Petalacte coronata are restricted to sites on deep sand.

(3) Preferentials (fidelity III): optimum in this association but occur often elsewhere:

(a) widespread: Metalasia muricata, Elegia stipularis, Salaxis flexuosa, Erica mammosa.

(b) somewhat restricted (missing from the mountain variation): Passerina vulgaris. Since this species pioneers on disturbed ground and intrudes in natural openings, it is not surprising that it should be absent at higher altitudes where the dense vegetation is least disturbed.

Both Metalasia muricata and Passerina vulgaris, tentatively included as preferentials to this association, may prove on statistical analysis to be more closely bound to the Coast Fynbos where they are equally if not more common. If, as I suspect, two distinct ecotypes of Metalasia muricata exist, one confined to the Coast and the other to the Inland Fynbos Alliance, it would be preferable to define their floristics at the level of the ecotype rather than of the species. Pryor, (quoted in Beadle and Costin, 1952) states that this may be desirable when dealing with Eucalyptus species in Australia.

Sub-associations

Communities differing markedly in structure or floristic composition, often having one or two local dominants, are described as distinct sub-associations. These bear no relationship to the four "units" previously discussed. None of these sub-associations have been shown separately. on Map 1.

(a) *Aspalathus-Phylica* Scrub Sub-Association

The rockiest places not only afford prolonged protection from fire but also appear to provide a suitable micro-climate for fynbos to develop eventually into a woody scrub. Suitable sites for this development are found along the western edge of the plateau escarpment (Plate 12) and on inland rock outcrops and screes (Plate 4). Examples of the latter are (1) the summit ridge of Rooihoogte; (2) most of the northern slope of the Anvil Ridge; (3) a north-facing scree on the summit of Klein Bonteberg.

Along the escarpment edge at Olifantsbos *Aspalathus capensis*, an almost tree-like woody shrub 6-8 ft (1.8-2.4 m) high with single stem and flat, spreading crown, forms dense closed stands. This species, like all Aspalathi, regenerates with vigour from seed when burnt but, unlike other Aspalathi, persists for long periods, probably twenty or thirty years, and has a place in the mature scrub community. *Phylica buxifolia*, a plant with similar form, is strongly associated, and the two together sometimes form grotesque miniature forests with a canopy not exceeding 8 ft (2.4 m) and a scant cover of *Myrsine africana* as undershrub in the subordinate layer. On screes and sheetrock where the canopy is open, fine-leaved shrubs such as *Coleonema album*, *Cliffortia* spp., *Erica mammosa* and *Aspalathus carnosa* partly fill the gaps, with succulents like *Othonna carnosa*, *Carpobrotus acinaciformis* and *Mesembryanthemae* in cracks between the rocks, and a few moribund Restionaceae between the shrubs. *Dolichos gibbosus* and sometimes *Fagelia bituminosa* occur as climbers.

After long protection, shrubby trees (*Cassine barbara*, *Colpoon compressum*, *Olea capensis*, *Pterocelastrus tricuspidatus*, *Rhus lucida*, *Tarchonanthus camphoratus*) begin to invade the community until, after perhaps thirty years or more, this scrub will develop into the Broad-leaved Scrub Formation. The latter is already found at the foot of the escarpment further south.

(b) *Metalasia*-*Passerina* Fynbos Sub-Association

South of the roads leading to Buffels Bay and Platboom Bay, excluding the Vasco da Gama - Cape Point mountain massifs and the limestone and littoral vegetation, this Sub-Association is found (Plate 18). Most of the area is lower in altitude than the typical localities of Mixed Fynbos, extending from about 100-250 ft (30-76 m) with the highest point at 350 ft (106 m). The more level substrate consists of deeper sand with unimpeded drainage, so the soil is drier. It may also receive less rainfall than Mixed Fynbos further north.

Typically the community is three-layered, the upper consisting of the two dominants, *Metalasia muricata* and *Passerina vulgaris*, 3-4 ft (90-120 cm) in height, with some local admixture of *Salaxis flexuosa*. Where this layer forms a closed canopy the lower layers are sparse, but generally there is room for development of a middle layer 1½-2 ft (45-60 cm) high, of Mixed Fynbos plants particularly *Elegia stipularis* and *Serruria vallaris*, though impoverished in species. On sand-patches, which are common in this locality, some of the character species of Sub-Association 2(e) e.g. *Leucospermum hypophyllocarpodendron*, *Protea scolymocephala* and the annuals *Gymnodiscus capillaris* and *Manulea tomentosa* transgress into the middle layer of the *Metalasia*-*Passerina* community. In addition, a few sand-loving constituents of the Mixed Fynbos such as *Penaea fruticulosa* and *Thamnochortus fruticosus* are more common than they are in typical Mixed Fynbos. The ground layer contains creeping succulents like *Carpobrotus acinaciformis* and *Ruschia sarmentosa* which occur commonly where the upper layers are very open, and smaller tufted Restionaceae and Cyperaceae such as *Restio cuspidatus* and *Ficinia ramosissima* which provide further evidence of affinity with the Coast Fynbos Alliance. Indeed, the boundary of this community towards the sea is by no means clearcut and the two dominants are frequently found in the sandy littoral.

Both *Metalasia muricata* and *Passerina vulgaris* are frequent on rocky ridges between Buffels Bay and Meadows where one would have expected to find the richer, more varied, typical Mixed Fynbos of the hills. Instead, only a few of the most characteristic saxicolous plants like *Erica coccinea*, *Tetraria compar*, *T. cuspidata* and *Saltera sarcocolla* occur, giving the appearance of a hardy remnant community resisting the advance of invaders. Various stages in impoverishment can be traced until, in the final stage, a dense stand of *Metalasia* and *Passerina* 6 ft (1.8 m) high has excluded almost all the original species except a few *Leucospermum conocarpodendron* bushes emerging to 8 or 10 ft (2.4-3.0 m), and some tenacious Restionaceae persisting in the ground layer. Both *Metalasia* and *Passerina* are vigorous colonisers of bare ground along roadsides and in other disturbed areas. The strong dominance of these two species in vegetation where dominance is seldom a feature in the pristine state suggests an invasion of these semi-pioneers into a community which has been disturbed in some way. The relic of Mixed Fynbos on rocky ridges lends support to this view. Martin (1965), working at Grahamstown near the eastern limit of fynbos, describes a "heath" community, probably owing its origin to disturbance, dominated by *Metalasia muricata*; he considers that burning may have a selective effect on certain species, of which *Metalasia muricata* is one.

It is suggested that before the advent of European man, *Metalasia muricata* and *Passerina vulgaris* were concentrated in the sandy, lower parts of the Reserve and that their spread to higher, rocky ground has been encouraged by repeated burning of the veld combined with grazing by domestic livestock. This degeneration could well have been accelerated if, as appears likely, rainfall, soil moisture and other habitat factors are less favourable than in typical Mixed Fynbos, so that the vegetation is inherently less stable. Smith's Farm is one of the oldest settlements on the Reserve and the area carried considerable herds of horses and cattle in the early days of this century. It is reasonable to suppose that the veld close to the homestead was frequently burnt to provide fresh grazing for these animals.

(c) Elegia-Salaxis Fynbos Sub-Association

Adjoining the Metalasia-Passerina community on the Platboom road and extending for nearly a mile in a north-westerly direction from Diaz Beacon, a community similar to the foregoing in over-all species content but differing markedly in physiognomy, is found. It is dominated by Elegia stipularis and the fine-leaved Salaxis flexuosa which form an even, single-layered, rather open canopy about 2 ft (60 cm) high. Other Mixed Fynbos species occur sparingly, some of them emerging to 3 ft (90 cm) while occasional Leucospermum conocarpodendron and Mimetes hartogii emerge to 10 ft (3 m).

The community occurs on the broad, windswept, coarse sandy ridge which forms the watershed of the southern end of the Reserve at an altitude, here, of about 400 ft (122 m). On poorly drained, almost level parts of the ridge the Tussock Marsh species Cliffortia subsetacea, Elegia parviflora and Restio bifurcus occur, and to the west the Salaxis community merges into Tussock Marsh of the central plateau. In the few rock outcrops Salaxis is replaced as dominant by other minor Ericaceous genera and the Mixed Fynbos is represented by species such as Anaxeton asperum, Alciope tabularis, Staberoha banksii and Tetraria thermalis. As in the Metalasia-Passerina community, these species take a subsidiary place and appear to have been invaded by the dominant Ericaceae. The same Ericaceous species (Blaeria spp., Syndesmanthus spp., and Scyphogyne muscosa) as well as Salaxis flexuosa, appear to be also invading the Tussock Marsh. What is thought to be the original community is still found in the north-western part, near the Gifkommetjie road, where a greater mixture of Ericaceous species including Erica corifolia, E. imbricata and E. pulchella, together with Leucadendron decorum, form a typical rich Plateau Fynbos.

The Elegia-Salaxis community appears to have been derived from Plateau Fynbos by the same means and for the same reasons as the Metalasia-Passerina community was derived from Mixed Fynbos. It exhibits the same symptoms of biotic disturbance and, being closer to Smith's Farm and having a moister soil, it was if anything even more suitable for grazing than was the Metalasia-Passerina of the south.

6. PROTEA LEPIDOCARPODENDRON TALL FYNBOS ASSOCIATION

The chief concentration of Tall Fynbos is found in the north-eastern corner of the Reserve from Rooihoogte along the slopes of Judas Peak to the Boer ridge at an altitude of 400-1,000 ft (122-305 m) (Plate 19). A small outlier occurs in the south on the lower slopes of Vasco da Gama Peak at 200-400 ft (61-122 m). Though Protea lepidocarpodendron does occur rarely on white Table Mountain Sandstone sands, the community as a whole is confined to strata containing iron oxides in solution. These oxides are deposited in the subsoil as impervious layers of ferricrete. In the Reserve these gravels of the Sandvlei Series occur chiefly on slopes and the shallow soil becomes very dry in summer. The surface soil is a fine yellow-brown sand with an admixture of small brown stones, gravelly pebbles or sometimes larger stones 4-8 in (10-20 cm) in diameter, stained light brown to dark purple from the impregnated iron. The litter layer, consisting largely of undecomposed Protea leaves and Restionaceae stems, is 1-2 in (2.5-5.0 cm) thick. Sometimes the ferricrete outcrops on the surface.

The vegetation is two-layered. The upper layer, 6-8 ft (1.8-2.4 m) high, consists of the single species Protea lepidocarpodendron giving a cover of over 85% when mature. This erect, narrow-crowned Protea with its dark-green oblong leaves and black-bearded bracts gives a characteristically sombre appearance to the community. The lower layer of Restionaceae and shrubs 1½-2 ft (45-60 cm) in height varies in vigour and density depending on the cover afforded by the Proteas. The chief species of this layer, and the most faithful character species for the community, is the tufted Hypolaena digitata which is very abundant throughout the ferricrete areas. Two other plants which occur sparingly, Peucedanum sieberianum and Tetraria fimbriolata, seldom found elsewhere on the Reserve, are reminiscent of the granite or shaley slopes around Stellenbosch. Leucadendron salignum which emerges from the lower layer to a height of 3 ft (90 cm) or more, is characteristic of the Tall Fynbos but ranges beyond this association to surrounding slopes. Other species with a similar distribution are Cliffortia stricta, Tetraria bromoides and Leucadendron adscendens. The last three species are again reminiscent of the vegetation of the mainland mountains. Most species of the lower layer, which is floristically rich and varied, show similarities to Mixed Fynbos communities: Elegia juncea and Erica cerinthoides, for example, are found in high, cool, habitats; Hypodiscus alboaristatus, Elegia stipularis and Serruria vallaris on the warmer lower hillslopes; Petalacte coronata in deep sand pockets and Rhus lucida on boulder scree.

There are indications of two phytogeographical elements on the Cape peninsula, a northern one related to the mainland mountains from Stellenbosch northwards and a southern element related to the coastal mountains on the eastern side of False Bay. The Tall Fynbos and the Pseudo-savannah contain species from both elements and are thought to be southern outliers of the northern element. Certainly the two character species of Tall Fynbos, Protea lepidocarpodendron and Hypolaena digitata, both so common and so distinctive in their respective layers, give this community a characteristic physiognomy which serves to set it clearly apart from any other community on the Reserve.

7. PROTEA ARBOREA PSEUDO-SAVANNAH ASSOCIATION

This community is limited to about 60 ac (24 Ha) of the escarpment in the extreme northeast corner of the Reserve, from the slopes of Judas Peak to the False Bay coast. Altitude ranges from 400 ft (122 m) to almost sea-level within a distance of some 300 yd (274 m) on a very steep slope with a uniform north-easterly aspect. Level bands of Table Mountain Sandstone tinged red-brown with iron oxide, traverse the slope; the shallow soil of coarse sand and the surface stones and pebbles are of the same colour.

Protea arborea ("Waboom") is the character species of the association, occurring at an even espacement of about 20 ft (6 m). It is a stoutly-branched, broadly-spreading, woody shrub 6-8 ft (1.8-2.4 m) high, with thick white stem and broad blue-grey leaves. Its light colour, large size and regular spacing make it a conspicuous feature of the landscape to which it gives the appearance of an orchard-like savannah. On the inland mountain ranges Waboom is characteristic of well-drained soil-covered screes or colluvial deposits near the base of steep slopes, not ironstone gravel. The drainage factor may be the important one in determining its distribution on the Reserve and the soil composition merely incidental.

In structure Protea arborea Pseudo-savannah comprises one variable layer 1½-3 ft (45-90 cm) high, with Protea arborea and the similar-shaped Leucospermum conocarpodendron emerging. The main layer contains many species common to Mixed Fynbos. The community thus resembles a savannah, in which the grass layer is replaced by fynbos plants. As in the case of Tall Fynbos, representatives of the higher mountain slopes and the lower hills are present, but species of deep sand, which is not found in this habitat, are absent. At lower altitudes an increasingly large proportion of coastal scrub species intrude, e.g. Salvia aurea, Ficinia ramosissima, Cassine barbara, Pterocelastrus tricuspidatus, Rhus lucida, Tarchonanthus camphoratus, due to the proximity of a small but well-developed patch of Tall Scrub at The Chair. Character species nearly confined to Pseudo-savannah here and found regularly in the inland community, are Montinia caryophyllacea, Rhus rosmarinifolia, Themeda triandra and Hermannia cuneifolia. The fact that these are also found occasionally in Tall Fynbos lends strength to the view that the two types of Proteavelds are akin. Cymbopogon marginatus and Bobartia indica, regularly occurring in Tall Fynbos, are also found in Waboomveld.

8. RESTIONACEOUS PLATEAU FYNBOS ASSOCIATION

Plateau Fynbos occupies the second-largest area on the Reserve. It is found on the level central plateau excluding areas occupied by Tussock Marsh which are usually sharply delineated. From Suurdam in the south it fans out north-westward to include the Smitswinkel Flats and the shallow drainage system of the Krom River. Altitude is about 300-450 ft (91-137 m) in the southern and central parts, decreasing to 100 ft (30 m) in the lower parts of the Krom River drainage system. Drainage is neither very poor nor very good: where standing water is encountered in winter, Plateau Fynbos gives way abruptly to Tussock Marsh. The Witsand soil is fine sand, usually grey from decomposed humus and very much deeper than the soil of the hills. There are no stones or rocks either on the surface or close beneath it. The soil is acid (pH 3.9-5.6) and litter does not decompose readily.

The main cover is afforded by a dense uniform layer of Restionaceae mixed with the more decumbent soft shrubs, 1-1½ ft (30-45 cm) in height. Above this, throughout most of the plateau north of the Suurdam, Leucadendron decorum forms a conspicuous but discontinuous layer about 3-4 ft (90-120 cm) in height (Plate 20).

Floristically this association contains no character species which distinguish it from the Mixed Fynbos of the hills on the one hand and the Tussock Marsh on the other. It might be described as a mosaic of these two communities with the hills flora predominating on the slightly raised ground, the marsh flora predominating on level or lower areas. The following considerations led to the decision to separate it from Mixed Fynbos: (1) the presence of species characteristic of Tussock Marsh; (2) the absence of certain groups of Mixed Fynbos species; (3) the rarity of other Mixed Fynbos shrubs and sub-shrubs; (4) the greater proportion of Restionaceae in the lower layer; and (5) the dominance in the upper stratum throughout the Plateau (except in the southernmost parts) of *Leucadendron decorum*. In respect of this community *L. decorum* is, in the Braun-Blanquet terminology, a preferent which has spread into, indeed dominated, large adjacent areas of Mixed Fynbos where the habitat is not dissimilar from Plateau Fynbos, e.g. along the western escarpment to Brightwater. Its spread might have been encouraged by veldburning since many of the seed-regenerating Leucadendrons are stimulated to such an extent by fire that they transgress their natural habitat boundaries.

Becking (1957) draws a distinction between the terms "character species" which should be used only to indicate sociological fidelity, and "indicator species" which should be reserved for species showing fidelity to an ecological factor. If *L. decorum* is more faithful to veldburning history than to a particular community, it should be termed a fire-indicator.

As a mosaic of two communities, Plateau Fynbos is floristically rich. No species are strongly faithful to it, the highest fidelity rating being Preferents (fidelity III) e.g. *Leucadendron decorum*, *Macrostylis villosa*, *Pentaschistis colorata* and *Staberoha cernua*. Indifferents, or wide-ranging species found often in Plateau Fynbos as well as in other communities, are: *Diastella serpyllifolia*, *Diosma hirsuta*, *D. oppositifolia*, *Erica imbricata*, *Haplocarpha lanata*, *Hypodiscus aristatus*, *Phylica imberbis*, *Penaea mucronata*, *Pentaschistis curvifolia*, *Restio cincinnatus* (or an ecotype?), *Tetraria microstachys* and *Thamnochortus dichotomus*. Species occurring more often in other communities fall into two groups: (a) species with their optimum occurrence in Tussock Marsh e.g. *Chondropetalum nudum*, *Elegia neesii*, *E. parviflora*, *Restio bifurcus*,

R. quinquefarius, Tetraria fasciata, T. flexuosa and Serruria glomerata; and (b) species with their optimum occurrence in Mixed Fynbos: Adenandra umbellata, Castalis nudicaulis, Corybium africanum, Elegia stipularis, Erica pulchella, Tetraria eximia and Watsonia tabularis. Mixed Fynbos species absent from Plateau Fynbos are: all the non-Proteaceous woody components (Rhus etc.), all the preferents of the Metalasia-Passerina and Ifloga-Petalacte communities, and all those confined to rocky slopes such as Leucospermum conocarpodendron, Mimetes hartogii, Staberoha banksii and Tetraria thermalis.

9. RESTIONACEOUS TUSSOCK MARSH ASSOCIATION (Plates 21 & 22)

Tussock Marsh is found where water is stagnant during winter but dries up during summer. This occurs (1) in shallow depressions within the central plateau, varying from about 50 sq yd (42 sq m) to 300 ac (120 Ha) in extent; (2) on the broad flats of the Krom and Schusters River valleys in the north; (3) on some terrace-steps where seepage is not sufficiently strong to support the Berzelia-Osmitopsis Seepage Scrub.

Tussock Marsh, strongly dominated by one or two species, is usually more sharply delineated than any other community on the Reserve. Occasionally, however, e.g. between the Krom River and Teeberg, and in the Garslandskloof area, where the flats slope very gently, there is a broad transition from Tussock Marsh via Plateau Fynbos to the drier communities.

The simplest Tussock Marsh is found in small shallow depressions to which there are no outlets. With sheetrock very close to the surface, drainage is so poor that standing water is often present throughout the rainy winter months, though the soil can become very dry in summer. The Cartref soil is of medium sand, dark grey on the surface, from decomposed organic matter. The vegetation consists typically of pure, dense, single-layered stands of Elegia parviflora some 12 in (30 cm) high. Other Restionaceae, for example Restio quinquefarius, R. bifurcus and Chondropetalum nudum, and a few low shrubs such as Erica clavisepala (endemic to the Reserve) and Serruria glomerata, may also occur sparingly, especially towards the edge of the community.

In the larger plateau depressions and river flats, where the soil (Witsand Series) is deeper and very wet, a moister Tussock Marsh with three Restionaceous layers is found. Elegia parviflora, still dominant, constitutes the lowest layer, Restio bifurcus and R. quinquefarius are conspicuous in an erratic middle layer about 2 ft (60 cm) in height, and the black-spiked Elegia cuspidata emerges to 3 ft (90 cm). The most varied layer is the middle one which contains soft-, small-leaved shrubs like Cliffortia subsetacea, the sprawling Diastella serpyllifolia, Erica corifolia, Scyphogyne muscosa, Serruria glomerata and Struthiola ciliata.

Some terrace-steps, e.g. near the turn-off to Brightwater, bear a rich Restionaceous mixture in which Elegia parviflora is dominant in the lower layer, Thamnochortus dichotomus, Restio cincinnatus, Hypodiscus aristatus and Chondropetalum nudum form the middle layer accompanied by a few forbs (Bobartia indica, Diastella serpyllifolia), and Elegia cuspidata emerges in scattered coarse black tufts to 3 ft (91 cm).

Occurring usually at the low-altitude margins of Inland Fynbos where it merges with the Coast Fynbos is a single-layered Tussock Marsh community 12-15 in (30-37.5 cm) high. In its simplest form near Ribboksdam it consists of two species evenly intermixed, Chondropetalum nudum and Erica subdivaricata. Beneath these are a few inconspicuous Restionaceae hardly contributing to the cover. At Hestersdam this community is more complex and contains, among others, the rhizomatous Elegia vaginulata.

10. BERZELIA-OSMITOPSIS SEEPAGE SCRUB ASSOCIATION

The plateau drops gradually into the broad stream-valleys in a series of terraces separated by abrupt shallow steps about 4-9 ft

(1.2-2.7 m) high. The seepage zones formed on these steps are permanently moist or wet. The soil beneath the footd-deep peaty litter is fine black silty sand. The vegetation is markedly different from that of Tussock Marsh. It is tall, shrubby and dense with no common Restionaceae.

In the south, Berzelia abrotanoides dominates the steps, sparsely mixed with a few Osmitopsis asteriscoides, a lean, erect Composite, both about 6 ft (1.8 m) high. The canopy is dense; only a few thin Cyperaceae e.g. Tetraria cf. cuspidata and Ficinia filiformis, occur in a feeble underlayer, and sparse rosettes of Drosera dot the ground. At plot 47 near Sirkelsvlei the upper layer, 7 ft (2.1 m) high, consists of a pure dense stand of Berzelia abrotanoides, the only other species on the 50 sq m plot being Cliffortia subsetacea, Leucadendron decorum (from the adjoining Plateau Fynbos), Danthonia cincta, Drosera curviscapa and Penaea mucronata, all occasional. Outside the plot, where the cover is more open, Chironia decumbens, Erica eburnea, Restio ambiguus, Tetraria flexuosa and Utricularia capensis occur, again sparingly.

Northward the upper layer of the seepage steps is richer, containing besides the above, Berzelia lanuginosa, Mimetes hirta, Psoralea aphylla and sometimes Psoralea pinnata. One step near plot 29 has a complex and very dense vegetation comprising, in addition, banks of pure Watsonia tabularis, Pteridium aquilinum and large cushion-like tufts of Restio compressus.

At plot 29 there is an open scrub of Psoralea pinnata to 8 ft (2.4 m) high, with a dense 12-in (30-cm) ground layer of grasses and Restionaceae in which Pentaschistis curvifolia and Staberoha distachya are common, the former locally dominant (Plate 24). This distinctive savannah-like community, only a few acres in extent, has not been seen elsewhere on the Reserve. Its relationship is uncertain. It occurs on almost level ground just below the complex seepage step mentioned above, which apparently feeds it with a permanent supply of slowly percolating soil moisture.

A seepage zone within the Pseudo-Savannah of the steep north-east slope below The Camp contains the very local endemic *Leucadendron macowanii*, emergent to 10 ft (3 m), plus *Tetraria punctoria* in the 6-ft (1.8-m) canopy layer and in the subordinate layer *Carpacoce spermacocea* (4 ft : 1.2 m), a soft-leaved sprawling herb smelling strongly of hydrogen sulphide when crushed. The last two species, like members of the surrounding Pseudo-Savannah, are more characteristic of the northern Cape Peninsula and inland mountain seepages.

On stream banks, *Berzelia abrotanoides* is usually common, *Psoralea pinnata* is occasional, and *Indigofera filifolia* is locally dominant in the northern areas.

Along the margins of marshy vleis, e.g. Skilpadvlei in the south and Groot Rondevlei in the north (Plate 23), is a richer flora with more complex structure. Besides the Tussock Marsh Restionaceae there are 6-ft (1.8-m) tufts of *Chondropetalum tectorum*, the two straggly *Berzelia* species (*B. abrotanoides* and *B. lanuginosa*), *Myrica quercifolia* and *Cliffortia ferruginea* (sprawling undershrubs), and *Danthonia cincta*, a tufted grass 3 ft (90 cm) or more in height.

SCRUB FOREST FORMATION

11. SIDEROXYLON SCRUB ASSOCIATION

In sheltered slacks of the littoral dunes the woody element invades and gradually ousts the Littoral Dune Mixed Fynbos, forming a dense scrub 6 - 8 ft (1.8 - 2.4 m) tall. Typically found are *Colpoon compressum*, *Euclea racemosa*, *Maytenus lucidus*, *Olea africana*, *Pterocelastrus tricuspidatus*, and *Rhus glauca*; *Linociera foveolata* occurs sparsely in the best-developed scrub. Openings are filled with 3-ft (90-cm) shrubs of *Chrysanthemoides monilifera*, *Helichrysum* maritimum, Metalasia muricata, while Carpobrotus acinaciformis, Cineraria geifolia, Ficinia ramosissima, Pentaschistis curvifolia form an open ground layer. Climbers are Antizoma capensis, Asparagus aethiopicus, Cynanchum africanum, Dolichos gibbosus, Galium tomentosum, Kedrostis nana and Solanum sp. A good litter is formed patchily from leaf-fall of Euclea racemosa and this breaks down into a rich, well-developed mull humus 2-3 in (5-8 cm) deep (Plate 25).

At a later stage in the succession Sideroxylon inerme appears in the mixed scrub and with prolonged protection this small tree with its broad glossy leathery leaves and dark trunk becomes dominant, forming the dense "Melkhout" thickets still found at Buffel's Bay, Bordjiesrif, Platboom and Bloubergstrand. Here Sideroxylon inerme occurs as almost pure stands 10-15 ft (3-4.5 m) in height with Cussonia thyrsiflora, a thickly woody scrambler, as its chief associate besides the climbers already listed. When directly exposed to the south-easter these thickets scarcely attain a height of 8 ft (2.4 m) and are wind-moulded into a humped, impenetrable scrub (Plate 26). Parts of the scrub have abrupt margins indicating their retreat from a former larger area, probably as a result of fire. Along sections of the False Bay coast especially at Bordjiesrif a very dense sward of Stenotaphrum secundatum abuts the scrub and retards its extension by inhibiting regeneration (Plate 7).

12. MAUROCENIA-LINOOIERA TALL SCRUB ASSOCIATION

With protection from fire, the Coleonema Fynbos of the rocky littoral develops into a low, dense, woody, mixed scrub, scarcely 5 ft (1.5 m) tall and quite impenetrable. The following species are conspicuous: Cassine maritima, Euclea racemosa, Maytenus lucidus, Pelargonium gibbosum, Pterocelastrus tricuspidatus, Rhus mucronata, Rhus lucida and Tarchonanthus camphoratus. At a later stage Olea exasperata, Cassine barbara and Cussonia thyrsiflora appear. Sideroxylon inerme is also sometimes found, though it does not become dominant.

With longer protection Euclea racemosa and Tarchonanthus camphoratus grow to over 15 ft (4.5 m) in height. Their spreading crowns and slender stems produce sheltered conditions, and their decaying leaves form well-rotted humus that creates a seedbed in which the two climax species, Maurocenia frangularia and Linociera foveolata, can germinate.

The highest development of scrub on the Reserve, indicated by the presence of these two species, occurs on the steep, bouldery, southerly slopes above Gifkommetjie where an encircling arc of sandstone cliffs has afforded protection from fire possibly for centuries (Plate 27). Other examples of well-developed scrub occur on the Atlantic coast among large boulders on the slopes above Bloubergstrand, and on the south-western slopes of the rocky escarpment from Brightwater to Hestersdam. On the False Bay coast there is a small patch of scrub forest at the foot of the steep northerly slopes of The Chair, half a mile south of Smitswinkel Bay; and a modified stunted scrub occurs on the south-easterly precipices in the vicinity of Batsata Cove.

The following account of the climax is based on observations made at Gifkommetjie, supplemented by data gathered at The Chair. Tarchonanthus camphoratus, a grey-leaved, many-stemmed spreading tree to 15 ft (4.5 m) high, is common, often dominant, frequently occurring in small pure stands. Maurocenia frangularia, a heavy-stemmed tree 15 ft (4.5 m) high, with spreading crown of broad, dark green, glossy, leathery leaves, is fairly common, co-dominant, almost confined to the climax. Linociera foveolata, a small erect tree, is only found in the climax community. Woody associates are Cassine barbara, Colpon compressum, Cussonia thyrsiflora, Euclea racemosa, Olea capensis, O. exasperata, Phylica buxifolia, Pterocelastrus tricuspidatus, Rhus glauca, Rhus lucida, R. mucronata, *R. tomentosa*, *Sideroxylon inerme*. Occasionally *Maytenus heterophylla* (= *Gymnosporia buxifolia*) is found on the east coast.

The shrub layer contains *Myrsine africana* where the canopy is open, e.g. along the margins. Shrubs commonly found in openings within the forest, such as *Pelargonium gibbosum*, *Polygala myrtifolia* and *Salvia aurea*, testify to the coastal affinities of this woody community. The herb layer is only developed in the rare places where there is an open glade under the trees. Here a dense cover of soft annual herbs (including *Australina lanceolata*) and grasses, only a few inches high, develops on the richly humified soil, interspersed with scattered herbacious perennials and semi-scandent shrubs such as *Knowltonia*, *Sutera*, *Solanum* and *Tetragonia*. Among the climbers, *Asparagus aethiopicus* is common, *Cynanchum obtusifolium* and *Kedrostis nana* are less so. *Astephanus neglectus*, *Cynanchum africanum*, *Dolichos gibbosus* (sprawling over crowns of trees in disturbed forest) and *Fagelia bituminosa* are more common in the early stages of the scrub.

Special scrub communities are dominated by a single species:
(a) *Tarchonanthus camphoratus* forms pure stands in warm sheltered places near the False Bay coast, for example at Platbank, where it grows to a height of 12 ft (3.6 m).
(b) *Philippia chamissonis*, a rounded bush about 8 ft (2.4 m) high with dense crown reaching to the ground, occurs in stands of two or three acres (about one hectare) near Pegram's Point and Matroosdam. Usually the bushes are spaced 6-12 ft (1.8-3.6 m) apart and form pure stands but sometimes, where long protected from fire, moribund *Philippia* has thinned to 15 or 20 ft (4.5-6 m), the spaces between being filled with woody shrubs typical of scrub, and undershrubs of Coast Fynbos. From this it appears that the *Philippia* community may be transitional to Tall Scrub. Nevertheless, the presence of a typical stand of *Philippia* at an altitude of 700 ft (213 m) on the Red Hill plateau, 3 miles (4.8 km) from the sea and surrounded by short mountain fynbos, is evidence that it is not always associated with the coast vegetation.

CHAPTER 5

QUANTITATIVE ANALYSIS

5.1 Ordination or classification?

Classification, in the words of Greig-Smith (1964, p.158), "involves arranging stands into classes the members of each of which have in common a number of characteristics setting them apart from the members of other classes." In ordination, on the other hand, "an attempt is made to place each stand in relation to one or more axes in such a way that a statement of its position relative to the axes conveys the maximum information about its composition." Both are "structuring" techniques (Lambert and Dale, 1964), aimed at seeking a simpler structure than that of the original raw data, the first by erection of classes, the second by construction of axes. Classification is best used for vegetation which exhibits considerable discontinuity in composition between concrete units in the field, ordination is more appropriate to continuous systems. The vegetation of the Cape of Good Hope Nature Reserve is continuous if Williams' definition of continuity given by Lambert and Dale (1964, p.73) is accepted. There is, however, no reason in principle why continuous systems should not be classified or "discontinuous" (i.e. markedly heterogeneous) systems ordinated; it depends on which technique is most useful for the purpose in hand, irrespective of any theoretical concept of the "real" nature of vegetation. In either case, as many constructs - classes or axes - are needed to accomodate the data completely as there are non-identical sites. Since the primary aim of both techniques is to summarise by reducing a complex situation to a simpler one, the number of classes or axes must be arbitrarily limited by the user in either case.

The techniques of classification may result in an over-emphasis of discontinuities (Greig-Smith,1964;p.161)and in the erection of artificial units, but at the extensive level these drawbacks assume less importance provided their existence is borne in mind. An ordination, like a classification, may be arbitrarily divided up into mappable units but, as with classification, this introduces a degree of subjectivity. Ordination will expose, without over-emphasizing, discontinuities in composition that are present in the data, provided it takes cognizance of the greater part of the available information. For extensive work ordination is unsuitable because it requires the collection of more detailed field data, and computation is correspondingly cumbersome.

The need in the present case is to establish vegetation units which can be mapped on an extensive scale. For this, classification seems to be the more useful approach. For later detailed work, ordination might well prove appropriate.

5.2 Methods of vegetation analysis

The association-analysis of the Cape of Good Hope Nature Reserve was aimed at the broad classification and mapping of the vegetation. As pointed out in the Introduction, the need was to test a statistically based method which could permit a comparison of the vegetation of different areas or which could be repeated on the same area to establish vegetational changes. As it was hoped to adapt the method used in this pilot survey to very much larger areas, quick and simple field techniques were essential.

Whittaker (1962) has reviewed the various schools of thought which have developed on vegetation analysis. Classifications based on statistical methods have, until recently, been unsuccessful. Blackman (1935) and Ashby (1935; 1936) pointed out the shortcomings of attempts made by Du Rietz and others to use the quantitative methods available at that time. During the last ten years, however, the development of electronic computers has enabled the use of complicated analyses which would otherwise have been impracticable owing to the very extensive computations involved. Statistical techniques have also been improved to provide practical methods which can be comparatively easily interpreted.

Association-analysis (Williams and Lambert, 1959; 1960) appears to be one such technique. The field work entailed may hardly be greater than that needed for a survey by "classical" methods or by Poore's (1962) "method of successive approximation", and the improvement in computer design enables the rapid processing of data which it would be well-nigh impossible to analyse by other means. In fact, Lambert and Dale (1964) are of the opinion that statistical analyses of vegetation on a regional scale may soon be possible.

Association-analysis measures the degree of association between species, "association" being used here strictly in its statistical sense. The use of interspecific associations for classifying vegetation was pioneered by Goodall (1953) who examined presence-or-absence data from random quadrats. Williams and Lambert showed that a method more efficient than Goodall's could be devised. Their raw data consists of the presence-or-absence of individual species in a number of equal-sized quadrats spaced systematically on a grid covering the whole area. The species represented are correlated in all possible pairs, and the set of sample plots is hierarchically divided into groups on the basis of those species which, at each successive subdivision, have the highest degree of association with all other species. This procedure they designate "normal" association-analysis. In normal analysis the quadrats can be regarded as being defined by a small number of underlying properties or "factors". The species, responding to these factors in varying degrees, are used as "tests" to identify the position of major discontinuities between groups of quadrats (Williams and Lambert, 1961).

Their method differs from Goodall's in three main respects: (1) They use negative as well as positive associations on the grounds that this greatly strengthens the analysis. Quadrat size then assumes great importance since negative correlations between species may occur by virtue of the fact that no two individuals can occupy the same site at any one time. (2) Instead of using the most frequent species as a basis for subdividing a potentially homogeneous group, they use the species with the largest χ^2, where I is the parameter chosen as a measure of association. Since there will be a number of alternative subdivisions which will subdivide the population so that all associations will disappear, Williams and Lambert introduce the concept of <u>efficient</u> subdivision, i.e. subdivision on that species which produces the smallest total number of significant associations in the two sub-classes. Goodall's division on the most abundant of those species showing significant positive association will not necessarily do so. Williams and Lambert selected the uncorrected index $\sqrt{\frac{\chi^2}{N}}$ (the correlation coefficient for presence-or-absence) as being the least likely parameter to generate "ambiguities". (3) They abandon the "pooling" of quadrats which do not form homogeneous groups, on the grounds that pooling involves discarding potentially valuable information; instead they retain all divisions once made and thus construct a hierarchical classification of quadrats into final groups, by reference to the species present.

Because the relative importance of different hierarchical subdivisions of the same order may vary, some measure of the heterogeneity of any class under examination is needed. Williams and Lambert chose the highest individual χ^2 (with Yates' correction) in a class as the most suitable. This, when shown in the diagram representing the course of subdivision, provides a ready indication of the fall in relative heterogeneity produced at different stages. The same measure is used as a criterion for terminating subdivision, which continues until no individual χ^2 exceeds 3.84 (corresponding to P=0.05). The relevant class is then designated a "final group". With Yates' correction, a class must exceed seven quadrats before this value can be attained, so any class containing less than eight quadrats is automatically declared a final group.

Normal analysis, whereby quadrats are grouped by the species they contain, may be followed by "inverse analysis" (Williams and Lambert, 1961) in which species are grouped according to the quadrats in which they occur; the two may be combined in a "nodal analysis" (Lambert and Williams, 1962) where each node is defined by a parameter for site and a parameter for species-group. This double classification is suitable for mapping, and the mapped species/site information gives an objective picture of habitat variation. Because time and suitable modifications to computer programmes were lacking, the present study was confined to normal analysis; the subsequent stages will not be discussed further.

Association analysis has now been programmed for electronic computation. In tests of their method on small areas, Williams and Lambert found that the mapped groups not only showed close correspondence with habitat factors but also exposed differences, previously overlooked, which were capable of ecological interpretation.

The success of association-analysis in reflecting natural vegetation units is limited, however, by the adequacy of the sampling technique. This is fixed, arbitrarily or almost so, at the beginning of each investigation, and is kept uniform throughout. It has been implied above that the use of small sampling units may introduce strong negative associations. A single quadrat size will seldom be equally suitable for any two communities because of differences in life-form and in the pattern exhibited by individual species. The uniform quadrat size chosen for an investigation could be too small for efficient sampling in part of the area, and the results may be differentially inaccurate. A similar danger lies in the number and spacing of sampling units. Williams and Lambert's tests have all been done on small areas with a relatively poor flora. In these cases, the number of samples greatly exceeded the number of species encountered. Despite Lambert and Dale's (1964) insistence that the method is suitable for primary survey, it is clear that in large areas of floristically rich and varied vegetation, the number of species will be much increased, while the number of samples may, for the sake of economy, have to be drastically reduced. At best the hierarchical representation of relationships is artificial and the delimitation of groups more clear-cut than in fact they really are. This will be enhanced if the size of sampling units is small and their number, relative to the number of species, is reduced.

A further objection to the method arises from the exclusive use of presence-or-absence data. This over-simplification of abundance may result in misclassifications from factors other than chance, as is shown later in this chapter. The important difference between stands lies in the finer degree of abundance of different species which is not recorded in association-analysis.

These drawbacks, considered in the light of the results of the present study, are discussed in more detail in section 5.5. The decision to use normal analysis despite the disadvantages of the method, was based on the ease of data-gathering, the availability of a computer programme, the objectivity of the results and the fact that it gives a clear-cut classification which can be mapped.

Association-analysis has been used to classify vegetation in South Africa, both on extensive and intensive scales, in five surveys completed recently (Van der Walt, 1962; Grunow, 1965; Roberts, 1966a; Downing, 1966; Miller, 1966). In all these surveys, which were done in the grassveld and bushveld vegetation of the summer-rain area, number of plots exceeded number of species. The present survey is the first of its kind in the fynbos of the winter-rain area of the South-Western Cape. Fynbos comprises an extremely rich flora occurring in rugged terrain with many intergrading habitats. It was felt that these conditions differed sufficiently from the others where association-analysis has already been applied, to justify testing the method for its applicability to fynbos.

5.3 Methods in the present study

5.3.1 The sampling unit

If results are to be comparable, sample plot size and shape should be consistent. Efficient plot size depends upon vegetation pattern. It also differs with the object of the investigation. In the present case the object is to delineate primary vegetation types, not the minor variations. Therefore a larger plot, which should obscure the minor variations, may be used.

Data needed for estimating the most efficient plot size were obtained by conducting a pilot enumeration. Twenty plots, each 10 x 10 metres, were located at random intersections of the grid-lines on the 1:18,000 map of the Cape Peninsula. Each plot was subdivided into ten sub-plots of 2 x 5 metres. Separate species lists were made for each sub-plot. "Species", in this account, means permanently recognizable species as explained in section 5.3.2. A Master List, showing presence of the 384 species in all sub-plots, was compiled, and the "accumulative number of species" occurring in each successive sub-plot, was calculated. Regression equations for plot sizes of 20, 50 and 100 square metres were derived and, by extrapolation, the number of species which one could expect to record in 350 plots of these sizes, was calculated. About 350 plots occur in fynbos vegetation in the Cape Peninsula, at the espacement of the grid-line intersections (1000 yd:914 m).

The results showed that, using plots of 100 square metres, 734 species could be expected. If the plot size were reduced to 50 square metres one could expect to record 624 species, while if the plot size were further reduced to 20 square metres the expected number of species drops to 469. Thus, a 50% reduction in plot size will result in only a 15% expected reduction in species present. This will not mean that the survey can be completed in half the time, however, since location and laying out of plots, and the recording of observational data, would take equally long in both cases.

Therefore with further reduction in plot size the time saved becomes less and less. The use of a 20 square metre plot, for example, would effect very little further saving in time while the expected number of species would be reduced by 36%. This would amount to an inefficient use of time.

To check these calculations, the mean number of additional species actually found in sub-plots 1, 2, 3 ... 10, was determined. The results agreed closely with the expected figures calculated theoretically.

Both for botanical survey (Brown, 1954; Cain and Castro, 1959) and for intensive ecological investigations (Greig-Smith, 1964; Kershaw, 1964) the rectangular plot holds advantages over the square. Rectangular plots are likely to cover greater variation in pattern (Greig-Smith) and to include a greater number of species (Brown) than square plots. The increased danger of edge effects is not of overriding importance where plots are large, as in the present case. The circular plot is simple to use in low vegetation and is the most efficient in reducing edge effects but is not favoured for the present study where the large radius makes for inaccuracy in delimitation especially as the height of the vegetation will at times make the describing of an unbroken arc difficult.

Consequently it was decided to use a rectangular plot of 5 x 10 metres to give an efficient size of 50 square metres.

The sample plots were placed systematically at intersections of the grid-lines on the 1:18,000 topographical map. One plot, marked X on Map 1, in the middle of an extensive thicket of <u>Acacia cyclops</u>, was discarded. Three specially chosen summit samples - on Judas Peak, Paulsberg and Vasco da Gama Peak - were added, giving 100 plots for the Reserve. Von Broembsen (pers.comm.) thought that about 60 to 100 samples would be sufficient to delineate the main vegetation types in an extensive survey. More intensive sampling might lead to over-classification, the lower-order groups becoming progressively more difficult to interpret ecologically.

The plots were located in the field by pacing distances from fixed points, scaled on the 1:18,000 map. These locations were checked with compass bearings and, on steep slopes, with altimeter readings. Using this method in a trial run, two independent observers fixed a point within 30 yd (27 m) of one another after pacing 1,100 yd (1006 m) on a fixed bearing. The resulting map error is negligible on this scale. Each plot was placed midway between the positions obtained in this way.

The following procedure for laying out plots was adopted. The point reached on locating the plot was taken as the south-west corner; the plot was laid out with the long sides facing north-south. The north-west and south-west corners were demarcated by stout wooden stakes protruding 3 or 4 ft (about 1 m) above ground. The stakes were left in position so that the plot could be re-visited. After about three years most of them were still standing. For listing, the plot boundary was demarcated by stout twine. Separate lengths of twine divided the plot into ten equal sub-plots to aid searching for rare and inconspicuous plants. Estimates of percentage crown-cover, stoniness etc. were made separately for each sub-plot, then added to give the total figure.

5.3.2 The data

Species lists were compiled for each sample plot. In a flora containing many annuals and geophytes, like the Cape flora, the visible components of the vegetation are bound to differ with the seasons. Total species lists compiled at different seasons will thus reflect different assemblages of plants on the same site. This difficulty was recognized by Adamson (1931) who confined his listing to summer or winter months when least annuals and geophytes are in flower. It was impossible to follow the same procedure in this survey which had to be carried out whenever opportunity offered during the year. If total species were recorded, annuals and geophytes appearing temporarily at different seasons would obscure true differences between species lists. Moreover, if it is to have practical value, a survey should reveal communities which can be recognized with equal facility at any time of year. The species lists for the computer analysis thus included only those species with permanently recognizable aerial parts. Nevertheless, plants appearing seasonally were noted separately for descriptive porposes.

Plants were identified down to the species wherever possible but where species could not be distinguished in the field they had to be combined. In the case of certain minor genera of the Ericaceae (detailed in App. IV and henceforth collectively referred to as "minor Ericaceae") this was felt to be justified since the amalgated species seem to grow in comparable habitats. Many of the Mesembryanthemae had perforce to be combined because their taxonomy has been inadequately worked out. Alien species, the subject of a separate study, were excluded from the survey.

All species in sub-plot 1 were listed first, the additional species encountered in each sub-plot being kept separate. Lists are thus available for plot sizes ranging from 5 to 50 square metres, so that a comparison of data from different plot sizes may later be made.

An assessment of abundance using Acocks' (1953) set of twenty abundance symbols, was made for each species on each plot. This information, while not needed for the association-analysis, was a valuable aid in describing the vegetation. It may be needed later if the data are used to compare association-analysis with agglomerative methods for which a finer measure of abundance is required.

After completing a species list for each plot, a supplementary list was made of additional species, characteristic of the local vegetation but occurring only outside the plot. These surround lists were extended until all conspicuous species belonging to the sampled community were noted, an area of approximately one-quarter to one acre (up to about half a hectare), depending on the pattern of the vegetation. The aim was to facilitate the subsequent placing of plots in the most appropriate vegetation unit. Surround lists have been proved their worth in this regard (see Chapter 6) and have also provided information on the varying pattern shown by different communities and species.

Post-burn period, based as far as possible on the branching of Proteaceous shrubs described by Hall (1959), was recorded so as to correlate the communities with the fire factor. Short descriptive notes, including dominance (if any), prevalent life-form, average height and crown cover, and obvious successional trends, were made on each plot to help to identify the groups revealed by association-analysis.

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

(1) Altitude, aspect and slope from map, compass and clinometer

(2) Possible influence of south-east cloud on the vegetation

(3) Stoniness, estimated according to the following size classes:

0 = no stones

1 = pebbles about 1 in (2.5 cm) in diameter (smaller pebbles were designated as "fragments")

2 = small stones, first size

3 = large rocks, roughly 1-3 ft (30-90 cm) in diameter

4 = boulders roughly 6-8 ft (1.8-2.4 m) in diameter

5 = bedrock near surface, partly protruding

For each plot an estimate was made of the percentage of ground covered by stones of the classes mentioned.

(4) Soil moisture, estimated as follows:

1 = dry (deep sand or steep north- or west-facing slopes)

2 = temporarily somewhat moist (steep south- or east-facing slopes)

3 = seasonally moist (depressions, plateau flats)

4 = seasonally wet (vleis)

5 = permanently wet (stream verges, bogs, seepages)

(5) The following descriptive notes were made on soil texture and geology: texture (fine or coarse); colour; humus; geological formation.

(6) A black-and-white photograph was taken of the vegetation of each plot, topographic features to indicate the habitat being included wherever possible.

Appendix V is a replica of the form devised to record these data. The field enumeration of the 100 samples was done in 45 days during the period January to November, 1966. I was accompanied in the field by one student assistant who laid out the plots and helped with the collection of environmental data.

5.3.3 The analysis

From the field data, an alphabetical list of the 452 species found on the plots was drawn up. The highest number of species per plot was 83, the lowest 5, and the average 38.26. All the species encountered in the survey are listed in Appendix IV.

After numbering the species, coded presence-or-absence data were prepared on a standardized form. Computation was done in 1968 on an ICT 1900 computer using the Fortran programme for association-analysis (AANAL) which is available at the Botanical Research Institute in Pretoria.

5.4 Results

Normal analysis resulted in a classification containing 23 final groups of sample plots (see App. VI). Because there were only 100 samples, all final groups contained seven or less plots; subdivision was thus automatically terminated before a common level of heterogeneity was reached. The mapped final groups (Map 2) did not yield entities which fitted the pattern of environmental variation satisfactorily. The final groups were therefore recombined and mapped at successively higher levels of association as follows:

At χ^2 of 7.5 : 15 groups (Map 3)
At χ^2 of 15.0 : 7 groups (Map 4)
At χ^2 of 30.0 : 3 groups (not reproduced)
At χ^2 of 60.0 : 2 groups (Map 5)

Even at the highest levels, where only the first subdivision (on presence or absence of Struthiola ciliata) was mapped, no close correlation with the environment was revealed. In other association-analysis studies in South African vegetation (e.g. Grunow, 1965; Downing, 1966) mapping of the first division made an ecologically interpretable pattern by separating the wetter from the drier sites. In the present study this was not the case. The first ten groups characterized by presence of Struthiola ciliata, for instance, contain not only the Inland Fynbos of dry rocky hills and mountains (shortly called "hillveld") but also the communities of the moist flats of the central plateau (group 5) and communities transitional to Coast Fynbos found on windblown sand (group 4). In the same way the major right-hand leg of the hierarchy shown in App. VI characterized by absence of Struthiola ciliata, contains the residue of hillveld and the major portion of the moist flats and coastal communities. It was thus apparent that no fusion of groups based solely on level of association would give a satisfactory interpretation of the hierarchy.

A closer examination of the species lists and field notes revealed that some final groups were decidedly less homogeneous, both ecologically and floristically, than others. Indeed, some groups (and not only the negatively defined ones) appeared to contain plots representing two or even three distinct communities.

To portray the composition of each group, a Summary of Plot Characteristics (App. VII) was compiled from data collected during the field survey. Appendix VIII (Summary of Group Characteristics) summarizes the variation in ecological and floristic content within each group, and gives an assessment of its homogeneity.

5.4.1 Homogeneity

According to Becking (1957) the homogeneity of a plant community can be judged by the constancy of certain species. Constancy of a species is its percentage occurrence in a group of sample plots of equal size taken in various phytocenoses (= stands). Degree of constancy is usually expressed in six classes as follows:

Class 0	: absent
Class I	: present in less than 20% of the plots compared
Class II	: present in 20 to 40% of the plots compared
Class III	: present in 40 to 60% of the plots compared
Class IV	: present in 60 to 80% of the plots compared
Class V	: present in 80 to 100% of the plots compared

In App. IX all species with a constancy of at least 80% in one or more groups have been listed and their constancy in all groups recorded. The constancy concept of the Zürich-Montpellier school, as expressed above, can be used to assess homogeneity of the groups revealed by association-analysis, by means of a Homogeneity Index (Appendix VIII). The reasoning employed is similar to that used by Curtis (1959) in developing Czekanowski's Similarity Index, where only two samples are compared. Where more than two samples are compared, as in most of the association-analysis groups, one would expect that a group containing many constant species (a group, that is, having many species common to all or nearly all the sample plots within it) would be floristically more homogeneous than a group containing few constants. The relative number of constant species per group will thus give a standard for comparing the homogeneity of groups. However, the Homogeneity Index does not always give expected results. In small groups, such as group 17 which contains only two plots, there are fewer degrees of freedom than large groups and the index gives distorted values. Factors such as species pattern must also influence constancy in samples of limited size. The Homogeneity Index is therefore only a rough guide to floristic homogeneity.

Nevertheless, in most cases this Index compares favourably with my prior subjective assessment in which both ecological and floristic homogeneity are judged, each according to a three-range scale (high, medium and low), giving a total of nine different combinations. Thus, high Homogeneity Indices are allotted to groups 1, 7 and 9 which have the highest subjective assessment, while the lowest Homogeneity Indices are to be found in the negatively-defined groups 13 and 23 containing the residue of unconformable plots.

5.4.2 Description of the final groups

The groups are defined by presence (denoted by "+") and absence (denoted by "-") of the dividing species which divide the set of samples dichotomously into a hierarchy; all the dividing species which together define a group are termed the defining species for that group. For more detailed information on plot characteristics, App. VII should be consulted.

Groups 1 - 10 are characterized by presence of *Struthiola ciliata*
Groups 1 - 3 " " " " " *Roella ciliata*
Groups 4 - 10 " " " absence " *Roella ciliata*

Group 1 (6 plots) is defined by:

- \+ *Struthiola ciliata*
- \+ *Erica imbricata*
- \+ *Salaxis flexuosa*
- \+ *Roella ciliata*
- \+ *Amphithalea ericaefolia*

Plots in this group are situated on rocky slopes of the western escarpment bounding the central plateau, and on the higher hills to the north-west. They consist of fairly recent post-burn regrowth of the hillveld. The vegetation of such habitats, especially in its early stages after burning, is characteristically rich in species: plot 8 with 83 species is the richest in the whole survey (Plate 11), and the mean number of species per plot (69) is the highest recorded in App. VIII. Except for the anomalous group 17 already discussed, group 1 has the highest Homogeneity Index recorded.

Group 2 (4 plots) is defined by:

+ Struthiola ciliata
+ Roella ciliata
+ Erica imbricata
- Amphithalea ericaefolia
- Salaxis flexuosa

This group comprises four plots also situated near the western escarpment, but unlike group 1 they occur on level, non-rocky, sandy flats (Plate 14). The vegetation on the whole is rich mixed fynbos in the early stages of regrowth, similar to group 1, but because the soil moisture is retained for longer periods, at least two of the plots (13 and 82) contain some species characteristic of moist flats as well as those of dry hills, resulting in decreased floristic homogeneity.

Group 3 (6 plots) is defined by:

+ Struthiola ciliata
+ Roella ciliata
- Erica imbricata

This group, partially negatively defined, lacks the homogeneity of the first two. All the plots occur on dry rocky sites, five in the north, one in the south. In plots 10 and 42 the Table Mountain Sandstone is reddened by infiltrations of iron oxide and the finer soil is light beige-brown in consequence; their flora contains elements found only in such localities. Plot 88 occurs on bedrock and the vegetation is dominated locally by minor Ericaceae; other representatives of the same community are placed in other groups, e.g. plot 71 in group 9. The three remaining plots occur on sites similar to group 1 but the vegetation is less rich in species and more variable in structure, with a tendency to dominance by species characteristic of disturbed sites (Plate 15).

Group 4 (4 plots) is defined by:

+ Struthiola ciliata
- Roella ciliata
+ Ficinia secunda
+ Ifloga seriphioides
+ Phylica stipularis

Whereas the first three groups comprised variations of the mixed fynbos of rocky hills, group 4 is distinct both ecologically and floristically. That it is floristically distinct is borne out by its separation from groups 5-10 at a high value of the subdivision parameter ($\chi^2 = 22.7$, the highest value for separation of a single group in this hierarchy). Its plots all occur on deep Table Mountain Sandstone sand which appears to have been windblown and re-deposited, probably during a dry climatic cycle. The vegetation remains basically Inland Fynbos but some Coast Fynbos elements (such as the three positive dividing species for the group) recur in all these inland sandy patches, so that they can always be readily recognized though many are small in area (Plate 4).

Group 5 (6 plots) is defined by:

+ *Struthiola ciliata*
- *Ficinia secunda*
- *Phylica stipularis*
- *Roella ciliata*
- *Ifloga seriphioides*
+ *Restio quinquefarius*

The dividing species *Restio quinquefarius*, being characteristic of moist flats, indicates that this group is also quite unlike the first three. The fact that group 5 has been split off at a high vlaue of the subdivision parameter ($\chi^2 = 16.3$) suggests that it is also floristically dissimilar from groups 6-10. Two members occur on higher river terraces in the north and three on the flats of the central plateau. All these show floristic features transitional between hillveld and the Restionaceous vegetation of moist flats. The sixth member of the group (plot 79, Plate 16) occupies a cool south-facing hill-slope exposed to the moisture-laden south-east winds and carries a Restionaceous vegetation rather unlike that of the moist flats of the plateau. The group as a whole embodies the Plateau Fynbos concept which was mentioned in Chapter 4 as being a mosaic of moist and dry sites and the transitions between them. This is the only group in the first ten (defined by presence of *Struthiola ciliata*) which contains plots on moist flats.

Group 6 (3 plots) is defined by:

- \+ *Struthiola ciliata*
- \- *Ficinia secunda*
- \- *Phylica stipularis*
- \+ *Leucadendron salignum*
- \- *Roella ciliata*
- \- *Ifloga seriphioides*
- \- *Restio quinquefarius*

Leucadendron salignum, the dividing species, is usually associated with other large Proteaceous shrubs on the high, cool, eastern mountain slopes overlooking False Bay. All plots of group 6 are found in such localities at altitudes between 500 and about 1,000 ft (152-305 m). The vegetation consists of Restionaceous species characteristic of the higher slopes (e.g. *Elegia juncea*) together with some Cyperaceae, ericöid shrubs and the larger Proteaceae (*Protea lepidocarpodendron*). It contains many species of the hillveld with which it merges on the lower slopes. Plot 67 which contains both dividing species for group 7 and is very similar to dry hillveld in composition, is one example of such a transition; another is plot 98 (Plate 9). Mountain vegetation is also found in groups 12 and 13 but the present group is the only one where post-burn period of the vegetation is consistently over twenty years.

Group 7 (7 plots) is defined by:

- \+ *Struthiola ciliata*
- \- *Ficinia secunda*
- \- *Phylica stipularis*
- \- *Leucadendron salignum*
- \+ *Staberoha banksii*
- \- *Roella ciliata*
- \- *Ifloga seriphioides*
- \- *Restio quinquefarius*
- \+ *Saltera sarcocolla*

These seven plots form not only a homogeneous group but also a distinct community similar to the western hillveld (groups 1 - 3) but occupying warmer and drier sites in the hills north and east of the central plateau, which are less affected by the cool winds of the Atlantic Ocean (Plate 10). The two dividing species of the group, *Saltera sarcocolla* and *Staberoha banksii*, are character species for this "dry hillveld" community which is described in Chapter 6. An unusual feature is the separation of this group from groups 8 to 10 at a higher χ^2 level than the previous division. This high value (14.0) supports the contention that the dividing species are good character species for a clear-cut floristic unit.

Group 8 (2 plots) is defined by:

+ *Struthiola ciliata*
- *Ficinia secunda*
- *Phylica stipularis*
- *Leucadendron salignum*
- *Staberoha banksii*
+ *Tetraria fasciata*
- *Roella ciliata*
- *Ifloga seriphioides*
- *Restio quinquefarius*
- *Saltera sarcocolla*
- *Tetraria microstachys*

As there are only two plots in this group, the Homogeneity Index of 18 is unreliable. The two plots do not appear similar ecologically, floristically or even physiognomically. Plot 40 at Rooihoogte, a hill in the north-east, is on deep fine sand with a tinge of iron oxide, on the edge of the Tall Fynbos Association (Chapter 4). Plot 54 on the south-western edge of the central plateau, is a low fynbos, dominated by minor Ericaceae, often found along the margin of the dry hillveld of group 7. Both plots thus occur in dry-habitat ecotones within the Inland Fynbos Alliance, but otherwise appear to have nothing in common. The positive dividing species for the group, *Tetraria fasciata*, has no strong habitat preference but tends to occur more frequently on moist flats; it is of no help in characterizing the group.

Group 9 (4 plots) is defined by:

+ *Struthiola ciliata*
- *Ficinia secunda*
- *Phylica stipularis*
- *Leucadendron salignum*
- *Staberoha banksii*
+ *Tetraria microstachys*
+ *Thesium spicatum*
- *Roella ciliata*
- *Ifloga seriphioides*
- *Restio quinquefarius*
- *Saltera sarcocolla*
- *Tetraria fasciata*
+ *Erica corifolia*

The plots of group 9 all occur on dry rocky ridges or sheetrock. All are floristically impoverished, bearing most resemblance to the mixed fynbos either of the western hills (plot 26), the dry hills (plots 36, 84) or the boundary community of low Ericaceous shrubs (plot 71). The latter plot is more similar, at least in habitat and physiognomy, to plot 54 in group 8 and plot 88 in group 3, than it is to any of the plots within its own group. *Salaxis flexuosa*, which indicates biotic disturbance where it is locally abundant (as in plots 36 and 84) is constant in this group (Plate 20).

Group 10 (5 plots) is defined by:

+ *Struthiola ciliata*
- *Ficinia secunda*
- *Phylica stipularis*
- *Leucadendron salignum*
- *Staberoha banksii*
+ *Tetraria microstachys*
- *Thesium spicatum*
- *Roella ciliata*
- *Ifloga seriphioides*
- *Restio quinquefarius*
- *Saltera sarcocolla*
- *Tetraria fasciata*
- *Erica corifolia*

This is a group also occupying dry, rocky ridges with coarse, white, sandy soil supporting an impoverished version of the mixed fynbos communities. In addition, the vegetation is moribund by reason of its high post-burn period, many of the short-lived, seed-regenerating ericoid species having died out, so that only the bushy Proteaceae and the tufted Restionaceae remain. The habitat of plot 62, for example, suggests that this plot, if burnt, would regenerate to typical western hillveld of group 1.

Groups 11 - 23 are characterized by absence of *Struthiola ciliata*

Groups 11 - 13 " " " presence " *Clutia alaternoides*

Groups 14 - 23 " " " absence " *Clutia alaternoides*

Groups 14 - 18 " " " presence " *Restio cincinnatus*

Groups 19 - 23 are characterized by absence of Restio cincinnatus

Group 11 (4 plots) is defined by:

- Struthiola ciliata	+ Clutia alaternoides
+ Metalasia brevifolia	+ Minor Ericaceae
+ Restio cuspidatus	+ Roella ciliata

One might have expected this group with its high degree of positive definition, to have been highly homogeneous. This is far from the case. It is a curious mixture both ecologically and floristically. Plots 1 and 2, on rocky hills in the north-west, bear an impoverished "western hillveld". Plot 52, on sandy flats near the coast, is transitional between the Inland and Coast Alliances, while plot 70 on windblown marine sand forming an inland dune, bears the Thamnochortus erectus Dune Fynbos of the Coast Alliance - very unlike any of the hillveld communities. The fact that both substrata, Table Mountain Sandstone and marine sand, are found within this group, is proof of its heterogeneity.

Group 12 (3 plots) is defined by:

- Struthiola ciliata	+ Clutia alaternoides
- Metalasia brevifolia	- Minor Ericaceae
- Restio cuspidatus	- Roella ciliata
+ Chironia baccifera	

Although these plots range from an altitude of about 140 ft (42 m) near the coast, to a mountain summit of 860 ft (262 m), they all occur on cool slopes and the vegetation is fairly homogeneous. It is similar to the mountain variety of hillveld found in group 6, tending to Broad-leaved Scrub in old stands. Much of the woody element is common in coastal scrub, so that this group, like the previous one, forms a link between the Inland and Coast Alliances.

Group 13 (5 plots) is defined by:

- *Struthiola ciliata*
- *Metalasia brevifolia*
- *Restio cuspidatus*
- *Chironia baccifera*
+ *Clutia alaternoides*
- Minor Ericaceae
- *Roella ciliata*

All plots of this negatively-defined group are very dissimilar. The three occurring on inland hills and mountains (23, 41 and 99) represent three different hillveld variations. One (94) occurring on a calcrete dune is ecologically and floristically distinct from any other sample. The remaining plot (95) is another example of the transition between the Inland and Coast Alliances. All plots are poor in species, the richest being the young regrowth in plot 99.

Group 14 (4 plots) is defined by:

- *Struthiola ciliata*
+ *Restio cincinnatus*
- *Clutia alaternoides*
+ *Anthospermum ciliare*

Plots 53, 72 and 73 are in coarse white sand without rocks at the base of hills rising from the plateau; the vegetation is a fairly homogeneous dense Restionaceous fynbos transitional between hillveld and plateauveld, similar to plot 79 in group 5. Plot 51 occurs on a rocky rise and its vegetation, unlike the other three members of the group, is very similar to the dry hillveld of group 7; one of the character species of the latter (and a dividing species of group 7), *Staberoha banksii*, is present, but the other dividing species, *Saltera sarcocolla* and *Struthiola ciliata*, are absent. This is a good example of a plot wrongly placed because of the chance absence of dividing species. This plot greatly reduces the homogeneity of the group.

Group 15 (3 plots) is defined by:

- *Struthiola ciliata*
+ *Restio cincinnatus*
+ *Passerina vulgaris*
- *Clutia alaternoides*
- *Anthospermum ciliare*

This group, like the foregoing, contains one plot which is ecologically misplaced. Plots 4 and 19 are on dry coastplain sandflats (deep white sand without rocks) at the foot of the western escarpment (Plate 12). Their vegetation is an ericoid-leaved fynbos about 3 ft (1 m) tall, dominated by Metalasia muricata and Salaxis flexuosa with an undercover of low, specialized Restionaceae. It is a simple, homogeneous community. Plot 14 occurs about two miles (3.2 km) from the coast. It has a thin layer of coarse skeletal soil over Table Mountain Sandstone bedrock and is wet in winter. Its vegetation, though difficult to classify, is most like the moist flats community of the central plateau and is quite distinct from the other two plots in this group.

Group 16 (4 plots) is defined by:

- Struthiola ciliata
+ Restio cincinnatus
- Passerina vulgaris
- Clutia alaternoides
- Anthospermum ciliare
+ Euphorbia tuberosa

All plots represent the Tussock Marsh of peaty depressions on the plateaus, dominated by a few specialized tufted Restionaceae of which Elegia parviflora is the most widespread. Due to its greater post-burn period, plot 22 appears physiognomically different from the rest - Leucadendron decorum is dominant, the Restionaceous layer moribund - but its species composition is similar to the others.

Group 17 (2 plots) is defined by:

- Struthiola ciliata
+ Restio cincinnatus
- Passerina vulgaris
+ Restio cuspidatus
- Clutia alaternoides
- Anthospermum ciliare
- Euphorbia tuberosa

As already mentioned, the high Homogeneity Index for this small group of plots is misleading. Both plots represent degrees of transition between the hillveld and moist flats communities - which intergrade completely - but at different ends of the scale. Plot 37 is a slightly moist variety of Upland Mixed Fynbos in which a few Tussock Marsh species occur sparsely, while plot 46 is very close to true Tussock Marsh. On mere presence or absence of species the two plots might appear similar, but when relative abundance is taken into account they differ considerably.

Group 18 (7 plots) is defined by:

- Struthiola ciliata
+ Restio cincinnatus
- Passerina vulgaris
- Restio cuspidatus
- Clutia alaternoides
- Anthospermum ciliare
- Euphorbia tuberosa

This group contains members of the two distinct communities of the moist flats. Plots 49 and 50 represent the Seepage Scrub, dominated by tall Berzelia and Osmitopsis, in which most of the Restionaceae are absent or rare. The remaining five plots represent various degrees of true Tussock Marsh, from the simple community of Elegia parviflora to the even simpler variety of the wettest part where Elegia cuspidata dominates locally (Plate 21). Characteristically, all plots are poor in species, the mean number for the group being 21.

Group 19 (5 plots) is defined by:

- Struthiola ciliata
- Restio cincinnatus
- Clutia alaternoides
+ Phylica stipularis

The affinity with group 4 suggested by the constancy of Phylica stipularis is substantiated both ecologically and floristically. All plots of this fairly homogeneous group occur on deep, coarse white sand. Where windblown it forms old dunes inland (plots 69, 77) or terraces near the coast (plot 86). Two plots (89 and 93), dominated by Metalasia and Passerina, differ in physiognomy from the rest. These plots occur where the natural sand communities have been superseded by the Metalasia-Passerina community as a result of biotic disturbance; they have been correctly placed in this group.

Group 20 (5 plots) is defined by:

- \+ *Struthiola ciliata*
- \- *Restio cincinnatus*
- \+ *Euclea racemosa*
- \- *Clutia alaternoides*
- \- *Phylica stipularis*
- \+ *Ficinia ramosissima*

This very homogeneous group comprises all five samples of the Broad-leaved Scrub occurring on old dunes rich in humus near both the east and west coasts. The scrub varies in composition but is consistently poor in species (mean for the group, 24 per plot). One recently-burnt sample of scrub has been included in this group where all the other members have been protected from fire for over thirty years.

Group 21 (3 plots) is defined by::

- \- *Struthiola ciliata*
- \- *Restio cincinnatus*
- \- *Euclea racemosa*
- \+ *Drosanthemum candens*
- \+ Mesembryanthemae
- \- *Clutia alaternoides*
- \- *Phylica stipularis*
- \- *Ficinia ramosissima*
- \+ *Exomis microphylla*

Ecologically this small group is very homogeneous, comprising plots on the littoral rock ledges of the False Bay coast (Plate 6). The flora is fairly uniform, consisting of semi-succulent, often procumbent shrubs (for example the positive dividing species) and a few stunted woody shrubs; in plot 80 many creeping grasses also occur. This flora is very poor in species (mean of 16 per plot).

Group 22 (3 plots) is defined by:

- \- *Struthiola ciliata*
- \- *Restio cincinnatus*
- \- *Euclea racemosa*
- \- *Drosanthemum candens*
- \- Mesembryanthemae
- \+ *Tetraria cuspidata*
- \- *Clutia alaternoides*
- \- *Phylica stipularis*
- \- *Ficinia ramosissima*
- \- *Exomis microphylla*
- \+ *Elegia parviflora*

This group comprises the remaining plots of the moist flats complex. Floristically they are not very homogeneous. Plot 18 consists of simple Tussock Marsh dominated by *Elegia parviflora*, similar to plot 11 of group 18. Plot 83 (Plate 22) is more complex, containing besides the moisture-loving Restionaceae, many ericoid shrubs such as *Cliffortia subsetaceae*; it resembles plot 7 of group 16. Plot 58 is typical of the bushy seepage scrub found also on plot 50 of group 18. The group is again poor in species (mean of 19 per plot). No obvious habitat feature separates this group from the rest of the moist flats samples in groups 16 and 18.

Group 23 (5 plots) is defined by:

- *Struthiola ciliata*
- *Restio cincinnatus*
- *Euclea racemosa*
- *Drosanthemum candens*
- Mesembryanthemae
- *Tetraria cuspidata*
- *Clutia alaternoides*
- *Phylica stipularis*
- *Ficinia ramosissima*
- *Exomis microphylla*
- *Elegia parviflora*

This final, completely negatively-defined group is the repository for all plots which are so unique or impoverished that they cannot be classified elsewhere. As there are no constant species, the group is completely heterogeneous. All the plots are very poor in species-content. Plots 29, 32 and 47 represent three separate, specialized variations of the moist flats communities. Plot 29 (Plate 24), at the base of a complex seepage scrub, occurs in a community of grasses and Restionaceae throughout which bushes of *Psoralea pinnata* 4-8 ft (1-2 m) high are scattered, savannah-like. This stand, less than 10 acres (4 Ha) in extent, is the only example of its kind known to occur on the Reserve. Plot 32 is an exceptionally tall, dense streambank community, containing besides many of the seepage scrub species, the rare endemic *Leucadendron macowanii* and some moisture-loving species of *Erica*. Plot 47, in contrast, is the extreme simplification of the seepage scrub, consisting of an almost pure stand of Berzelia abrotanoides with only four associates sparsely present in the ground layer.

The remaining two plots both belong to the Coast Alliance. Plot 43 is a semi-pioneer littoral dune almost completely covered by Myrica cordifolia. Plot 91 (Plate 5) is the only example of a rare and highly specialized coastal marsh community characterized by Juncus kraussii, Scirpus nodosus and Helichrysum orbiculare, found in a few small depressions on the flats along the Atlantic coast.

5.4.3 Summary and evaluation of the final groups

The final groups obtained in the present study, unlike those in previous association-analyses of South African vegetation, do not combine into a classification which accords closely with the ecological patterns of the Reserve. Instead, the major ecological units, as reflected in the major plant associations described in Chapter 4, are fragmented and interspersed among the groups. This is shown in Appendix VII, where each plot is assigned to its approximately equivalent association as mapped. To summarize, the communities of the Coast Alliance are found in groups 4, 15 and 19 - 21. The Upland Mixed Fynbos of the rocky hills and mountains, including their transitions and impoverished forms, occurs in groups 1 - 3, 6 - 10, 12 and 14. The Tussock Marsh and Seepage Scrub and their transitions with Upland Mixed Fynbos, are found in groups 5, 16, 17, 18 and 22. Groups 11, 13 and 23 (the latter negatively defined) are very heterogeneous, containing aberrant members of the major vegetation units. Regrouping at higher levels of the subdivision parameter (χ^2 = 7.5, 15.0, 30.0 or even 60.0) does not eliminate this scattering of ecological units.

Some of the smaller communities described in Chapter 4, such as the Aspalathus-Phylica Scrub and the Pseudo-Savannah, have not been sampled at all by the association-analysis plots; others like the Coleonema Fynbos and the Protea lepidocarpodendron Tall Fynbos are represented only fragmentarily in "transitional" plots. Furthermore, plots which from their total species-content and physiognomy appear to belong to the same natural unit, sometimes occur in different final groups of the hierarchy. For example, the low Ericaceous variety of dry hillveld occurring on bedrock, is found in plot 88 (group 3), plot 54 (group 8) and plot 71 (group 9); the simple Tussock Marsh dominated by Elegia parviflora is represented by plot 11 (group 18) and plot 18 (group 22); the complex Tussock Marsh containing many ericoid shrubs is represented by plot 7 (group 16) and plot 83 (group 22); and the bushy Seepage Scrub is found in plot 50 (group 18) and plot 58 (group 22). A more ~~harmoniuous~~ harmonious combination of these plots is shown in the Synthesis Tables of the following chapter.

Some groups embrace a wide range of values of recorded ecological factors such as post-burn period, degree of stoniness, soil moisture index. Other groups are homogeneous in respect of some factors, e.g. recently burnt vegetation in group 2, non-rocky substratum in groups 2, 4 and others, dry soil in groups 1, 3 and others. Attempts to correlate the values of these factors with their occurrence in certain groups, by means of histograms and by analyses of variance, failed to indicate that the hierarchy can be satisfactorily interpreted in terms of these factors alone.

The fynbos of the South-Western Cape has long been considered a vegetation type having no discernible clear-cut communities. While it is true that some fynbos species do show great ecological tolerance, most species nevertheless have an optimum habitat in which they are more common than in others. If a fine measure of abundance had been used, a close correspondence with habitat might have been obtained. In association-analysis, however, the only record of abundance is the crude "present" or "absent" rating, resulting in great loss of information. When fairly large samples are used, as in the present study, a species is likely to be recorded as present irrespective of whether it is abundant or occasional, so the optimum habitat of tolerant species will not be revealed by this technique. Many of the dividing species responsible for forming the hierarchy in this study appear to be such tolerant or wide-ranging species. Since this could explain the scattering of ecological units among the final groups, it might be fruitful to examine the dividing species more closely.

5.4.4 The dividing species

If a species is to be useful in characterizing a group or groups, it must be faithful to those groups and it should preferably be constant in them. While all dividing species, extracted statistically by a monothetic method, are necessarily completely constant in the groups which they separate from the remainder, Appendix IX shows that most dividing species in this study have no overall fidelity to these groups; they often occur in many groups outside their area of local definition. On the whole, therefore, our dividing species are not diagnostic or character species in the Braun-Blanquet sense.

The first dividing species is, of course, an exception. Since it splits the whole set of plots into two, it is not only completely constant in, but also completely faithful to, that portion of the hierarchy in which it occurs. In this study the first division is on presence or absence of _Struthiola ciliata_, a virgate shrub widespread in drier inland habitats. This species divides the hierarchy into groups 1 - 10 (+ _S. ciliata_) and groups 11 - 23 (- _S. ciliata_). _S. ciliate_ is thus a true character species for groups 1 - 10. However, the presence of a single character species does not prove that the portion of the hierarchy which it characterizes is a natural vegetation unit. If it is, then other species should have a similar distribution. Appendix IX shows that no other important species have a distribution similar to _S. ciliata_. This is substantiated by a Sneath's Modulus test (see Chapter 6) applied to the first subdivision of the hierarchy. The Modulus value for

S. ciliata is of course 100, and the next highest value is only 64.6. If other species had had frequency distributions similar to that of *S. ciliata*, they would have shown Modulus values much closer to 100.

The first dividing species should, in theory, split the vegetation into two major units which can be related to an overriding habitat feature, usually substratum. On subjective grounds, it seems clear that the two major vegetation units in the Reserve are the Inland and Coast Alliances, the former occurring only on Table Mountain Sandstone, the latter mainly (but not always) on marine sands. Plots in groups 1 - 10 (+ *S. ciliata*, + Table Mountain Sandstone substratum) belong to the Inland Alliance and transitions with the Coast~~al~~ Alliance, while some plots in groups 11 - 23 (- *S. ciliata*, + Table Mountain Sandstone substratum) also belong to the Inland Alliance. *S. ciliata* is thus not a character species for the Inland Alliance as a whole, nor does it divide the hierarchy edaphically.

Groups 1 - 10 represent variations of the hillveld and some of its transitions with moist flats communities (group 5) and with the Coast Alliance (group 4). *S. ciliata* is thus a tolerant species found in hillveld and various intermediate habitats, but because some hillveld variations occur in groups 11 - 23, *S. ciliata* is not even a constant character species for hillveld. It can be positively stated, however, that *S. ciliata* does not occur in true Coast Alliance or true Tussock Marsh, all plots of which are in groups 11 - 23.

Field observation suggests that *S. ciliata* is common in young regeneration following a burn but becomes less abundant as the vegetation ages; it also becomes more difficult to recognize, especially when not in flower, and it flowers less profusely. This might explain why it is absent from the hillveld in group 14. The constituent plots in this group have not been burnt for at least 12 years, and *S. ciliata* is so rare in this old veld that it does not occur in the sample plots, though it is present in two of the four plot-surrounds. While the first division of the hierarchy cannot be solely attributed to the fire factor because analysis of variance of post-burn age between the two arms showed no significance, this factor may nevertheless account for some anomalies such as group 14.

The next dividing species, *Roella ciliata*, is present in only one plot (in group 15) besides groups 1 - 3 and 11 where it is positive. Consequently it has a constancy and fidelity to its positive sections almost as high as that of *S. ciliata*, and can be described as a good character species for groups 1 - 3 and 11. Groups 1 - 3 comprise a mixture of hillveld of the western hills, its close variety on non-rocky flats and some impoverished variations; group 11 is much more heterogeneous (see plot descriptions, Appendix VII). *R. ciliata* does not, therefore, appear to characterize a distinct community. This again is substantiated by reference to species distributions in App. IX and by Sneath's Modulus which reveals that the next highest Modulus value is only 55.8. Like *S. ciliata*, *R. ciliata* dies out when vegetation remains long unburnt (none of the plots in which it occurs are older than 10 years); it is never dominant; in the vegetative condition it is inconspicuous and easily confused with *Roella triflora*, a close relative. These considerations might help to explain why it characterizes an artificial unit.

The next three dividing species (*Erica imbricata*, *Amphithalea ericaefolia* and *Salaxis flexuosa*) all occur in many other groups besides those which they divide, so they are not character species for their positive sections. *E. imbricata* is a tolerant species common in hillveld but extending into the transitions between rocky hills and moist flats, becoming increasingly rare in moister habitats. Its constancy distribution (App. IX) confirms this: it is found in most of groups 1 - 18 which contain all hillveld and moist flats communities except the wettest. *A. ericaefolia* is a hillveld species intolerant of moist soils: it is found in most of groups 1 - 14 which contain all hillveld variations, with the notable exception of group 5, the only one where the soil of all plots is moist. *S. flexuosa* is a species of both rocky hills and sandy flats; it tends to dominate on disturbed sites especially on deep, dry sand; it is intolerant of moist soils. Again these preferences are reflected in its frequency distribution: it occurs in most of groups 1 - 19 containing all variations of hillveld and sandflats, being most frequent in groups 4 (inland sandveld) and 9 (disturbed, impoverished hillveld) and in the two coast sandflats plots of group 15, but absent from groups 5, 16 and 18 (moist flats and its transitions).

In App. VI, the - *R. ciliata* section comprises seven groups which are stepped progressively downwards towards the right-hand side, a feature indicating increased impoverishment and lack of definition towards the right.

Ficinia secunda, *Ifloga seriphioides* and *Phylica stipularis*, which divide group~~s~~ 4 from groups 5 - 10, are all good indicators of deep sandy soils; they all occur predominantly in groups 4, 11, 15 and 19 which comprise habitats of windblown sand patches, coast sandflats and inland dunes. That they are also good character species for a homogeneous floristic unit is shown by the fact that they separate group 4 at a high level of the subdivision parameter ($\chi^2 = 22.7403$) while the next group is separated at a considerably lower level ($\chi^2 = 16.3095$). *P. stipularis* recurs as a dividing species for group 19. This suggests that groups 4 and 19 are basically the same community; the difference is that in group 4 the sandveld occurs in small patches intermixed with hillveld (indicated by presence of *S. ciliata*) while in group 19 (-*S. ciliata*) the sand is more extensive, giving rise to a distinct dune community.

Restio quinquefarius, the dividing species for group 5, is a moisture-loving species which nevertheless tolerates fairly dry conditions. It is faithful to groups 5, 15, 16, 17 and 18 in which only four of the 22 plots have a Soil Moisture Index of 1 (= dry).

Leucadendron salignum, the dividing species for group 6, is more widespread than it is common. It occurs in only six plots but is also found in the surrounds of six others. While most of these sites are on the eastern mountain slopes, some are in adjoining sand and hill habitats. L. salignum, being one of the seed-regenerating Proteaceae which do not set seed within about four years of a burn, is liable to be exterminated in frequently-burnt veld. This might explain why its distribution shows a geographical rather than an ecological pattern.

Saltera sarcocolla and Staberoha banksii, the dividing species which separate group 7 from groups 8 - 10, are limited in distribution. S. banksii is constant only in group 7 but occurs in one plot in each of groups 1, 6, 13 and 14. Since these four plots all resemble group 7 in overall species content, S. banksii is a good character species for the dry hillveld community. Saltera sarcocolla also has a compact distribution; besides its constant occurrence in both groups 6 and 7 (reflecting its preference for mountain as well as dry hillveld sites) it occurs only in plot 23 (group 13) which has features characteristic of both dry hillveld and mountain communities.

The second major subdivision of the hierarchy is characterized by absence of Struthiola ciliata. None of the higher units of this subdivision (groups 11 - 13, 14 - 18, 19 - 23) coincide with major ecological or floristic units, except that all communities of the rocky hills and mountains are absent from groups 19 - 23 (- Restio cincinnatus). The inference is that S. ciliata, though predominantly a hillveld species, is not by itself sufficiently characteristic of all hillveld variations to separate hillveld from the remaining vegetation units; when both S. ciliata and Restio cincinnatus are absent, however, hillveld never occurs.

Little need be said of the dividing species for groups 11 - 17 viz. Clutia alaternoides, Restio cincinnatus, Metalasia brevifolia, minor Ericaceae, Restio cuspidatus, Roella ciliata (already dealt with), Chironia baccifera, Anthospermum ciliare, Passerina vulgaris and Euphorbia tuberosa. Appendix IX shows that all these species occur in many other groups and that none of them, therefore, characterize the groups which they divide; nor, indeed, do they characterize distinct communities. Despite this, some of these groups as already discussed in section 5.4.2, are ecologically intelligible. Group 18, though negatively defined, is also a comparatively homogeneous and interpretable unit.

The dividing species for groups 19 - 23, on the other hand, are generally more characteristic not only of groups but also of communities. Phylica stipularis, which divides group 19 from the remainder, has already been discussed (p.96).

Group 20 was described (p. 89) as a very homogeneous group comprising all five plots found in the woody littoral scrub; both dividing species (Euclea racemosa and Ficinia ramosissima) were mentioned in Chapter 4 as being characteristic of Broad-leaved Scrub. That these species are found together only in groups 12, 13 and 20 which all contain plots of the woody coastal element, supports the contention that they are good character species for this community. There is only a small difference in the subdivision parameter values of groups 19 and 20 (χ^2 = 13.6273 as against 11.6839) while the parameter value for the next subdivision is much lower (χ^2 = 6.5360). This suggests that groups 19 and 20 are more similar to each other than are either or both to the remaining groups 21 - 23, because the removal of the first group from the matrix does not appreciably reduce the level of heterogeneity, while the removal of both reduces it much more. This is substantiated by the descriptive account in Chapter 4, where Broad-leaved Scrub (equivalent to group 20) is said to replace Dune Fynbos communities (group 19) when the latter is protected from fire; they are seral stages of one "association" in the Clementsian sense.

Two of the three dividing species for group 21 (Drosanthemum candens and Exomis microphylla) are completely faithful to this group which forms a good ecological unit equivalent to the simplest form of Coleonema Fynbos occurring on hot, dry aspects of the rocky littoral (sect. 4.5). The third dividing taxon, Mesembryanthemae, is by no means faithful; but since most species of Mesembryanthemae were treated as one taxon in view of their uncertain taxonomic position, no ecological interpretation can be placed on its distribution.

Of the two dividing species for group 22, Elegia parviflora occurs predominantly in the "moist" groups 5, 16, 17, 18 and 22 and is a character species for the simple Tussock Marsh described in section 4.5. Tetraria cuspidata, on the other hand, is a common, widespread species occurring with high frequency in most of groups 1 - 18 which contain all variations of dry hillveld and sandflats. Its constancy in group 22 is surprising and may best be explained by the fact that my concept of "T. cuspidata" embraces morphologically similar taxa which are extremely difficult to differentiate in the field. Their forms range from slender wiry tufts scarcely 1 ft (30 cm) high (occurring mainly in hillveld) to coarse, erect plants of 2 - 3 ft (60-90 cm) found on poorly-drained flats; a lax, soft-stemmed plant which may be T. sylvatica has been included under this name. Dr. M.R. Levyns (pers. comm.) has suggested that the taxonomy of this complex is incompletely known; when this has been clarified, it may well be found that the dividing species for group 22 is distinct from the true T. cuspidata but closely allied to it - probably the tall, coarse plant of poorly-drained flats.

Finally, all dividing species are absent from group 23 which is consequently negatively defined.

5.4.5 Summary

The thirty-two species which divide the hierarchy into sections and groups, fall into five categories.

Eleven species (Ficinia secunda, Ifloga seriphioides, Phylica stipularis, Restio quinquefarius, Saltera sarcocolla, Staberoha banksii, Euclea racemosa, Ficinia ramosissima, Drosanthemum candens, Exomis microphylla and Elegia parviflora) are restricted to a few groups and have been shown to be good character species for natural vegetation units, four of which are in the Coast Fynbos Alliance, two in Tussock Marsh and one in the "dry hillveld" community of the Upland Mixed Fynbos Association of the Inland Fynbos Alliance.

The remaining dividing species range widely in many groups.

Ten species (Clutia alaternoides, Thesium spicatum, Roella ciliata, Erica corifolia, minor Ericaceae, Amphithalea ericaefolia, Restio cuspidatus, Anthospermum ciliare, Salaxis flexuosa and doubtfully Passerina vulgaris) are included in the list of species (sect. 4.5), which have some character value for the Upland Mixed Fynbos Association. Assuming the descriptive survey of Chapter 4 is sound, all the final groups in which these species show high constancy - not only the groups which they divide - can be expected to contain elements of Upland Mixed Fynbos. As this involves many groups, it is plain that Upland Mixed Fynbos has not emerged as a single homogeneous unit but has been split into scattered and often unintelligible fragments. This supports the conclusion reached in Chapter 4 that Upland Mixed Fynbos is a complex, variable continuum which is difficult to subdivide further. The association-analysis has perforce subdivided it, but not into natural units.

Six species (Struthiola ciliata, Restio cincinnatus, Tetraria microstachys, Erica imbricata, Leucadendron salignum and Euphorbia tuberosa) show no preference for any one of the communities analysed in the Synthesis Table of Chapter 4. All that can be said of the groups in which these species are highly constant, is that they comprise elements of association 5 - 8 of Chapter 4.

Two species (Chironia baccifera and Tetraria fasciata) were not recorded in the Chapter 4 analysis and one (Metalasia brevifolia) was so rare that it was ignored. In the groups where these species occur, elements other than associations 5 - 8 can be expected to preponderate.

Tetraria cuspidata and Mesembryanthemae are of no value because they are taxonomically intractable.

5.4.6 Discussion

In a monothetic, subdivisive method like association-analysis, the final groups are determined by presence or absence of a small set of dividing species. In the analysis, no account is taken of finer differences in abundance among the sites nor of subsidiary species which might help to characterize the groups (although this can easily be determined later by Sneath's Modulus).

If natural vegetation units were discrete, with no transitions between them, the final groups of an association-analysis would no doubt reflect these natural units exactly. If transitions occur, they will be composed of tolerant species common to the intergrading units. Where tolerant species act as dividing species in an association-analysis, transitional plots will fall into different groups in which a dividing species is present on the one hand and absent on the other. If these tolerant dividing species operate at a high χ^2 level, the transitional groups will be widely separated in the hierarchy. The greater the degree of intergradation between vegetation units and the greater the number of tolerant dividing species (especially at high χ^2 levels) the greater will be the fragmentation of legitimate communities into uninterpretable groups situated far apart in the hierarchy.

This would seem to explain the anomalies of the present association-analysis hierarchy. Fynbos communities in general intergrade freely. Many of the dividing species on the Cape of Good Hope Nature Reserve, as shown in the foregoing account, have wide ecological amplitude; many of the final groups comprise transitions and anomalous, heterogeneous variations of natural units widely separated in the hierarchy.

However, this does not mean that natural units do not exist. There are indeed natural units characterized by blocks of faithful species (see Chapter 6) but if the faithful species are not dividing species, the natural units will not be revealed in an association-analysis.

Anomalous groups may arise not only from transitions between natural units but also from variations within them, provided the dividing species for these groups are sensitive to the factors causing the variations. We have seen, for instance, (p.82) that *Leucadendron salignum*, a wide-ranging dividing species, seems to be a "stray" in plot 67 rather than a true indicator of its habitat, thus placing plot 67 in the "wrong" group. Again, *Struthiola ciliata*, *Roella ciliata* and others are sensitive to fire, being abundant in recently-burnt stands, occasional in long-unburnt stands. Such species will occur in all plots in recently-burnt stands but will be absent from some plots in unburnt stands; the latter plots will be relegated to a second group, often widely separated from the first, although both groups represent basically the same community. In addition, the second group may contain plots representing transitions between this community and another (in which the dividing species are missing for reasons other than fire) so that this second group will comprise a mixture of natural units.

On examining the mode of regeneration of dividing species it appears that many of those which regenerate from seed are poor character species for the groups which they divide, whereas most of those which regenerate from coppice or sprouts are good character species for the groups which they divide. Examples of the former are *Struthiola ciliata*, *Roella ciliata*, *Erica imbricata*, *Salaxis flexuosa*, *Erica corifolia*, *Thesium spicatum*, *Metalasia brevifolia*, minor Ericaceae, *Chironia baccifera*, *Anthospermum ciliare* and *Passerina vulgaris*. Examples of the latter are *Ficinia secunda*, *Ifloga seriphioides*, *Phylica stipularis*, *Restio quinquefarius*, Saltera sarcocolla, Staberoha banksii, Euclea racemosa, Ficinia ramosissima and Elegia parviflora. Seed-regenerating species are more sensitive to fire history of the vegetation than sprouting plants, being more abundant or more rare in often-burnt veld depending on their regeneration potential and the frequency of fires; whereas abundance of sprouting plants is much less affected by fire. Other factors which could affect the abundance of dividing species (and thus the grouping of plots) without radically altering the community, might be the intensity and rotation of grazing, the depredations of baboons, the influence of man, local changes in habitat occasioned by biotic factors or small climatic variations, e.g. blown sand or dessication of seepages.

Another cause of misplaced plots is the human factor, i.e. the accuracy of the field worker in recording data. This factor is independant of the method of data-gathering, but where mere presence or absence of a single species is of prime importance, as in association-analysis, its effect on the results will be much more serious than where several degrees of abundance, or alternatively a group of species, is used to characterize a vegetation unit. The effect is enhanced where, as at Cape Point, the key species - the dividing species in association-analysis - are inconspicuous or difficult to identify at certain stages or seasons. Normally, the human factor is not regarded as a serious source of error if the field worker is trained and observant. However, the Cape Fynbos is a rich flora containing many closely related plants often difficult to distinguish in the field, and the systematic position of some taxa is still uncertain. The danger of inaccuracies resulting from misidentifications will thus be greater than in simpler, better known floras.

5.5 Conclusions

The association-analysis has revealed some groups which are ecologically meaningful: their relation with habitat is discernible.

Most groups, however, represent such small, isolated fragments of natural units that they do not give a harmonious picture of the vegetation. Moreover, these fragments cannot be combined simply by raising the level of association. Instead, they must be regrouped selectively on extrinsic characters of habitat, and this introduces a subjective element.

The fact that some misclassifications are bound to occur in a monothetic divisive system is a major drawback to its use. The effect is enhanced if the occurrence of dividing species depends on factors other than habitat, as appears often to be the case in this study. The danger of accepting misclassifications at face value could be reduced if final groups were characterized by a set of species rather than by a single dividing species. This may be achieved by using Sneath's Modulus to reveal additional species which are important in distinguishing one group from another. Though this does not eliminate flaws inherent in the groups themselves, comparing these sets of "distinguishing species" would provide a sounder method of assessing similarities between groups.

The occurrence of a dividing species in a sample is greatly influenced by plot size which remains constant throughout the investigation regardless of the different patterns exhibited by different communities and species. The plot size used in the Cape Point survey is too large to be sensitive to the varying abundance which reflects the response of some species to habitat; it is too small to be truly representative of the stand where the flora is rich and the community composition variable. The number of plots (representing 0.006% of the total area of the Reserve), if systematically distributed over the whole area, is ~~fa~~ far too small to cover the variation sufficiently to give an accurate picture of the total vegetation. If stratified by the readily discernible major ecological units, the use of only 100 plots would be more efficient, while subjectivity would be minimized.

The present association-analysis is unusual in that the number of attributes (species) exceeds the number of individuals (samples). This has the following disadvantages: (1) the effect of misplacement of a few plots due to chance or to "degree of absence" (absence in the plot through reduced abundance in the stand) will be relatively great; (2) because of the low number of constituent plots, final groups are terminated not by the limiting level of heterogeneity (usually $\chi^2 = 3.84$) but by the limiting number of seven plots. Their χ^2 values are thus above 3.84 but have not been determined. Consequently, while the final groups are not equally heterogeneous, their variation is not known; some might be capable of many further subdivisions, others of none, before reaching the limiting level. These drawbacks could to some extent be relieved by adopting the techniques of Crawford and Wishart (1968) who use a rapid agglomerative method after the initial divisive process, to check for any misclassifications.

A technique which uses all the attributes in a universe is at best unwieldy and expensive, the more so in a rich and diverse flora. Some means of limiting the number of attributes is desirable, but the selection of species at the start of the investigation must be largely subjective, if not arbitrary, which nullifies the advantages of objective analysis. Alternatively, some attribute other than species might be used, e.g. physiognomy or life-form. The late Mr H.H. von Broembsen (pers. comm.) was at the time of his death, developing a classification of "eco-organs" with the aim of simplifying both data-gathering and data-processing.

The advantages of association-analysis are that it produces a rapid, objective classification which can be mapped. However, if the classification cannot be related to habitat without lengthy and complicated re-interpretation by someone with a detailed knowledge of the ecology of the area, the prime advantage of association-analysis is nullified and the map based upon it is equally subjective. Indeed, if the original crude, inaccurate and unaesthetic "block map" is transformed merely by rounding the outlines, the position of boundaries - especially where distances between points are large as in the present case - will be very much less accurate than where the map is drawn from an orthodox descriptive survey. On the other hand, if boundaries are interpolated by field re-examination, as much "subjectivity" is employed as in orthodox mapping.

The authors of association-analysis claim it to be a very useful tool in primary survey (Williams and Lambert, 1959). The aim of primary survey is not to elucidate minor factors causing community variation but to expose major habitat discontinuities reflected by major vegetational changes. It appears that association-analysis, as applied in this survey, makes a premature attempt at the former without accomplishing the latter.

To summarize, the chief objection to association-analysis is that it is a monothetic method involving a rigid series of successive divisions. The possibility of error is great in such methods, which may not yield natural groups though they do produce clear classifications. Furthermore, the sequence of choices and hence the resultant groups will be markedly affected by plot size (McIntosh, 1967).

In a rich, variable flora, especially where attributes exceed individuals in number, an agglomerative method such as Heterogeneity Analysis (Hall, 1967), which employs a more sensitive measure of abundance than mere presence or absence, may be more suitable. Such methods combine units which are most similar, starting from individual plots and fusing the groups at successively higher levels of the parameter used. In this way a picture is obtained of the degree of similarity rather than the amount of difference between units. Lambert and Dale (1964) prefer subdivisive methods because they "start from maximal information obtained over the whole population, while agglomerative techniques start from single units of minimal information. Secondly, subdivisive methods can be terminated at any convenient level, while agglomerative methods require the whole analysis to be completed before the large-scale divisions at at the top of the hierarchy can be obtained." It is true that agglomerative methods, being built up from the lowest level, often include much unwanted material, but if they are also polythetic they have the great advantage of being less sensitive to chance presence or absence of any single species.

Though a trial of alternative quantitative methods such as those suggested by Roberts (1967) is outside the scope of this project, an independent assessment of the association-analysis hierarchy is necessary in order to view my critiscisms without bias. Such an assessment is made using the Synthesis Tables discussed in the next chapter.

CHAPTER 6

PHYTOSOCIOLOGICAL ANALYSIS

6.1 The Zürich-Montpellier School of Phytosociology

Having found the results of association-analysis unsatisfactory on subjective assessment, it was necessary to provide concrete evidence in support of these conclusions. The original data were thus re-examined to determine whether a community classification that showed better correlation with environmental factors could be produced.

The main objection to association-analysis was shown to be the successive subdivision of the sample set on a single species at each subdivision. The method of the Zürich-Montpellier school of phytosociology, originated by J. Braun-Blanquet (1932), commended itself primarily because it overcame this objection. It is a synthesis method in which more than one species is used to characterize each community.

The Braun-Blanquet method has been successfully used by Continental phytosociologists for nearly half a century but has in the past been poorly received by workers not trained in Europe. This was due largely to the fact that the earlier published work contained no precise description of the actual method of synthesis, which was consequently misunderstood and severely criticized.

Braun-Blanquet's method is based on species lists compiled for sample plots - or even sample areas of variable size - deliberately placed in vegetation that is floristically relatively homogeneous. From tabular comparison of these lists, vegetation units ("associations" in the Braun-Blanquet terminology) are synthesized by amalgamating samples in which sets of defined "character species" occur together, the units being progressively combined into a hierarchical classification of vegetation. The intentional selection of samples was criticized by Poore (1955) and others who maintained that the vegetation units were derived by circular argument because associations were first determined subjectively in the field and sample plots then placed in areas typical of the presumed associations. This criticism results from a misunderstanding of the process, for as Moore (1962) points out, associations are not distinguished in the field at all. The first step simply involves listing in areas of relatively homogeneous vegetation. The abstract associations are synthesized later "at the phytosociologist's desk" after sufficient relevés (or samples) have been analysed. Whittaker (1962) has defended the subjective choice of sample plot as being quite consistent with the aims of the method, provided it is practised by a skilled worker.

Another criticism is that Braun-Blanquet's system does not produce a "natural" classification. In the present day of computer ecology there is, however, a growing awareness of the fact that no classification of vegetation can be regarded as truly natural. Kershaw (1968) recognizes that all classifications, in an ecological context, give arbitrary units which are discontinuous simply because the method of extraction has imposed a discontinuity where none necessarily existed. The Braun-Blanquet system introduces discontinuity by carefully selecting homogeneous stands and ignoring intermediates; an association-analysis does so by using only crude presence-or-absence data and ignoring the degree of abundance, which is an integral part of the concept of a plant community. Both methods, in different ways, consciously impose an artificial discontinuity. Neither method claims to produce a "natural" classification.

The prime advantage of the Braun-Blanquet method, already mentioned, is that it makes use of a set of character species to define associations which are built up solely from the floristic data obtained for individual samples. The exclusion of environmental data minimizes the danger of circular reasoning. The resulting associations can be mapped. Because of its simplicity and flexibility the method is well suited for use in broad primary surveys where the vegetation is still largely unknown. This cannot be done effectively by a quantitative method, if only because the number of sample plots, when located without bias, would have to be greatly increased.

Continental plant sociologists have used the method successfully to produce practical classifications which harmonize well with the environmental patterns of the areas studied. Moore (1962) has claimed that the method is the most suitable for providing a comprehensive vegetation analysis in a short time. Whittaker (1962) has stated that no other system can claim successful application over an equally wide range of vegetational conditions and research purposes. That the method is now accepted as useful even by acknowledged advocates of "quantitative" ecology (Whittaker, 1962; Kershaw, 1964; 1968) is sufficient justification for using it to substantiate my criticisms of association-analysis in the present study.

Braun-Blanquet's techniques have now been revised, improved and comprehensively described. The first detailed English account of the compilation of Braun-Blanquet's synthesis tables (Küchler, 1967) became available to me only when my work was already well advanced. For preparing the earlier tables in this study, Becking's (1957) review, which gives few practical details of the method employed, was the only reference available. Küchler's more precise account has been followed only in the preparation of the Synthesis Table for the Hillveld Sub-Alliance.

6.2 Adaption for the present study

Since the intention was to establish whether a more satisfactory classification could be made from the original data, the application of Braun-Blanquet techniques in this study deviates from standard practice in some respects. In the first place, the original data were collected objectively by systematic sampling on a grid. The basic tenet of Braun-Blanquet methodology - deliberate choosing of sample sites - was thus not applied. For this reason ecotonal areas have been sampled and these obscure the picture of the associations emerging from manipulation of the tables. As a first step, however, plots were grouped into three broad vegetation types of relative similarity, before drawing up separate tables for each type. This is equivalent to the Braun-Blanquet practice of including only relatively homogeneous vegetation within a single analysis.

Secondly, all species were not included in the tables. To do so would have enormously increased their complexity and the time spent on their construction because of the very rich flora in which the work was undertaken. The number of species was reduced by extracting only the "character species" (those having a fidelity value of III - V) for the vegetation type under examination, thus excluding "companions" and "strangers". These are in any case not used in the Braun-Blanquet methodology except in distinguishing sub-associations and variants, which was not done in the present survey.

Thirdly, cover-abundance and sociability estimates for species in sample plots were not included in the tables because the coded data, assembled for the association-analysis, were available only in the form of presence-or-absence. However, estimates of abundance, recorded in field notes, could be referred to in doubtful cases.

Lastly, because the standard plot size was not always large enough to include all species representative of a particular association, species in "surround lists" were included in the tables. This, according to Becking (1957), is consistent with Braun-Blanquet procedure. In order that constancy values could be compared, however, constancy was calculated only for occurrences within sample plots (for which computed data were available), the occurrences in surrounds being omitted.

Innovations in this study included checking the "goodness" of plot-groupings by means of a Peculiarity Index and species-groupings by Sneath's Modulus.

6.3 The Synthesis Tables

By employing the additional information on vegetation and habitat gathered during the survey, plots were first grouped into three broad vegetation types: (1) the Coast Fynbos Alliance plus the Broad-leaved Scrub Formation which is its presumed successional development (here termed collectively the Coast Alliance), (2) the Inland Fynbos communities of damp, level sites represented by associations 8 - 10 of Chapter 4 (here termed the Moist Flats Sub-Alliance), and (3) the Inland Fynbos communities of dry, hilly sites represented by associations 5 - 7 of Chapter 4 (here termed the Hillveld Sub-Alliance). The tables were compiled in this order, starting with what was thought to be the most distinct and least complex vegetation and proceeding to the more complex. In the final view, however, the later tables appear to be the more satisfactory, partly perhaps due to progressive refinement of technique, but partly because they appear to contain more valid units, though many transitions still occur between them.

To help choosing the species for each synthesis table, a Species Constancy Table was compiled, of which Appendix IX is a summary. This table, showing the percentage occurrence of each of the 452 species in each of the 23 association-analysis groups, was derived from a computed print-out.

Details of the method for compiling the tables will be discussed for each table separately. Briefly, the procedure was as follows: (1) Plots were subjectively assigned to the most appropriate of the three vegetation types (henceforth called alliances in the sense of Braun-Blanquet), doubtful plots being placed in more than one type to establish where they fitted best; (2) species of presumed character value were chosen to represent each alliance;

(3) a Raw Table (Küchler, 1967) was compiled; (4) this was redrawn many times, manipulating the order of plots and species until "blocks" of plots, represented by character species, emerged. The best arrangement of species-in-plots was termed the Provisional Table; (5) the plots comprising these blocks (the associations of Braun-Blanquet) were subjected to a Peculiarity Index test to determine whether they were appropriately placed. The improved arrangement resulting from this test was depicted in the Final Table; (6) Sneath's Modulus was used to determine which species were most characteristic of the units already erected, and thereby to assess the efficacy of the species already chosen. While a few better character species were sometimes revealed, the Final Tables were not redrawn to include them. This would only have improved the appearance of the blocks without altering their plot-composition; (7) the associations were mapped and (8) their validity evaluated.

6.4 The Peculiarity Index

Subjectively assessed, the blocks of plots set up in the Provisional Tables can in general be identified with the descriptive associations of Chapter 4, but it would be preferable to have some objective measure of their validity as natural units. After several attempts to find a suitable criterion it was decided to use the Peculiarity Index developed by Hall (1965). A computer programme for the calculation of this function is available at the University of Cape Town.

The Peculiarity Index was developed for use in numerical taxonomy to show the relative proportions of unusual features in taxa. It is written for data coded in simple two-state form, 0 or 1. Briefly, the function operates by reducing the abundance values of the more common attributes to zero, weighting the rare ones in proportion to their rarity and summing all values to give the Peculiarity Index for each taxon. This permits rapid recognition of unusual taxa in a group. Such taxa, which have rather higher values than any other member of the group, might be better classified in a different group from that under study.

Having been developed for taxonomy, the method assumes that the number of attributes examined for each taxon remains constant. When applied in ecology, however, where the taxon is equivalent to the plot and the attributes to the species, the number of attributes (species) per taxon (plot) varies greatly. The value of the Peculiarity Index will thus bear a direct relationship to the number of species in the plot. To provide for this, the Peculiarity Index was divided by the number of species in the plot and (for convenience) multiplied by one hundred. This standardized value is referred to as the "P.I.". Its use will be demonstrated in the individual alliance descriptions.

The use of this rather sophisticated technique with the two-state data of the present ecological study may result in distorted values where only one individual of a rare species happens to be present by chance. This is analogous to the misclassifications obtained, for the same reason, in association-analysis. The P.I. can therefore only be a rough indication, not an exact measure, of the "peculiarity" of each plot, and must be used with discretion. For example, the synthesis of strong community blocks must always have preference over the harmonious arrangement of P.I. values, where the two are in conflict. The P.I. values may be false, whereas the blocks are indisputable.

6.5 Sneath's Modulus

This function, developed by Sneath (1962) and discussed by Hall (1968), provides a quantitative assessment of the importance of each species in distinguishing between two groups of samples. As it examines all the species occurring in the two groups - not just the selection used for compiling the tables - the Modulus provides a reliable check on the chosen character species. A computer programme for calculating this function is also available at the University of Cape Town.

Sneath's Modulus is calculated by comparing the percentage frequency of occurrence of each species present in one or both of any two groups of samples. In the Cape Point study the Moduli were determined separately for each alliance. Plots representing the associations being examined (ignoring transitions) were assigned to group one, while the remaining plots in the alliance (including transitions) were assigned to group two. The Modulus for each species within one alliance is simply the difference in percentage frequency of that species in the two compared groups. The computer was programmed first to print out the percentage frequency of each species in each group, then to list their differences (i.e. the Moduli) in descending order of magnitude.

When dealing with abstract associations synthesized from a number of widely separated stands, as in this study, the so-called percentage frequencies of species, obtained from an examination of equal-sized samples, are strictly speaking a measure of their constancy, not frequency (Oosting, 1956). Thus, the percentage frequencies are henceforth referred to as constancy.

If we want to assess the character value of species for specific associations, we cannot uncritically accept those with high Moduli as the best character species. Character value depends not only on the constancy of a species but also, more especially, on its fidelity. The Moduli must therefore be analysed in detail to determine both constancy and fidelity.

(1) Constancy. A species with a Modulus value of 100% will be completely constant in one group and entirely absent in the other but the Modulus value by itself does not indicate in which group the species is constant. To determine this, the original print-out of constancies ("percentage frequencies") must be examined. If the species has the higher constancy in group 1 (the association under examination) the Modulus is designated positive; if in group 2, negative. Only those species with positive Moduli are examined further. According to Küchler (1967) character species which define

associations by the Braun-Blanquet method must have a constancy of at least 50% in the defined association.

(2) Fidelity. Although a species may have a positive Modulus of 100% and is thus completely faithful to one association in the alliance under study, it may have an equally high Modulus for another association in a different alliance, when this association is compared with the remainder of its alliance. Overall fidelity (i.e. complete fidelity to one association only, in the whole of the study area), as distinct from local fidelity, can only be finally assessed from a knowledge of the constancy of a species occurring in the whole study area, not just within one alliance. For the present purpose, only those species with sufficiently high overall fidelity were selected as character species.

Becking (1957, Table VIII) outlines a standard procedure for determining fidelity where values not only for presence but also for cover-abundance are available. Since cover-abundance was not recorded in the present study, fidelity was assessed from a subjective interpretation of Braun-Blanquet's "fidelity classes" given by Becking (loc. cit. Tab. VII). Fidelity class III - the lowest qualification of a character species - is described as "Plant species often occurring in other vegetation units but with their optimum definitely in one vegetation unit." This leaves wide scope for interpretation but was taken, for this study, to mean a ratio of two occurrences within the community being examined, to one outside it. Occurrence values were converted to percentages because absolute values, when the number of plots per community differs widely, are misleading.

If, to qualify as faithful, a species must have a constancy of at least 50% and a minimum relative constancy-ratio of 2:1, then Sneath's Modulus for this species must be at least 25.0.

The method of using Sneath's Modulus to determine the character value of species can now be described in detail. Only those species with positive Moduli ranging from 100.0 to 25.0 are examined. Of these, only species satisfying both the following requirements are selected: (1) a constancy of 50% and over in group one, (2) a minimum constancy ratio of 2:1 in favour of group one. The information for each association is tabulated separately. After listing the species numbers, the Moduli and the botanical names of the species selected, the following procedure is adopted:

(1) Convert the percentage constancies for group one into absolute occurrences and enter into column 1;
(2) convert the percentage constancies for group two into absolute occurrences and enter into column 2;
(3) add columns 1 and 2 to obtain total occurrence within the alliance (column 3);
(4) enter the computer print-out for "Total frequency" (i.e. total number of occurrences in all 100 plots on the Reserve) in column 5;
(5) subtract column 3 from column 5 to obtain occurrences outside the alliance (column 4).

This procedure is necessary to obtain constancy values within the alliance and outside it. These absolute values must now be converted to percentages:

(6) Convert column 3 to percentage value (column 6);
(7) convert column 4 to percentage value (column 7);
(8) where the value in column 6 is more than twice that in column 7, place a star in column 8;
(9) enter, to the nearest 1%, the computed "percentage frequency" for group 1, in column 9;
(10) do the same for group 2 (column 10);
(11) where the value in column 9 is more than twice that in column 10, place a star in column 11.

Single-starred species exhibit only local fidelity to the association under study. Double-starred species have overall fidelity (values III - V on the Braun-Blanquet scale), and a constancy of over 50% to the association under study. These species fulfil the requirements for association character species, at least within the Cape Point vegetation complex. Absolute character species (rare endemics restricted to relict habitats) and differentiating species with local character value but a fidelity of less than III (Becking, 1957) have been excluded by the method of selection since they are not deemed sufficiently important at this scale of survey.

The efficacy of double-starred species in characterizing the association by virtue of their constancy and fidelity, can now be assessed by assigning numerical values to them, thus:

(12) enter the "Fidelity factor" in column 12. This is simply the relative constancy within the association divided by the relative constancy outside the association, and provides a more precise expression of the qualitative fidelity classes of Braun-Blanquet. However, where relative constancy outside the association is zero, the fidelity factor is spurious. Such values are placed in brackets. In Tables 3 to 10, species have been rearranged in the order of their Fidelity Factors, and columns 1 - 5 in the above procedure have been omitted.

In practice it was found that the Moduli usually confirmed the species already chosen, the extent of agreement being roughly proportional to the distinctness of the unit defined. The use of the Modulus may be justified for particularly intractable units but in general the time spent on the analysis does not seem justified by the results.

6.6 The Coast Alliance

6.6.1 Choice of plots and species

Twenty-two plots from seven association-analysis groups, thought to contain all representatives of the Coast Alliance, were chosen. Later it appeared that a further two plots (95 and 96) containing a number of the character species extracted, could be added. The final number of plots was thus 24, distributed in eight association-analysis groups.

The following species-categories were included in the Raw Table: (1) all positive dividing species of the plots selected above, (2) other species described in Chapter 4 as character species for the relevant communities, (3) additional species that an examination of the Species Constancy Table showed were almost confined to groups 4, 19, 20 and 21, i.e. those groups included in toto in the Raw Table. This gave a total of sixty species.

6.6.2 The Tables

The species were listed alphabetically in the left-hand column and their distributions in the chosen plots (listed horizontally in numerical order along the top of the table) indicated by an"x" in the relevant columns. The initial appearance of this Raw Table was puzzling and inconclusive, no doubt because the two basic tenets of the Braun-Blanquet school - to sample only the most typical segments of homogeneous vegetation and to use a plot size not smaller than the minimal area of the community - were not followed. In the Coast Alliance, which includes Broad-leaved Scrub, the plot size may well be too small in some cases. It was thus decided to include records of the chosen species occurring in the plot surrounds; these are indicated by an "o" in the table.

The next step was to eliminate those species with a total frequency, in the whole population of one hundred plots, of 2% or less. The elimination of very rare species is standard practice in the Braun-Blanquet school, and Scheepers (1969) found that a 1.7% "mask" gave a readily interpretable association-analysis classification of grassland in the Kroonstad area of the Highveld Region. Of the remaining species, only those with a fidelity value of III, IV or V to the plots in the table were retained. In the Coast table, fidelity determination was based on absolute constancy values; the use of relative values might have improved the table somewhat. No less than seven out of the fourteen dividing species had insufficient fidelity and were thus eliminated. Altogether, twenty-two species were eliminated on grounds of low frequency or low fidelity, leaving a total of thirty-eight.

Next, a graphical test for homogeneity of the plots, based on the 38 species retained, was attempted. According to Becking, this is permissible where sampling is random <u>or</u> systematic, but the test was abandoned because all species had not been included, thus truncating the curve and making it difficult to judge homogeneity. The full complement of plots was thus retained.

The 38 species in the table were then critically examined for assemblages regularly recurring in different plots. The Raw Table was redrawn three times to arrange blocks of species-in-plots together in the most satisfactory way in the Provisional Table. Thus, directly from manipulation of the Raw Table, and without prejudgement, three major groupings emerged. Only at this stage, and not before, were the blocks evaluated.

6.6.3 Evaluation

The plots originally extracted as representing the Coast Alliance fall naturally into three associations but some transitions occur.

(1) The first association, Dune Fynbos, comprising all plots of groups 4 (Plate 4) and 19 (Plate 3) and plots 52 and 70 from the heterogeneous group 11, corresponds to Associations 1 and 2 of Chapter 4. Plot 95 from group 13 (also a heterogeneous group) contains some character species of both this and the following category, and may be placed here.

(2) The Coast Scrub, comprising all plots of group 20 (Plate 25) plus plot 94 (group 13) and plot 96 (group 12) corresponds to the Broad-leaved Scrub Formation of Chapter 4.

In addition, plot 43 which in the association-analysis was relegated to the negatively-defined group 23 for lack of defining species, could be placed in this association because many of the character species occurred in its surrounds. Plots 94 (group 13) and 85 (group 20) appear transitional between associations 1 and 2. (3) The Rocky Littoral consists of the three plots of group 21 representing the succulent variation of Coleonema Fynbos described in Chapter 4 (Plate 6). The overlap of the character species Rhus glauca, Cineraria geifolia and Limonium scabrum shows that the Rocky Littoral is linked (apparently successionally in this case) to Coast Scrub, and emphasizes the continuity of this vegetation.

Finally, the single anomalous plot 91 from the negatively-defined group 23 (Plate 5), which is the only representative of the rare coastal marsh community (Association 3 of Chapter 4), could not be placed in any of the above associations for lack of character species. This was realized when it was included in the Raw Table but it would not fit anywhere else.

Most of the species in the Raw Table fall naturally into the three associations of the Provisional Table but eight unspecialized species were listed separately, below the blocks, as companions.

The validity of the three associations was now tested by means of the standardized P.I., the values of which, for the 24 plots of the Provisional Table, range from ten to twenty-two. Compared with the P.I.'s for other alliances, these values are high, showing that the Coast Alliance concept is rather wide and varied. The sequence (shown at the foot of App. X) is irregular; there is no central core of "typical" plots. Plots could not be rearranged in a more harmonious P.I. sequence without destroying the block-groupings. Accordingly no rearrangement was attempted. Nevertheless, some segregation of the P.I. values within the three associations may be detected. Thus, P.I.'s for Dune Fynbos range from 10 to 15, those for Coast Scrub are concentrated mainly at values 14-15 (the transitional plots 95 and 85 being lower), the Rocky Littoral are in the 17-19 range (with one of 14) and the anomalous plot 91, as is to be expected, has the highest value of 22.

The Final Table (App. X) still contains the three basic associations but transitional plots (94, 95 and 85) have been placed together between associations 1 and 2. *Leucadendron sabulosum*, *Indigofera brachystachya* and *Pelargonium betulinum* are confined to plots 69, 70, 77 and 94 which all occur on inland dunes and represent a distinct sub-association, 1(a), roughly equivalent to Sub-Associations 2(c) and (d) of Chapter 4. Associations 1, 1(a) and 2 thus overlap in plots 94, 95 and 85. The lack of sharp distinctions between associations is the result of systematic sampling in continuously varying vegetation. The transitions demonstrate the marked variability of coast vegetation.

Sneath's Modulus tests were now applied to determine whether the character species were correctly chosen.

(1) Dune Fynbos Association

No Modulus figures are available for this Association which was amended and subdivided after the Modulus computations had been carried out.

(2) Coast Scrub Association

The Sneath's Modulus analysis (Tab. 3) shows that four of the original character species (*Ficinia ramosissima*, *Kedrostis nana*, *Rhus glauca* and *Galium tomentosum*) possess high fidelity factors to Coast Scrub. Four other species (*Pterocelastrus tricuspidatus*, *Helichrysum crispum*, *Euclea racemosa* and *Ehrharta villosa*) also qualify for inclusion in the Coast Scrub block by the standards arbitrarily set for the Modulus, but have been relegated to the list of companions because more faithful species are available. Only *Rhus mucronata* and *Cassine barbara* might have been added to the Final Table. The former was overlooked during the original selection; the latter was deleted from the Raw Table for having a fidelity (based on absolute instead of relative constancy) of only II.

(3) Rocky Littoral Association

Again, the only two character species originally chosen (*Drosanthemum candens* and *Exomis microphylla*) are the best according

TABLE 3

SNEATH'S MODULUS ANALYSIS : COAST SCRUB ASSOCIATION

Sneath's Modulus	Species	Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid Factor
		In	Out		In	Out		
1	2	3	4	5	6	7	8	9
83.3	Ficinia ramosissima (C)	25	3	*	83	0	*	(83.0)
50.0	Cassine barbara	12	3	*	50	0	*	(50.0)
61.1	Kedrostis nana (C)	21	0	*	67	6	*	11.2
61.1	Rhus glauca	21	0	*	67	6	*	11.2
44.4	Pterocelastrus tricuspidatus	16	0	*	50	6	*	8.3
44.4	Galium tomentosum (C)	16	0	*	50	6	*	8.3
38.9	Helichrysum crispum	21	1	*	50	11	*	4.5
72.2	Rhus mucronata	45	3	*	100	28	*	3.6
55.6	Euclea racemosa	41	1	*	83	28	*	3.0
33.3	Ehrharta villosa	25	1	*	50	17	*	3.0
	Total no. of plots involved	24	76		6	18		

Explanation

Columns 3 and 6 : Percentage constancy within the Alliance and Association respectively.

" 4 " 7 : Percentage constancy outside the Alliance and Association respectively.

" 5 " 8 : Starred when the Fidelity Factor is greater than 2.0.

Species with stars in both columns qualify as character species.

Species marked (C) are used as character species in the Synthesis Tables.

TABLE 4

SNEATH'S MODULUS ANALYSIS : ROCKY LITTORAL ASSOCIATION

100.0	Drosanthemum candens (C)	12	0	*	100	0	*	(100.0)
100.0	Exomis microphylla (C)	12	0	*	100	0	*	(100.0)
66.7	Spergularia marginata	8	0	*	67	0	*	(67.0)
66.7	Diplopappus fruticosa	8	0	*	67	0	*	(67.0)
61.9	Limonium scabrum	12	1	*	67	5	*	13.4
61.9	Asparagus capensis	12	1	*	67	5	*	13.4
	Total no. of plots involved	24	76		3	21		

were assigned by comparing percentage instead of absolute occurrence within and outside the sub-alliance; (2) species with a total frequency of 2% or less were eliminated only after adding surround occurrences. This made some species worth retaining by increasing their frequencies to over 2%. Seventeen of the original 47 species were eliminated for lack of fidelity or constancy, including no less than five dividing species out of a total of seven.

Next, the positions of the 30 species and 27 plots in the Raw Table were manipulated so that blocks of species-in-plots emerged, again without prejudgement.

6.7.3 Evaluation

The resulting Provisional Table showed only two distinct blocks of species-in-plots.

(1) The smaller block contained four plots representing the bushy vegetation of seepage steps; as *Osmitopsis asteriscoides* was the most conspicuous of the faithful species, this block was named the *Osmitopsis* Seepage Scrub Association.

(2) The larger block contained 13 plots representing the wetter Tussock Marsh in which *Elegia cuspidata* was consistently present. It was accordingly named the *Elegia cuspidata* Tussock Marsh Association.

The remaining species occurred with varying constancy both in the two associations and in the remaining ten unclassified plots. Attempts to synthesize a third association failed; there were no character species faithful to specific plots. Instead, the species formed a matrix of companions present in varying degrees throughout the sub-alliance. Habitat and vegetation data showed that at least eight of the unclassified plots comprised simpler tussock marsh assemblages and their transitions to Hillveld, while two plots (29 and 47) were anomalous.

The problem was now to decide whether to retain all unclassified plots in the Provisional Table or whether to transfer some of them to Hillveld. Accordingly, a measure of the "Moist Flats floristic element" of each plot, was sought. After lengthy trials it became clear that "Relative Richness" provided a reliable measure. For each plot, this is simply the number of Moist Flats character species present, divided by the total number of species on the plot and expressed as a percentage.

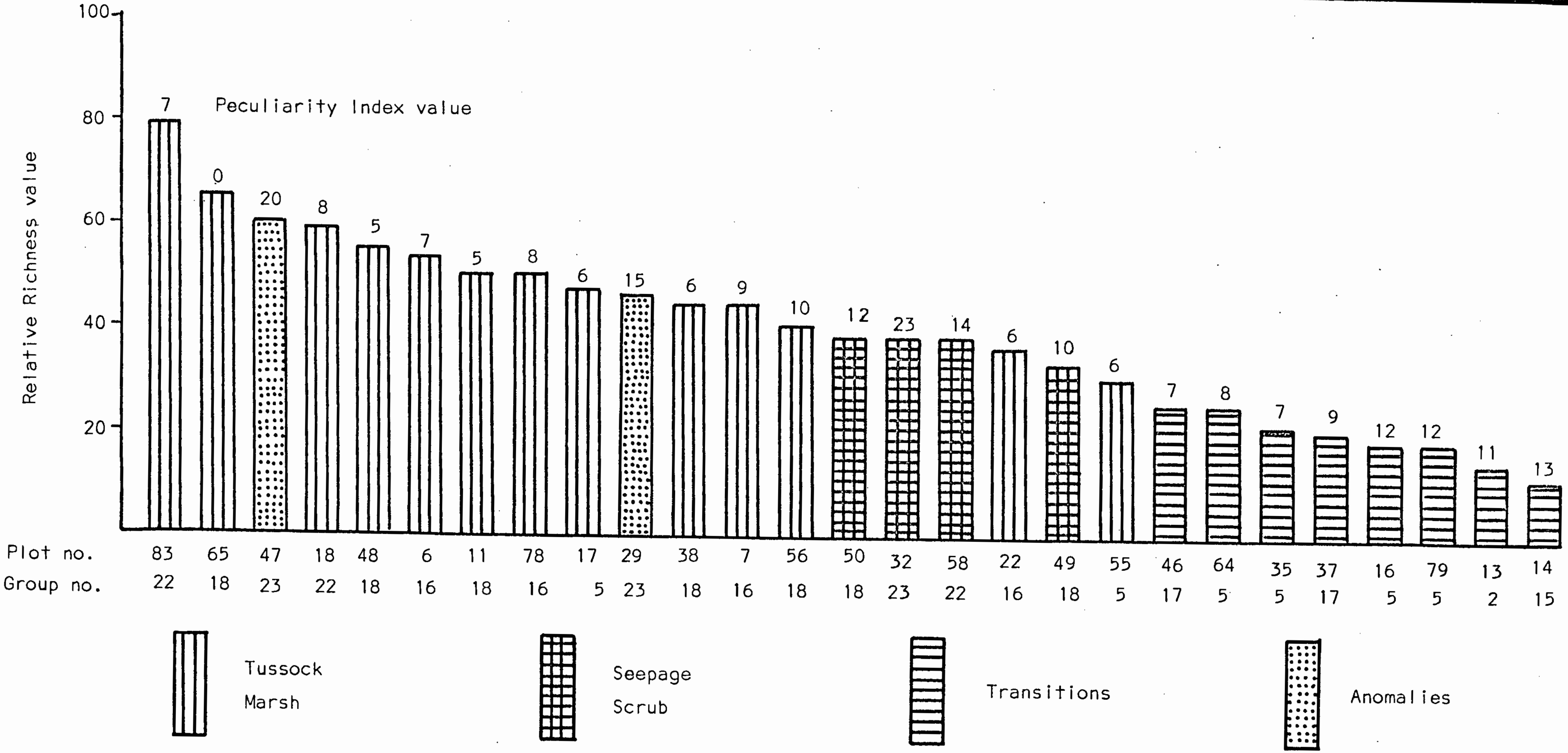
If the Relative Richness values are arranged in order in a histogram (Fig. 1) they form a smoothly descending series with Tussock Marsh at the top, Seepage Scrub in the centre and Transitions at the lower end. (Two exceptions are the anomalous plots 29 (Plate 24) and 47, both rare variations of the Seepage Scrub with very low total species composition resulting in unusually high richness values). While Relative Richness values confirmed the previous allocation of plots to associations, they did not help in deciding whether to remove some transitional plots, as there was nowhere a distinct disjunction in the series.

Provisionally, therefore, all 27 plots were retained and the standardized P.I. was computed for them all. For comparison, nine of the unclassified plots - the suspected transitions - were included in the synthesis tables for Hillveld (discussed later) and their P.I.'s computed again for the Hillveld assemblage. This gave a double value of the P.I. for each of the nine plots. A comparison of these values indicates the most suitable allocation of each plot. Tab. 11 shows that three of the plots are somewhat closer to the Hillveld concept than to Moist Flats, one is distinctly closer to Moist Flats, but five have equal affinity to both. Therefore, at least six of these plots could be included in the Moist Flats synthesis table and at least eight in the Hillveld table. However, in order to emphasize the continuity of fynbos vegetation it was decided to include all nine plots in the Final Table for Moist Flats. The total of 27 plots was thus retained.

The P.I.'s for the Moist Flats as a whole range from 0 to 23. Plots of the Tussock Marsh Association are concentrated in the lower

F I G U R E I

RELATIVE RICHNESS OF PLOTS IN MOIST FLATS SUB-ALLIANCE



values 0 to 10, showing that they approach closest to the central concept for the sub-alliance. In fact, plot 65 (Plate 21), with a value of 0 (thus having no "peculiar" or unusual species) can be regarded as the most typical member of the Moist Flats Sub-Alliance as here defined. Plots of the Seepage Scrub Association, together with the two special variations, occur mainly in the highest ranges (14 to 23) with one value of 10 and one of 12, while the simpler assemblages and transitions occupy a central position in the range 7 to 13. This fully supports field observations: Seepage Scrub is certainly very different, in both physiognomy as well as species content, from Tussock Marsh, while the transitions approach Tussock Marsh more closely.

The Final Table (App. XI) was now compiled by rearranging the sequence of plots. The most meaningful arrangement shows the true Seepage Scrub Association on the left, the Tussock Marsh Association in the centre, the simpler assemblages and transitions on the right, with the two anomalous seepage communities (plots 29 and 47), which have little except habitat in common with the true Seepage Scrub Association, on the extreme right-hand side. In this way the P.I. values, depicted as a histogram at the foot of the Final Table (App. XI), form a fairly symmetrical U-shaped curve. The fact that the P.I. values harmonize well with the synthesized associations suggests that the latter can be accepted as real and "natural" vegetation units.

The Final Table shows that the association-analysis groups are fairly scattered through the synthesized communities. This confirms some of the observations already made in the group descriptions (Chapter 5), e.g. (1) groups 5 and 17 contain mostly transitional plots; (2) group 16 is composed of typical Tussock Marsh; (3) groups 18 and 22 comprise mainly Tussock Marsh and a few plots of Seepage Scrub (both are mixed groups); (4) group 23 contains the most atypical members, as reflected by their high P.I. values.

Of the two associations shown in the Final Table, Seepage Scrub has the most faithful character species; those of Tussock Marsh tend to transgress singly into adjoining communities where they are rare, however, since they occur more often in surrounds than within plots. Indeed, the distinctions between Tussock Marsh and the simpler and transitional assemblages consist mainly of fine differences in abundance and dominance, but any stand with at least three character species can confidently be placed in the Tussock Marsh Association.

The Tussock Marsh Sub-Associations (a) and (b) were synthesized later with the assistance of drs. M.J.A. Werger. As this was done purely "at the phytosociologist's desk" without reference to the vegetation - which drs. Werger had never seen - it is of great interest to note that the two sub-associations show striking differences in floristic and habitat features, as follows:

Sub-Association (a) characterized by Ursinia tenuifolia, Prismatocarpus sessilis, Rafnia crassifolia: basically simple, low (12 in : 30 cm), one-layered Tussock Marsh in which Elegia parviflora is dominant or conspicuous and the association character species are rare or inconspicuous; recently burnt vegetation (3-4 years since last burn); seasonally moist flats or shallow depressions.

Sub-Association (b) characterized by Bobartia indica: basically complex, taller, two- or three-layered Tussock Marsh in which the association character species are common, sometimes with Leucadendron decorum dominant or conspicuous as an upper layer of 3-4 ft (c. 1 m); unburnt vegetation (10-20 years since last burn); seasonally wet marshy flats or terraces near seepage steps.

As in other cases already mentioned, cover-abundance values would have shown up the tabulated differences more plainly.

To discover whether more suitable character species could be found, a Sneath's Modulus analysis was done for each association.

TABLE 5

SNEATH'S MODULUS ANALYSIS : SEEPAGE SCRUB ASSOCIATION

Sneath's Modulus	Species	Sub-Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid. Factor
		In	Out		In	Out		
100.0	Restio compressus (C)	15	0	*	100	0	*	(100.0)
50.0	Osmitopsis asteriscoides (C)	7	0	*	50	0	*	(50.0)
66.3	Berzelia lanuginosa (C)	19	0	*	75	9	*	8.3
37.0	Erica capensis	19	0	*	50	13	*	3.8
32.6	Restio cf. pusillus	22	0	*	50	17	*	3.0
28.3	Erica bruniades	25	1	*	50	22	*	2.3
	Sp. with insufficient fidelity to the Association:							
31.5	Berzelia abrotanoides	50	0	*	75	43		
	Sp. with insufficient constancy and fidelity to the Sub-Alliance:							
82.6	Penaea mucronata	30	22		100	17	*	
	Character spp. with insufficient constancy to plots:							
20.7	Danthonia cincta (C)	8	0	*	25	4	*	6.2
20.7	Psoralea pinnata (C)	8	0	*	25	4	*	6.2
	Total no. of plots involved	27	73		4	23		

TABLE 6

SNEATH'S MODULUS ANALYSIS : TUSSOCK MARSH ASSOCIATION

Sneath's Modulus	Species	Sub-Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid. Factor
		In	Out		In	Out		
69.8	Elegia cuspidata (C)	41	0	*	77	7	*	11.0
54.4	Restio dodii (C)	33	0	*	62	7	*	8.9
33.0	Tetraria flexuosa	44	1	*	62	29	*	2.1
	Spp. with insufficient fidelity to the Association:							
41.8	Restio bifurcus	63	4	*	85	43		
34.6	Elegia parviflora	67	3	*	85	50		
26.4	Tetraria fasciata	56	10	*	69	43		
25.3	Lachnaea densiflora	41	5	*	54	29		
	Sp. with insufficient fidelity to the Sub-Alliance:							
41.2	Erica corifolia	56	33		77	36	*	
	Character sp. with insufficient constancy to plots:							
23.6	Serruria glomerata (C)	19	1	*	31	7	*	4.4
	Total no. of plots involved	27	73		13	14		

fidelity factor to over 5, which shows S. glomerata to be a good character species for the stands examined, as distinct from the plots. This condition, higher presence in surrounds than in plots, is characteristic of most rare species: they are likely to be found only when examining whole stands, not small samples. The Braun-Blanquet phytosociologists consider some of the rarer plants to be important character species because of their presumed narrow tolerance range, and the present example confirms this.

Finally, the map of the Moist Flats Sub-Alliance (Map 7) exhibits good correlation with the prime habitat factor, moisture. There is a marked concentration of plots in the central plateau and in the drainage basins both of the Schusters River (plots 6 and 7) and the Krom River with its tributaries (plots 11, 13, 14, 16, 17, 18 and 22). In contrast, the maps of the association-analysis groups (Maps 2 to 5) even at high χ^2 levels, show no such correlation with habitat.

In summary, the Moist Flat Sub-Alliance consists of two associations (Tussock Marsh and Seepage Scrub) and ten unclassified plots which represent (a) simpler assemblages similar to Tussock Marsh; (b) transitions to Hillveld; (c) specialized seepage communities. A large number of companion species occur throughout the sub-alliance. The two associations are thought to be real vegetation units because (1) their constituent plots can be arranged in a meaningful series according to their P.I.'s (2) the Sneath's Modulus test confirms the previously chosen character species (3) the mapped communities show good correlation with habitat factors.

6.8 The Hillveld Sub-Alliance

Compared with the two other vegetation units, Hillveld is extremely complex: it is far richer in species and covers a much greater range of habitats. The construction of synthesis tables was therefore a long and difficult task and it was necessary to follow the precise methods of Küchler (1967) closely.

6.8.1 Choice of plots and species

Because of this complexity and variability, all transitional plots were first excluded so as to obtain the simplest picture. Accordingly, for the Raw Table 51 plots from groups 1 - 3 and 6 - 15 were chosen. Later, transitions were tested against the original framework and some community concepts enlarged. In the Final Table, 14 transitional plots were added bringing the total to sixty-five.

The species were chosen in the usual way, but because of the larger number qualifying for selection, the final choice was made by a Sneath's Modulus test. The original 84 species of the Raw Table were reduced to only 25 in the Final Table.

6.8.2 The Tables

Since species with frequencies over 60% and under 12% are seldom of use in characterizing communities (Küchler, 1967, p.235), these were first deleted. The Frequency Table contained 59 species rearranged in descending order.

At first, despite the reduced size of the table, it was very difficult to find species with coincident distributions. It proved easier to look for coincident gaps in distribution. Also, since plots of similar richness were often alike in their species content, it proved helpful to group plots roughly into richness classes and to examine each class separately. Gradually, three groupings appeared, later named the Dry Sandflats, Dry Hillveld and Mountain Associations. When plots were rearranged to show these blocks more clearly, a fourth, later named the Western Hillveld Association, became apparent. Next, species characterizing the blocks (either by their presence or by their absence) were extracted and the order of plots rearranged in an Extract Table to improve the blocks still further.

At this point, 15 plots transitional between Hillveld/Moist Flats and Hillveld/Coast Alliance were added and a revised Extract

Table prepared to test whether the extra plots could be incorporated into the Hillveld concept. P.I.'s were calculated for all 66 plots in the new set. The paired P.I.'s obtained in this way for the transitions (Tab. 11) helped to decide which plots to retain in the Hillveld tables, as already discussed (p.126). Consequently it became plain that plot 29, having no Hillveld character species and an exceptionally high P.I. in Hillveld, should be removed. The other transitional plots were retained since all plots contained some Hillveld species and there were no great discrepancies between their paired P.I. values.

Eventually, a Final Table, incorporating the 14 newly added plots, was drawn up (App. XII). The construction of this table entailed repeated rearrangement so as to obtain the most rhythmic sequence of P.I. values while yet retaining, indeed, strengthening where possible, the community concepts already formed.

6.8.3 Pattern in species distribution

On adding surround occurrences in the Frequency Table it was noticed that some species were more often added in surrounds than others. Since surround occurrences are taken into account when synthesizing communities from the tables but are disregarded in calculating Sneath's Modulus, the character value of a species obtained by these two methods may differ considerably. To help explain these discrepancies, surround occurrences were examined in more detail.

All degrees of this plot/surround relationship exist. At one extreme are those species regularly found within the compass of the plot. In the tables, these species have no "o" symbols. In the Frequency Table, which excludes the transitions, the following species show this condition. Figures in brackets represent number of occurrences (out of a total of 51): *Thamnochortus dichotomus* (46), *Restio cincinnatus* (45), *Elegia stipularis* (42), *Tetraria microstachys* (35), *Ficinia filiformis* (29), *Amphithalea ericaefolia* (24), *Thesium virgatum* (14), *Thesium acuminatum* (13), *Senecio* triqueter (12) and Penaea fruticulosa (9).

Because the plot size of 50 square metres is always large enough to accommodate them, these species have high densities wherever they occur. Moreover, wherever absent from the plots they are also absent from the stands. Those with high constancy and fidelity are therefore efficient character species because they should be found even in small samples of the community.

On these grounds (apart from considerations of constancy and fidelity) Struthiola ciliata - the first dividing species - is not one of the most efficient species for identifying small samples. It occurs in 36 plot lists and was added in four surrounds, i.e. the plot size of 100 square metres was large enough to accommodate it in only 36 out of the 40 stands in which it occurs. Expressed relatively (36/40 x 100), S. ciliata has a "recognition value" of 90%. In contrast, Elegia stipularis, for example, has a recognition value of 100% and is, moreover, more conspicuous.

At the other extreme are species which have many "o" symbols in the tables. They are species of low density, often absent from 50 square metre plots but present when the area is increased. They have low recognition values. Table 12 shows the ten species with the lowest recognition values in the Frequency Table. Even those with the necessary constancy and fidelity will not be revealed as character species when sampling with 50 square metre plots because they are likely to be excluded from plots of this size. Despite this, many of them are large, conspicuous plants which could be useful in identifying the community as a whole.

The fact that plots were exhaustively searched for species while surround lists were somewhat perfunctorily compiled may have the effect of distorting the picture in the present case. Nevertheless the method gives scope for thorough investigation because more autecological information is needed for the interpretation of synecological problems.

TABLE 12

TEN SPECIES WITH LOWEST RECOGNITION VALUES

Species	Occurrence		Recognition Value
	Plots	Surrounds	
Mimetes hartogii	4	9	31
Rhus lucida	15	21	42
Leucospermum conocarpodendron	9	11	45
Alciope tabularis	5	6	45
Erica phylicifolia	3	3	50
Tetraria thermalis	10	9	53
Danthonia macrantha	14	12	54
Erica cerinthoides	16	13	55
Diastella serphyllifolia	16	13	55
Serruria vallaris	8	6	57

6.8.4 Evaluation

Like the two vegetation units already described, Hillveld has no discrete communities. Transitions occur in all directions between communities and even between alliances. While the Final Table (App. XII), attempts to portray this continuity to best advantage it is impossible to show all the relationships clearly in a two-dimensional diagram.

(1) The Mountain Association (Plate 9)

Criteria for this association are presence in the stand of at least three of the four character species, together with absence of most companion species, and a high P.I. (over 14). These criteria are so distinctive that they might justify the removal of this community from the Hillveld Sub-Alliance in a more detailed treatment of the vegetation.

The Sneath's Modulus analysis (Tabl. 7) shows that the first three character species have been correctly chosen; the fourth, Leucadendron salignum, lacks sufficient constancy but this is improved by addition of surround records. Of the other possible character species suggested by the Moduli, Danthonia macrantha, Leucospermum conocarpodendron and Rhus lucida are widely spaced species whose distribution pattern becomes less distinct with the addition of surround records. They are indicator species of rocky outcrops rather than character species of the Mountain Association. Knowltonia capensis, Myrsine africana and Arctotis aspera, being infrequent, were not included in the Frequency Table. The first two are members of the field layer in tall bush, the third is usually a pioneer in recently burnt stands; they are thus better classed as indicators of past fires than as character species of the Mountain Association.

The transitions to the left of this association show some similarity to the Protea lepidocarpodendron Tall Fynbos (section 4.5) which, however, was not well sampled by the grid technique. Plots 41 and 42 are of special interest. They were located within 50 yards of one another, plot 41 in long-unburnt Protea lepidocarpodendron Tall Fynbos, plot 42 in a firebelt in which the same community had been burnt about a year previously. The sample was purposely duplicated to test the effect of the fire factor. In the association-analysis, the two plots fall into two quite different groups separated in the first division of the hierarchy. In the synthesis tables they are adjacent, and no other positions are as suitable. The burnt plot (42) contains the three most common Hillveld companion species, including Struthiola ciliata, which are absent in the unburnt vegetation. This supports the conclusion reached in section 5.4.4 that presence of S. ciliata, the first dividing species, is dependent, in some circumstances, on the occurrence of fires.

The transitions to the right of the Mountain Association inter-

TABLE 7

SNEATH'S MODULUS ANALYSIS : MOUNTAIN ASSOCIATION

Sneath's Modulus	Species	Sub-Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid. Factor
		In	Out		In	Out		
60.0	Knowltonia capensis	5	0	*	60	0	*	(60.0)
76.7	Berkheya ilicina (C)	9	0	*	80	3	*	26.6
56.7	Myrsine africana	8	3	*	60	3	*	20.0
56.7	Arctotis aspera	8	3	*	60	3	*	20.0
70.7	Leucospermum conocarpodendron	15	0	*	80	10	*	8.0
50.0	Asparagus compactus	14	6	*	60	10	*	6.0
83.3	Danthonia macrantha	23	0	*	100	17	*	5.9
83.3	Clutia alaternoides (C)	23	6	*	100	17	*	5.9
48.3	Elegia juncea (C)	15	0	*	60	12	*	5.0
56.7	Rhus lucida	27	9	*	80	23	*	3.5
	<u>Sp. with insufficient fidelity to the Association:</u>							
28.3	Bobartia gladiata	33	0	*	60	32		
	<u>Spp. with insufficient constancy & fidelity to the Sub-Alliance:</u>							
60.0	Cassine barbara	5	6		60	0	*	
60.0	Ficinia ramosissima	5	14		60	0	*	
55.0	Olea capensis	9	6		60	5	*	
53.3	Anthospermum aethiopicum	31	17		80	27	*	
	<u>Character sp. with insufficient constancy to plots:</u>							
33.3	Leucadendron salignum	9	0		40	7	*	5.7
	<u>Total no. of plots involved</u>	65	35		5	60		

grade with Dry Hillveld; some plots, indeed, contain almost the full complement of the character species of both. While plots of the Mountain Association fall into the two association-analysis groups 12 and 13 (group 12 having already been described as mountain vegetation) the transitional plots comprise various groups, most of which were said to be transitional or depauperate (section 5.4.2). Plot 81, the only member of group 12 not included in the Mountain Association, is widely separated in the present classification. App. XII confirms that this plot has less affinity with mountain vegetation than any other member of its group.

(2) The Dry Hillveld Association (Plate 10)

Appendix XII shows that the core of this association comprises all plots of association-analysis group 7, described in section 5.4.2 as a distinct and homogeneous unit similar to Western Hillveld but occupying warmer and drier sites. Two of the dividing species for the group (Saltera sarcocolla and Staberoha banksii) are also character species for the association. The criterion for Dry Hillveld is presence in the stand of all character species (at least two being in the plot), together with absence of mountain species. Sneath's Modulus (Tab. 8) shows that the four chosen character species far exceed any others in character value, which lends support to the view that the association as depicted is a natural unit.

(3) The Western Hillveld Association (Plate 11)

The criterion for this association is presence in the sample plot of at least four of the five character species. The Sneath's Modulus analysis (Tab. 9) reveals a great many character species when judged by accepted criteria (constancy at least 50%, fidelity factor greater than 2). Since it would be unwieldy to include in the synthesis table such a large block of character species, those less suitable can be eliminated by arbitrarily raising the standards for qualification to, say, a constancy of over 80% and

TABLE 8

SNEATH'S MODULUS ANALYSIS : DRY HILLVELD ASSOCIATION

Sneath's Modulus	Species	Sub-Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid. Factor
		In	Out		In	Out		
93.1	Sarcocolla tetragona (C)	17	0	*	100	7	*	14.3
93.1	Staberoha banksii (C)	17	0	*	100	7	*	14.3
62.8	Tetraria thermalis (C)	15	0	*	71	9	*	7.9
73.6	Lobelia pinifolia (C)	20	3	*	86	12	*	7.2
61.6	Danthonia lanata	31	3	*	86	24	*	3.6
41.6	Erica mammosa	20	3	*	57	16	*	3.6
58.1	Bobartia gladiata	33	0	*	86	28	*	3.1
56.4	Erica plukenetii	34	6	*	86	29	*	3.0
42.1	Willdenowia lucaeana	33	0	*	71	29	*	2.4
36.9	Amphithalea ericaefolia	38	0	*	71	35	*	2.0
	Spp. with insufficient constancy & fidelity to the Sub-Alliance:							
43.3	Restio eleocharis	18	11		57	14	*	
34.7	Penaea mucronata	26	20		57	22	*	
	Total no. of plots involved	65	35		7	58		

TABLE 9

SNEATH'S MODULUS ANALYSIS : WESTERN HILLVELD ASSOCIATION

Sneath's Modulus	Species	Sub-Alliance			Association			
		Const.%		Fid. Fact. >2.0	Const.%		Fid. Fact. >2.0	Fid. Factor
		In	Out		In	Out		
	Spp. with constancy over 80% and fidelity factor over 4:							
81.7	Osteospermum polygaloides (C)	18	0	*	89	7	*	12.7
89.3	Thesium acuminatum (C)	23	6	*	100	11	*	9.1
72.8	Lobelia setacea (C)	26	11	*	89	16	*	5.6
72.8	Thesium virgatum (C)	26	11	*	89	16	*	5.6
69.2	Pentaschistis subulata	29	3	*	89	20	*	4.4
67.5	Roella ciliata (C)	31	3	*	89	21	*	4.2
67.5	Stoebe sphaerocephala	31	0	*	89	21	*	4.2
	Other spp. with constancy over 50% and fidelity factor over 2:							
52.0	Aspalathus abietina	11	0	*	56	4	*	14.0
52.0	Erepsia bracteata	11	0	*	56	4	*	14.0
48.4	Lampranthus austricolus	14	6	*	56	7	*	8.0
48.4	Lobelia comosa	14	6	*	56	7	*	8.0
56.0	Tetraria sylvatica	18	0	*	67	11	*	6.1
54.2	Senecio triquetra	20	0	*	67	13	*	5.2
44.8	Acrolophia lamellata	17	0	*	56	11	*	5.1
71.4	Metalasia cephalotes	38	0	*	100	29	*	3.4
62.1	Agathelpis dubia	34	0	*	89	27	*	3.3
45.2	Thesium spicatum	27	3	*	67	21	*	3.2
56.7	Anaxeton asperum	40	0	*	89	32	*	2.8
35.9	Lobelia coronopifolia	25	6	*	56	20	*	2.8
35.9	Rochea subulata	25	0	*	56	20	*	2.8
49.2	Corymbium scabrum	34	3	*	78	29	*	2.7
49.2	Gnidia imbricata	34	0	*	78	29	*	2.7
41.7	Liparia parva	31	0	*	67	25	*	2.7
41.7	Macrostylis villosa	31	3	*	67	25	*	2.7
32.3	Metalasia brevifolia	27	3	*	56	23	*	2.4
32.3	Cullumia setosa	27	3	*	56	23	*	2.4
42.1	Tetraria compar	42	3	*	78	36	*	2.2
28.8	Helichrysum sesamoides	31	0	*	56	27	*	2.1
	Spp. with insufficient constancy and fidelity to the Sub-Alliance:							
43.8	Erica corifolia	40	37		78	34	*	
38.1	Pentaschistis curvifolia	33	40		67	29	*	
30.6	Euphorbia tuberosa	29	17		56	25	*	
	Total no. of plots involved	65	35		9	56		

a fidelity factor of at least four. By these improved standards, the five character species chosen for the synthesis tables and only two others, Pentaschistis subulata and Stoebe sphaerocephala, prove the best.

Western Hillveld is composed, with one exception, of association-analysis groups 1 to 3 which represent mainly the rich mixed fynbos of the rocky western edge of the plateau (section 5.4.2). The exception, plot 16 (group 5), was originally placed in the Moist Flats table. Nevertheless, it not only satisfies the criteria for Western Hillveld but also fits very well geographically. Three more Moist Flats transitions, together with other representatives of groups 1 to 3, are placed in the transitional block to the right of Western Hillveld.

(4) The Dry Sandflats Association (Plate 12)

As shown by its high P.I. values, this association is rather far removed from the typical Hillveld concept. It represents an alliance-transition between the Hillveld and Coast Alliances; in fact three of its plots are better placed in the coastal synthesis table. The unit is difficult to define and characterize. The difficulty arises because widespread species which assume different roles in different conditions are used as character species. In the true Dry Sandflats Association, all character species occur consistently together and either Passerina vulgaris or Salaxis flexuosa is dominant; moreover, certain companion species are consistently absent. These conditions are found on wind blown sand, for example below the edge of the western escarpment. But the two above-mentioned character species also behave as indicators of disturbed hillveld and thus occur, singly or together, in disturbed areas outside the Dry Sandflats Association, on Table Mountain Sandstone inland. In such cases, for example in plots 28, 45, 3, 2 and 1, the usual set of companion species is generally present, together with some character species of the associations of which these plots are impoverished members (not association-transitions in the usual sense). To define the Dry Sandflats Association, therefore, three conditions, presence of all three character species, absence of the relevant companion species, and absence of most species characterizing other associations, must be fulfilled. The use of structural characteristics employed by the Zürich-Montpellier School (cover-abundance and sociability) would undoubtedly have improved the characterization of this diffuse community.

The Sneath's Modulus analysis underlines the difficulty of defining the Dry Sandflats Association. Most species listed (Tab. 10) have insufficient fidelity to the Hillveld Sub-Alliance to be used as character species for Dry Sandflats. They are mainly indicators of deep sand and for that reason are more often found in the Coast Alliance proper. Four additional species might, however, have helped to characterize Dry Sandflats: Willdenowia striata (very faithful but not very constant), Crassula nudicaulis and Disparago lasiocarpa (less faithful) and Agathosma imbricata (least faithful but more constant). Of the remainder, only the two chosen character species, Passerina vulgaris and Salaxis flexuosa, have sufficient fidelity to qualify; moreover, both are highly constant. The third chosen character species, Ficinia filiformis, though absolutely constant in the association, has insufficient fidelity to qualify.

It is noteworthy that the most sensitive indicator of disturbed hillveld, Passerina vulgaris, is absent from all plots of true Dry Hillveld and Western Hillveld in App. XII, lending support to the assertion that these are undisturbed natural associations.

(5) Ill-defined assemblages

Because they do not possess Hillveld character species, plots to the right of Dry Sandflats cannot be defined as Hillveld communities. They can nevertheless be grouped into the following assemblages showing some distinct floristic and habitat features:

(a) Plots 81, 93, 89, 95 and 20: further examples of transitions between the Hillveld Sub-Alliance and Coast Alliance (Tab. 11);

(b) Plots 53, 73 and 72: Restionaceous fynbos assemblage found at the boundary between hills and plateau;

(c) Plots 37, 64, 35 and 46: transitions between the Moist Flats and Hillveld Sub-Alliances (Tab. 11);

(d) Plots 71, 26, 62 and 88: variations of the Dry and Western Hillveld concepts.

The P.I. values of these ill-defined groupings form a steadily descending series, those for (d) being the lowest in the Synthesis Table (App. XII). Because plots with low P.I. values should represent the central concept or "core" of the unit, the (d) grouping might have been placed roughly in the centre of the Table, between Dry and Western Hillveld. In that position, however, it would have destroyed the continuity of the Dry and Western Hillveld transitions. This anomaly - that plots known to be impoverished possess the lowest P.I. values - may be rationalized as follows: impoverished plots contain the basic matrix of species common to most members of the population (i.e. the "usual" or companion species) but lack those which differentiate one community from another (i.e. the "unusual", "peculiar" or character species). If plots lack the peculiar species, their P.I.'s are <u>ipso</u> <u>facto</u> low. This emphasizes the danger of adapting the P.I., a taxonomic function, to interpret ecological data.

Lastly, the map (Map 8) again reflects the success of the synthesis. Plots of the Mountain Association and its transitions are concentrated on the peaks of the False Bay coast, with outliers on the northern boundary hills; Dry Hillveld is found as an arc northward round the central plateau; Western Hillveld occurs on the north-western hills and along the Atlantic plateau rim; and Dry Sandflats are confined to the west coast. None of the association-analysis maps show such a close relationship with habitat.

TABLE 11

COMPARISON OF STANDARDIZED PECULIARITY INDICES FOR TRANSITIONAL PLOTS

Plot No.	Standardized Peculiarity Index			Best classification
	Coast Alliance	Hillveld	Moist Flats	
13		11	11	Transition
14		11	13	Hillveld
16		8	12	Hillveld
20	15	10		Hillveld
24	13	11		Hillveld
29		23	15	Moist Flats
35		7	7	Transition
37		9	9	Transition
46		7	7	Transition
52	13	11		Hillveld
61	12	10		Hillveld
64		8	8	Transition
79		9	12	Hillveld
89	12	12		Transition
93	10	14		Coast Alliance
95	11	11		Transition
96	15	17		Coast Alliance

SUMMARY

The aim of the survey was to test whether association-analysis, which has been successfully used to classify other vegetation types in South Africa, could be meaningfully applied to the distinctive fynbos vegetation of the South-Western Cape.

The initial descriptive account of the vegetation, undertaken before the results of the association-analysis became available, recognized two formations, Fynbos and Broad-leaved Scrub. Fynbos was subdivided into two alliances, Coast and Inland, and ten associations, which could be correlated with edaphic and other habitat factors.

The association-analysis, based on 100 grid samples each 5 x 10 metres in extent, revealed 23 final groups, many of which could not be readily interpreted in terms of habitat factors. Each final group comprised between two and seven sample plots, and since the computer was programmed to stop subdivision automatically when a group was reduced to less than eight samples (this being the minimum size in which significant associations can be manifested), final groups possessed different levels of heterogeneity. In order to obtain a classification that accorded with habitat, the final groups could not be combined simply by raising the level of heterogeneity; instead, their constituent plots had to be regrouped selectively. This introduced a subjective element which was enhanced by the differential heterogeneity of the groups.

Of the 32 species subdividing the hierarchy, only 11 were restricted to specialized habitats. The remaining 21 dividing species possessed wide ecological amplitude, thus having little or no character value for natural vegetation units. Dividing species, by definition, effect the most efficient subdivision of sets of plots. In the present study, those subsets that do not represent recognizeable plant communities, may reflect the response of the vegetation to a subsidiary ecological factor such

as fire or grazing. Analysis of variance and other tests failed, however, to reveal a simple correlation. In association-analysis where the path of subdivision depends solely on presence or absence of a single dividing species at each stage, the size, location and number of samples are crucial factors in determining the classification that results. In some instances, the plots used in this survey appear to be too large to reflect a single vegetation unit, while their systematic location makes for the inclusion of many transitions. There are, in any case, too few plots to provide a picture of communities that can be accurately mapped.

To provide an independent assessment of the association-analysis, synthesis tables were constructed from the original plot data using the revised techniques of the Continental phytosociologists together with some modifications. Despite the drawbacks inherent in the data, standardized manipulation of the tables revealed blocks of plots, represented by character species, which provided a better correlation with habitats than either the final or recombined association-analysis groups.

It is concluded that, at this level of sampling intensity, the synthetic phytosociological method provides a more natural classification of fynbos communities of the Cape of Good Hope Nature Reserve than does the monothetic, subdivisive association-analysis method.

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APPENDIX I

METHODS USED IN SOIL ANALYSIS

(1) Particle size distribution

After removal of organic matter by hydrogen peroxide decomposition, silt and clay were determined by the hydrometer method. Sand fractions were separated by sieving. The following particle size-classes used by A.O.C. Technical Services (1967) were adopted:-

Coarse sand: particles 2.0 - 0.5 mm diam.
Medium sand: " 0.5 - 0.2 mm diam.
Fine sand : " 0.2 - 0.02 mm diam.
Silt : " 0.02 - 0.002 mm diam.
Clay : " less than 0.002 mm diam.

(2) Net extractable metal cations

Metal cations (Na, K, Ca and Mg) were leached from the soil with 1N ammonium acetate solution buffered at pH 7. Ca and Mg were determined in the combined leachates by titration with EDTA, and Na and K by flame photometry. Results were expressed as milli-equivalents per 100 gm of oven dry soil (me/100 gm). Total extractable cations are designated by "S".

(3) Cation Exchange Capacity (C.E.C.)

After leaching with ammonium acetate solution as described, the soil was further leached with 96% alcohol and then with 0.5 N potassium sulphate (pH 2.5). The NH_4^+ in solution was determined by distillation into boric acid. Results were expressed as milli-equivalents per 100 gm oven dry soil (me/100 gm).

(4) Soil reaction (pH)

The pH of soil paste, saturated with distilled water, was determined with a Metrohm pH meter (model E 396) using a glass electrode.

(5) Electrical resistance (R60°F)

Resistance of the same "saturated paste" was measured with a Metrohm Konduktometer E 382.

(6) Organic carbon (Org. C %)

The percentage of organic carbon was determined by sulphuric acid-dichromate decomposition (Walkey-Black method).

APPENDIX II

DESCRIPTION AND ANALYSIS OF SOIL SAMPLES

Description					Analysis													
Sample No.	Horizon	Depth (in)		Munsell colour D=Dry W=Wet	Particle size distrib. (%)					Net extractable cations (me/100 gm)					CEC.	pH	R60°F (ohms)	Org. C (%)
		Hori-zon	Free water		Sand			Silt	Clay	Na	K	Ca	Mg	"S"				
					C.	M.	F.											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	10 LONGLANDS FORM			**10-1 Witsand Group**						**10-1-0-2 Witsand Series**								
C1	Teeberg flats: broad alluvial flats of the Krom River valley with complex Tussock Marsh																	
	A_1	0-18		D10YR7/1 light grey W10YR6/1 grey	17.5	58.5	21.2	1.2	1.6	0.13	0.02	0.59	0.27	1.01	1.39	4.8	4,800	0.87
	A_2	18-36		D10YR8/2 white W10YR7/2 light grey	16.4	42.2	38.4	1.6	1.4	0.06	0.01	0.11	0.10	0.28	0.15	5.6	10,600	0.17
	B_2	36-45		D10YR5/3 brown W10YR4/3 dark brown	24.8	33.8	35.2	2.2	4.0	0.11	0.02	0.20	0.13	0.46	1.39	5.3	4,000	0.47
	C_1	45-54		D10YR8/2 white W10YR7/2 light grey	29.0	32.6	31.8	2.4	4.2	0.09	0.01	0.08	0.12	0.30	1.10	5.3	4,400	0.12
	C_2	54-75		D10YR8/2 white W10YR8/3 v.pale brown	18.0	24.8	31.2	14.0	12.0							4.5	1,800	0.12
	C_3	75↓		Weakly cemented material														
E4	Brightwater road turn off: Moist terrace below seepage step with Restionaceous Tussock Marsh																	
	A_1	0-?		D10YR6/1 grey W10YR4/1 dark grey	4.7	53.7	38.5	0.4	2.7	0.29	0.03	0.54	0.46	1.32	2.83	3.9	900	1.46
	A_2	(26)	26	D10YR6/1 grey W10YR5/1 grey	4.6	48.4	43.8	2.2	1.0	0.16	0.01	0.15	0.14	0.46	0.30	4.7		0.21
	B_2h	?-38		D5YR3/1 v. dark grey W5YR2/2 dark redbrown	5.7	47.5	41.1	1.7	4.0	0.36	0.01	0.98	1.24	2.59	15.10	4.4		3.90
	B	38↓		Weakly cemented ortstein														
F4	Near Old Main Gate: Depression in plateau with Restionaceous Plateau Fynbos																	

F4 Near Old Main Gate: Depression in plateau with Restionaceous Plateau Fynbos

A_1	0-12		D10YR6/1 grey W10YR5/1 grey	27.2	61.5	8.7	1.6	1.0	0.10	0.01	0.73	0.21	1.05	1.82	4.5	4,900	0.78
A_3	12-15		D10YR7/1 light grey W10YR5/1 grey	24.0	65.8	7.2	2.4	0.6	0.07	0.01	0.25	0.14	0.47	0.56	4.6	6,700	0.26
B_{2h}	15-45	36	D7.5YR5/2 brown W7.5YR4/2 brown	23.8	59.2	11.8	3.2	2.0	0.12	0.01	0.11	0.06	0.30	1.01			0.44
B_{2hl}	(48)		D7.5YR6/2 pink-grey W7.5YR4/2 brown	23.0	54.8	13.6	4.8	3.8	0.17	0.01	0.11	0.09	0.38	1.31			0.31
C_1	-60		D10YR8/2 white W10YR8/3 v. pale brown	6.2	54.2	28.6	5.8	5.2	0.14	0.01	0.13	0.07	0.35		4.6	2,200	0.07
C_2	60↓		Weakly cemented material														

10-1-0-3 Sandvlei Series

L2 Rooikrans Quarry: broad ridge with Protea lepidocarpodendron Tall Fynbos

A_1	0-6		D10YR5/3 brown W10YR3/3 dark brown	9.4	43.8	41.0	3.2	2.6	0.35	0.10	2.02	0.88	3.35	5.98	5.2	1,400	2.82
A_2	6-18		D7.5YR6/4 light brown W7.5YR4/4 brown	33.2	31.0	31.8	1.6	2.4							5.8	4,800	0.30
B_2irh	18-20		D7.5YR3/2 dark brown W7.5YR2/0 black	43.3	22.4	27.1	6.1	1.1	0.84	0.08	1.34	1.08	3.34	8.24	6.2	1,800	2.24
B_2ir	20-50		D10YR8/6 yellow W10YR6/6 brown-yellow	57.6	9.0	16.3	7.9	9.2	1.22	0.10	1.34	1.19	3.85	5.02			0.85

12 CARTREF FORM

12-0-0-2 Cartref Series

B5 Platboom Rd. Windmill: small pan with Elegia parviflora Tussock Marsh

A_1	0-?		D10YR7/1 light grey W10YR5/1 grey	12.5	54.5	29.8	2.2	1.0	0.18	0.03	1.92	0.70	2.83	3.51	5.1	4,800	1.26
A_{12}	(24)		D10YR7/1 light grey W10YR5/1 grey	10.6	54.0	34.2	0.4	0.8							4.8	12,000	0.31
A_2	?-42		D2.5Y 8/0 white W10YR7/1 light grey	8.4	52.8	37.4	0.2	1.2	0.05	0.004	0.08	0.00	0.13	<0.15	5.6	21,900	0.03

E2 Gifkommetjie Road: depression in plateau with Elegia parviflora Tussock Marsh

A_1	0-6		D10YR5/1 grey W10YR3/1 v. dark grey	7.5	61.6	29.3	1.0	0.6	0.35	0.03	0.63	0.51	1.52	3.51	3.9		1.86
A_{21}	6-12		D10YR7/1 light grey W10YR6/1 grey	6.6	59.6	30.8	2.0	1.0							4.8		0.18
A_{22}	12-52	24	D10YR8/1 white W10YR7/1 light grey	8.4	60.0	30.4	1.0	0.2	0.13	0.01	0.10	0.06	0.30	<0.15	5.4	2,900	0.04
R	52↓																

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	13 MISPAH FORM			13-0 Acid, non-humic Group					13-0-01 Moeras Series, shallow phase									
A2	Kanonkop:			rocky hills with rich Upland Mixed Fynbos														
	A_1	0-2		D10YR6/1 grey W10YR3/1 v. dark grey	11.9	56.0	28.3	2.6	1.2	0.25	0.05	2.11	0.78	3.19	7.45	4.7	3,500	3.32
	R	2↓																
				13-0 Non-humic Group					13-0-0-1 Moeras Series, deeper neutral phase									
G1	Springholsgat:			Table Mountain Sandstone coastal shelf with Coast-shelf Fynbos														
	A_1	0-18		D10YR7/1 light grey W10YR6/1 grey	11.0	71.8	14.5	0.0	2.7							6.3	2,100	0.91
	C	18-21		D10YR7/1 light grey W10YR6/1 grey	10.0	69.4	18.4	1.0	1.2	0.16	0.02	2.17	0.53	2.88	2.48	6.2	2,400	0.78
	R	21↓																
				13-0 Alkaline, non-humic Group					13-0-0-1 De Hoop Series, shallow calcareous phase									
G3	Platboom Point:			shelly marine terrace with grassy var. of Coast-shelf Fynbos														
	A_1	0-?		D10YR7/1 light grey W10YR5/1 grey	48.3	23.9	16.5	3.9	7.4							8.0	800	2.20
	C/A_2	?-9		D10YR7/1 light grey W10YR6/1 grey	53.4	25.0	12.6	3.2	5.8	0.98	0.09	Free lime			3.44	8.1	500	1.65
	R	9↓																
	14 FERNWOOD FORM			14-1 Maputa Group					14-1-0-2 Fernwood Series									
B1	Teeberg Slopes:			sandy hills/valley transition with Ifloga-Petalacte Dune Fynbos														
	A_1	0-12		D10YR6/2 light brown-grey W10YR5/2 grey-brown	18.7	51.0	27.5	1.2	1.6							5.6	5,400	1.00
	C_1	12-27		D10YR6/3 pale brown W10YR5/3 brown	22.0	52.0	23.0	1.0	2.0	0.08	0.02	0.55	0.27	0.92	1.04	5.8	7,700	0.12
	C_2	27↓																
B2	North of Klein Rondevlei:			Lower slopes of escarpment with Ifloga-Petalacte Dune Fynbos														

C_2	27↓															

B2 North of Klein Rondevlei: Lower slopes of escarpment with Ifloga-Petalacte Dune Fynbos

A_1	0-12	D10YR7/1 light grey W10YR6/1 grey	5.3	48.1	43.6	1.8	1.2							5.0	4,400	1.10
C_1	12-54	D5YR7/1 light grey W10YR6/1 grey	4.8	48.8	44.8	1.2	0.4	0.07	0.01	0.25	0.13	0.46	0.46	5.0	13,000	0.19
C_2	54↓	D2.5Y8/0 white W10YR8/1 white	13.2	42.2	43.6	1.0	0.0							5.0	11,000	0.02

K1 Ribboksdam: deep local windblown sand-patch with Thamnochortus erectus Dune Fynbos

A_1	0-?	D2.5Y8/0 white W10YR7/1 light grey	11.4	56.2	29.8	1.6	1.0							4.8	3,200	0.26
C_1	?-54	D10YR8/1 white W10YR7/1 light grey	14.0	47.2	35.8	2.0	1.0	0.06	0.01	0.16	0.09	0.32	<0.15	6.2		0.03
C_2	54↓	Loose, stoney														

14-2 Langebaan Group

14-2-0-2 Langebaan Series, humic calcareous variant

G2 Olifantsbos Point: coastal dunes with woody var. of Coast-shelf Fynbos

A_1	0-?	D10YR8/1 white W10YR6/1 grey	18.9	66.4	7.4	2.0	5.3							7.8	440	2.86
C_1	?-54	D7.5YR8/0 white W10YR8/1 white	33.8	63.0	1.2	1.0	1.0	0.34	0.02	Free lime			<0.15	8.7	3,000	0.04
C_2	54↓															

14-2-0-2 Langebaan Series, calcareous variant

J3 Rietveld: Inland dune with Thamnochortus erectus Dune Fynbos

A_1	0-?	D10YR5/1 grey W10YR3/1 v. dark grey	1.4	69.7	24.3	1.0	3.6	0.23	0.03	Free lime			2.00	8.1	1,700	0.73
C_1	?-60	D10YR7/1 light grey W10YR6/2 lt. brown-grey	1.0	71.6	22.6	2.8	2.0	0.20	0.02	Free lime			<0.15			0.15
C_2	60↓															

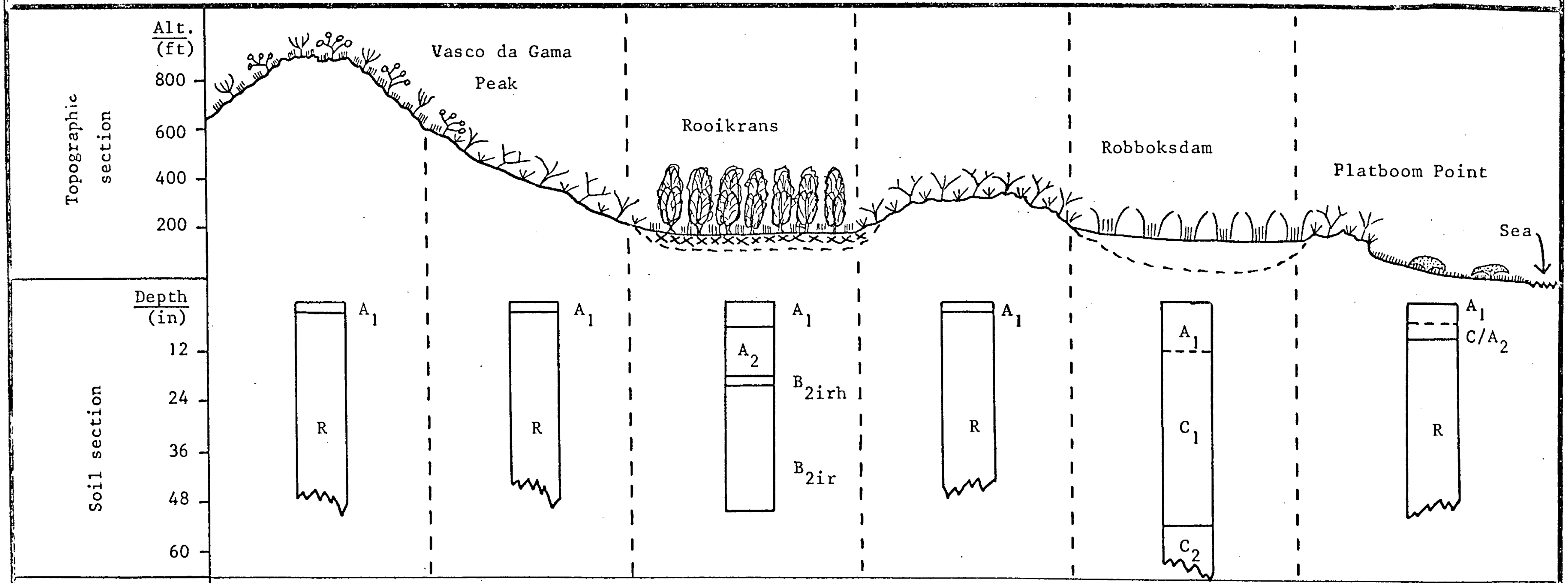
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	14-2-0-2 Langebaan Series																	
K2	Bloubergstrand: Coastal sandflats with Thamnochortus erectus Dune Fynbos containing coastal elements																	
	A_{11}	0-?		D5YR5/1 grey W5YR4/1 dark grey	1.6	63.6	33.4	0.4	1.0							6.0	1,700	0.85
	A_{12}	?-18		D5YR5/1 grey W5YR4/1 dark grey	2.4	67.6	27.0	2.0	1.0	0.17	0.02	1.39	0.25	1.83	1.36	6.6	1,400	0.81
	C	18↓																
	14 FERNWOOD FORM (sample data insufficient for series classification)																	
H1	Krom River dunes: sandy coastal dunes with Littoral Mixed Fynbos																	
	O	0-1		D10YR2/1 black W10YR2/1 black														18.28

Note: Where horizon depth was not recorded, depth of base of sample is given (in brackets).

APPENDIX III

DIAGRAM OF RELATIONSHIPS BETWEEN VEGETATION, TOPOGRAPHY AND SOILS

(1) SOUTHERN MOUNTAINS TO COAST

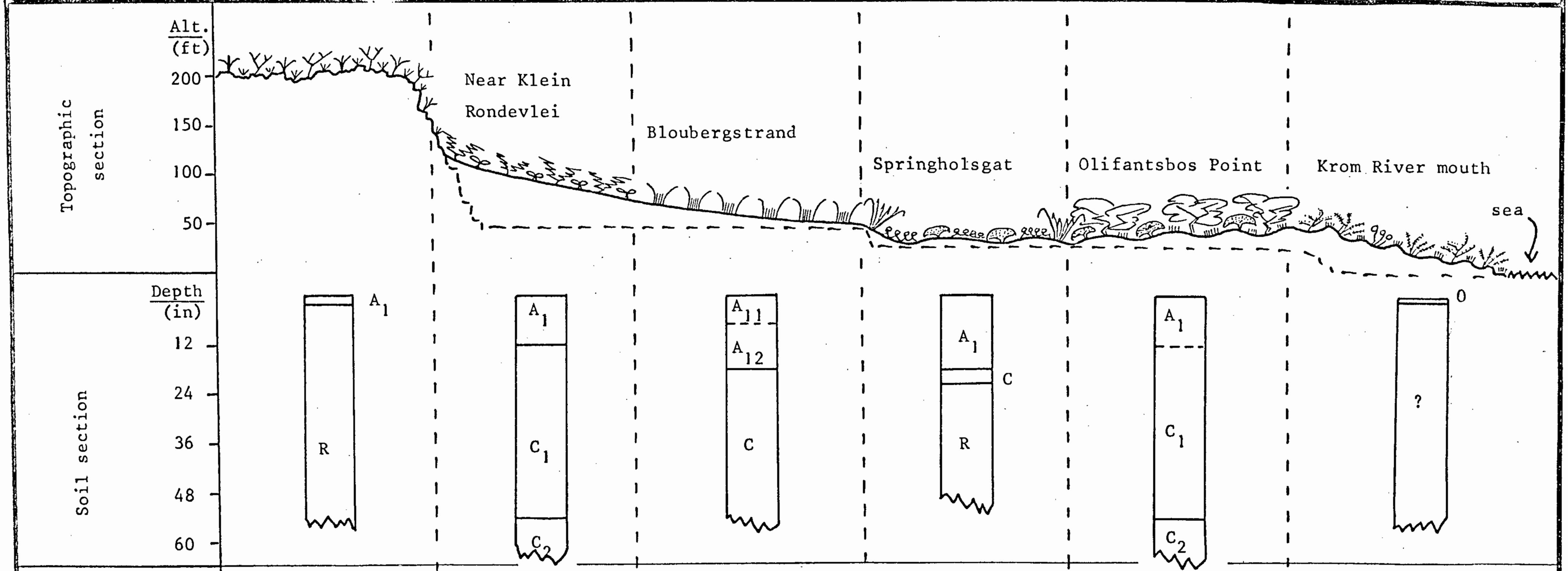


Plant community	Upland Mxd. Fynbos (Mountain var.)	Upland Mxd.Fynbos	Protea lepido. Tall Fynbos	Upland Mxd.Fynbos	Thamno. erectus Dune Fynbos	Coast-shelf Fynbos (grassy var.)
Landform	Mountains over 600 ft.	Lower rocky slopes	Broad level ridge	Rocky hills	Inland marine sandflats	Shelly marine terrace
Soil series	Moeras (shallow)	Moeras (shallow)	Sandvlei	Moeras (shallow)	Fernwood	De Hoop
Soil sample no.	A2	A2	L2	A2	K1	G3

APPENDIX III

DIAGRAM OF RELATIONSHIPS BETWEEN VEGETATION, TOPOGRAPHY AND SOILS

(2) WESTERN ESCARPMENT TO COAST

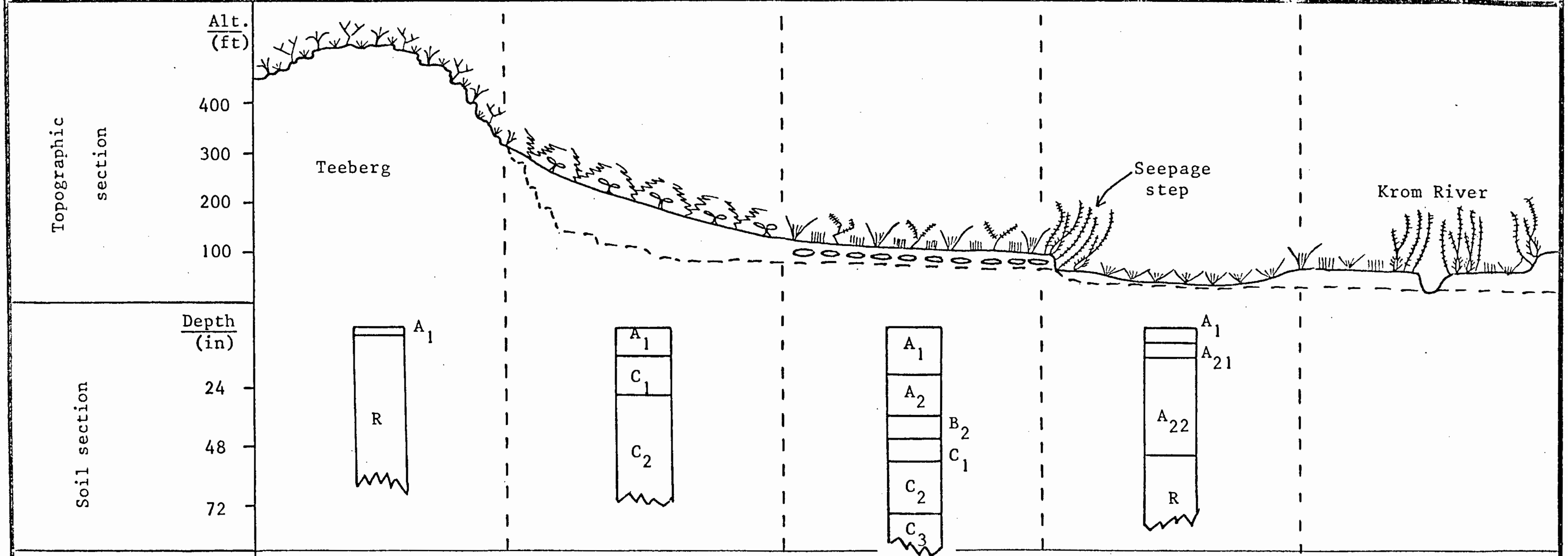


Plant community	Upland Mxd. Fynbos	Ifloga-Petalacte Dune Fynbos	Thamno. erectus Dune Fynbos	Coast-shelf Fynbos	Woody var. of Coast-shelf Fynbos	Littoral Dune Mixed Fynbos
Landform	Escarpment	Deep sand on lower slopes	Upper marine terrace	Lower marine terrace	Dunes near coast	Littoral dunes
Soil series	Moeras (shallow)	Fernwood	Langebaan	Moeras (deeper)	L'baan (hum. calc.)	(Fernwood Form)
Soil sample no.	A2	B2	K2	G1	G2	H1

APPENDIX III

DIAGRAM OF RELATIONSHIPS BETWEEN VEGETATION, TOPOGRAPHY AND SOILS

(3) HILLS TO RIVER VALLEYS

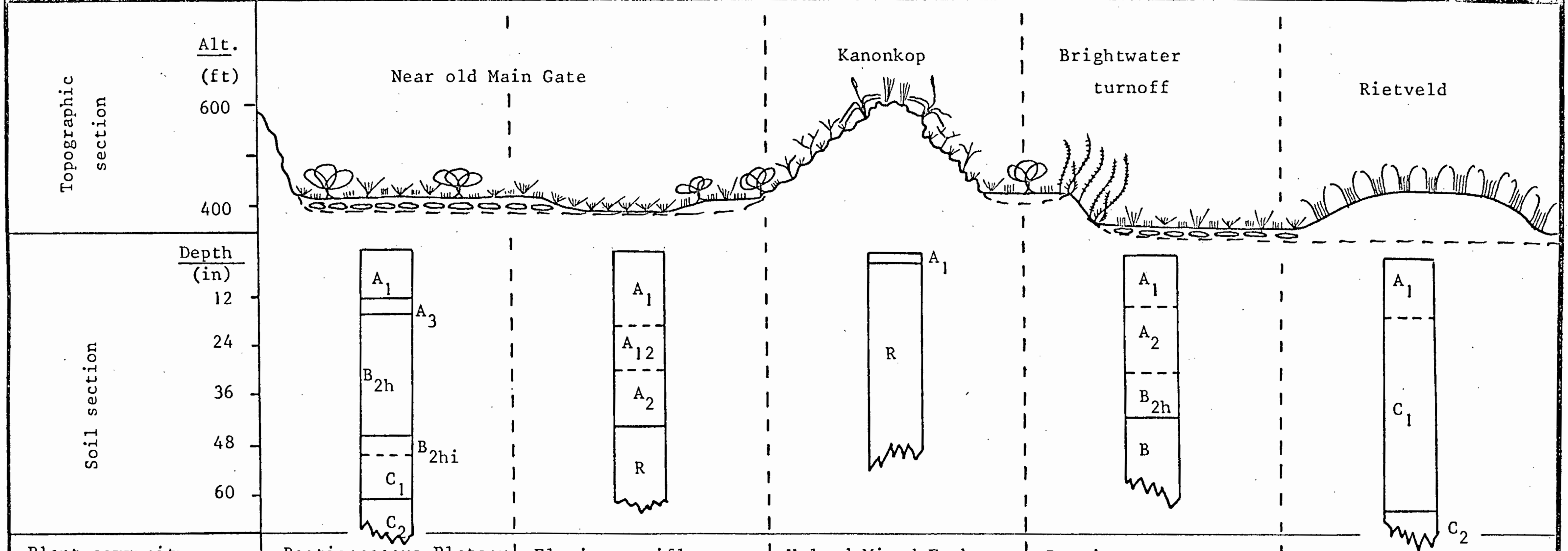


Plant community	Upland Mxd. Fynbos	*Ifloga-Petalacte* Dune Fynbos	Complex Tussock Marsh	*Elegia parviflora* Tussock Marsh	*Berzelia-Osmitopsis*
Landform	Rocky hills	Deep-sand slopes	Alluvial flats	Depression	River banks
Soil series	Moeras (shallow)	Fernwood	Witsand	Cartref	-
Soil sample no.	A2	B1	C1	E2	-

APPENDIX III

DIAGRAM OF RELATIONSHIPS BETWEEN VEGETATION, TOPOGRAPHY AND SOILS

(4) CENTRAL PLATEAU



Plant community	Restionaceous Plateau Fynbos	*Elegia parviflora* Tussock Marsh	Upland Mixed Fynbos (dry var.)	Restionaceous Tussock Marsh	*Thamno. erectus* Dune Fynbos
Landform	Plateau	Plateau-pan	Rocky Hills	Moist terrace below seepage step	Inland dune
Soil series	Witsand	Cartref	Moeras (shallow)	Witsand	L'baan (calc. var.)
Soil sample no.	F4	B5	A2	E4	J3

APPENDIX IV

SYSTEMATIC LIST OF SPECIES ENCOUNTERED IN THE PRESENT SURVEY

Specimens of my collections are housed in the Government Herbarium, Stellenbosch, with duplicates where available in the National Herbarium, Pretoria, and the Guthrie Herbarium, University of Cape Town. Numbers before species-names are code-numbers of the species encountered in the association-analysis plots. Species with the same number, being indistinguishable in the vegetative condition, have been treated as one taxon in the association-analysis. Species without numbers are mentioned in the text but not used in the association-analysis. An asterisk (*) indicates an alien species mentioned in the text.

Most determinations have been done by the Government Herbarium, Stellenbosch or the National Herbarium, Pretoria. Names in Adamson and Salter's (1950) "Flora of the Cape Peninsula" have been accepted except where superseded by published revisions.

PTERIDOPHYTA

POLYPODIACEAE

326. Pteridium aquilinum (L.) Kuhn

GYMNOSPERMAE

PINACEAE

*Pinus pinaster Ait.

ANGIOSPERMAE : MONOCOTYLEDONS

GRAMINEAE

Agropyrum distichum (Thunb.) Beauv.

Ammophila arenaria (L.) Link

94. Cymbopogon marginatus Stapf

93. Cynodon dactylon (L.) Pers.

98. Danthonia cincta Schrad.

99. D. lanata Schrad.

100, 295. D.macrantha Schrad.

109. Ehrharta bulbosa Sm.

110. Ehrharta ramosa Thunb. var. aphylla Gluckmann
111. E. rehmanii Stapf
461. E. villosa (L.f.) Schult.f.
481. Festuca scabra Vahl
182. Gram. sp. indet.
476. Imperata cylindrica (Lam.) Beauv.
223. Lasiochloa longifolia (Schrad.) Kunth
*Lolium rigidum Gaud.
285. Pentaschistis angustifolia (Nees) Stapf
*Paspalum dilatatum Poir.
*P. urvillei Steud.
286. P. aspera (Thunb.) Stapf
287. P. aurea (Steud.) McClean
290. P. colorata (Steud.) Stapf
288. P. curvifolia (Schrad.) Stapf
289. P. aff. curvifolia (woolly sheaths)
291. P. steudelii (Nees) McClean (= Afrachneria capensis (Steud.) Adamson)
292. P. subulifolia Stapf
293. P. thunbergii (Kunth) Stapf
294. P. sp. indet.
296. Pentameris macrocalycina (Steud.) Schweick.
306. Plagiochloa uniolae (L.f.) Adamson & Sprague
380. Sporobolus virginicus Kunth
387. Stenotaphrum secundatum (Walt.) Kuntze
Themeda triandra Forsk.

CYPERACEAE

97. Cyp. sp.indet.
452. Cyperus thunbergii Vahl
119. Epischoenus quadrangularis (Boeck.) C.B.Cl.
152. Ficinia anceps Nees
153. F. argyropa Nees
154. F. bracteata Boeck.
155. F. bulbosa (L.) Nees
156. F. composita (Nees) Nees
157. F. deusta (Berg.) Levyns
158. F. filiformis (Lam.) Schrad.
160. F. lateralis (Vahl) Kunth
162. F. paradoxa (Schrad.) Nees
163. F. pinguior C.B.Cl.
164. F. ramosissima Kunth
165. F. rigida Levyns
166. F. secunda (Vahl) Kunth
168. F. striata (Thunb.) Kunth (= F. indica (Lam.) Pfeiffer) (= F. capitella (Thunb.) Nees)
170. F. tenuifolia Kunth
171. F. zeyheri Boeck.
167. F. sp. indet.
363. Scirpus ecklonii Steud.
475. S. membranaceus Thunb.
364. S. nodosus Rottb.
83. Tetraria brevicaulis C.B.Cl.
402. T. bromoides (Lam.) Pfeiffer
403. T. capillacea (Thunb.)C.B.Cl.
404. T. compar (L.) Lestib.
405. T. cuspidata (Rottb.) C.B.Cl.
406. T. eximia C.B. Cl.
407. T. fasciata (Rottb.) C.B.Cl.
463. T. fimbriolata (Nees) C.B.Cl.
408. T. flexuosa (Thunb.) C.B.Cl.
409. T. microstachys (Vahl)Pfeiffer
410. T. punctoria C.B. Cl. (= Neesenbeckia punctoria (Vahl) Levyns)
411. T. pygmaea Levyns
412. T. sylvatica (Nees) C.B.Cl.
413. T. thermalis (L.) C.B.Cl.
414. T. ustulata (L.) C.B.Cl.

ARACEAE

460. Zantedeschia aethiopica (L.) Spreng.

RESTIONACEAE

59. Chondropetalum hookerianum (Mast.) Pillans
60. C. microcarpum (Kunth) Pillans
61. C. nudum Rottb.
C. tectorum (L.f.) Pillans
113. Elegia cuspidata Mast.
112. E. juncea L.
114. E. neesii Mast.
115. E. parviflora Kunth
116. E. stipularis Mast.
470. E. thyrsiflora (Rottb.) Pers.
117. E. vaginulata Mast.
206. Hypodiscus alboaristatus (Nees) Mast.
207. H. aristatus (Thunb.) Nees
208. H. willdenowianus (Nees) Mast.
209. Hypolaena digitata (Thunb.) Pillans
226. Leptocarpus fruticosus Mast.
227. L. gracilis (Mast.) Pillans
478. L. membranaceus Pillans
228. L. vimineus (Rottb.)Pillans
329. Restion. sp. indet.
330. Restio ambiguus Mast.
331. R. bifurcus Nees
333. R. cincinnatus Mast.
332. R. compressus Rottb.
334. R. cuspidatus Thunb.
335. R. dodii Pillans
336. R. egregius Hochst.
337. R. eleocharis Nees
R. cf. pusillus Pillans
339. R. quinquefarius Nees
340. R. tenuissimus Kunth
456. R. sp. indet.
383. Staberoha banksii Pillans
384. S. cernua (L.f.) Dur. & Schinz
385. S. distachya (Rottb.) Kunth
415. Thamnochortus dichotomus (Rottb.) R. Br.
416. T. erectus (Thunb.) Mast.
418. T. fraternus Pillans
417. T. fruticosus Berg.
T. spicigerus (Thunb.) R. Br.
440. Willdenowia humilis Mast.
441. W. lucaeana Kunth
442. W. striata Thunb.
443. W. teres Thunb.
453. W. sp. indet.

JUNCACEAE

216. Juncus kraussii Hochst.

LILIACEAE

462. Asparagus aethiopicus L.
37. A. capensis L.
36. A. compactus Salter
A. stipulaceus Lam.
A. thunbergianus Schult.

HAEMODORACEAE

103. Dilatris corymbosa Berg.
103. D. pillansii Barker

IRIDACEAE

19. Aristea africana (L.) Hoffmg.
119. A. glauca Klatt
20. A. thyrsiflora (DelaR.) N.E.Br.
42. Bobartia filiformis (L.f.) Ker
43. B. gladiata (L.f.) Ker
44. B. indica L.
437. Watsonia pyramidata (Andr.) Stapf
439. W. tabularis Mathews & L. Bol. var. concolor Lewis

ORCHIDACEAE

1. Acrolophia lamellata (Lindl.) Schltr. & Bol.

ANGIOSPERMAE : DICOTYLEDONS

MYRICACEAE

465. Myrica cordifolia L.
265. M. quercifolia L.
267. M. serrata Lam.

URTICACEAE

Australina lanceolata (Thunb.) N.E. Br.

PROTEACEAE

102. Diastella serpyllifolia Knight
229. Leucadendron adscendens R. Br.
230. L. decorum R. Br.
L. macowanii Phillips
231. L. sabulosum Salter
232. L. salignum R. Br.
233. Leucospermum conocarpodendron (L.) Buek (= L. conocarpum R. Br.)
234. L. hypophyllocarpodendron (L.) Druce (= L. hypophyllum R. Br.)
256. Mimetes hartogii R. Br.
319. Protea acaulis Thunb.
P. arborea Houtt. (= P. grandiflora Thunb.)
321. P. cynaroides L.
322. P. lepidocarpodendron L.
P. scolymocephala Reich.
374. Serruria foeniculacea R. Br.
375. S. glomerata R. Br.
376. S. vallaris Knight
457. S. sp. indet.

SANTALACEAE

78. Colpoon compressum Berg. (= Osyris compressa (Berg.) A.DC.)
420. Thesidium hirtum Sond.
421. Thesium acuminatum A.W. Hill
422. T. aggregatum A.W. Hill
423. T. carinatum A.DC.
424. T. funale L.
425. T. nigromontanum Sond.
426. T. spicatum L.
427. T. strictum Berg.
428. T. viridifolium Levyns
429. T. virgatum Lam.

LORANTHACEAE

434. Viscum capense Thunb.

CHENOPODIACEAE

149. Exomis microphylla (Thunb.) Aell. var. axyroides Aell.
(= E. axyroides Fenzl)

AIZOACEAE

448. Aizoon paniculatum L.
48. Carpobrotus acinaciformis (L.) L. Bol.
108. Drosanthemum candens (Haw.) Schwant.
120. Erepsia bracteata (Ait.) L. Bol.
220. Lampranthus austricolus (L. Bol.) L. Bol.
221. L. bicolor (L.) N.E. Br.
252. L. promontorii (L. Bol.) N.E. Br.
222. L. spp. indet.
251. Mesembryanthemae spp. indet.
314. Pharnaceum cordifolium L.
315. P. lanatum Bartl.
308. Polpoda capensis Presl.
357. Ruschia sarmentosa (Haw.) Schwant.
401. Tetragonia fruticosa L.

CARYOPHYLLACEAE

203. Herniaria arenicola Adamson
377. Silene burchellii Otth ex DC.
378. S. sp. indet.
379. Spergularia marginata (DC.) Kitt.

RANUNCULACEAE

218. Knowltonia capensis (L.) Huth.

MENISPERMACEAE

15. Antizoma capensis (Thunb.) Diels

LAURACEAE

51. Cassytha ciliolata Nees

CRUCIFERAE

193. Heliophila incana Ait.
194. H. linearis (Thunb.) DC. var. linearifolia (Burch. ex DC.) Marais (= H. elongata (Thunb.) DC.)
195. H. scoparia Burch. ex DC.

DROSERACEAE

Drosera curviscapa Salter

CRASSULACEAE

Cotyledon grandiflora Burm.f.
C. orbiculata L.
84. Crassula cymosa L.
85. C. flava L.
86. C. lycopodioides Lam.
87. C. nudicaulis L.
88. C. ramosa Thunb.
482. Rochea coccinea (L.) DC.
355. R. subulata (L.) Adamson

SAXIFRAGACEAE

Montinia caryophyllacea Thunb.

BRUNIACEAE

40. Berzelia abrotanoides Brongn.
41. B. lanuginosa Brongn.
381. Staavia radiata Dahl

ROSACEAE

65. Cliffortia atrata Weim.
66. C. falcata L.f.
67. C. ferruginea L.f.
68. C. filifolia L.f.
449. C. glauca Weim.
69. C. obcordata L.f.
70. C. polygonifolia L.
71. C. ruscifolia L.
72. C. stricta Weim.
73. C. subsetacea Diels ex Bol. & Wolley-Dod
466. C. spp. indet.

LEGUMINOSAE

*Acacia cyanophylla Lindl.
*A. cyclops A. Cunn.
*A. longifolia Willd.
9. Amphithalia ericaefolia (L.) Eckl. & Zeyh.
18. Argyrolobium filiforme (Thunb.) Eckl. & Zeyh.
21. Aspalathus abietina Thunb.
22. A. argyrella MacOwan
23. A. callosa L.
33. A. capensis (Walp.) R.Dahlgr. (= A. sarcodes (Vog.) Walp.)
24. A. carnosa Berg.
480. A. chenopoda L.
25. A. divaricata Thunb.
26. A. ericifolia L.
27. A. hispida Thunb. (= A. thymifolius L.)
28. A. laricifolia Berg. ssp. canescens (L.) Dahlgr.
30. A. linguiloba R. Dahlgr.
31. A. microphylla DC. (= A. divaricatus Thunb. var. microphyllus (DC.) Harv.)
32. A. retroflexa L.
35. A. sericea Berg. (= A. linifolius Steud.)
34. A. serpens R. Dahlgr. (= A. suffruticosus DC.)
473. Aspalathus spp. indet.
Dolichos gibbosus Thunb.
150. Fagelia bituminosa (L.) DC.
211. Indigofera angustifolia L.
212. I. brachystachya E. Mey.
I. filifolia Thunb.
213. I. glomerata E. Mey.
479. I. mauretanica (L.) Thunb.
214. I. sarmentosa L.f.
224. Lebeckia meyeriana Eckl. & Zeyh.
241. Liparia parva Vog. ex Walp.
*Ornithopus sativus Brot.
Psoralea aphylla L.
323. P. asarina (Berg.) Salter
324. P. fruticans (L.) Druce
455. P. imbricata (L.) Salter
464. P. laxa Salter
458. P. pinnata L.
325. P. repens L.
328. Rafnia crassifolia Harv.
347. Rhynchosia ferrulaefolia Benth. ex Harv.
*Trifolium fragiferum L.
*T. subterraneum L.

GERANIACEAE

174. Geranium incanum L.
279. Pelargonium betulinum (L.)Ait.
280. P. capitatum (L.) Ait.
281. P. cucullatum (L.) Ait.
P. gibbosum (L.) Ait.
278. P. myrrhifolium (L.) Ait.
282. P. tabulare (L.) L'Hérit.

LINACEAE

240. Linum africanum L.
240. L. thunbergii Eckl. & Zeyh.

ZYGOPHYLLACEAE

445. Zygophyllum flexuosum Eckl. & Zeyh.
446. Z. procumbens Adamson
446. Z. spinosum L.

RUTACEAE

2. Adenandra umbellata Willd.
4. Agathosma ciliaris (L.) Druce
5. A. hookeri Sond.
6. A. imbricata (L.) Willd.
4. A. lanceolata (L.) Engler
77. Coleonema album Bartl.
104. Diosma hirsuta L.
105. D. oppositifolia L.
248. Macrostylis villosa Sond.

POLYGALACEAE

259. Mundia spinosa (L.) DC.
260. Muraltia acipetala Harv.
261. M. demissa Wolley-Dod
263. M. rosmarinifolia Levyns
264. M. thunbergii Eckl. & Zeyh. (= M. phylicoides (Thunb.) DC.)
450. M. spp. indet.
309. Polygala bracteolata L.
310. P. garcini DC.
311. P. myrtifolia L.
312. P. recognita Chod.

EUPHORBIACEAE

3. Adenocline ovalifolia Turcz.
74. Clutia alaternoides L.
75. C. ericoides Thunb.
76. C. polygonoides L.
Euphorbia caput-medusae L.
145. E. erythrina Link
146. E. genistoides Berg.
147. E. tuberosa L.
225. Leidesia obtusata (Thunb.) Müll. Arg.

ANACARDIACEAE

342. Rhus glauca Desf.
343. R. lucida L.
344. R. mucronata Thunb.
345. R. rosmarinifolia Vahl
R. tomentosa L.

CELASTRACEAE

49. Cassine barbara L.
50. C. maritima (Bol.) L. Bol.
250. Maurocenia frangularia Mill.
Maytenus heterophylla (Eckl. & Zeyh.) N. Robson (= Gymnosporia buxifolia (L.) Szysz.)
327. Pterocelastrus tricuspidatus (Lam.) Sond.

RHAMNACEAE

301. Phylica buxifolia L.
302. P. ericoides L.
303. P. imberbis Berg.
304. P. parviflora Berg.
305. P. stipularis L.

STERCULIACEAE

199. Hermannia cuneifolia Jacq.
201. H. trifoliata L.

FRANKENIACEAE

471. Frankenia hirsuta L.

PENAEACEAE

283. Penaea fruticulosa L.f.
284. P. mucronata L.
361. Saltera sarcocolla (L.) Bullock

THYMELAEACEAE

89. Cryptadenia grandiflora (L.f.) Meisn.
178. Gnidia imbricata L.f.
179. G. pinifolia L.
180. G. viridis Berg.
219. Lachnaea densiflora Meisn.
275. Passerina ericoides L.
276. P. paleacea Wikstrom
277. P. vulgaris Thoday
394. Struthiola ciliata (L.) Lam.
395. S. dodecandra (L.) Druce
396. S. salteri Levyns
474. S. striata Lam.

HALORRHAGIDACEAE

467. Laurembergia repens Berg.

ARALIACEAE

92. Cussonia thyrsiflora Thunb.

UMBELLIFERAE

16. Apium graveolens L.
53. Centella affinis (Eckl. & Zeyh.) Adamson (= C. glabrata L. var. affinis (Eckl. & Zeyh.) Adamson)
54. C. bupleurifolia (Rich.) Adamson
54. C. glabrata L.
477. C. macrocarpa (Rich.) Adamson
55. C. tridentata (L.f.) Domin
181. Cnidium suffruticosum (Berg.) Cham. & Schlechtd.
177. Glia gummifera (L.) Sond.
202. Hermas villosa (L.) Thunb.

Peucedanum sieberianum Sond.

ERICACEAE

257. Blaeria ericoides L.
121. Erica blancheana L. Bol.
122. E. bruniades L.
123. E. calycina L.
124. E. capensis Salter
125. E. capillaris Bartl.
126. E. cerinthoides L.
127. E. clavisepala Guth. & Bol.
128. E. coarctata Wendl.
129. E. coccinea L.
130. E. corifolia L.
E. eburnea Salter
132. E. imbricata L.
133. E. mammosa L.
124. E. laeta Bartl. var. incisa Bolus
134. E. multumbellifera Berg.
135. E. obliqua Thunb.
136. E. parviflora L.
137. E. phylicifolia Salisb.
138. E. plukenetii L.
139. E. pulchella Houtt.
140. E. subdivaricata Berg.
454. E. spp. indet.
257. Minor Ericaceous genera indet.
Philippia chamissonis Kl.
300. P. leeana Kl.
358. Salaxis flexuosa Kl.
365. Scyphogyne muscosa (Ait.) Druce
257. Simocheilus depressus (Licht.) Benth.
257. Sympieza labialis (Salisb.) Druce
257. Syndesmanthus articulatus (L.) Kl.

MYRSINACEAE

266. Myrsine africana L.

PRIMULACEAE

Samolus porosus Thunb.
360. S. valerandi L.

PLUMBAGINACEAE

238. Limonium scabrum (Thunb.) Kuntze

SAPOTACEAE

46. Sideroxylon inerme L. (= Calvaria inermis (L.) Dubard)

EBENACEAE

356. Diospyros glabra (L.) de Winter (= Royena glabra L.)
144. Euclea racemosa Murr.

OLEACEAE

239. Linociera foveolata (E. Mey.) Knobl.
Olea africana Mill.
268. Olea capensis L. subsp. capensis
269. O. exasperata Jacq. (= O. humilis Eckl.)

GENTIANACEAE

56. Chironia baccifera L.
57. C. decumbens Levyns
58. C. emarginata Jarosz

Orphium frutescens (L.) E. Mey.

433. Villarsia ovata (L.f.) Vent.

ASCLEPIADACEAE

Astephanus neglectus Schltr.

95. Cynanchum obtusifolium L.f.
96. C. africanum R. Br.

CONVOLVULACEAE

151. Falkia repens L.f.

BORAGINACEAE

246. Lobostemon fruticosus (L.) Buck.
246. L. montanus (DC.) Buck.

VERBENACEAE

Chascanum cernuum (L.) E. Mey. (= Bouchea cernua (L.) Schauer)

388. Stilbe ericoides L.
468. S. vestita Berg.

LABIATAE

359. Salvia aurea L.

SOLANACEAE

Solanum sp.

SCROPHULARIACEAE

249. Manulea tomentosa L.
397. Sutera hispida (Thunb.) Druce
398. S. lychnidea (L.) Hiern
444. Zaluzianskya dentata (Benth.) Walp.

SELAGINACEAE

447. Agathelpis dubia (L.) Hutch.
366. Selago dregei Rolfe
367. S. scabrida Thunb.
368. S. serrata Berg.

Selago spuria L.

LENTIBULARIACEAE

Utricularia capensis Spreng.

PLANTAGINACEAE

307. Plantago carnosa Lam.

185. Helichrysum crassifolium (L.) D. Don
186. H. crispum (L.) D. Don
187. H. cymosum (L.) D. Don
188. H. metalasioides DC.
189. H. maritimum (L.) D. Don ex G. Don
190. H. orbiculare (Thunb.) Druce
191. H. sesamoides (L.) Willd.
192. H. vestitum (L.) Schrank.
196. Helipterum canescens (L.) DC.
197. H. gnaphaloides (L.) DC.
198. H. speciosissimum (L.) DC.
205. Hippia pilosa (Berg.) Druce
210. Ifloga seriphioides (Berg.) Bol. & Wolley-Dod
472. Leontonyx glomeratus (L.) DC.
253. Metalasia brevifolia (Lam.) Levyns
254. M. cephalotes (Thunb.) Less.
254. M. divergens (Thunb.) Don (= M. cephalotes (Thunb.) Less.)
255. M. muricata (L.) Don
270. Osmitopsis asteriscoides (L.) Cass.
272. Osteospermum polygaloides L.
Othonna arborescens L.
~~O. carnosa~~
273. O. quinquedentata Thunb.
298. Petalacte coronata (L.) D. Don
313. Phaenocoma prolifera (L.) D. Don
369. Senecio arnicaeflorus DC.
370. S. burchellii DC.
371. S. paniculatus Berg.
372. S. pubigerus L.
373. S. triqueter Less.
371. S. umbellatus L.
390. Stoebe plumosa (L.) Thunb.
391. S. rosea Wolley-Dod
392. S. sphaerocephala Schltr.
393. S. sp. indet.
399. Tarchonanthus camphoratus L.
Ursinia ciliaris (DC.) N.E.Br.
430. U. crithmoides (Berg.) Poir.
431. U. tenuifolia (L.) Poir.

APPENDIX V

FIELD DATA SHEET :

BOTANICAL SURVEY OF THE CAPE OF GOOD HOPE NATURE RESERVE

PLOT NO.: POSITION /

LOCALITY:

DATE/REFS:

PHOTOS:

DIRECTIONS

MAP & PHOTO

VEGETATION DATA

	Individuals in 200 yd radius		
1. ALIENS: Species	12"	1'-6'	> 6'

2. NOTES (Dominance, life-form, height, crown-cover, post-burn period):

SITE DATA

1. Altitude, Aspect, Slope:
2. S.E. Cloud:
3. Stoniness:
4. Soil moisture:
5. Soil texture, geology:
6. General:

APPENDIX VII

SUMMARY OF PLOT CHARACTERISTICS

Plot No.	No. of spp. per plot	Post burn period(yrs)	Stoniness		Soil Moisture Index	Sub-stratum	Soil	Habitat	Vegetation	Altitude (ft)	Aspect	Slope (degrees)	Community Designation	
			Class	%									Initial Survey (Chapter 4)	Phytosociological Analysis (Chapter 6)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
									GROUP 1					
8	83	3	0	0	1	T	Coarse white with quartz pebbles	Slope, locally without rocks (exceptional)	Restionaceae-ericoid shrubs with scattered Proteaceae; cf. 45(1)	350	SW	7	Upland Mixed Fynbos	Western Hillveld
9	77	3	3	18	1	"	"	Rocky slope	As for 8; slightly depauperate	415	SE	4	"	"
44	59	7	2	5	1	"	"	"	As for 8	180	S	4	"	(Western Hillveld)
45	53	9	5	4	1	"	"	"	"	260	SW	1	"	Western Hillveld/ Dry Hillveld
75	76	1	3	10	1	"	"	"	" Cf. 87(2)	120	SSW	1	"	Western Hillveld
76	65	1	3	15	1	"	"	"	As for 8; slightly moister, cooler (<u>Elegia juncea</u>); cf. 75(1)	300	W	7	"	"
									GROUP 2					
13	44	5	0	0	3	T	Deep sand, little humus	Level sandy flats	Restionaceae-ericoid shrubs with scattered Proteaceae; transition	140	-	0	Upland Mixed Fynbos/ Tussock Marsh	(Western Hillveld)+ (Tussock Marsh)
15	66	3	0	0	1	"	Coarse white sand	"	As for 13	50	-	0	Upland Mixed Fynbos, flats variety	(Western Hillveld)
82	74	1	0	0	3	"	Deep sand, "peat" below	"	As for 13 but few shrubs; cf. 87(2)	300	-	0	Upland Mixed Fynbos/ Tussock Marsh	Western Hillveld
87	71	1	0	0	1	"	"	"	As for 13 but few shrubs, many annuals	250	-	0	Upland Mixed Fynbos, flats variety	Western Hillveld
									GROUP 3					
3	68	7	3,4	23	1	T	Coarse white with quartz pebbles	Rocky slope	Depauperate var. of group 1	250	-	0	(Upland Mixed Fynbos)	(Western Hillveld)
5	59	3	2,3	50	1	"	"	"	As for group 1	400	N	7	(Upland Mixed Fynbos)	Western Hillveld

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
									GROUP 3 (contd.)					
10	75	2	3	3	1	T	Fine brown with ferricrete pebbles	Pebbly lower slope	Atypical Rest.-Gram. with Pseudo-Sav., Tall Fynbos & coastal elements	280	NNE	9	Upland Mixed Fynbos with Tall Fynbos elements	(Mountain)
12	66	3	3,5	27	1	"	Medium white over fine grey	Level bedrock terrace on lower slope	Restionaceae-*Aspalathus*-*Thesium* spp.	100	-	0	(Upland Mixed Fynbos)	Western Hillveld
42	54	1	3	10	1	"	Fine brown with ferricrete pebbles	Rocky slope	Newly regenerating shrubs, annuals and grasses. Young stage of 41(13)	550	NE	16	Tall Fynbos, early regen. stage	(Mountain)
88	23	10+	3,5	80	1	"	Medium white over fine grey	Bedrock outcrop on low koppie	Low bushy heath of Minor Ericaceae; cf.54(8); 71(9)	300	SW	1	Upland Mixed Fynbos, Ericaceous var.	(Hillveld)
									GROUP 4					
20	48	13	0	0	1	T	Coarse white sand with quartz fragments	Level sandy terrace	Straggly shrubs (*Salaxis flexuosa* domt.) + open Restionaceous groundlayer	185	N	2	Plateau Fynbos with sand-patch elements	(Dry sandflats)+ Dune Fynbos
24	46	4	0	0	1	"	"	Sandy dune-like slope	Low ericoid shrubs, mixed	300	N	6	Dune Mixed Fynbos & Inland elements	Dry sandflats + Dune Fynbos
61	48	7	0	0	1	"	"	Coastplain sandflats	Heathy flats with low Restionaceous patches; cf. 86(19), more heathy	70	SW	3	Coast Alliance with Inland elements	Dry sandflats + Dune Fynbos
92	39	24	0	0	1	"	"	Level section of dune-like hill	Open *Eriocephalus* groundlayer with scattered *Thamnochortus erectus* tufts	180	SSW	9	Dune Mixed Fynbos	Dune Fynbos
									GROUP 5					
16	51	3	0	0	2	T	Medium white over fine grey sand	Upper river terrace	Restionaceae, sedges & grasses of moist flats, with ericoid shrubs	75	-	0	Upland Mixed Fynbos/ Tussock Marsh	Western Hillveld + (Tussock Marsh)
17	32	3	0	0	3	"	"	"	As for 16 with *Elegia cuspidata*	75	-	0	Tussock Marsh	Tussock Marsh
35	43	12	0	0	2	"	"	Central plateau	As for 16	250	-	0	Plateau Fynbos	(Tussock Marsh) + (Hillveld)
55	33	14	0	0	3	"	"	"	As for 17 (*Elegia parviflora* locally dominant)	325	-	0	Plateau Fynbos	Tussock Marsh
64	36	14	3	1	2	"	"	Central plateau with local rock outcrop	Ecotone: Moist Flats Restionaceae + bushy heath on rock outcrop	370	-	0	Plateau Fynbos + (Upland Mxd. Fynbos)	(Tussock Marsh) + (Hillveld)
79	57	20+	3	15	1	"	"	Cool slope exposed to moist cool wind	Low upland shrubs + Restionaceae, grasses, sedges; not the same as 16	450	S	9	Upland Mxd.Fynbos, Restionaceous var.	(Western Hillveld)+ (Tussock Marsh)

GROUP 6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
67	49	20+	4	40	1	T	Medium fine with little iron over fine grey	Rocky ridge at base of mountain	Mixed ericoid shrubs + Restionaceae-sedges (*Staberoha banksii*, *Hypolaena digitata* present)	550	N	9	Upland Mixed Fynbos with mountain elements	Mountain/Dry Hillveld
74	39	20+	4,5	40	2-5	"	Medium fine over fine grey with humus	Cool steep slope exposed to moist, cold wind	Dense shrubs + few mountain Restionaceae e.g. *Elegia juncea*	500	SW	28	Upland Mixed Fynbos, mountain variety	(Mountain)
98	48	20	3	49	1,2	"	Fine grey over humus; iron admixed	Mountain summit with rock outcrop	Rather stunted tall Proteaceae (*P. lepidocarpodendron*) + mountain Restionaceae	1060	SSW	8	Tall Fynbos/Upland Mixed Fynbos, mountain variety	Mountain/Dry Hillveld

GROUP 7

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
27	51	19	3	20	1	T	Medium coarse white over grey	Rock outcrop on central plateau	Xeric Restionaceae (*Staberoha banksii*) and straggly *Ericaceae* (*Salaxis flexuosa*)	270	-	0	Upland Mixed Fynbos, dry variety	Dry Hillveld
30	51	18	3	7	1	"	"	Sandy corridor between rock outcrops	Moribund xeric Restionaceae-Ericaceae with sandy elements (*Petalacte*); open	350	-	0	"	"
31	51	11	3,4	60	1	"	Fine white over grey with much humus	Rock outcrop on gentle ridge	As for 27 but heaths lower & denser + sedges (*Tetraria thermalis*)	600	-	0	"	"
34	47	13	3	50	1	"	Medium fine with dark organic matter	Rock outcrop on central plateau	As for 31	230	SSW	2	"	"
39	51	21+	3	22	1	"	Fine with much humus	Steep slope of high rocky ridge	Xeric Restionaceae, Ericaceae & tall Proteaceae (*Leucadendron decorum* 4'), all dense	500	SW	15	"	"
57	31	21	3	23	1	"	Coarse white	Rock outcrop on central plateau	As for 31	375	-	0	"	"
66	40	16+	1,3	50	1	"	Medium coarse with humus	Isolated rocky slope	As for 31, with *Aspal. capensis* 5', locally dominant in parts	550	W	16	"	"

GROUP 8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
40	36	11	0	0	1	T	Deep fine sand, slight yellow-brown tinge (iron?)	Mountain terrace near nek	Specialised Restionaceae-protea veld: *Hypolaena digitata*, *Elegia stipularis*, *Protea lepidocarpodendron*	750	NE	6	Tall Fynbos	(Mountain)
54	35	14	0	0	1	"	Coarse white over grey	Gentle slope near rock outcrop; bedrock close beneath	Low bushy heath of minor Ericaceae cf. 71(9); 88(3)	250	W	1	Upland Mixed Fynbos, Ericaceous variety	(Dry Hillveld)

GROUP 9

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
26	39	12	3	8	1	T	Medium fine white over grey	Rock outcrop on central plateau	Restionaceae-Ericaceae-Protea mixture, c. 2'	220	-	0	Upland Mixed Fynbos/ Plateau Fynbos	(Hillveld)
36	42	14	3	6	1	"	Coarse white over grey	Part rock ridge; part sand over bedrock	Straggy *Salaxis* domt. 3', dry Restionaceae-Ericaceae sparse; depauperate	315	-	0	(Upland Mixed Fynbos)	Dry Hillveld/ Western Hillveld
71	35	12	3	15	1	"	"	Low rock outcrop on plateau; bedrock close below	Low bushy heath of Minor Ericaceae cf. 54(8): 88(3)	375	-	0	Upland Mixed Fynbos, Ericaceous variety	(Hillveld)
84	33	10	0	0	1	"	"	Ridge: locally sand over bedrock	Remnant dry Restionaceae invaded by *Salaxis*-domtd. heath 2', depauperate	400	NNE	2	*Elegia*-*Salaxis* Fynbos	(Dry Hillveld)

GROUP 10

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21	37	15	3	15	1	T	Medium coarse white over grey	Rock outcrop along upper river terrace	Restionaceae + straggly *Salaxis* + *L. decorum*, open	100	-	0	(Plateau Fynbos)	(Dry Hillveld)
28	38	21	1,3	6	1	"	Medium fine white	Rock terrace above river	As for 21, moribund	260	N	8	(Plateau Fynbos)	"
59	41	15	2-4	40	1	"	Medium coarse white over grey	Rock outcrop at base of mountain	Dry Restionaceae-Ericaceae + *L. decorum*	575	N	6	(Upland Mixed Fynbos)	(Dry Hillveld)/ (Mountain)
62	26	19	3	4	1	"	Coarse white with quartz fragments	Sandy plateau	Restionaceae - *L. decorum* + Proteaceous small trees (*Mimetes hartogii*)	270	W	2	"	(Hillveld)
63	38	19	0	0	1	"	Coarse white over grey	Sandy plateau; bedrock close	Depauperate Restionaceae-straggly Ericaceae (*Salaxis* 4')	300	-	0	"	(Dry Hillveld)

GROUP 11

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	52	8	3,5	43	1	T	Coarse white with quartz fragments	Rocky slope	Impoverished Restionaceae-Ericaceae with scattered Proteaceae & straggly ericoids	125	N	7	(Upland Mixed Fynbos)	(Western Hillveld)
2	48	5+	5	30	1	"	"	Level bedrock terrace on rocky ridge	As for 1	150	N	6	"	"
52	46	7	0	0	1	"	Coarse white, probably transported	Sandy coastal shelf	Low mixed Restionaceae-Ericaceae + sand elements e.g. *Phylica stipularis*	40	S	1	Coast/Inland	Dry sandflats + (Dune Fynbos)
70	65	2	0	0	1	M	Fine greyish dune sand, rounded grains: wind-blown	Inland undulating dune	*Thamnochortus erectus* + low matted shrubs mainly dune spp.	325	SW	3	*Thamnochortus erectus* Dune Fynbos	Inland Dune Fynbos

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								GROUP 12						
81	44	17	3	10	2	T	Fine grey with humus	Cool slope at base of coastal escarpment	Scattered tall Proteaceous bushes 8' with mixed Restionaceae-grass-ericoid field layer	140	S	26	Upland Mixed Fynbos, mountain variety	(Dry Sandflats)
96	48	20	4	5	2	"	"	Cool mountain slope	Dense scleroph. shrubs with woody bushes 6' (e.g. Tarchonanthus, Cassine)	400	SSW	25	"	Mountain
100	60	2	3,4	60	1	"	Coarse white with dark humus below	Mtn. summit exposed to cool moist winds	Mtn. Restionaceae-grass with few low ericoids & soft mesophylls	860	Var.	1	"	"
								GROUP 13						
23	25	15	5	60	1	T	Bedrock outcrop with dark humus pockets	Near summit of rocky hill	Tall scleroph. shrubs (e.g. Phylica buxifolia 6') with scattered Restionaceae & undergrowth	440	NE	16	Upland Mixed Fynbos, mountain variety	Mountain
41	15	20	1	20	1	"	Fine beige humus-rich with brown iron pebbles; leaf-mould	Rocky slope	Protea lepidocarpodendron 8' domt., with specialised moribund field layer	530	NE	15	Tall Fynbos	"
94	28	17	0	0	1	M	Fine grey (with humus) above calcrete	Calcrete dune facing cool SE wind off sea	Dense specialised Restionaceous-ericoid field layer with scattered Leucadendron sabulosum 3'	250	SE	1	Dwarf Dune Mixed Fynbos	Inland Dune Fynbos
95	28	20	0	0	1	T	Coarse white	Gentle sandy slope from low rocky ridge	Moribund Restionaceae-Ericaceae with emergent ericoids; woody shrubs invading	150	NE	4	Inland/Coast	(Dry Sandflats)+ (Dune Fynbos/Coast Scrub)
99	36	1	3,4	77	1	"	Medium fine grey (ash) with iron fragments	Rocky mountain summit	Young grass-Restionaceae regeneration + geophytes, annuals & biennials	1200	Level + E	0 + 14	Upland Mixed Fynbos, mountain variety	Mountain
								GROUP 14						
51	36	15	3	37	1	T	Course white with quartz fragments; grey below	Rock outcrop on top of low koppie	Xeric Restionaceae-Ericaceae cf. group 7	475	Var.	2	Upland Mixed Fynbos, dry variety	(Dry Hillveld)
53	40	20	0	0	1-2	"	Coarse white over grey hard "peat"	Gentle slope above stream	Mainly Restionaceae with few Ericaceae & spreading shrubs (Diastella)	150	S	1	Upland Mixed Fynbos Restionaceous var.	(Hillveld)
72	34	25	0	0	1	"	Coarse white over grey	Gentle slope at base of rock ridge	Mainly Restionaceae with scattered emergent ericoids & mesophylls; cf. 79(5)	430	SW	3	"	"
73	42	1.+	0	0	1	"	"	"	cf. 72(14) but with straggly ericoids, no mesophylls	575	SW	6	"	"

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GROUP 15														
4	30	18	0	0	1	T	Coarse white, probably transported	Sandy coastal shelf	*Metalasia muricata* 3', domt., sparse undercover of ericoids & special Restionaceae	20	-	0	(Coastal-shelf Fynbos)/ (*Metalasia-Passerina* Fynbos)	Dry Sandflats
14	45	3	5	6	3	"	Coarse white over grey	Along streamlet on upper river terrace; bedrock close beneath	Restionaceae-sedge-grass of moist sites + scattered shrubs	220	S	4	(Tussock Marsh)/ (Upland Mixed Fynbos)	(Western Hillveld)+ (Tussock Marsh)
19	27	17+	0	0	1	"	Coarse white, probably transported	Sandy coastal shelf	As for 4, with *Salaxis* co-domt. with *Metalasia*	30	-	0	(Coast-shelf Fynbos)/(*Metalasia-Passerina* Fynbos)	Dry Sandflats
GROUP 16														
6	30	3	0	0	3	T	Medium fine white over grey	River flats	Moist Restionaceae markedly domt. 2': scattered ericoids and Proteaceae emergent	175	-	0	Tussock Marsh	Tussock Marsh
7	34	4	0	0	3	"	Fine, black below	River terrace	As for 6 but denser low, tufted ericoids	250	-	0	"	"
22	33	20	0	0	2	"	Medium fine, humus below	Plateau above seepage step	Moist Restionaceae dominating field layer, conspicuous *L. decorum* 4'	190	-	0	Plateau Fynbos	"
78	24	5+	0	0	4	"	Medium fine, humus below	Terrace between seepage steps	Moist Restionaceae with few ericoid shrubs 12"	375	-	0	Tussock Marsh	"
GROUP 17														
37	35	25	5	5	1	T	Coarse white with quartz fragments	Terrace above river	Mixed Restionaceae mainly moist, with conspicuous *L. decorum* 3'	200	-	0	Plateau Fynbos	(Hillveld) + (Tussock Marsh)
46	28	15	0	0	2	"	Medium coarse white over grey humus	Terrace above central flats	cf. 37 but moister Restionaceae	275	-	0	Tussock Marsh/ Upland Mixed Fynbos	(Tussock Marsh) + (Hillveld)
GROUP 18														
11	22	3	0	0	3	T	Medium fine grey above black humified sand	Lower river flats	Low Restionaceae of moist flats (*El. parviflora* domt.) with scattered nanophylls	20	-	0	Tussock Marsh	Tussock Marsh
38	18	12	0	0	4	"	"	Narrow depression between low ridges on central plateau	Low moist Restionaceae-sedges with scattered *L. decorum* emergent 3'	280	-	0	Plateau Fynbos	"
48	22	10	0	0	4	"	"	Flats on central plateau	Low moist Restionaceae + tufted *El. cuspidata* 3' plus moist leptophylls	275	-	0	Tussock Marsh	"

GROUP 18 (contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
49	21	18	0	0	3	T	Coarse white, partly water-transported	Eroded stream verge & bank, central plateau	Mixed moist Restionaceae-shrubs 4' with low bushy ericoids 12"	375	-	0	Seepage Scrub/ (Plateau Fynbos)	Seepage Scrub
50	24	8	0	0	3	"	Medium fine white over grey	Seepage step between terraces	Moist bushy & slender shrubs 4' with few Restionaceae & sedges in field layer	430	S	1	Seepage Scrub	"
56	20	14	0	0	4	"	Thin layer fine white over black	Flats on central plateau	*El. cuspidata* 3'6" domt., field layer of moist low tufted Restionaceae	300	-	0	Tussock Marsh	Tussock Marsh
65	20	15	0	0	4	"	Fine grey over black boggy mud	Flats below seepage step, central plateau	Moist Restionaceae: *El. parviflora* & *El. cuspidata* locally domt.	400	-	0	"	"

GROUP 19

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
69	35	4	0	0	1	T	Rather fine, windblown	Dry sandy hummock in stream flats; western scarp	*Thamnochortus erectus* domt. 3'6", openings between with sparse creeping sub-shrubs	225	S	1	*Thamnochortus erectus* Dune Fynbos	Inland Dune Fynbos
77	24	13	0	0	1	"	Medium fine white over grey	Sandy plateau near inland dune	Waist-high shrubs-Restionaceae of inland dunes with moribund lower ericoids	380	-	0	"	"
86	50	2	0	0	1	"	Coarse white, probably transported	Sandy coastal shelf	Mixed sand Restionaceae, grasses & low shrubs with bare openings	40	S	1	Do./Coast shelf Fynbos	Dune Fynbos
89	24	15	3	6	1	"	Coarse white over grey	Sandy slopes near calcrete ridge	Tall ericoid shrubs, *Passerina vulgaris* and *Metalasia muricata* domt.	270	NNE	4	*Metalasia-Passerina* Fynbos	Dune Fynbos + (Dry Sandflats)
93	29	20+	0	0	1	"	"	Sandy flats of southern plateau	Low rhizomatous Restionaceae-sedge field layer, few taller woody shrubs	225	-	0	"	"

GROUP 20

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
25	14	30+	0	0	2	M	Fine grey dune sand with shell fragments & humus	Depression in coastal shelf, near vlei	Coastal woody scrub with sparse sand-loving Restionaceae, sedges & grasses	20	E	1	*Sideroxylon* Scrub	Coast Scrub
33	21	30+	0	0	1	"	"	Littoral dune	Coastal woody scrub with *Metalasia* domt. on seaward edge	15	-	0	"	"
68	26	3	0	0	1	"	"	"	Coastal woody scrub recently burnt: openings with annuals & sprouts	20	SW	5	"	"
85	36	30+	0	0	1	"	"	Littoral sandy slope	Dense coastal scrub patches; openings with coastal ericoids (e.g. *Phylica ericoides*)	70	-	0	"	Coast Scrub/ Dune Fynbos

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GROUP 20 (contd.)														
90	22	30+	0	0	1	M	Fine grey dune sand with shell fragments & humus	Littoral sandy shelf	Stunted caostal scrub remnant with coastal ericoids (e.g. *Passerina ericoides*)	20	NE	6	*Sideroxylon* Scrub	Coast Scrub
GROUP 21														
60	16	++	3	30	1	T	Mauve-brown rock debris + organic matter (birds?)	Rock ledges above False Bay	Sparse salt-loving hardy shrubs, mainly succulent, procumbent	40	E	34	Semi-succulent var. of Coast Alliance	Rocky Littoral
80	24	++	3	55	1	"	Coarse white sand	Sloping shelf above rocky littoral	Mostly creeping plants: littoral grasses, sedges, succulents	10	ESE	16	"	"
97	7	++	3	50	1	"	Fine grey-brown sand with iron admixed	Talus scree above rocky littoral	*Diplopappus fruticosus* domt. + low shrubs & succulents	20	NE	25	"	"
GROUP 22														
18	22	3	0	0	3	T	Medium fine white over grey	Lower river terrace	Dense tufted low moist Restionaceae (*El. parviflora* domt.) with few ericoid forbs; cf. 11(18)	125	-	0	Tussock Marsh, simple variety	Tussock Marsh
58	21	19	0	0	4	"	Fine grey over black silt	Seepage zone, edge of marshy flats	Bushy *Berzelia*, *L. decorum* 6', moist Restionaceae, sedges & shrubs 2'-3'; cf. 50(18)	450	-	0	Seepage Scrub	Seepage Scrub
83	14	10	0	0	4	"	Black silt	Marshy flats	Low moist Restionaceae with many low ericoid shrubs; cf. 7(16)	375	-	0	Tussock Marsh, complex variety	Tussock Marsh
GROUP 23														
29	13	10+	2-3	1	3	T	Medium fine grey with much humus	Flats below seepage step on central plateau	*Psoralea pinnata* savannah 4'-8' with Restionaceae & grasses (*Pentaschistis*) beneath	240	-	0	Seepage Scrub, *Psoralea* variety	(Seepage Scrub)
32	13	10	0	0	5	"	Much dark semi-decomposed litter	Streamside seepage zone	Tall dense lanky streamside shrubs 12'-15', incl. endemic *Leucadendron macowanii*	450	-	0	Seepage Scrub	Seepage Scrub
43	13	20+	3	20	1	M	Coarse white shelly beach sand	Coastal dune	Dense low spreading woody shrubs, *Myrica cordifolia* dominant	25	NE	10	Pioneer/Littoral Dune Mixed Fynbos	Coast Scrub
47	5	18	0	0	5	T	Fine black silt	Perched seepage terrace above central plateau	Almost pure stand of spindly *Berzelia abrotanoides* 7'	300	-	0	Seepage Scrub, specialised var.	(Seepage Scrub)
91	9	20	0	0	4	M	Coarse shelly marine sand, brown below	Marsh on coastal flats	Special spikey tufted sedges scandent herbs & soft-leaved shrubs	20	-	0	*Helichrysum-Scirpus* Marsh	(Coast Alliance)

Explanatory examples of symbols and abbreviations

Column 3: ++ (group 20) = age cannot be determined, probably over 30 years

Columns 4 & 6: For explanation of estimate-symbols, see text, section 5.3.2

Column 7: T = Table Mountain Sandstone soils; M = transported sands of marine origin

Column 10: cf. 87(2) = observed in field notes to be similar to plot 87 (group 2)

As for 8 = characteristics under this heading are as described for plot 8

Column 14: Upland Mixed Fynbos/Tussock Marsh = transitional

(Upland Mixed Fynbos) = depauperate or atypical

Column 15: Western Hillveld/Dry Hillveld = transitional between two associations of one alliance (occurring in the dashed-line blocks of both associations)

(Western Hillveld) = depauperate or atypical of the association (occurring in the dashed-line block of one association only)

(Hillveld) = depauperate or atypical of the alliance (plots unallocated to blocks)

Dry Sandflats + Dune Fynbos = occurring in the synthesis tables for both alliances (in this example, Hillveld & Coast Alliances)

APPENDIX VIII

SUMMARY OF GROUP CHARACTERISTICS

	ECOLOGICAL								FLORISTIC						HOMOGENEITY.			
Group No.	Post burn Period (Yrs)		Stoniness				Soil Moisture Index	Sub-stratum	No. of Plots in group	No. of Spp. in group	No. of Species in Plots				Index	Subjective Assessment		Habitat and Vegetation
			Class		Percentage													
	Min	Max	Min	Max	Min	Max					Min	Max	Mean	Range		Ecol.	Flor.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	9
1	1	9	0*	5	0*	18	1	T	6	145	53	83	69	30	25	High	High	Western hills and escarpment bearing recent post-burn regrowth of Western Hillveld, rich in species
2	1	5	0	0	0	0	1,3	T	4	126	44	74	64	30	10	High	Med.	Sandy flats along western escarpment; Western Hillveld with some Tussock Marsh elements
3	1	10+	2	5	3	80	1	T	6	159	23	75	57	52	6	Low	Low	Dry hill slopes and ridges with outcropping bedrock, sometimes iron-impregnated; depauperate or atypical Western Hillveld or Tall Fynbos
4	4	24	0	0	0	0	1	T	4	107	39	48	45	9	9	Med.	Med.	Patches of deep sand on coastal shelf or inland; Dry Sandflats Association with added coastal elements
5	3	20+	0	3	0	15	1-3	T	6	107	32	57	42	25	16	Med.	High	Poorly drained flats with Plateau Fynbos; plot 79, on a cool, moist slope, bears Restionaceous Upland Mixed Fynbos
6	20	20+	3	5	40	49	1-5	T	3	88	39	49	45	10	15	Med.	High	High, cool, eastern slopes, mostly with iron-impregnated bedrock; long-unburnt Mountain Fynbos with Dry Hillveld elements
7	11	21+	1	4	7	60	1	T	7	108	31	51	46	20	19	High	High	Warm, dry, rocky hills bearing homogeneous Dry Hillveld
8	11	14	0	0	0	0	1	T	2	60	35	36	35	1	18	Low	Med	Heterogeneous dry-habitat ecotones; transitional or depauperate Tall Fynbos or Upland Mixed Fynbos
9	10	14	0	3	0	15	1	T	4	70	33	42	37	9	19	High	High	Dry, rocky ridges or sheetrock; depauperate Upland Mixed Fynbos
10	15	21	0	4	0	40	1	T	5	79	26	41	36	15	21	High	Med.	Dry, mainly rocky ridges with coarse, white sand; moribund (over-mature Plateau Fynbos or Upland Mixed Fynbos
11	2	8	0	5	0	43	1	T+M	4	135	46	65	53	19	5	Low	Low	Either rocky hills with depauperate Western Hillveld; or sandy flats or dunes with Dune Fynbos
12	2	20	3	4	5	60	1,2	T	3	99	44	60	51	16	13	Med.	High	Cool boulder-slopes or summits; Mountain Fynbos with Coast Scrub elements where protected from fire
13	1	20	0	5	0	77	1	T+M	5	99	15	36	26	21	3	Low	Low	Heterogeneous: rocky summits and slopes; deep sandy plateau; calcrete dune; vegetation correspondingly varied
14	12+	25	0	3	0	37	1-2	T	4	92	34	42	38	8	7	Low	Low	Gentle sandy slopes with Restionaceous Mixed Fynbos; except for plot 51 on rock outcrop with depauperate Dry Hillveld
15	3	18	0	5	0	6	1,3	T	3	76	27	45	34	18	8	Med.	Med.	Sandy coastal plain with Dry Sandflats Fynbos; except for plot 14 on sheetrock with atypical Tussock Marsh/Upland Mixed Fynbos transition
16	4	20	0	0	0	0	2-4	T	4	65	24	34	30	10	11	High	Med.	Moist flats with Restionaceous Tussock Marsh, bushy in plot 22
17	15	25	0	5	0	5	1,2	T	2	46	28	35	32	7	37	Med.	High	Boundary between rocky hills and moist flats; vegetation containing elements of both Upland Mixed Fynbos and Tussock Marsh
18	3	18	0	0	0	0	3,4	T	7	61	18	24	21	6	3	Med.	Med.	Moist flats with simple or complex Tussock Marsh; or seepage steps with bushy Scrub

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
19	2	20+	0	3	0	6	1	T	5	99	24	50	32	26	8	Med.	High	Inland dunes, sandy slopes or coastal terraces; Dune Fynbos or *Metalasia-Passerina* Fynbos
20	3	30+	0	0	0	0	1,2	M	5	70	14	36	24	22	11	High	High	Stabilized littoral dunes with woody *Sideroxylon* Scrub
21	Over	30	3	3	30	55	1	T	3	37	7	24	16	17	8	High	Med.	Rocky littoral with semi-succulent variety of the Coast Alliance
22	3	19	0	0	0	0	3,4	T	3	40	14	22	19	8	5	Med.	Med.	Moist flats with simple or complex Tussock Marsh; or seepage step with bushy Scrub
23	10	20+	0	3	0	20	1-5	T+M	5	47	5	13	11	8	0	Low	Low	Completely heterogeneous as to both habitat and vegetation

Symbols and abbreviations

* exceptional values

Columns 4, 5 and 8: For explanation of estimate-symbols, see text, section 5.3.2

Column 9: T = Table Mountain Sandstone soils; M= transported sands of marine origin

Column 16: For explanation of Homogeneity Index values, see text, section 5.4.1

Column 17: Ecological assessment

Column 18: Floristic assessment

APPENDIX IX

SPECIES CONSTANCY PER GROUP

(Only species with constancy 80% or more in one or more groups are included) • = Dividing species

No. of plots per group	6	4	6	4	6	3	7	2	4	5	4	3	5	4	3	4	2	7	5	5	3	3	5
Group Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Adenandra umb.	100	75	67	25	33	100	100		75	100	50	67	20	75	33		50		40				
Agathelpis dub.	100	50	33	25		67	57	50	50		50		20										
Agathosma hook.	33	50	17				43			80				25									
A.imbricata	83	75	17	100	17				50	60	50	100	20	50	33				60	20			
•Amphithalea er.	100		50	25		33	71		75	60	50			25									
Anexton asp.	83	25	50		33	100	71		25	40	50	33		25									
Anthosp.aeth.	17		50	25		100	43		25		50	100	80						80	20			
•A. ciliare	83	75	83			33	86	50	75	100	75	33		100									
Arctotis asp.												100	40						20				
Aristea afr.	83	100	33	75	67		43	50	25	60	100		20	75	100	75	100	14	40				
Bobartia glad.	67		33		17	33	86	50	25	20	25	100	20										
Castalis nud.	33	75	33			100	14		25	20	25			50									
•Chironia bacc.												100							20				20
Chondrop.nudum		50		50	50				25		25				67	100	100	29	20			33	20
Chrysocoma com.				25		33						100	20						20				
Cliffortia falc.	17		33	50								33	40						80				
C.subsetacea		50		25	83			50		20	25			25	33	100	100	71	20			67	20
•Clutia alat.	33		33			33					100	100	100										
Corymbium gla.	100	75	33	25	50	33	57	50	75	60		33	40	25			100	29					
C. africanum	100	50	50	25	33	67	29		75	20	25					16							
Crassula nud.	17		33	100			14			20	25										33		
Danthonia lan.	50	25	17		33	67	86			80				50									
D.macrantha	17	25	50			33	14					100	60	25					20				
Diastella serp.	50	100	17	25	50		43	50	25	20	25			50		25	50						
Dilatris cf. pillansii	17	50	17		83		43	100		20				25		50		14					
•Drosant.cand.																					100		
Ehrharta vill.											25								40	80			
•Elegia parviflora		25			63										33	75	100	71				100	
E.stipularis	100	75	100	75	50	67	100	100	100	100	50		20	100	67		50	14	20				
Erepsia bract.	83	25		25																			
•Erica corifolia	67	75	33		83	33	71	50	100		50			25		50	50	71	20			67	
•E. imbricata	100	100		25	100	33	86		100	80	25			100	33		100	71					
E.plukenetii	33		33		33	100	86	50	25	20	50	67		25	33				20				
E.puchella	17	75		50	100	33	71	100	50	80	50			50		25	100	29					
•Euclea racemosa												67	40						40	100			
•Euphorbia tub.	33	50	50	50	33		29	50	25	20	50			25	33	100							20
•Exomis micr.																					100		
Ficinia bulbosa	50	50	83				43		50	40	75	33	20	25	33		50		80				
F. filiformis	33	75	67	50	67	33	43		50	60	75	33		75	100	50	50	14				67	
•F. ramosissima												67	20							100			
•F. secunda				100							50		20		67				80				
Galium tom.																				80			
Gnidia imbr.	100	50	33		33		43	50	50	40		33		50									
G. viridis	83	75	50	25		33	43	50			50	33	20	25	67				20				
Hypodiscus ar.	100	50	33	25	50	33	71	50	100	100				25	33	25	100	57					20
H. willd.	33	100	17		17			50	25	40	25			75			50		40				
•Ifloga seriph.			17	100							25								20	20			
Kedrostis nana																				80	33		
Leucadendron dec.	50	50	33	50	67	33	86	50	50	100	25			50	33	50	100	57	20			33	20

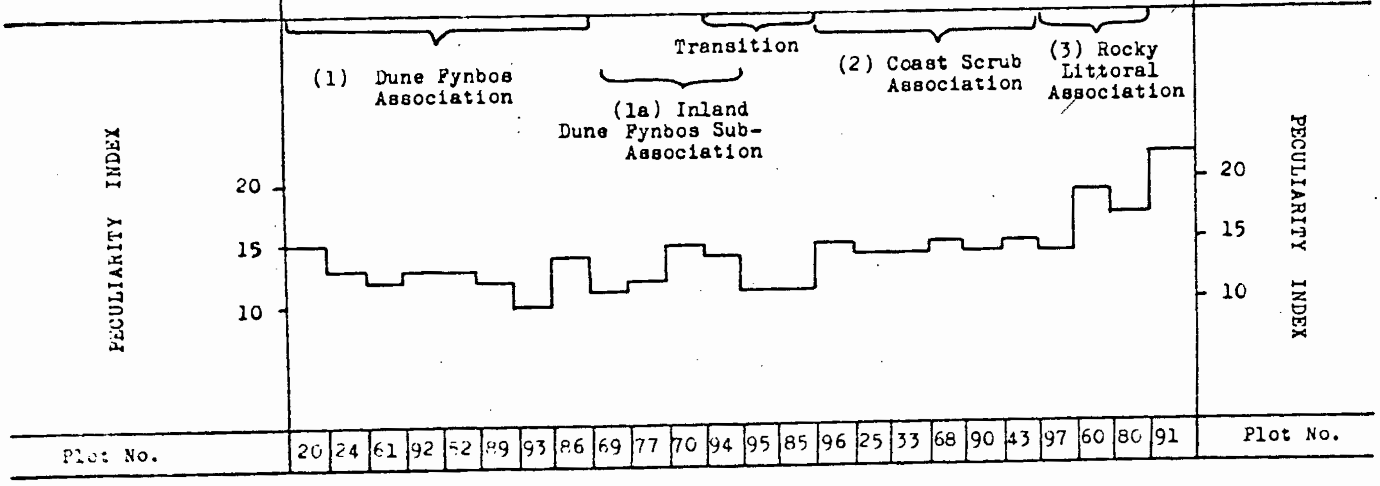
No. of plots per group	6	4	6	4	6	3	7	2	4	5	4	3	5	4	3	4	2	7	5	5	3	3	5
Group Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
•L. salignum				25		100							40										
Leucosp.conoc.	33		33									100	40				50						
Liparia parva	83		50		17	33	43	50		40	25	67		25									
Lobelia cor.	83	50	33		17	33	29	50	25		25			25		25							
L. pinifolia			50			67	86					33					50	14					
Macrost. vill.	83	75	33	25	67		14	50		20				25	33	25							
•Mesem.	33	25	17	25		33			25		75		20	25					40	40	100		
•Metalasia brev.	67	75	50	50					75		100												
M. cephalotes	83	75	50		33	33	57	100	75	20				25									
M. muricata	17	50	67	75	50	67	57		75	20	100	67	40		100	25		14	80	60		33	40
•Minor Eric.	50	50	67	75	100	67	86	50	100	60	100			75	33	25	50	29				33	
Myrsine afr.				25		33						100	20										
Olea capensis	17											100	40	25						20			
Osteosp.polyg.	83	50	33		17						50												
•Passerina vulg.			33	50						40	50	100	20	25	100				40	20			
Penæa mucr.	50		50		17	100	57	50		20				25		25		43				33	40
Pentasch. col.	83	75	17		100	100	86	50	50	100				100		75	100	43					
P. curvifolia	50	75	50	50	83	33			25	20	25			50	33	100	50	57	20			67	20
P. subulifolia	83	50	50	25	17		43			20	25	33		25									20
Phylica imb.	100	100	100	50	50	100	43	100	50	40	75	67	60	75	67	25			40				
P. parviflora						33					50								80				
•P. stipularis		50	50	100							50		20		33				100				
Pteroc.tricusp.																				80			
Restio bifurcus		25			83			50						50		75	50	71				67	
•R. cincinnatus	100	100	67	100	83	67	100	100	100	100	75	67	40	100	100	100	100	100					
•R. cuspidatus	83	100	100	100	83	67	71	50	100	100	100			50	67		100		80				20
•R. quinquef.					100										100	100	100	71				33	20
Rhus glauca																				80	33		
R. lucida	33		17	25			14			40	25	100	80	50			50		40				20
R. mucronata				25								67	20		33				60	80			20
•Roella ciliata	100	100	100								100				33								
•Salaxis flex.	100		50	100	17	33	86		100	60	50		20	25	67		50		60				
•Saltera sarc.						100	100						20										
•Staberoha banks.	17					33	100						20	25									
S. cernua	33	100	33	50	67		43	100	50	80				50	67	75	100	71					
Stoebe sphaer.	100	50	33	25	33		14	50	50	60													
•Struthiola cil.	100	100	100	100	100	100	100	100	100	100													
Tetraria comp.	83	75	67		33	67	29		75	20		33		75	33	25							
•T. cuspidata	67	50	33	25	67	100	100	100	75	60	75	67	20		67	75	100	85				100	
T. eximia	83	75	17		100		86	50	75	80				75		25	50	14				67	
•T. fasciata		25			83	33	14	100						75	33	100		43				33	
T. flexuosa					33			50								50	100	71				33	
•T. microst.	100	75	67	25	50	67	100		100	100			20	75		25	50		20				
Thamno.dichot.	100	100	83	100	83	100	100	100	100	100	75	33	60	100	67	50	100	57	60				
Thesium acum.	67	100	50		17		29		25		25								20				
•T. spicatum	83		33		17	33	43		100		50				33								
T. virgatum	100	50	33	25	50		14				50	33		25		25			20				
Ursinia crith.	33	50	50			67	57		100	60	25		20	50	33								
Willden. luc.		25	83			67	71			60	25		40	25	33		50						
Spp. with Const. V. per group	36	12	9	10	17	13	20	11	13	17	7	13	3	6	6	7	17	2	8	8	3	2	0
Total spp. per group	145	126	159	107	107	88	108	60	70	79	135	99	99	92	76	65	46	61	99	70	37	40	47
Homogeneity Index	25	10	6	9	16	15	19	18	19	21	5	13	3	7	8	11	37	3	8	11	8	5	0

Note: Groups determined by dividing species are underlined

APPENDIX X

FINAL SYNTHESIS TABLE FOR COAST ALLIANCE

Group No.	4	4	4	4	11	19	19	19	19	19	11	13	13	20	12	20	20	20	20	23	21	21	21	23	Associations
Plot No.	20	24	61	92	52	89	93	86	69	77	70	94	95	85	96	25	33	68	90	43	97	60	80	91	
Species																									
Manulea tomentosa			x	x			o	x																	(1) Dune Fynbos Association
Pentaschistis thunb.	x	x		x	x	x		x	x									x							
Ifloga seriphioides	x	x	x	x	x			x				x		x											
Pharnaceum lanatum	x	x	x		x	o		x	x					x											
Crassula cymosa		x		x		x		x					x												
Aspalathus hispida			x	x	x	o		x	x		o			x											
Thamnochortus erectus				x		o	o	x	x	x	x														Transition
Ficinia secunda	x	x	x	x	x	x	x	x	x		x		x												
Phylica stipularis	x	x	x	x	x	x	x	x	x	x	x		x												
Chondropetalum micro.							x			x		x													(1a) Inland Dune Fynbos Sub-Assoc.
Leucadendron sao.							o		x	x	x	x													
Indigofera brachy.									x	x	x	x				o									
Pelargonium betulinum									o	o	x	x													
Colpoon compressum							o						o	o	o	o	x	o		o					(2) Coast Scrub Association
Ficinia ramosissima												o		x	x	x	x	x	x						
Passerina paleacea												x		x		x	o	o	x	o					
Helichrysum mar.															x	o	x	o	x		o				
Kedrostis nana																	x	x	x	x				x	
Olea exasperata											o	o		x	o		o	x							
Maytenus lucidus													o	o	x	o	x	o							
Sideroxylon inerme														o			o	o	x		o				
Galium tomentosum														x			x	x	x						
Phylica ericoides												o		o	x				x	o			o		
Rhus glauca												o				x	x	x	x	o	o	x			Transition
Cineraria geifolia														x				x	x			x	o		
Limonium scabrum												x		x		o	o	o			o	x	x		
Drosanthemum candens																					x	x	x		(3) Rocky Littoral Association
Exomis microphylla																					x	x	x		
Thesium aggregatum								x										o	x	o		x			Companion Species
Salvia aurea				x								o		o				x	o						
Helichrysum crispum				x				x						o	x		x		o	x			o		
Carpobrotus acinacif.				x		x			o			o	o	o	o	o	x	o	x						
Ehrharta villosa					x			x	x					x		o	x	x	x						
Euclea racemosa							x		x		o	x	x	x	x	x	x	x	x	o	o				
Pterocelastrus tric.						o	o	o				o	o	x	o	x	x	x		o					
Geranium incanum														x					x						



A P P E N D I X XI

FINAL SYNTHESIS TABLE FOR MOIST FLATS SUB-ALLIANCE

Group No.	23	22	18	18	22	16	18	5	16	18	16	18	18	18	5	22	16	17	5	5	17	2	5	5	15	23	23	Associations
Plot No.	32	58	50	49	18	6	11	17	7	56	22	38	65	48	55	83	78	46	35	64	37	13	16	79	14	29	47	
Species:																												
Restio compressus	x	x	x	x																								(1) Seepage Scrub Association
Osmitopsis aster.	x	o	x	o																								
Berzelia lanuginosa	x	x	o	x	x	o																						
Danthonia cincta	o	x	o																									
Psoralea pinnata	x	o	o																							x		
Psoralea aphylla	o		o	o																								
Restio dodii	o	o	o		o	o			x	x	x	x	o	x	x	x	x											(2) Tussock Marsh Association
Elegia cuspidata				x	o	o	o	x	x	x	x	o	x	o	x	x	x	o										
Serruria glomerata						x	x	o	o		o	x	o	o	x	o		o				x						
Ursinia tenuifolia					x		x	x	x	o							o								x	o		(2a) Sub-Association
Prismatocarpus sessilis					x	x	x	x	x																			
Rafnia crassifolia					x	x	o	x															o					
Bobartia indica										o	x		x		o				x									(2b) Sub-Association
Berzelia abrotanoides	o	x	x	x		o	o	x	x	x	x	o	x	x	o	x	o	o	o			x		x	o			Companion Species
Chondropetalum nudum				o	x	x	o		x	o	x		x	x	o		x		x	x	x	x	x		x	x		
Cliffortia subsetacea			x		x	x	x	x	x	x	x	o	x	x	o	x	x	x	x	x	x	x	x	x				
Erica parviflora		x	o		x	x	x	x	x	o	o	x	x	x	x	x	x	x	x	x	x		x		x	x		
Erica corifolia			o	x	x	x	x	x	x	x	o	x	x	o	x	x	o	x	x	x	o	o	x		o			
Pentaschistis curvifolia		x	x		o	x	x	x	x	o	x		x	x	x	x	x	o	x		x		x	x	o	x		
Restio bifurcus			o	x	x	x	x	x	x	o	x	x	x	x	x	x	o	x	x	x		x		x				
R. quinquefarius			x		x	x	x	x	x	o	x	x	x	x	x		x	x	x	x	x		x	x	x	x		
Scyphogyne muscosa				x	x	x		x	x	x	o		x			x	x		o	x	x		x	x		o		
Tetraria fasciata					x	x	x	o	x	o	x	o	x	x	x		x		x	x		o	x	x	o			
T. flexuosa			x		x			x		x	x	x	x	x	x	o	x	x	o		x				o			
Staberhoha distachya					x		x			o												x	x		x	x		
Erica bruniades		x	x			x		x	x	x	o		o	x	o		o		o						o			
E. capensis	o	x	x			x	o	x					o			x					o							
Elegia neesii																	x	o		x				x				
Helichrysum orbiculare	x																x							x				
Elegia vaginulata						x					x													x				

(1) Seepage Scrub Association

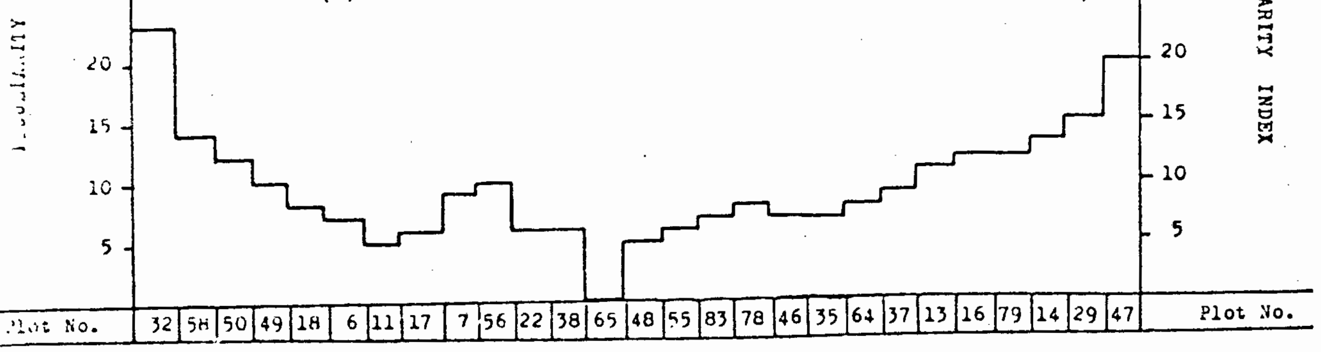
Sub-Association (2a)

Sub-Association (2b)

(2) Tussock Marsh Association

(3) Simpler Tussock Marsh assemblages and transitions

Anomalous plots



*C = Coast Alliance; M = Moist Flats Sub-Alliance

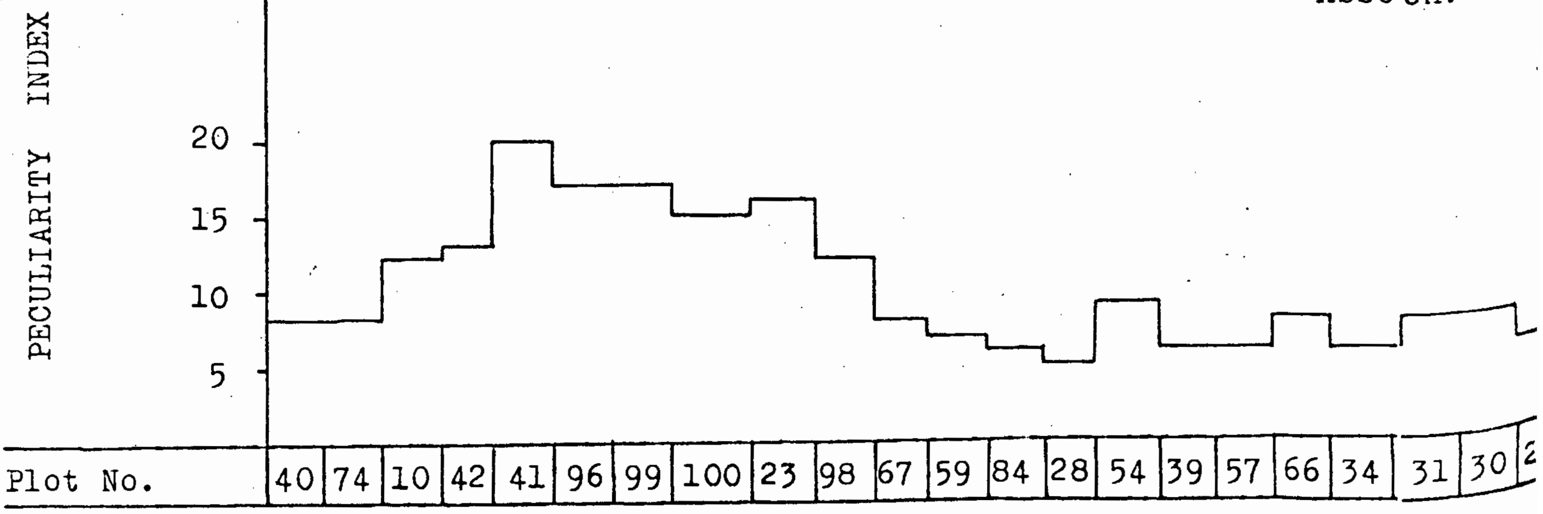
Alliance Transitions*						C															
Group No.	8	6	3	3	13	12	13	12	13	6	6	10	9	10	8	7	7	7	7	7	7
Plot No.	40	74	10	42	41	96	99	100	23	98	67	59	84	28	54	39	57	66	34	31	30
Species																					
Clutia alat.		o	x	x	x	x	x	x	x	x	o			o							
Elegia junc.	o	x	x	x	o	x	x	x	o	x	o	o	x								
Berk. il.						x	x	x	x	x	x							o			
Leucad. sal.		x		o	x	o	x	o		x	x	o									
Lobelia pin.				x				x	o	x	x	o	o	o	o	o	x	x	x	x	x
Saltera sarc.		x				o		o	x	x	x			o	o	x	x	x	x	x	x
Staber.banksii									x		x		o	o	o	x	x	x	x	x	x
Tetr. therm.	o						o		o	x	x	x	o		x	o	x	x	x	x	o
Roella cil.			x	x																	
Lobelia set.																			x		x
Thesium virg.				x				x												x	
Thesium acum.				x														x			
Ost. polyg.																					o
Ficinia fil.								x			x		x	x		x			x		
Passerina vulg.			x			x		x	o					x							
Salaxis flex.										x			x	x		x	x	x		x	x
Elegia stip.	x	x	x	x							x	x	x		x	x	x	x	x	x	x
Restio cusp.	x	x	x	x						o	x	x	x	x		x	o		x	x	x
Struth. cil.	x	x	x	x						x	x	x	x	x	x	x	x	x	x	x	x
Erica imbr.	o		o								x	x	x		o	x	x	x	x	o	x
Hypod ar.										x		x	x	x	x	x	o	x	x	x	o
Tetr. eximia												x	x		x	x	x		x	x	x
Pentasch. col.		x								x	x	x		x	x	x	x	x		x	x
Metal. ceph.	x										x	x	x		x		o	o	x	x	x
Macr. vill.	x		x																		x

Transition

(1) Mountain Association

Transition

(2) Dry Hillveld Assocn.



APPENDIX XII

SYNTHESIS TABLE FOR HILLVELD SUB-ALLIANCE

																		M			M	M	M				C
7	7	7	7	7	14	10	10	9	1	1	1	1	3	3	2	2	1	5	1	2	5	2	15	3	11	11	4
56	34	31	30	27	51	63	21	36	45	75	9	8	12	5	82	87	76	16	44	15	79	13	14	3	2	1	24
											x	x	o			o							o		x	x	
																	x				x						
o																											
					o																						x
x	x	x	x	x	o	o	o	o	o				x								o						o
x	x	x	x	x						o		o															
x	x	x	x	x	x	o		o	x																		
x	x	x	o	x	x		o		o	o	o																
					o				x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	
	x		x	x	x		o		o	x	x	x	x	x	x	o	x	x	o	x	o		x	x	o	x	x
		x			x				x	x	x	x		x	x	x	x	x	x	o	x	o			x		x
x				x				x		x	x	x	x	x	x	x	x	x		x		x					
			o	o		o			x	x	x	x	x	x		x	x	x			o	x			x	x	
	x			x	x	x		x	o	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x
							x		o														x	x	o	x	x
x		x	x	x		x	x	x	x	x	x	x	x	x			x	x	x					x	x	o	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	x	o	o	x
x	x	o	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	o				
x	x	x	o	x	x	x	x	x	x	x	x	x		o	x	x	x	x	x	o	x		x	x			
	x	x	x	x	x	x	x	o	o	x	x	x	o		x	x	x	x	x	o	x	x	o		o		
x		x	x	x	x	x	x			x	x	x			x	x	x	x	x	x	x		o	x			
o	x	x	x	x	x	o		o	o	x	x	x	x	x	x	x	x	x	x	x	o		o	o	o		
			x			x	o		x	x	x	x			x		x	x		x	x	x	x	x			

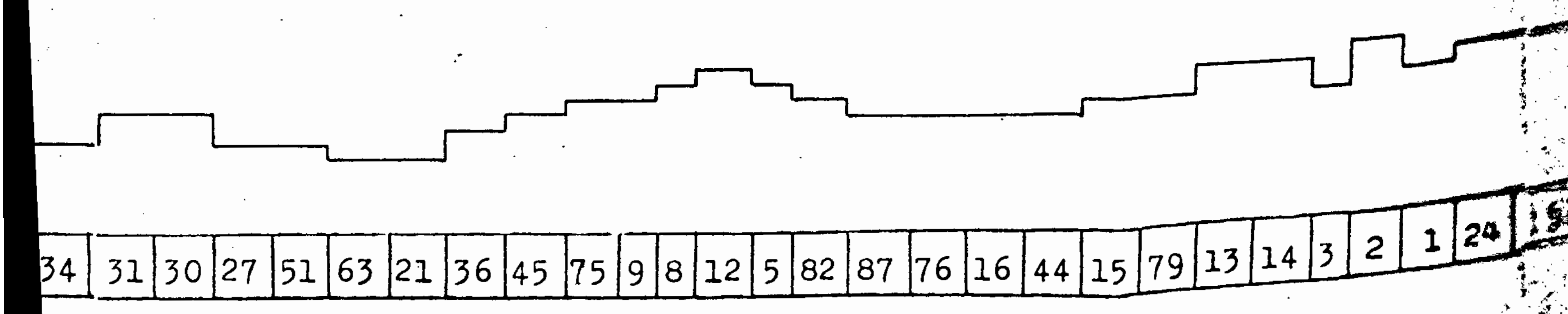
Dry Hillveld Assocn.

Transition

(3) Western Hillveld Association

Transition

(4) Dry

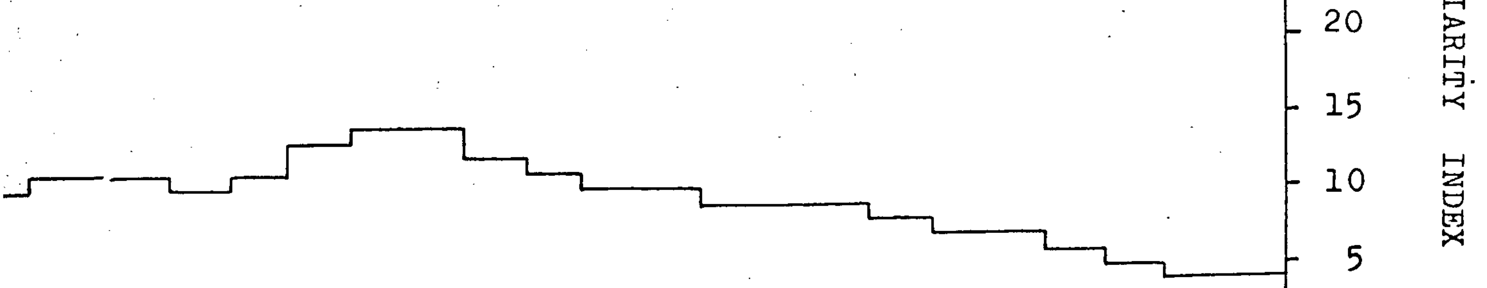


	C	C	C				C	C	C	C				M	M	M	M					
1	4	11	4	15	15	12	19	19	13	4	14	14	14	17	5	5	17	9	9	10	3	Associations -
1	24	52	61	19	4	81	93	89	95	20	53	73	72	37	64	35	46	71	26	62	88	
x		x				x			x													(1) Mountain Assoc.
														o						o		
	x																					(2) Dry Hillveld Assoc.
	o													x			o				x	
																			o			
																				o		
x		x																			x	(3) Western Hillveld Assoc.
x	x														o							
	x																					
x																						
x	x	x	x	x	x						x	x		x	x	x				x	x	(4) Dry Sandflats Assoc.
x	x	x	o	x	x	x	x	x	x				x									
o	x	x	x	x	x			x	x	x		x				o	x	x	x	o		
x	x	x	x		x		x		x	o	x	x	x		x	o	x	x	x	x	x	Companion Species
x	x	x	x	x			x	x		x	x			x	x	x	x	x	x	x	x	
o	x		x							x	o	o	x		x	x		x	x	x	x	
			x	o						o	x	x	x	x	x	x	x	x	x	x	o	
										x			o	x			x	x	x	x	x	
										o	x		x	x	x	x	o	x	x	x	x	
											x	x	x	x	x	x	x	x	x	x	o	
												o	o		x			x	x		x	
										x		x	o		x	x				o		

4) Dry Sandflats Assoc.

(a) (b) (c) (d)

(5) Ill-defined assemblages



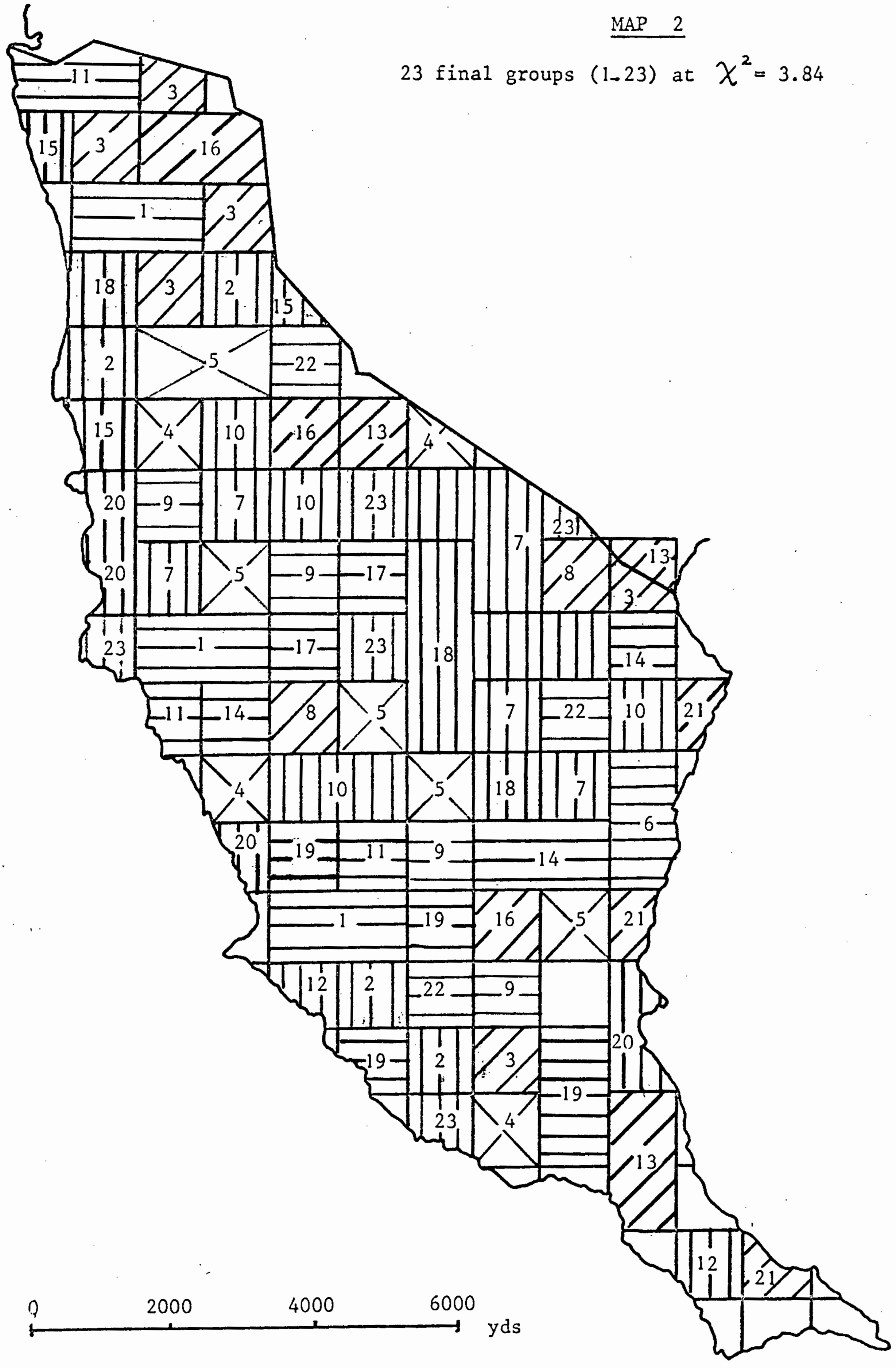
1	24	52	61	19	4	81	93	89	95	20	53	73	72	37	64	35	46	71	26	62	88

ASSOCIATION-ANALYSIS GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE

MAP 2

23 final groups (1-23) at $\chi^2 = 3.84$

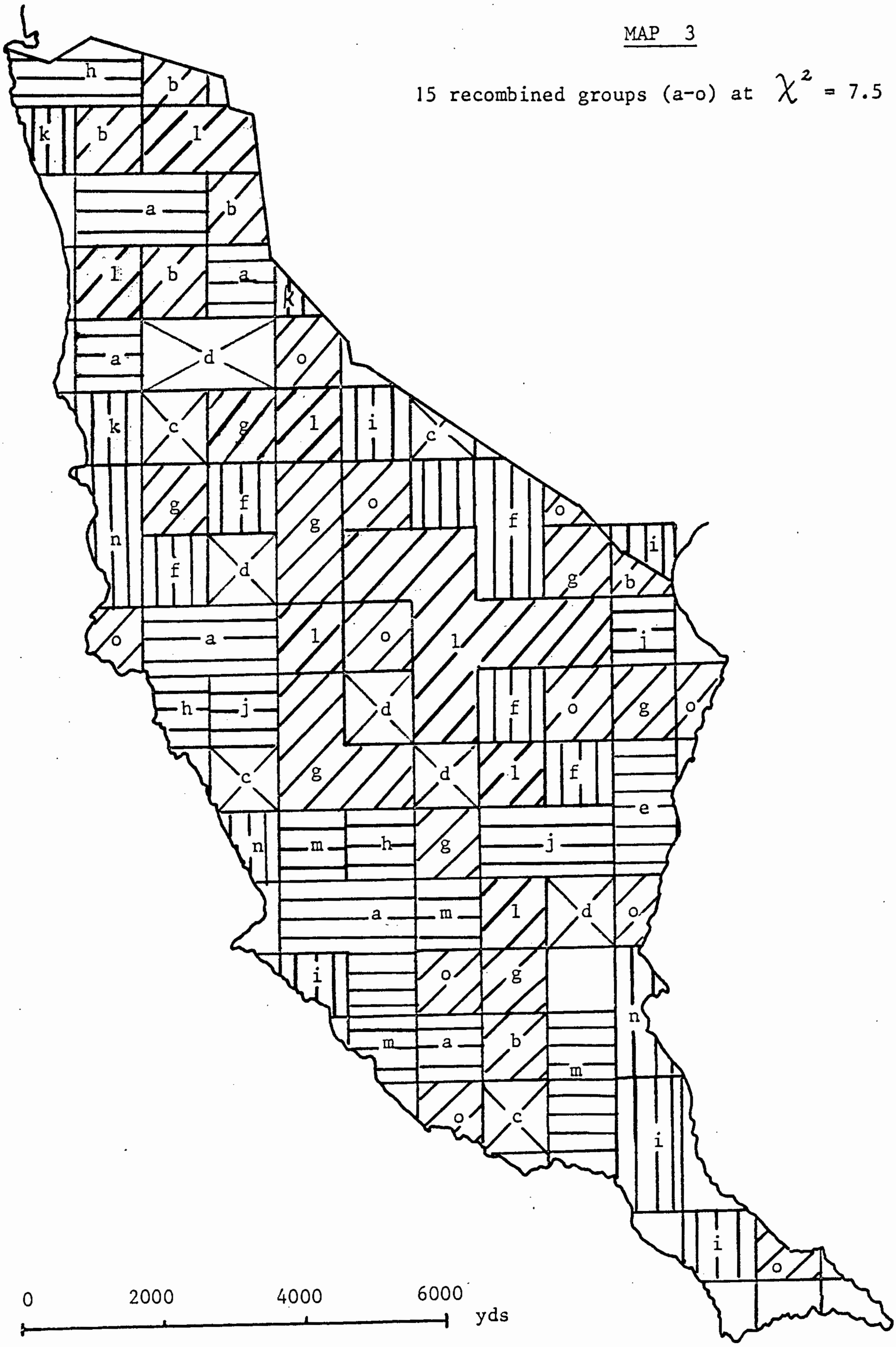


ASSOCIATION-ANALYSIS GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE

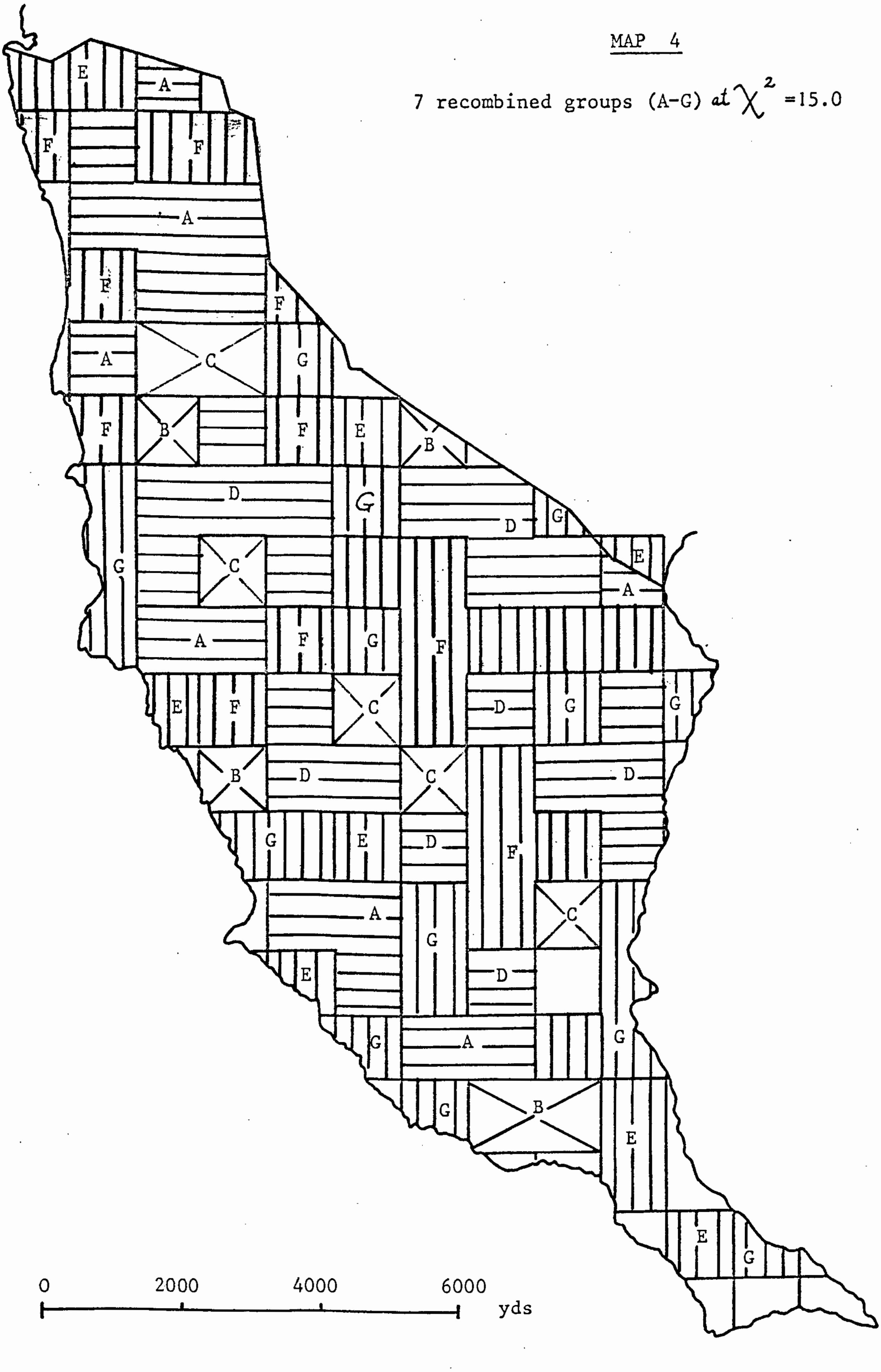
MAP 3

15 recombined groups (a-o) at $\chi^2 = 7.5$



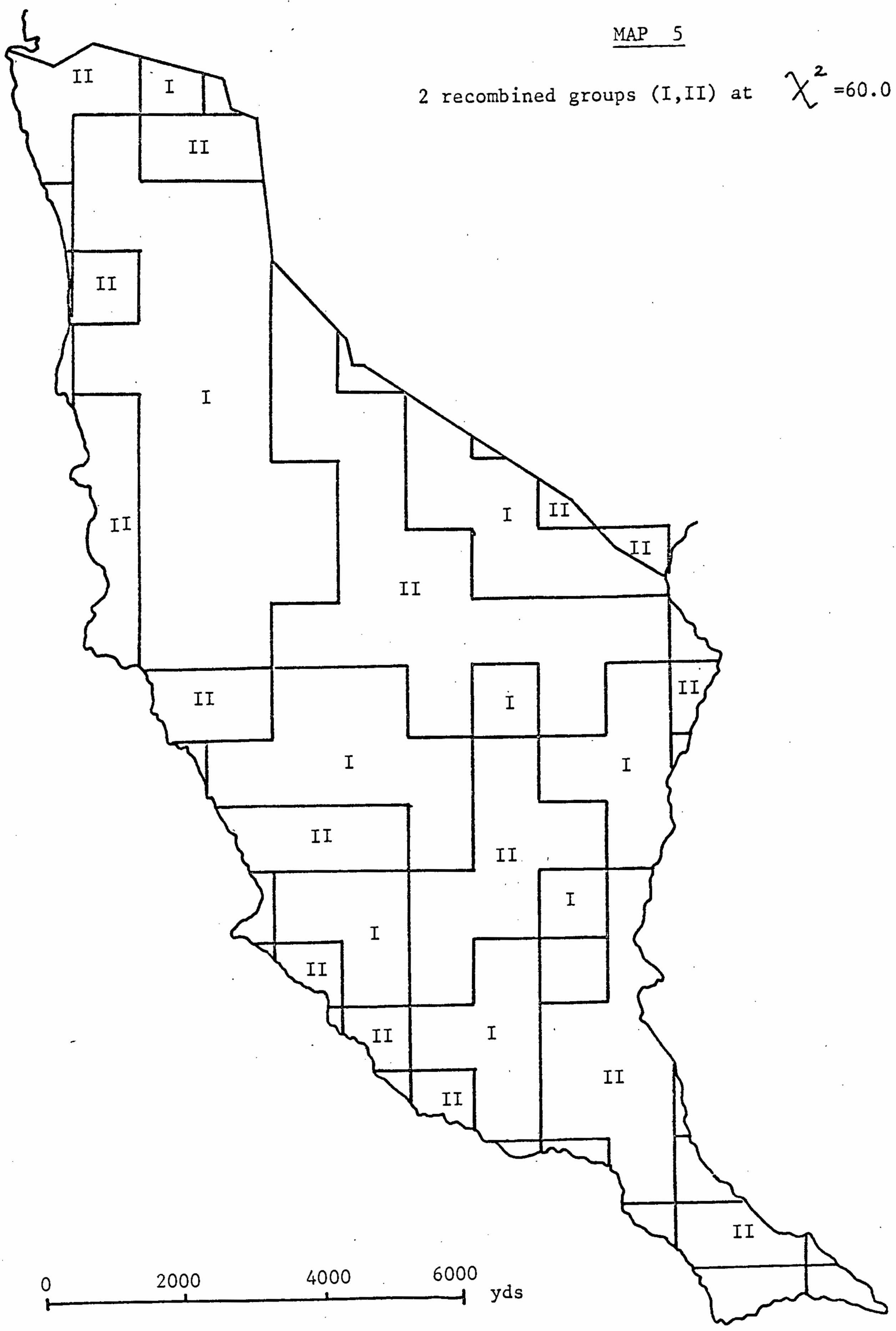
ASSOCIATION-ANALYSIS GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE



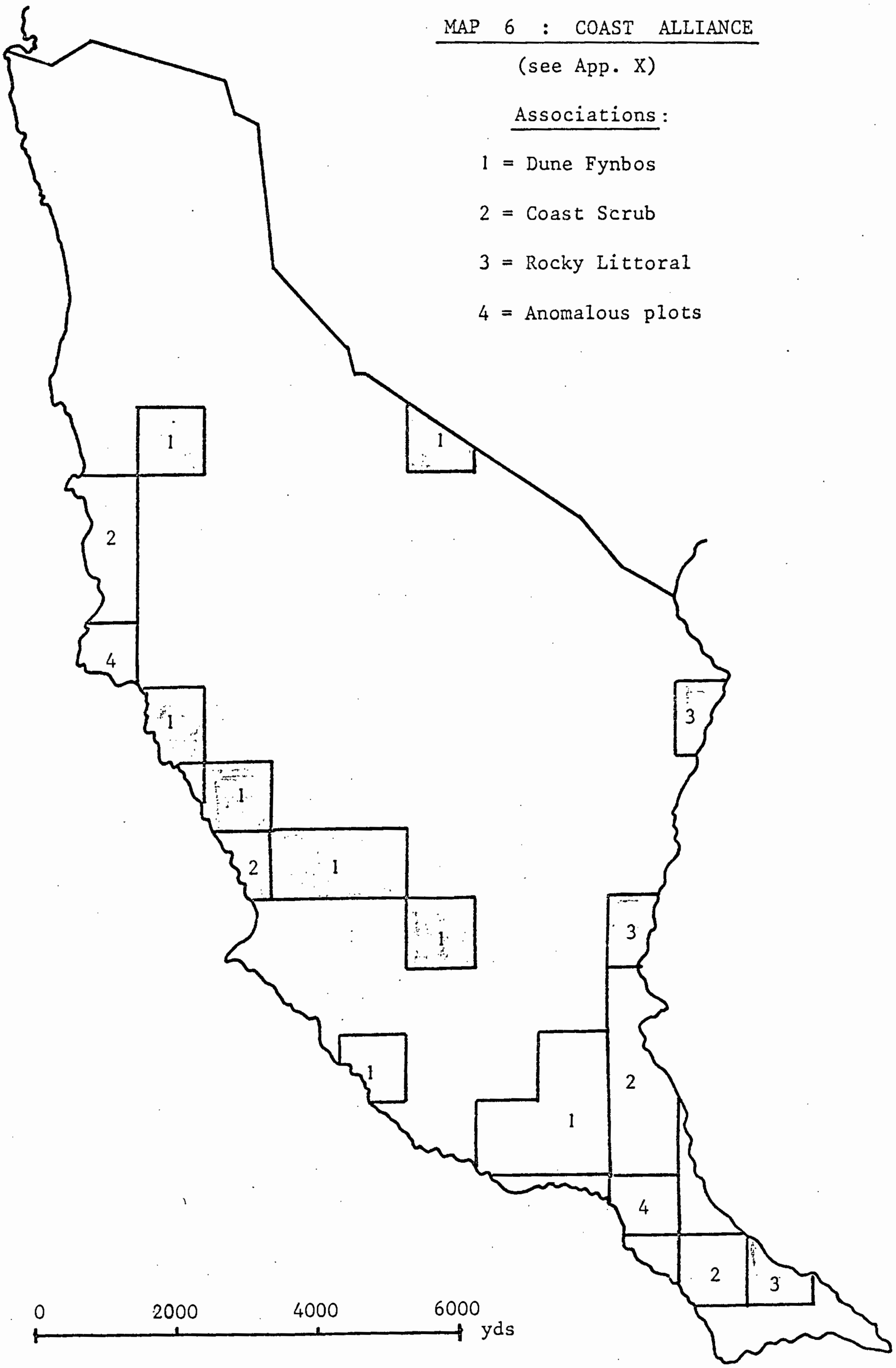
ASSOCIATION-ANALYSIS GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE



PHYTOSOCIOLOGICAL GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE



MAP 6 : COAST ALLIANCE

(see App. X)

Associations:

1 = Dune Fynbos

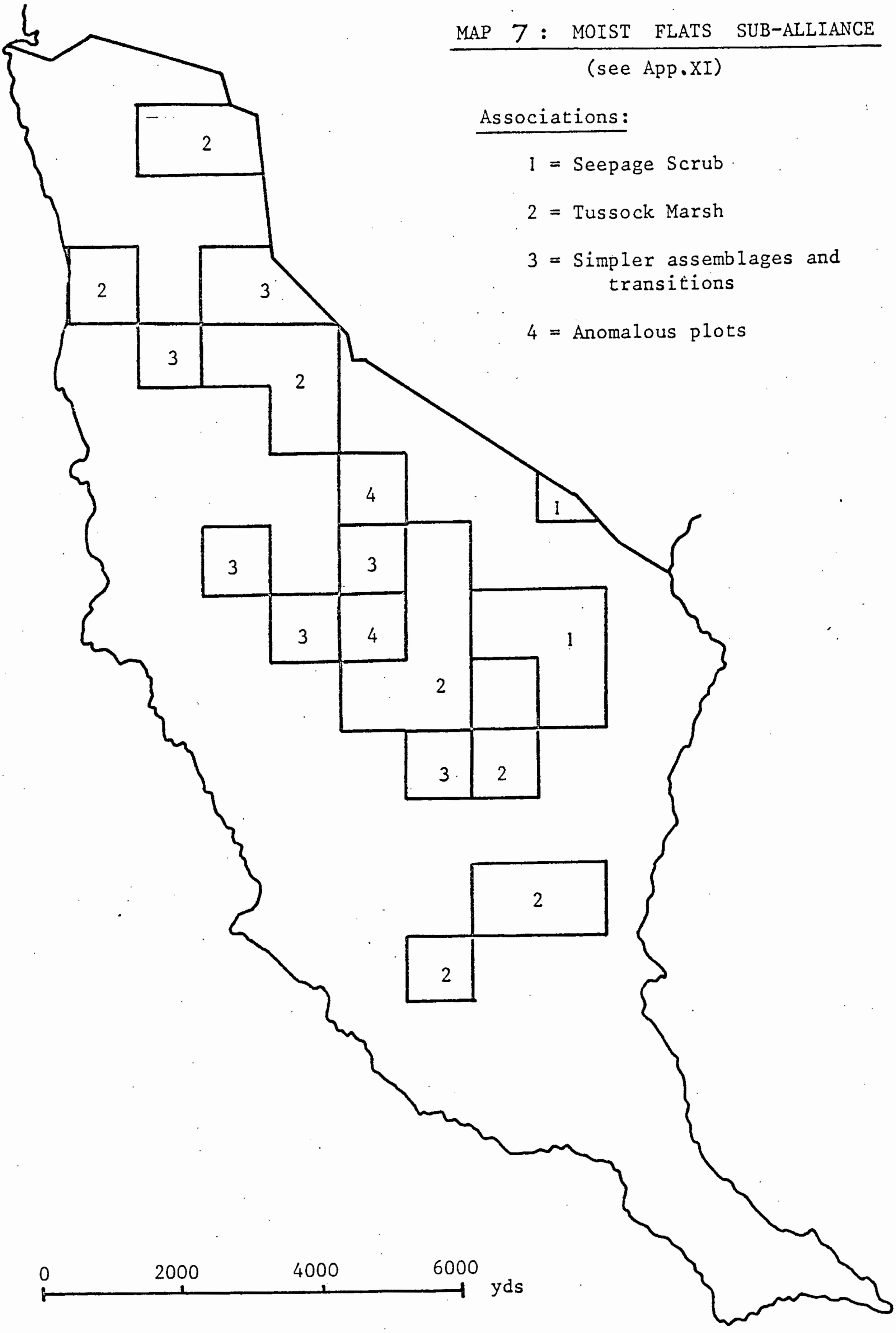
2 = Coast Scrub

3 = Rocky Littoral

4 = Anomalous plots

PHYTOSOCIOLOGICAL GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE



MAP 7 : MOIST FLATS SUB-ALLIANCE

(see App.XI)

Associations:

1 = Seepage Scrub

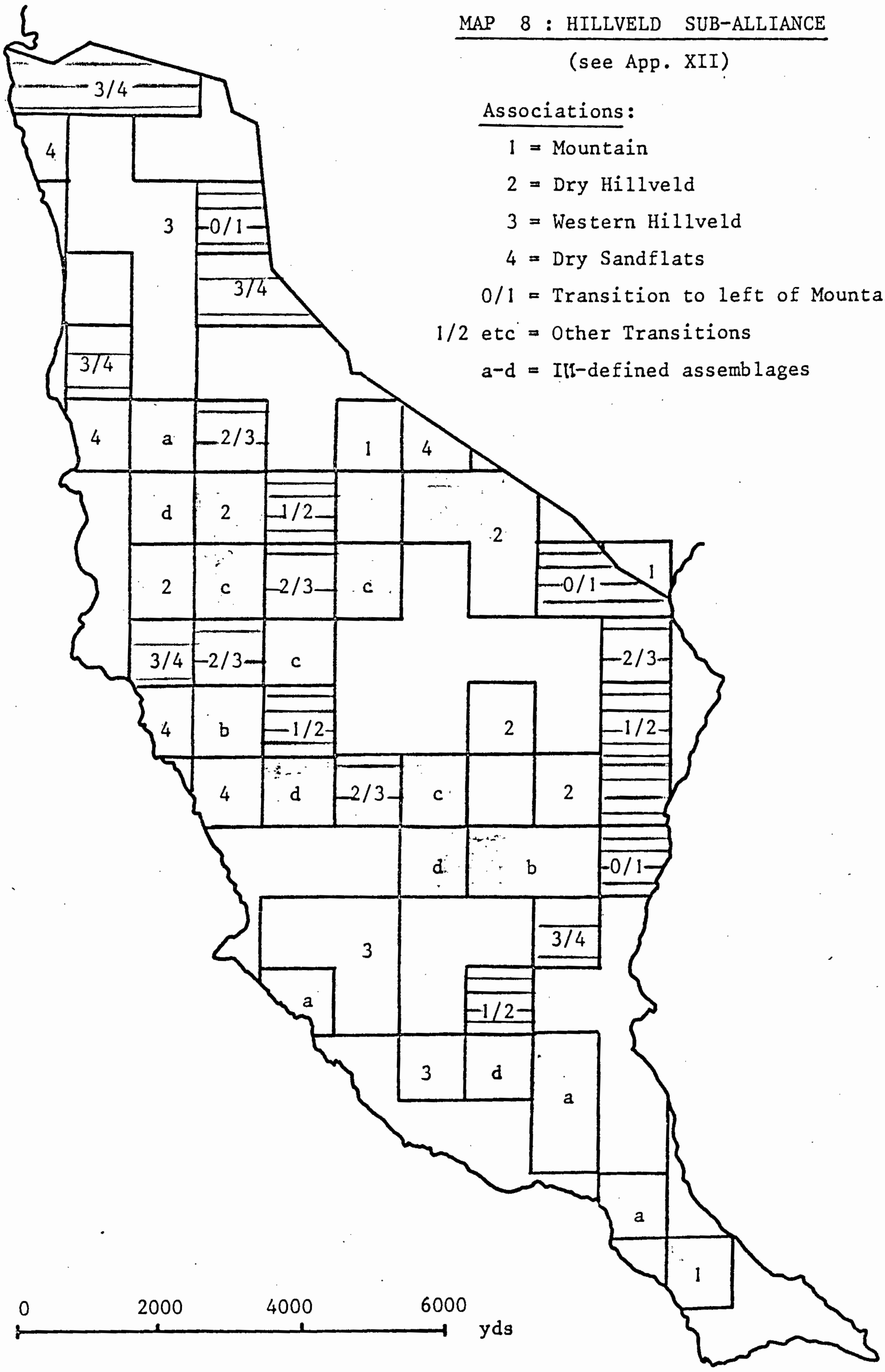
2 = Tussock Marsh

3 = Simpler assemblages and transitions

4 = Anomalous plots

PHYTOSOCIOLOGICAL GROUPINGS:

CAPE OF GOOD HOPE NATURE RESERVE



MAP 8 : HILLVELD SUB-ALLIANCE

(see App. XII)

Associations:

1 = Mountain
2 = Dry Hillveld
3 = Western Hillveld
4 = Dry Sandflats
0/1 = Transition to left of Mountain
1/2 etc = Other Transitions
a-d = Ill-defined assemblages

MAP 10

GEOGRAPHICAL LOCATION OF THE STUDY AREA

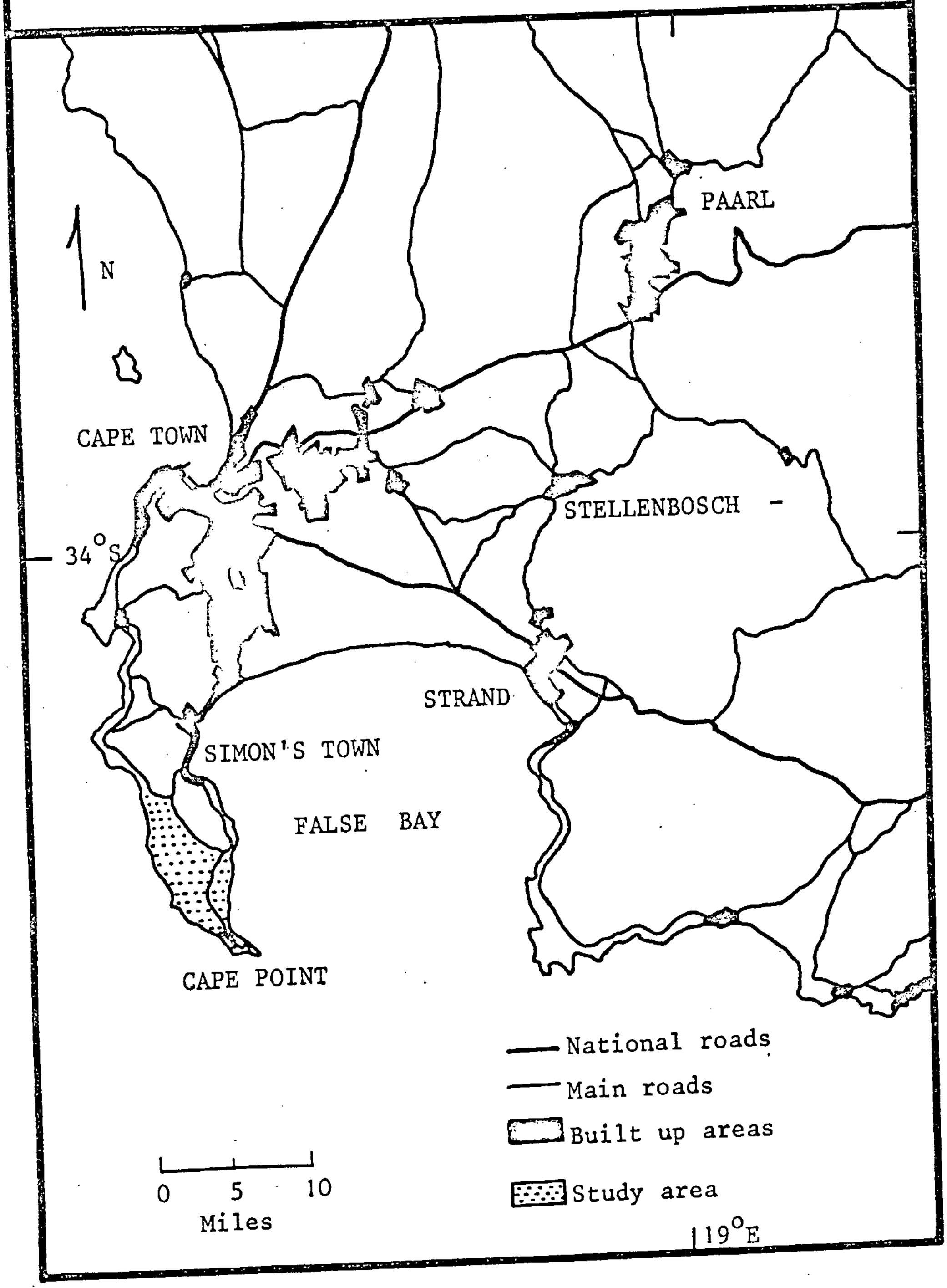


PLATE 1. Littoral Dune Mixed Fynbos near Krom River lagoon. Metalasia muricata and Indigofera brachystachya in depressions; wind-moulded humps of pioneer Broad-leaved Scrub (mainly Pterocelastrus tricuspidatus)to 6 ft (1.8 m) high.

PLATE 2. Dwarf Dune Mixed Fynbos, Platboom Road. Thamnochortus fraternus c. 12 in (30 cm) on calcrete ridge in centre, flanked by Leucadendron sabulosum to 8 ft (2.4 m) in dune slacks to left and right, with the darker-foliaged alien Acacia cyclops invading, especially on the right.

PLATE 3. Plot 69, group 19. Almost pure stand of Thamnochortus erectus on inland dune above Brightwater. Crown cover barely 50%.

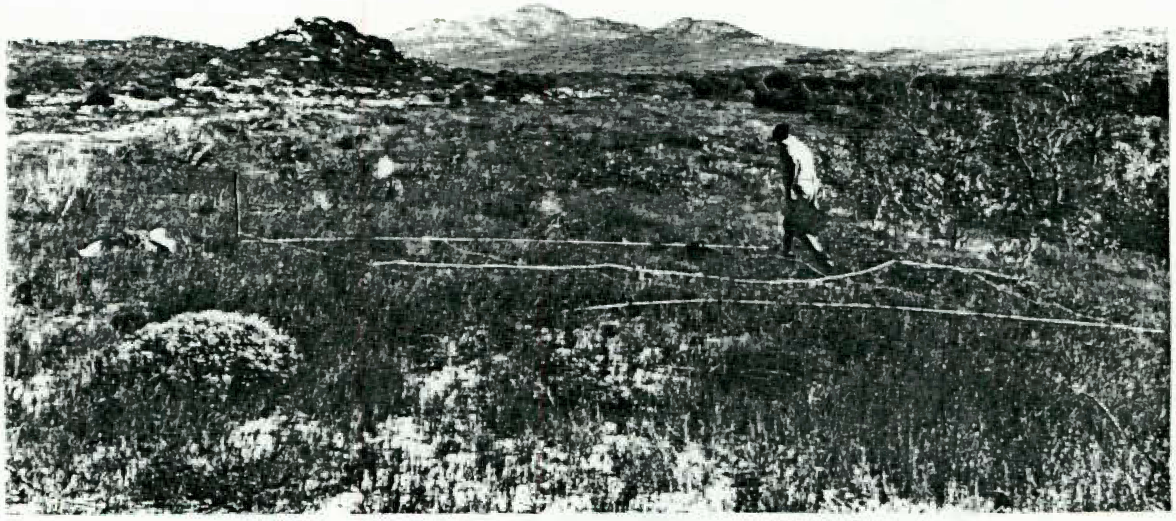


PLATE 4. Plot 24, group 4. Inland sand-patch near Klaasjagers with admixture of Upland Mixed Fynbos species e.g. Staavia radiata, left foreground. Alien Acacia cyanophylla invading right; Aspalathus-Phylica Scrub on conical hill left of centre.

PLATE 5. Plot 91, group 23. Helichrysum-Scirpus Marsh at Potbank. Grey Helichrysum orbiculare and erect Scirpus nodosus in foreground. Beyond and right, Metalasia muricata and Myrica cordifolia in Coast-shelf Fynbos. Left, old calcrete dunes with Broad-leaved Scrub developing on the southerly aspect. Centre, the open dune at Platboom.

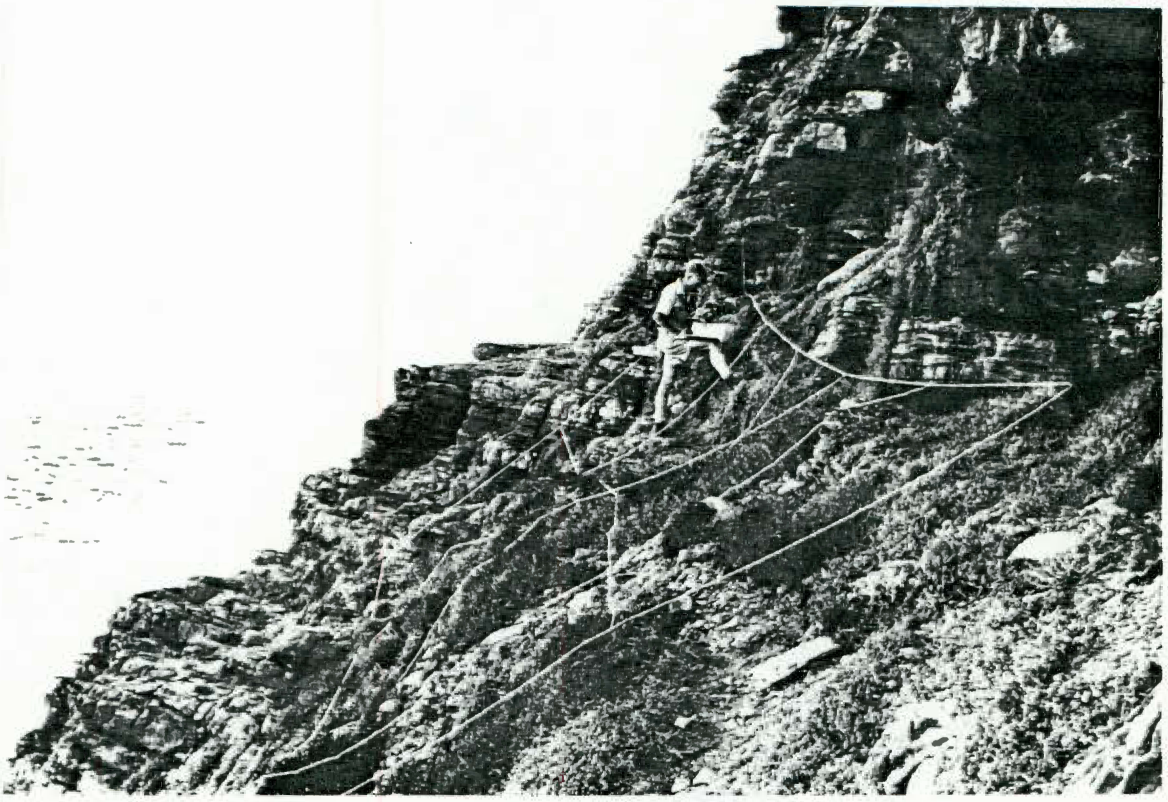


PLATE 6. Plot 60, group 21. Rocky Littoral Association at Batsata Cove on the precipitous False Bay coast. Succulents and stunted plants of the Broad-leaved Scrub, none over 3 ft (91 cm).

PLATE 7. Truncated peaks of the False Bay coast. Paulsberg (centre) is the highest point on the Reserve (1203 ft; 366 m). Below this, the rounded calcrete hummocks, pitted with caves, bear Dwarf Dune Mixed Fynbos, with a sward of Stenotaphrum secundatum between these and the rocky coast. Note the wind-sheared scrub at left.

PLATE 8. Cliff-ledges formed by weathering of the soft basal shales at Cape Maclear (250 ft; 76 m). Right, exposed calcrete. Foreground, Broad-leaved Scrub.

PLATE 9. Plot 98, group 6. Summit of Judas Peak. Mountain Fynbos with admixture of Dry Hillveld. Tetraria thermalis, Elegia juncea; Leucadendron salignum left and right foreground.

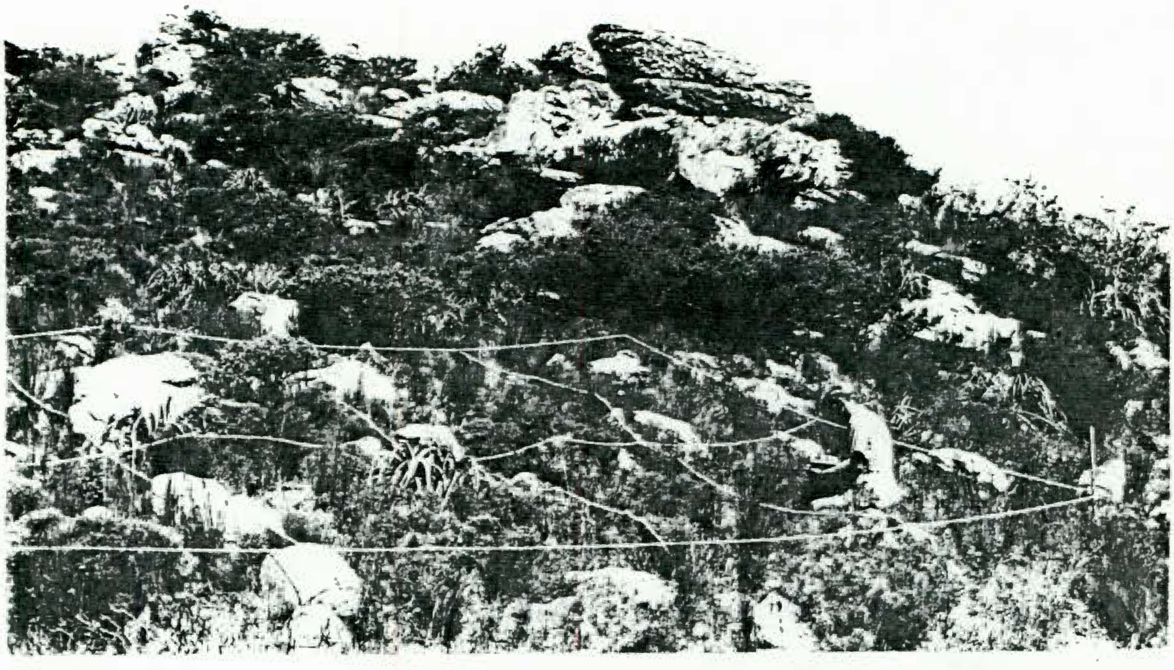


PLATE 10. Plot 66, group 7. Typical Dry Hillveld, Kanonkop. On plot, Tetraria thermalis (lax, coarse-leaved clumps), Staberoha banksii (dark, erect tufts). Beyond at base of boulders, Aspalathus capensis. Post-burn period at least 16 years.

PLATE 11. Plot 8, group 1. Typical Western Hillveld of the Upland Mixed Fynbos, south slope of Bonteberg. The richest plot in the survey (83 species), burnt c. 3 years previously. The rounded bushes of Mimetes hartogii (up to 7 ft (2.1 m) high) form stem-sprouts after a fire. Note block weathering of the Table Mountain Sandstone.

PLATE 12. Plot 19, group 15. Dry Sandflats Association on deep windblown sand of western escarpment near Klein Rondevlei, over 17 years since last burn. Metalasia muricata (white flowers) and Salaxis flexuosa co-dominant. Isolated Acacia cyclops invading, left middle distance. Aspalathus-Phylica Scrub between the scattered Table Mountain Sandstone blocks of the escarpment.

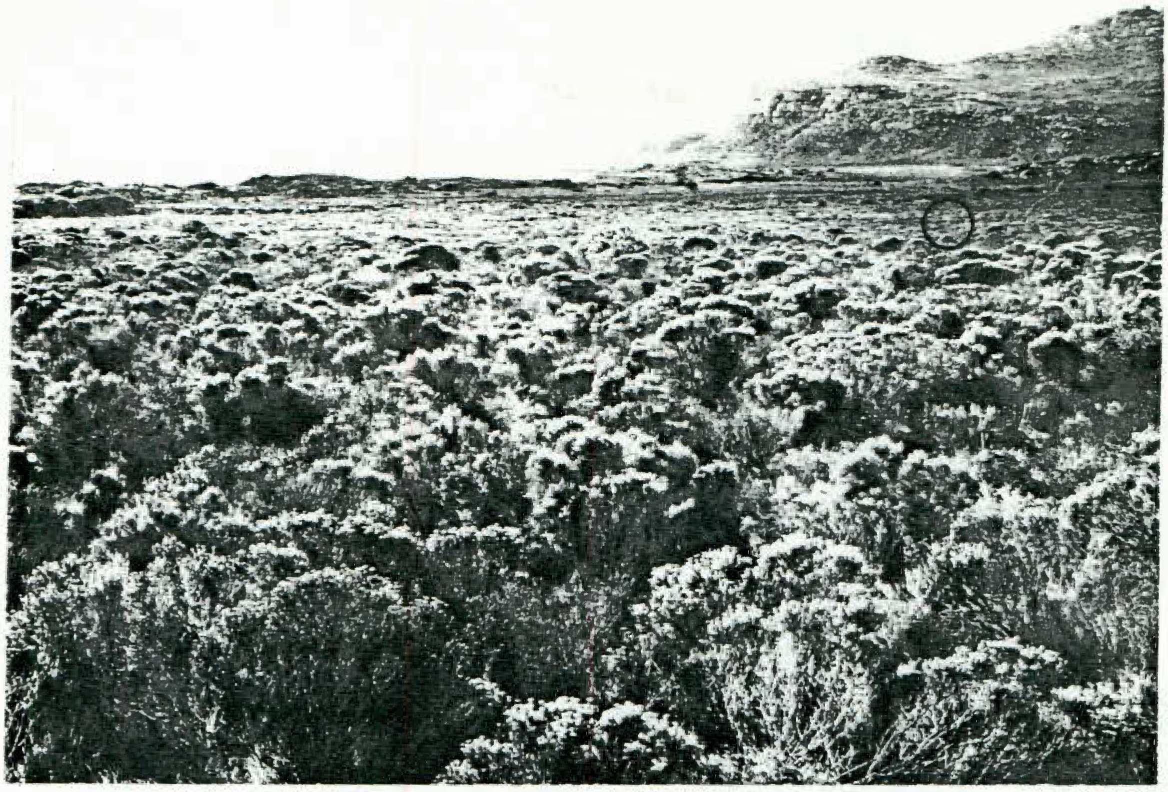


PLATE 13. Dry Sandflats Association near Groot Rondevlei, *Metalasia*-*Salaxis* again co-dominant in long-unburnt vegetation. Circle indicates position of plot 15 (Plate 14).

PLATE 14. Plot 15, group 2. The same community as in Plates 12 and 13 but burnt about three years previously. This plot, with 66 species compared to 27 in plot 19, contains some character species of Western Hillveld and the companion species which are absent in the long-unburnt vegetation of plot 19. (See App.XII).

PLATE 15. Plot 12, group 3. Somewhat depauperate Western Hillveld on rocky shelf with bedrock close beneath; southern foot of Bonteberg. The silvery tufts of Danthonia cincta (e.g. near figure) are conspicuous on rock outcrops three years after fire. Note encroachment of Pinus pinaster and Acacia longifolia along the Krom River, left middle distance.

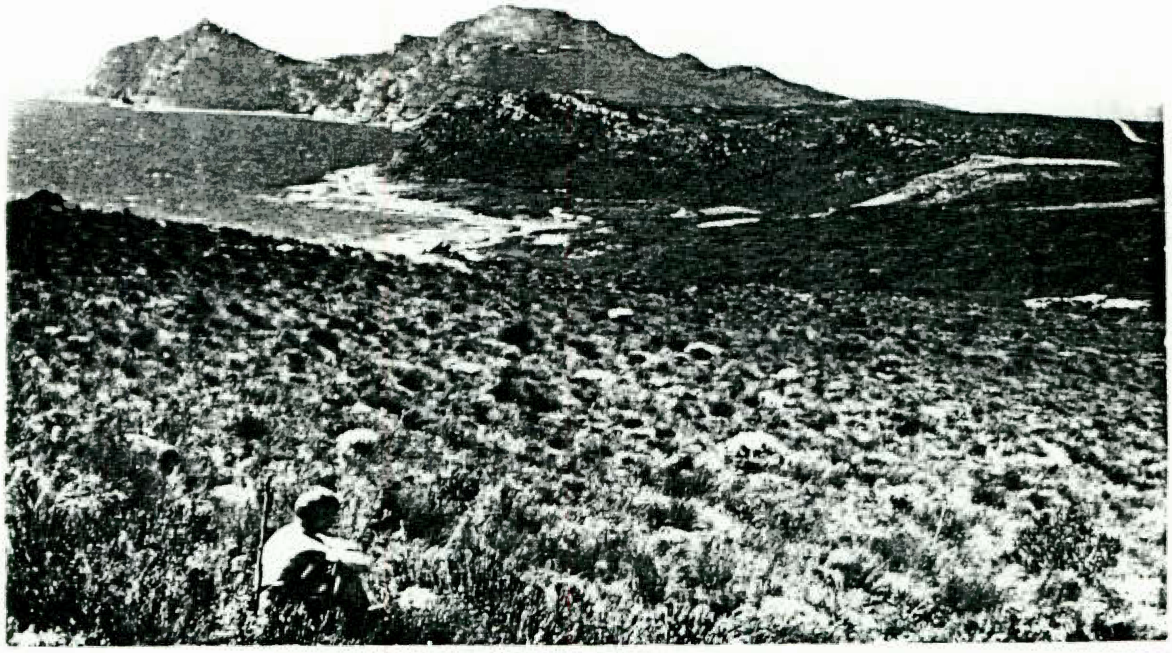


PLATE 16. Plot 79, group 5. Restionaceous Hillveld with some Moist Flats species admixed. Helichrysum vestitum flowering. Cape Point in the distance, with granite boulders at sea level.

PLATE 17. Restionaceous Hillveld on the southern plateau near Diaz Beacon. Scattered bushes of *Leucospermum conocarpodendron* and *Mimetes hartogii* to 8 ft (2.4 m).

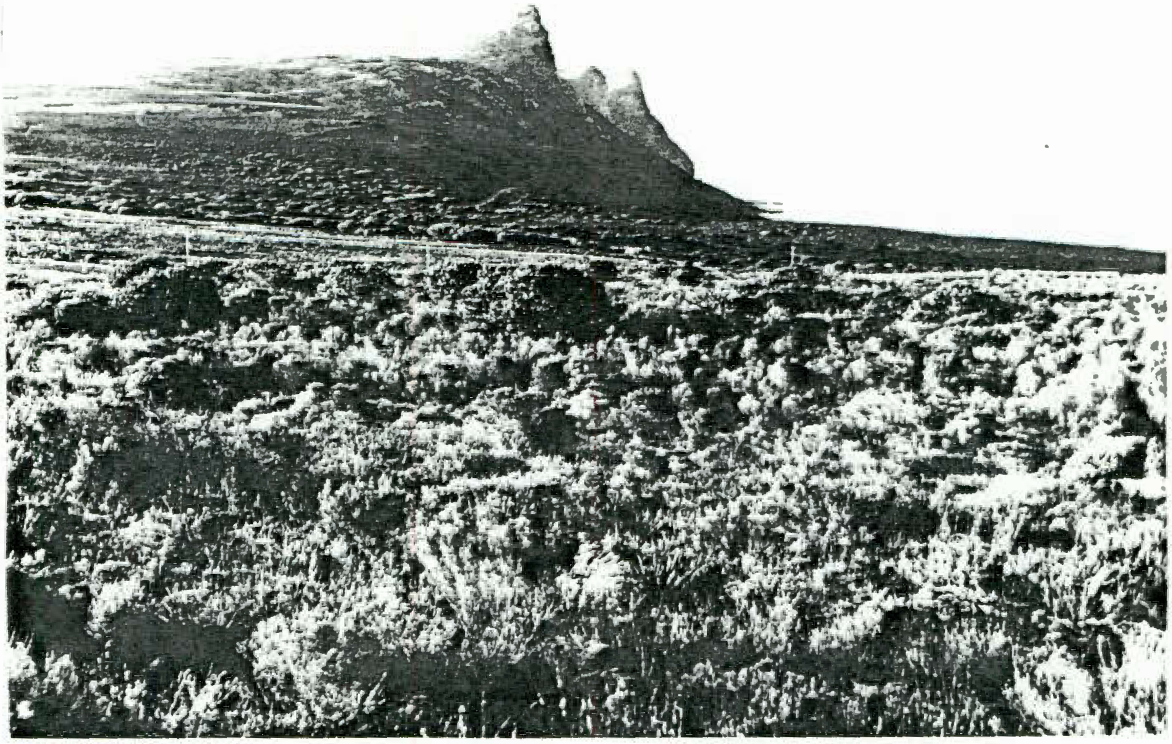


PLATE 18. The biotic *Metalasia*-*Passerina* Sub-Association supplanting the Restionaceous community shown in Plate 17; *Leucospermum conocarpodendron* moribund. Near Platboom road turnoff.

PLATE 19. Protea lepidocarpodendron Tall Fynbos on western slopes of Judas Peak and Die Boer Ridge. Dark-foliaged 7-ft (2.1-m) P. lepidocarpodendron right foreground, with the lighter-coloured, lower Leucadendron salignum in front.

PLATE 20. Plot 36, group 9. Restionaceous Plateau Fynbos with Leucadendron decorum 3-4 ft (about 1 m) high, at least 14 years since last burn. Near Sirkelsvlei.

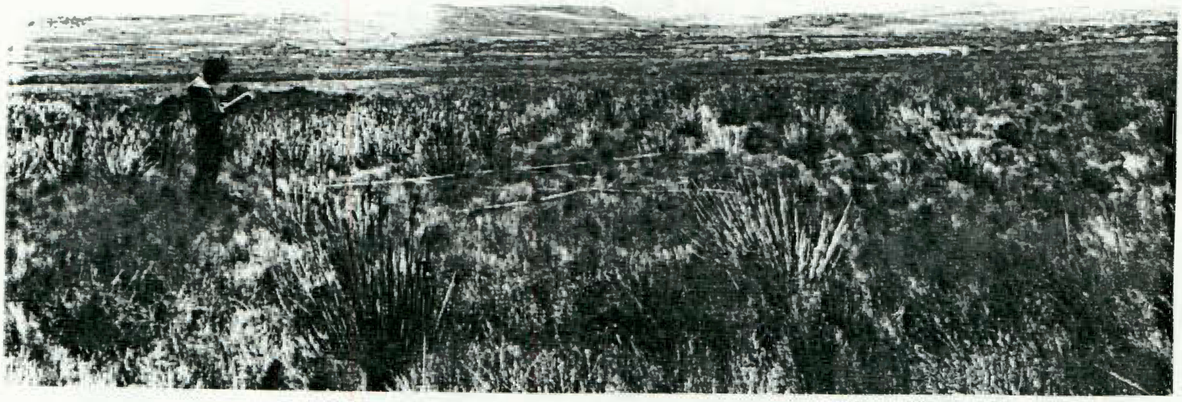


PLATE 21. Plot 65, group 18. Restionaceous Tussock Marsh near Brightwater road turnoff. Tall, black-spiked Elegia cuspidata in foreground and beyond plot; many other Restionaceae, with Elegia parviflora dominant, comprise the lower layers.

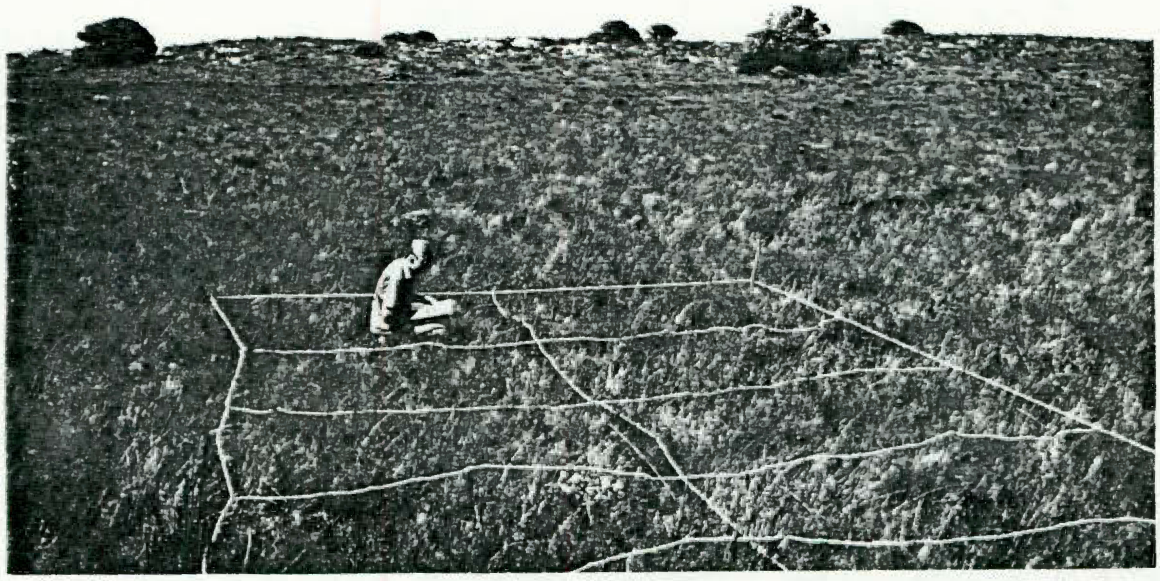


PLATE 22. Plot 83, group 22. Variety of Restionaceous Tussock Marsh with many ericoid shrubs. Suurdam.

PLATE 23. Seepage Scrub 4-6 ft (1.2-1.8 m) high, at edge of Groot Rondevlei: mainly Berzelia lanuginosa (round white flower-heads) and Psoralea aphylla. On pan floor, creeping Sporobolus virginicus and Laurembergia repens with (left) three black-spiked tufts of Chondropetalum tectorum.

PLATE 24. Plot 29, group 23. Distinctive savannah-like variety of Seepage Scrub with scattered Psoralea pinnata to 8 ft (2.4 m) above a dense ground layer of grasses and Restionaceae. Smitswinkel Flats.

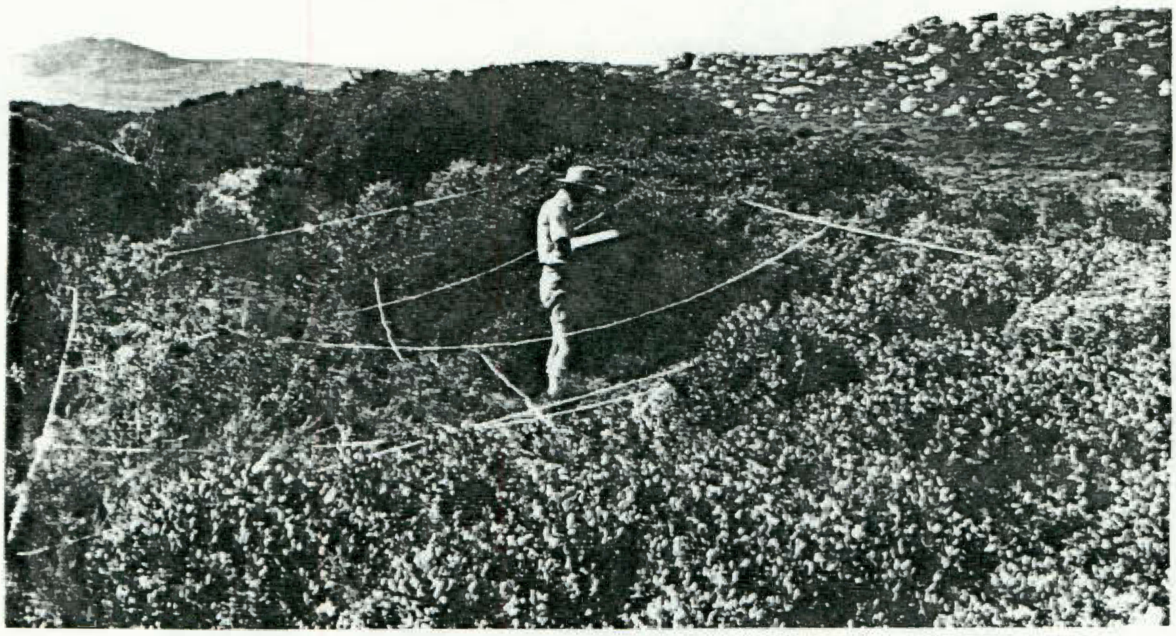


PLATE 25. Plot 25, group 20. Coast Scrub with Euclea racemosa 6 ft (1.8 m) foreground, Cassine barbara 8 ft (2.4 m) behind. Escarpment edge on right skyline, with seepage step below it. Olifantsbos.

PLATE 26. Sideroxylon Scrub about 12 ft (4 m) high, wind-moulded into a humped, impenetrable scrub. Alien Acacia cyclops encroaching below the white cliffs on ridge. Buffels Bay.

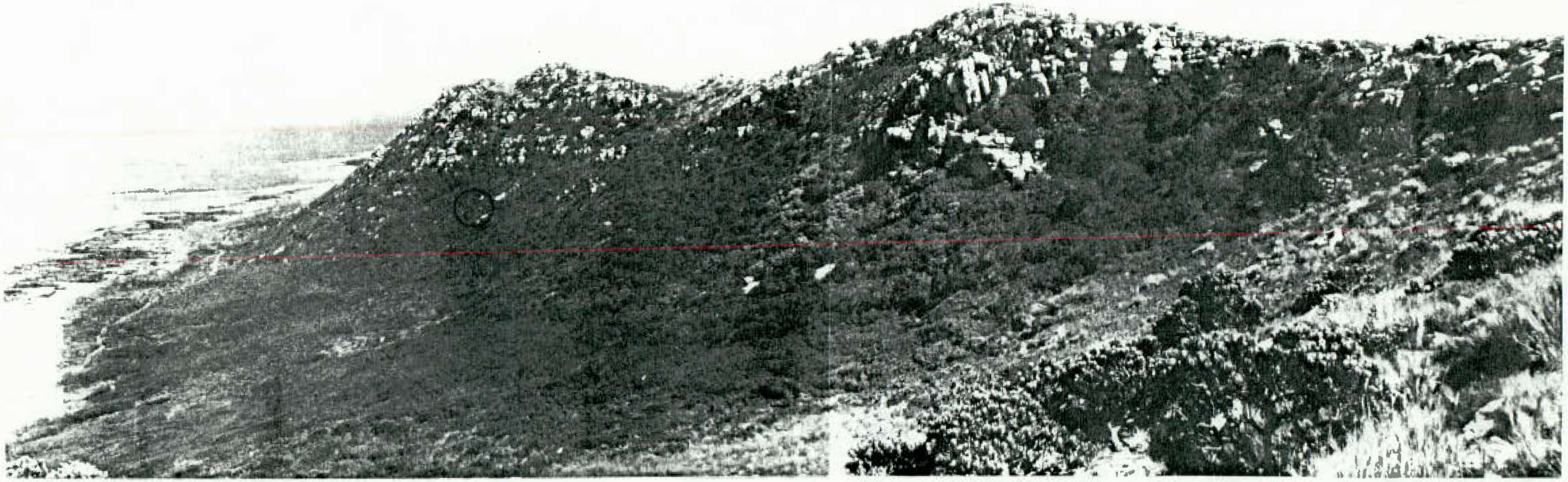


PLATE 27. Tall Scrub on steep talus slopes at Gifkommetjie. Top right, Maurocenia frangularia (dark foliage); centre, Tarchonanthus camphoratus (light foliage). Lower slopes, tangled, wind-moulded Coast Scrub on marine sand of the coastal shelf. The boundary between the two communities, following the soil distinction, is well-marked. Circle indicates the position of plot 81, an ill-defined bushy Hillveld assemblage, long-unburnt.

PLATE 28. Bush-cutting Leucadendron sabulosum on fringe of inland dune to encourage grass regeneration for game. Near plot 78, Gifkommetjie road turn-off.

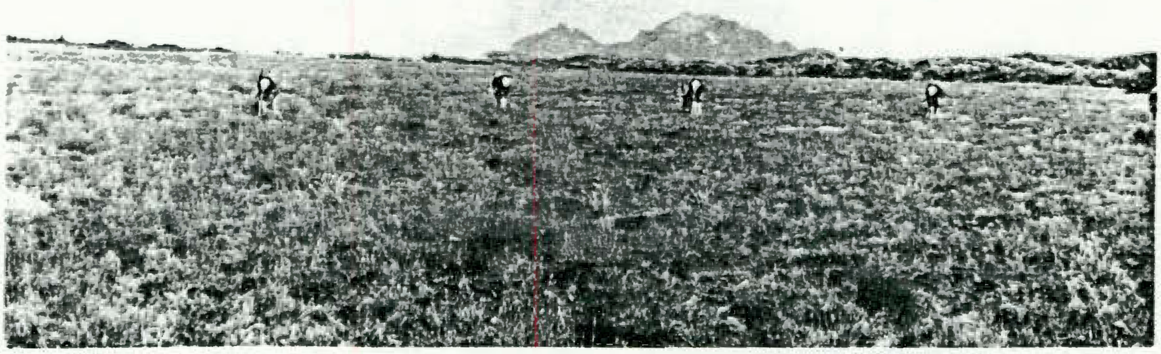
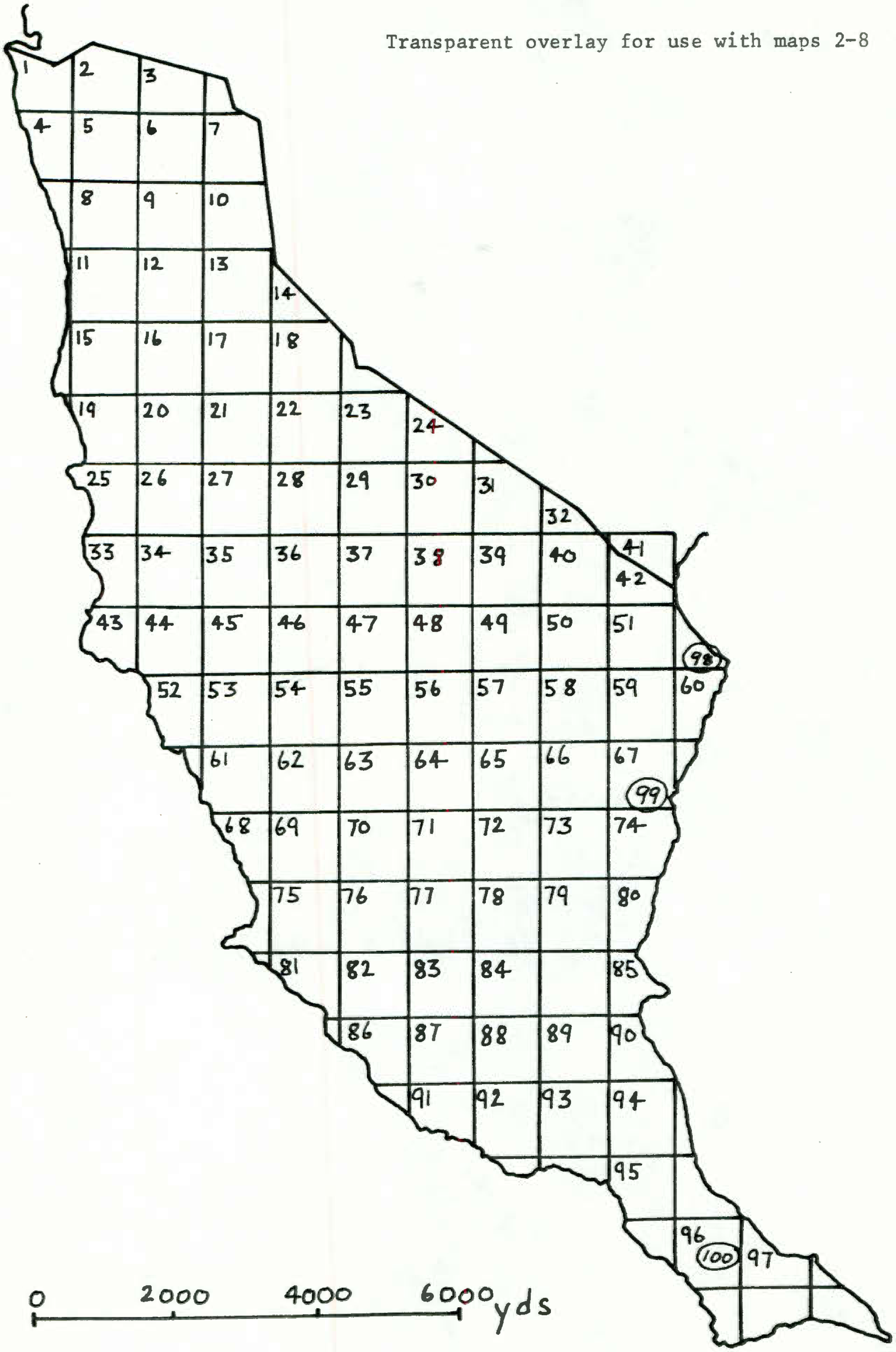


PLATE 29. Bontebok on artificial pasture, Gifkommetjie road turn-off.

MAP 9

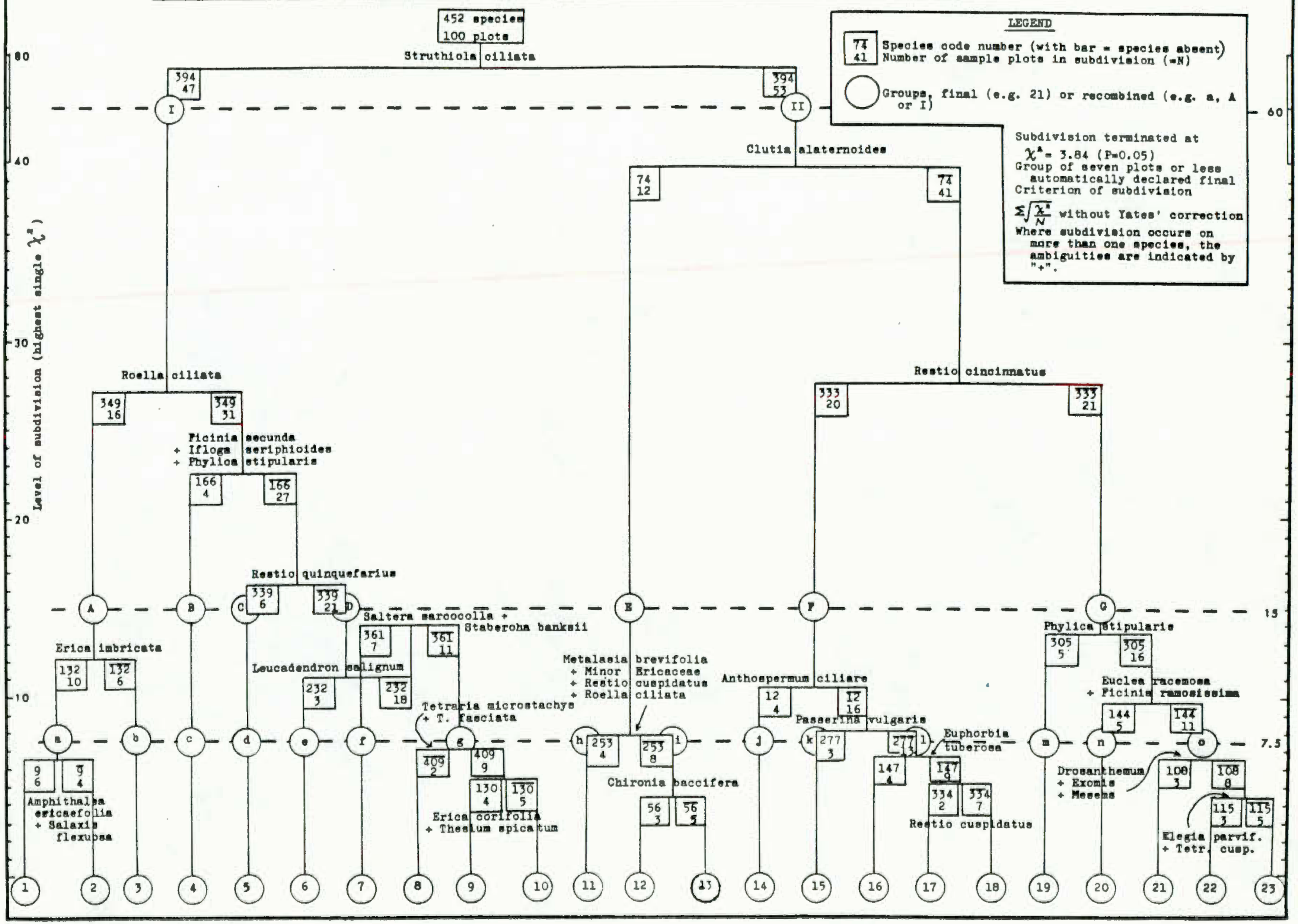
SAMPLE PLOT NUMBERS : CAPE OF GOOD HOPE NATURE RESERVE

Transparent overlay for use with maps 2-8



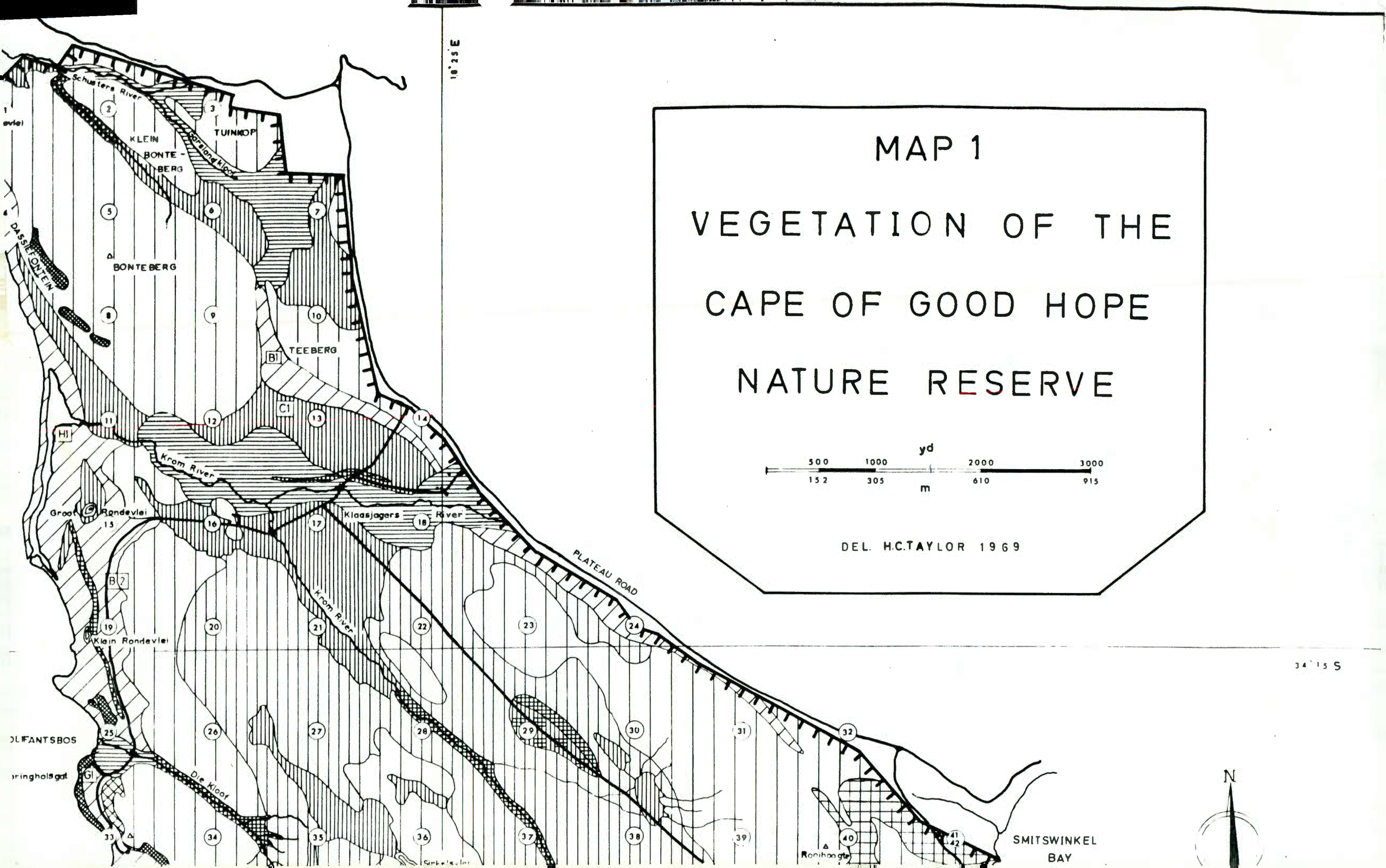
APPENDIX VI

ASSOCIATION-ANALYSIS HIERARCHY : CAPE OF GOOD HOPE NATURE RESERVE

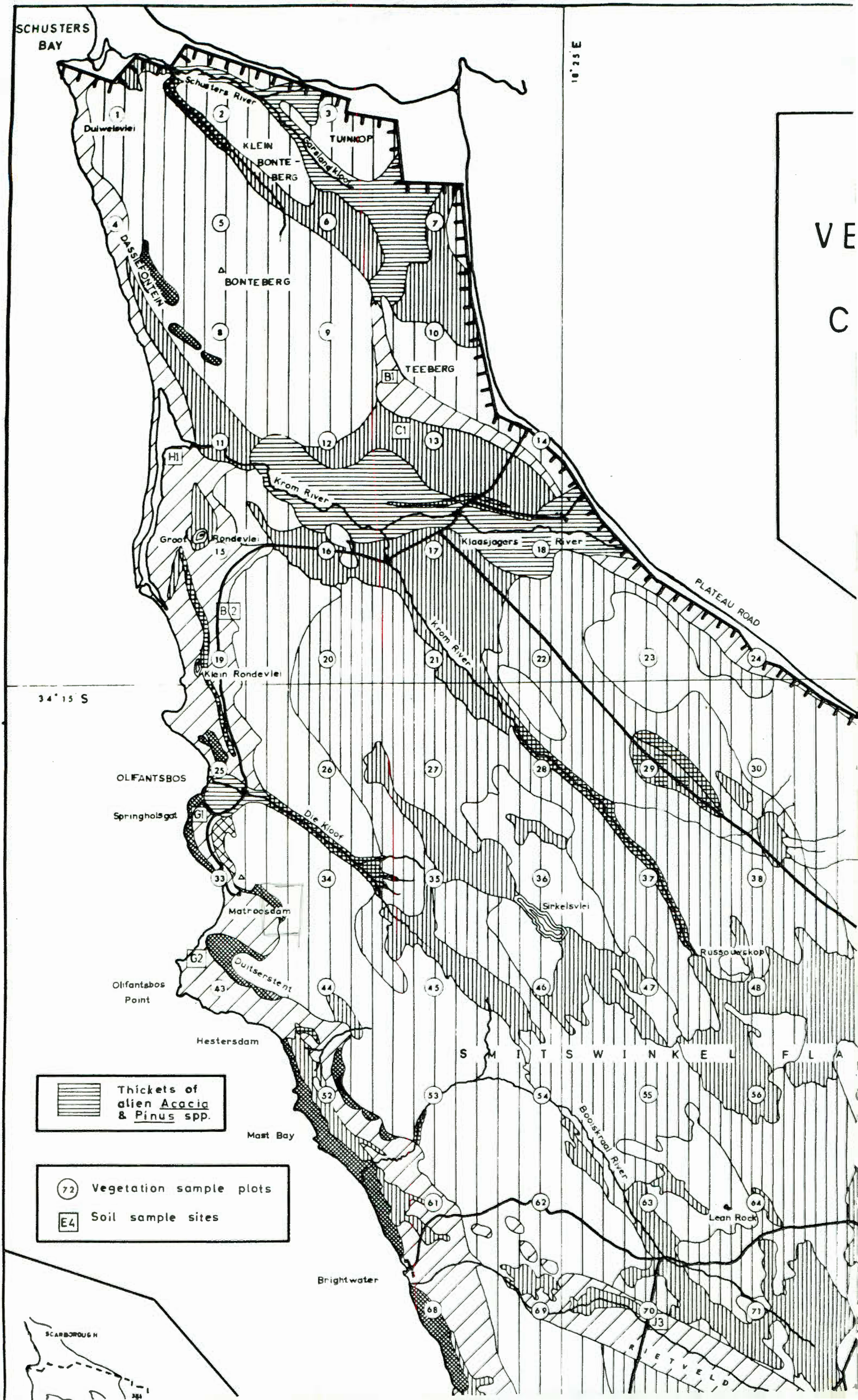


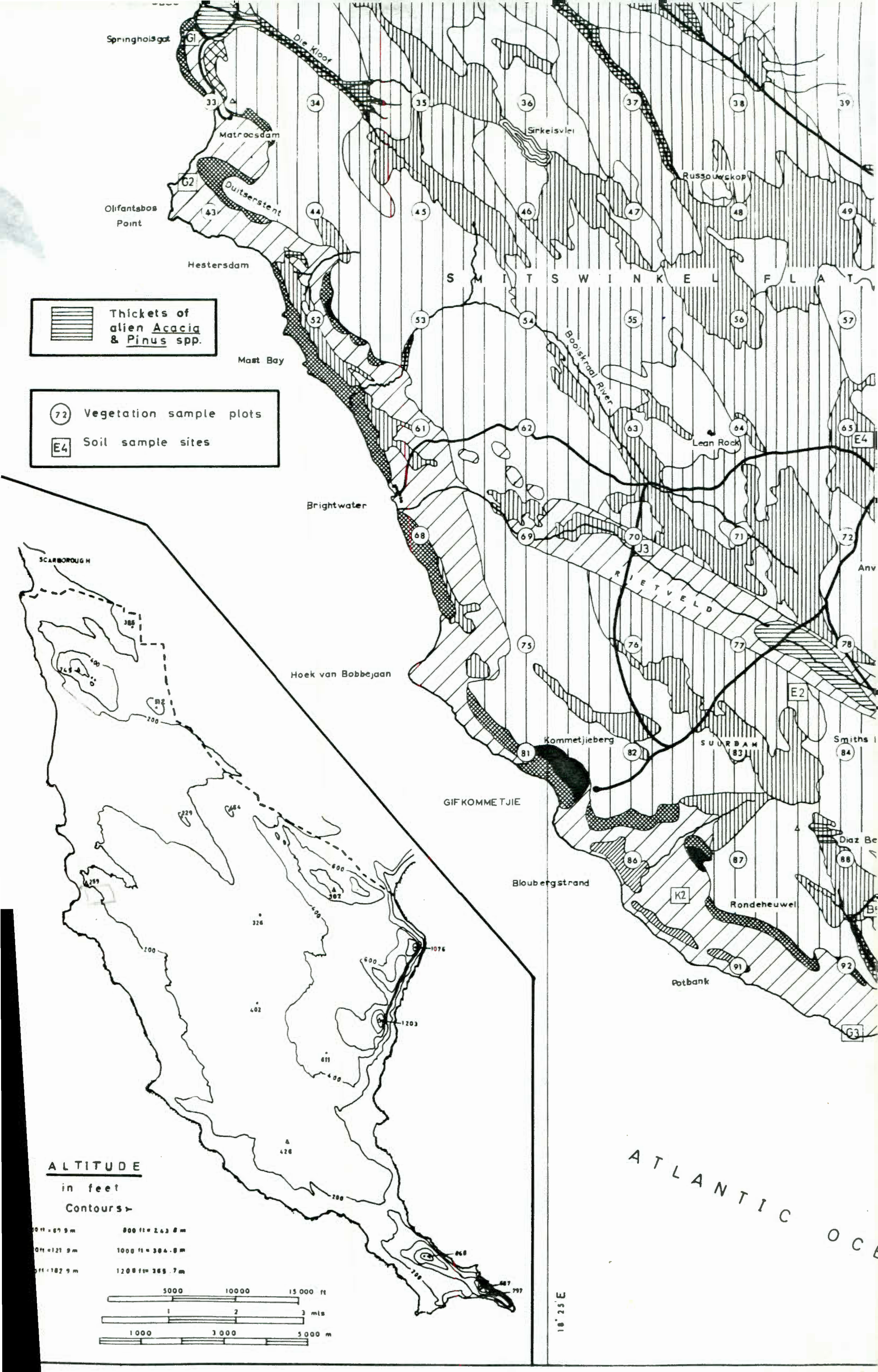
MAP 1

VEGETATION OF THE CAPE OF GOOD HOPE NATURE RESERVE



DEL. H.C.TAYLOR 1969


SCHUSTERS BAY
18°25'E
VE
C
Dulwelsvlei
Schusters River
KLEIN BONTEBERG
Sorelandkloof
TUINKOP
DASSIEFONTEIN
BONTEBERG
TEEBERG
B1
C1
H1
Krom River
Groot Rondevlei
Klaasjagers River
PLATEAU ROAD
B2
Klein Rondevlei
34°15'S
OLIFANTSBOS
Springholsgat
G1
Die Kloof
Matroosdam
Sirkelsvlei
Russouwskop
G2
Olifantsbos Point
Duitserstent
Hestersdam
SMITSWINKEL FLA
Booiskraal River
Mast Bay
Lean Rock
Brightwater
J3
RIETVELD
SCARBOROUGH
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 33 34 35 36 37 38 43 44 45 46 47 48 52 53 54 55 56 61 62 63 64 68 69 70 71
Thickets of alien Acacia & Pinus spp.
72 Vegetation sample plots
E4 Soil sample sites

Springholsgat
G1
Die Kloof
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Matroosdam
Sirkelsvlei
G2
Duitserstent
Russouwskop
Olifantsbos Point
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Hestersdam
S M I T S W I N K E L F L A T
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Thickets of alien Acacia & Pinus spp.
Mast Bay
Booiskraal River
72 Vegetation sample plots
E4 Soil sample sites
61
62
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Lean Rock
E4
Brightwater
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J3
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Anv
R I E T V E L D
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Hoek van Bobbejaan
E2
Kommetjieberg
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S U U R D A M
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Smiths
84
GIFKOMMETJIE
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Diaz Be
Bloubergstrand
K2
Rondeheuwel
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Potbank
G3
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512
200
229
684
600
259
382
326
400
200
1076
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402
1203
611
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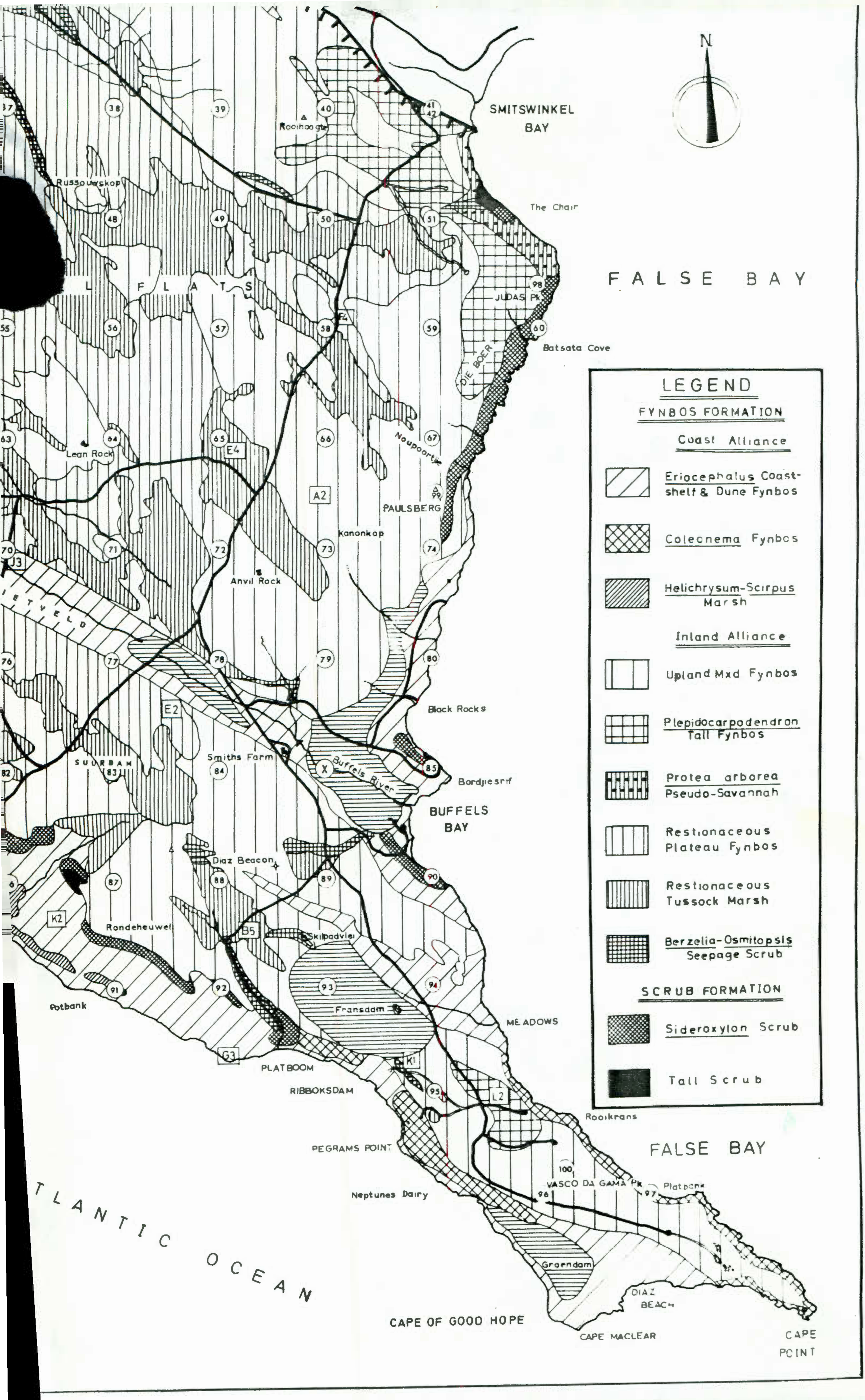
426
200
868
200
687
797
ALTITUDE
in feet
Contours
00 ft = 60.9 m
0 ft = 121.9 m
ft = 182.9 m
800 ft = 243.8 m
1000 ft = 304.8 m
1200 ft = 365.7 m
5000
10000
15 000 ft
1
2
3 mls
1000
3000
5000 m


N
SMITSWINKEL BAY
The Chair
FALSE BAY
JUDAS Pk
Batsata Cove
DIE BOER
Noupoort
PAULSBERG
Kanonkop
Rooihoogte
Russouwskop
FLATS
Lean Rock
Anvil Rock
VELD
SUURBAN
Smiths Farm
Buffels River
Black Rocks
Bordjiesrif
BUFFELS BAY
Diaz Beacon
Skilpadvlei
Rondeheuwel
Potbank
Fransdam
MEADOWS
PLATBOOM
RIBBOKSDAM
PEGRAMS POINT
Neptunes Dairy
Rooikrans
FALSE BAY
VASCO DA GAMA Pk
Platbank
Groendam
DIAZ BEACH
CAPE OF GOOD HOPE
CAPE MACLEAR
CAPE POINT
ATLANTIC OCEAN
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J3
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X
B5
K2
G3
K1
L2
LEGEND
FYNBOS FORMATION
Coast Alliance
Eriocephalus Coast-shelf & Dune Fynbos
Coleonema Fynbos
Helichrysum-Scirpus Marsh
Inland Alliance
Upland Mxd Fynbos
Plepidocarpodendron Tall Fynbos
Protea arborea Pseudo-Savannah
Restionaceous Plateau Fynbos
Restionaceous Tussock Marsh
Berzelia-Osmitopsis Seepage Scrub
SCRUB FORMATION
Sideroxylon Scrub
Tall Scrub