# A SYNECOLOGICAL STUDY OF THE EAST LONDON COAST DUNE FORESTS

by

MICHAEL EDMUND REID BURNS

Thesis presented in partial fulfilment for the Degree of Master of Science in the Faculty of Science, Rhodes University, Grahamstown.

Department of Plant Sciences
Rhodes University
GRAHAMSTOWN

October 1986

CONTENTS

ABSTRACT

Quantitative community descriptions, based on point quarter sample data, are made for a number of dune forest units along the East London coast. These are supported by multivariate classifications and ordinations which illustrate the inter community variation between the sampled seaward, landward and dune valley sites. Climax valley forest is floristically most characteristic and can be clearly distinguished from the seaward and landward thicket communities which tend to show a degree of similarity.

Within-forest community differences are shown to be more significant than variation along the coast. This appears to indicate that climoedaphic gradients established laterally to the coast induce a greater floristic response than the rainfall gradient within the study area. The state of development within the dune soil profile and the rate and effect of salt spray deposition are considered to be important factors influencing dune forest succession and are discussed in some detail. An overview of certain other climatic variables as well as the geological features within the study area is also given.

A phenology study of the dune forest, scrub-thicket and strand plant communities shows some general patterns of flowering and fruiting phenorhythms. Although much variation was observed, there appears to be a bimodal hyperactive phenophase response which is thought to be related to rainfall or periods of favourable soil moisture conditions.

A brief discussion of some of the positive and negative human influences on the coastline is given. This includes a description of the management activities carried out in the area as well as the demands placed on the coastal resource.

A Synecological Study of the
East London Coast Dune Forests

## 1. Introduction

This report represents a much condensed summary of some of the more pertinent information contained in the M.Sc. thesis of the above title, which was submitted by myself in October 1986. The descriptive nature of the thesis makes it difficult to review it adequately in the text which follows and the report has therefore been designed to highlight only the most conclusive or original work contained in the submitted document. A brief overveiw of the biogeographical position of the East London coast dune forests within the South African forest biome is provided in Section 2, which also reviews some of the environmental features of the study area, as well as the conservation status of the forests. Sections 3, 4 and 5 discuss the relevant chapters on forest succession and zonation within the dune vegetation, phenology and the phytosociological patterns exhibited by the forest, as recored during the detailed vegetation survey.

The original study aims are given below and it can be seen that most of them are covered to a certain extent in this report.

(i) To floristically classify the woody component of the dune forests into identifiable communities by means of a quantitative approach.
(ii) To establish which species contribute most significantly towards the floristic composition of the dune forests
(iii) To establish whether any gradients exist in the hierarchy of species dominance along the coastline included in the survey.
(iv) To describe the successional processes operative in the creation and development of the various dune communities.
(v) To describe certain phenological phenomena exhibited by the dune vegetation.
(vi) To provide an overview of some of the most important environmental variables, including the geology, soils and climate, which influence the dune vegetation.
(vii) To describe some of the human influences which have both positive and negative impacts on the coastal environment.

## 2. The Study Area

The area in which the study was carried out includes a stretch of approximately 90 km of the East London coastline between the Kei River in the north (32 41'S; 28 23'E) and the Mcantzi River at Kidds Beach in the south (33 09'S; 27 42'E).

Seven forest units occupying the narrow dune cordon adjoining the predominantly sandy coastline were studied in detail. All of these are situated on State Forest land which was demarcated in 1904 and have been retained in a relatively well preserved state.

The regional climate is described as sub-tropical to warm temperate and is influenced to a large extent by the warm Agulhas current which extends sub-tropical conditions southward into the study area. A gradient exists along the coastline in the rainfall received between the northern- and southernmost study sites. Kei Mouth receives more than 1000 mm of rainfall, while East London receives significantly less, at 808 mm. Dune topography influences the local temperature regimes experienced at the various sites. A study which was conducted shows that seaward slopes tend to experience a more equitable climate than landward slopes due to their south-eastern aspect and proximity to the moderating sea air. Landward slopes tend to be both hotter during the day due to aspect and colder at night due to the chilling effect of katabatic cold air drainage from the hinterland. If temperature alone is considered, it is apparent that vegetation occupying the latter slopes experiences the most harsh climate and evidence of a degree of moisture stress can be seen in the relatively sparse nature of the thicket communities. The prevailing winds are orientated more or less paralell to the coastline, although the stronger summer winds have a slight onshore component, originating from an east-north-easterly direction. These winds in particular, transport significant loads of salt spray which are deposited on the dune vegetation. Measured gradients in the rate of salt spray fall-out show that more than 70% of the transported salt is deposited within 50 m of the high water mark, although small quantities were recorded reaching the forest canopy at almost 1 km from the sea. The pruned, wedge-shaped appearance of the seaward dune thicket is clear evidence of the effect which salt spray has on the canopy structure of this community.

The majority of the geological formations encounterd along the East London coast belong to the Beaufort Series of the Karoo System. Other formations include the comparitively more recent intrusions of dolerite and deposits of limestone and aeolianite. The oldest fixed dunes were laid down during the late Pleistocene and are included in the group of higher rainfall fersiallitic dunes. Pedogenesis, particularly in the most recently formed dunes has not progressed far and edaphic succession has resulted in the formation of a weakly defined A-horizon over regic sand in most soil profiles studied. Duplex soils, with some structural development in a neocutanic B-horizon, were encountered only in some of the oldest and most established fixed dunes.

A study to establish the presence of gradients in certain soil characteristics was carried out across a dune system from a site where no soil development had occurred to one where a soil profile was most evident, on a site occupied by climax dune forest. Pricipal component analysis was used to ordinate the various samples, with organic carbon, pH, calcium and the soil S-value being the characteristics which contributed most towards the sample differentiation. Increasing organic carbon values, decreasing pH and decreasing calcium (through leaching) were responsible for creating the gradient evident across the dune system. This pattern matched the vegetational successional trend. Soil samples taken from the strand plant pioneer zone and from the climax forest site were located at opposite extremes on the ordination, with the remaining samples distributed between these two points. Upper profile samples could also be distinguished on the ordination from those taken lower down by trends of increasing calcium with depth.

The dune forests comprise part of the "Southern Tongaland - Pondoland regional mosaic" and are also classified as belonging to the "Coastal Forest and Thornveld" veld type. The progressive decrease in the number of tree and shrub species from the tropics southwards, leaves the species diversity in the Eastern Cape dune forests characteristically low. Affiliation with the Afrotemperate forest flora is, however, greater because of the proximity to the coast of the upland areas and the presence of migration pathways in the form of valley bushveld links. The forest composition is a conglomerate of elements derived from the Afrotemperate Equatorial Rain Forest, Savanna and Cape Heath floristic units. Endemic species are, however, also present, such as Mimusops caffra which is a dominant canopy contributor. It is estimated that only 1,6 per cent (1776 $km^2$) of the south eastern Subtropical Coast forest biome is conserved. Only 1 per cent (50,1 $km^2$) is adequately conserved in the Cape Province and most of this occurs on State Forest land. The eastern Cape dune forests represent only a small fraction of the above vegetation type (1200 ha), but over 70 per cent thereof is controlled by the Forestry Branch of the Cape Provincial Administration. Three areas of pristine forest covering some 790 ha have been proclaimed as Nature reserves in the region, under the Forest Act 1984 (no. 122 of 1984).

## 3. Succession and zonation

Dune succession is one of the processes to which both recent and older concepts of succession can be applied with relative ease. Primary succession in particular appears to follow a definite sequence which creates the species and community zonation typical of the East London coast. The Clementsian successional model, which assumes that a series of species suites succeed one another on a particular site until a climax community developes which can reproduce itself indefinately, is very applicable to dune succession. Here, the early seral stages play an essential role in stabilising mobile sand, enriching the soil and creating a more sheltered environment for other plants to become established.

Along the East London coast, the model or ideal dune plant succession is comprised of four zones, each seral to the one folowing. The dune pioneer zone or strand plant community occurs closest to the sea is is comprised for the most part of grasses and succulent leafed herbs which are mostly wind and water dispersed. The plants have a stoloniferous or sympodial growth form which enables them to grow ahead of accumulating sand.

Efficient root systems bind the sand and partially fix it, thus creating the first embryonic dunes. Soil development in this zone is minimal and the little organic matter, consisting often of driftline material, is efficiently exploited by the plant roots. The community structure is simple, with the single field layer reaching 0,5 - 1 m in height. As protection against sand and salt spray increase, the habitat becomes modified and an "open shrub community" developes. An increase in species diversity occurs landward and a more woody shrub component becomes evident. The community is generally two-layered, with the field layer measuring approximately 0 - 0,5 m and the shrub layer 1 - 2,5 m in height. Creepers link the two strata. Bush clump nuclei develop in the more sheltered areas, where the second stage species are able to overtop the pioneer vegetation and create perch sites. The bush clumps can eventually merge to form the following seral stage. The "closed dune scrub thicket" community contains a mixture of woody and half-woody species, many of which are present in the climax dune forest. Structurally, it is defined as being a thicket with a population of multistemmed individuals having a very compact canopy. Subordinate strata are usually absent due to the shading effect of the canopy, the height of which varies between 1 and 4 m. Edaphic succession within the dune soil increases its humus content and makes it more capable of supporting a climax forest community. Emergents appear on the more sheltered sites such as dune valleys and the development of subordinate strata, including a ground layer is stimulated by the increased light penetration.

The shrubs of early seral stages become overtopped by tree elements and the vegetation is gradually transformed into littoral thicket or dune forest, the canopy of which varies in height between 8 and 15 m, with an intermediate layer at 2,5-7 m.

The ideal successional pattern can seldom be seen as such in the field. Generally, the communities consist of a vegetational mosaic of primary and secondary origin which only broadly conform to the zonation model. A situation which is more commonly encountered along the East London Coast occurs where the pioneer and open shrubland zones are absent due to wind and tidal erosion and the forest or thicket stage immediately adjoins the beach.

A study was also made of the secondary successional processes which are operative in the recovery of dune forest after fire. This involved a phytosociological comparison between damaged and undamaged forest, 3 years after the occurrence of a fire. A major secondary community could be identified with four variations to it. Compositional differences between it and the unburnt community were evident. Certain climax species were either absent in the recovering vegetation or their community significance had been greatly reduced. Other species reacted extremely well to the fire and increased their status from sub-dominant to co-dominant. The status of certain species remained unchanged. The recovery of some of the typical sub-canopy species was interesting, particularly since this had occurred without the presence of a true canopy. It is thought that this response may have been assisted by the false canopy of creepers and lianes which utilized the scaffolding of dead trees for support. One of the conclusions made from this study is that recovery after fire is quite remarkable for a forest which is considered to be very sensitive to such disturbances and slow to recover. However, while infrequent fires may not have drastic consequences for the community composition, repeated fires could well have and retrogressive succession could set in particullarly as a result of nutrient deficits. Measured changes in soil characteristics, when compared with those of the unburnt site did, for example, indicate reductions in organic carbon and basic cations and a corresponding increase in the soil pH.

## 4. Phenology

A phenology study was carried out on three components of the dune vegetation - the strandplant, dune scrub-thicket and dune forest communities. Monthly assessments of flowering and fruiting patterns of some 66 species were made throughout the study area over a three year period. The data of the more common species comprising the above vegetation components were summarized and presented in the form of bar graphs which expressed as a percentage of the total number of species, the species flowering of fruiting each month. The results were studied for any evident phenorythms and an attempt was made to correlate the data with climatic variables such as rainfall and sunshine hours. Phenodiagrams were evaluated in terms of the effect which drought may have had on flowering or fruiting reaction.

A large degree of variability in phenophase activity was noted between the various dune species and between individuals of the same species. Certain trends were, however, evident. The species comprising the forest component exhibited an equinoctial, bimodal pattern of flowering, with peaks during autumn and spring and less active periods during winter and summer. The fruiting behaviour was similar but somewhat retarded, with peaks in late spring and mid autumn and low fruiting percentages in late autumn and late summer.

The phenophase response of the scrub-thicket component was not as well defined as in the case of the forest species. Flowering peaks occurred in spring and early summer and late autumn, with little activity during late summer and early autumn and winter. A constant level of fruiting was recorded for 10 months of the year with a peak during late spring and a low point during late summer.

The strand species exhibited an interesting behaviour, with an almost constant level of fruiting and flowering activity for 8 months of the year and a single developed peak in the pattern during summer and autum.

Rainfall, as a stimulant and temperature, as an inhibitor appear to play a role in the the behaviour of the forest and scrub-thicket components. The bimodal rainfall peaks during spring and autumn are exploited for the production of fruit by the various species, while the hottest summer period has a negative reaction in this respect. The flowering and fruiting patterns of the strand species can be interpreted as having several advantages for the species concerned. Flowering occurs during the least windy months, when the risk of sand inundation and abrasion is lowest, while fruiting exploits high soil moisture conditions and windy periods for dispersal.

## 5. Forest Phytosociology

The dune forest can be classified, physiognomically, into three types, relating to their seaward or landward exposure and to the degree of shelter provided within the deeper dune valleys. The seaward communities tend to be comprised of thickets which are stunted, closed and relatively unstratified, while the landward communities, which have a similar thicket-like structure, are drier, more sparse and are generally more stratified. The valley communities are tall and structurally complex, with well developed woody, shrub and herbaceous sub-canopy strata.

In order to establish whether corresponding compositional differences existed between these three forest components an intensive sampling operation was carried out within the seven units studied. The sampling technique used was the point-quarter method and with the allocation of composite importance values to the canopy and sub-canopy species recorded throughout, quantitative community descriptions could be provided for the various associations within each unit. Unbiased ordinations and classifications using the sample data supported these descriptions. The establishment of dominance hierarchies within canopy and sub-canopy strata and the degree of floristic continuity between adjacent communities provided much insight into the successional dynamics of dune forest development. The seaward thicket represents an early seral stage in the development sequence, while the valley forest can be regarded as the climax dune community. The landward thicket appears to be transitional between the two latter communities and although it exhibits certain early successional features, it has significant compositional and structural links with the valley forest.

During the analysis of the sample data, the information for the canopy strata produced the best classification and ordination results. Community variations were found to be less apparent in the case of the sub-canopy data, in response to the moderating influence of the canopy on certain external environmental variables such as insolation and salt spray.

The ordination which was carried out on the data set for the entire study area did not illustrate the presence of a significant compositional gradient along the coast. However, what was apparent from the results, was the degree of similarity between the various valley communities and the polarization between this group and the other seaward and landward communities. This would seem to imply that the valleys must experience a certain uniform set of environmental or climoedaphic infuences which encourages the development of forests of similar composition. In the study carried out on the salt spray fall-out rate, the lowest values were recorded for the valley site which must induce a specific floristic response. The state of soil development, which was shown to be consideratly more advanced in the case of the valley than tha other sites investigated, must similarly contibute significantly towards assisting the establishment of climax forest species.

The location of the forests at the southern extreme of the true dune forests of South Africa and their transitional floristic nature produced interesting results during the survey. The reduction in a sub-tropical climatic influence accounted for the drop-off in a number of species between the northern- and southernmost study sites and induced a corresponding response in certain temperate species which increased in importance southwards. As a supplement to floristic data already assimilated for the dune forests of Natal and Zululand, it is considered that the results of this study are of some value.

ACKNOWLEDGEMENTS

The assistance and motivation provided by the following persons during the course of the study is greatly appreciated:

Dr. R.A. Lubke for his supervision of the project;

Dr. K.L. Tinley for his encouragement and advice, particularly on sampling techniques;

Mr. A.R. Palmer for his invaluable assistance and advice on most aspects of the study;

Mr. D. Everard for his assistance with the multivariate analysis techniques which were usea;

Mr. A.M. Avis for willingly parting with his knowledge of coastal ecosystems;

Mr. D. Grey for his comments and assistance with the soil analyses;

Mrs E. Brink and Dr A. Jacot-Guillarmod who assisted with most of the plant identifications;

Mr E.H.F. Steenkamp who, as Forester in charge of the East London Coast State Forest, assisted with much of the fieldwork;

Mr L.M. Pike whose companionship and help during the collection of field data was of tremendous value;

Mr L. Wingate who generously offered the use of his computing facilities as well as other assistance;

Messrs. T. Paulsen and J. Robinson and Dr. K. Klugman for their constructive comments on the study;

Mr J.E. Cobby for his patience and support throughout the study;

The Director-General of the Department of Environment Affairs for granting permission to undertake the project at State expense;

Mrs C.J. Eller for typing the manuscript, and to my wife Karin who assisted wherever possible and who provided the inspiration to complete the manuscript.

PERSONAL COMMUNICATIONS

The names and addresses of personal communications referred to in the text are listed below.

Grey, D.C. Department of Environment Affairs.
Saasveld Forestry Research Station,
Private Bag X6515,
George. 6530.

McDevette, D. Department of Environment Affairs.
Natal Forest Region,
Private Bag X9029,
Pietermaritzburg. 3200.

Palmer, A.R. Department of Nature and Environmental Conservation,
Private Bag 1006,
Grahamstown. 6140.

Tinley, K.L. Department of Conservation and Environment,
1 Mount Street,
Perth. 6000.
Western Australia

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

# CHAPTER 1

## INTRODUCTION

The forests of the Indian Ocean coastal belt have been divided into two major phytochoria on the basis of the distribution limits of component species, and the presence of Afrotemperate linking species (White, 1983; Moll and White, 1978). They are the northern Zanzibar-Inhambane and southern Tongaland-Pondoland Regional Mosaics which in part consist of the discontinuous cordon of dune forests situated along the eastern and south-eastern margin of the African sub-continent. The eastern Cape dune forests fall within the southern defined area which Acocks (1975), in his classification of the South African vegetation, has included within the veld type definition of Coastal Forest and Thornveld.

The forest communities are comprised of a conglomerate of elements derived from several floristic units including Afrotemperate (Podocarpus falcatus), Equatorial Rain Forest (Diospyros natalensis), Savanna (Acacia karroo), and in the south, Cape Fynbos (Metalasia muricata). The species diversity decreases southwards from the tropics to the Eastern Cape where the floristic composition of the dune forests is characteristically poor. The Afrotemperate influences is however considerably greater in this coastal region than further north due to the proximity of the upland areas and the presence of seaward migration routes in the form of numerous riparian thicket links (Tinley, 1985).

The coastal flora of the Eastern Cape is transitional in nature as a result of the parallel subtropical and more temperate influences and in this respect deserves investigation. Very little research however has been carried out on any of the forest communities, including those occupying the dunes, and scant quantitative documentation is available in the case of the latter. These facts prompted the initiation of this study, particularly as it was felt that information about the forests could be quite significant since they are located at the southern extreme of the true dune forests of South Africa. As a supplement to existing information assimilated for the dune forests to the north, it was also felt that any data resulting from the study could perhaps later be profitably used in extensive coastal floristic gradient studies.

Of the environmental parameters which are discussed or have been studied, salt spray and the nature of the dune soils are considered to play a major role in determining community zonation and the other phytosociological and structural patterns evident within the forests. A suitable technique was used to collect data on the salt spray fall-out pattern across a representative dune system and the implications of this for the vegetation are discussed. Edaphic succession within the dune substrate is closely related to the successional development of the vegetation which it supports and environment- and biotic-induced soil gradients can be identified both vertically and laterally within and across the dunes. These gradients are illustrated in the study by means of a multivariate analysis of the chemical characteristics recorded for a number of representative soil samples.

Although the dune vegetation tends to form a successional continuum, a number of relatively homogeneous forest or thicket communities can generally be identified according to the sites which they occupy. Obvious physiognomic differences formed the basis for the initial community differentiation which was made during the study and this was later supported by the phytosociological classifications which were carried out using the survey data. The latter was collected from within a number of forest units along the coast using a point quarter sampling technique which was found to be satisfactory. The various community differences which were identified within the forest units are discussed and speculation is made as to any anticipated upper hierarchy species changes which could occur in the future. In this respect, reference is made to the regenerative potential of the canopy by individuals currently contributing towards the sub-canopy strata and information on the latter was kept discrete for this purpose.

The successional processes operative in the development of the dune vegetation are discussed, as well as the application of traditional and more recent approaches towards the concept of plant succession. A case of secondary succession after fire was also investigated and the state of recovery of the vegetation is compared with the adjacent unburnt forest.

A final aspect covered by the study includes a brief investigation into the flowering and fruiting phenophases exhibited by certain of the dune species, particularly in response to drought conditions. The periods of low and high activity recorded for the Forest, Scrub-thicket and Strand elements are discussed in terms of coinciding climatic conditions and the behavioural differences of a number of individual species are also discussed.

## 1.1 AIMS OF THE STUDY

The aims of this study can be summarized as follows:

(a) To floristically classify the woody component of the dune forests into identifiable communities by means of a quantitative approach.

(b) To establish which species contribute most significantly towards the floristic composition of the dune forests.

(c) To establish whether any gradients exist in the hierarchy of species dominance along the coastline included in the survey.

(d) To describe the successional processes operative in the creation and development of the various dune communities.

(e) To describe certain phenological phenomena exhibited by the dune vegetation.

(f) To provide an overview of some of the most important environmental variables, including the geology, soils and climate, which influence the dune vegetation.

(g) To describe some of the human influences which have both positive and negative impacts on the coastal environment.

## 1.2 THE STUDY AREA

The area in which the study was carried out includes a stretch of approximately 90 km of the East London coast between the Kei River in the north (Lat. 32°41'S; Long. 28°23'E) and the Mcantzi River at Kidds Beach in the south (Lat. 33°09'S; Long. 27°42'E), as indicated in Fig. 1. A narrow dune system, which is intersected at intervals by a number of river mouths, has developed along much of the shoreline adjacent to the predominantly sandy and mixed sandy and rocky beaches. The most prominent feature of the system is the large, landward barrier dune which is aligned more or less parallel to the coastline, of the type which is often referred to as a precipitation ridge. The latter is fixed by vegetation in various stages of successional development, including the thicket and forest communities about which this study is centred.

The majority of the dune plant communities are included within the boundaries of the East London Coast State Forest which were demarcated in 1904 and they have therefore been retained in a relatively well preserved state. The seven forest units which have been included in the study are distributed at intervals along the coast and are considered to be representative for the area. Their localities are indicated in Fig. 1.

As stated, scant applicable information is available on the East London dune forests, with the only published descriptive literature being that of Comins (1962a and 1962b). The latter author provides a

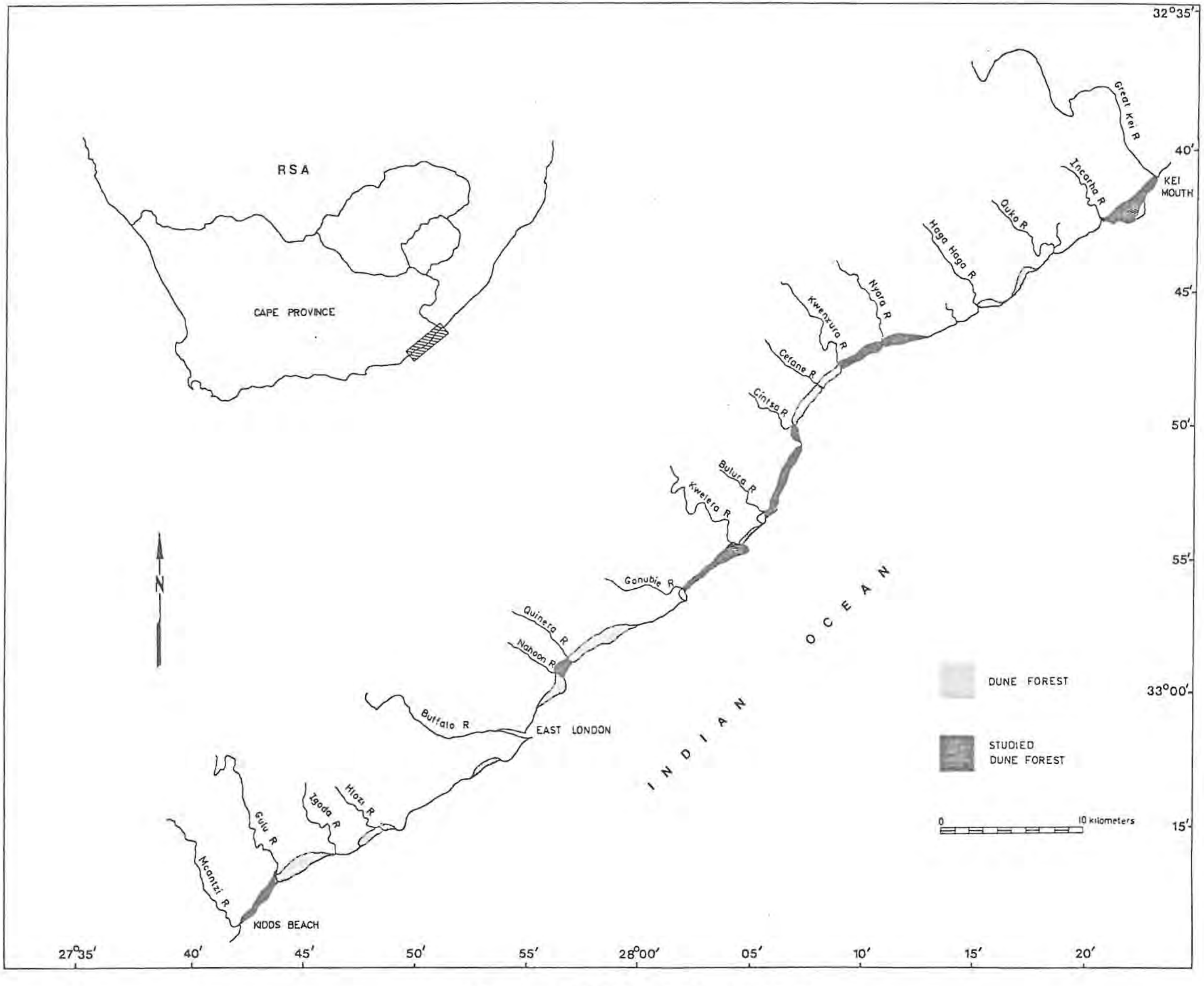



Fig. 1. Location of the Study Area.

brief overview of the vegetation which he refers to as Coast Dune Bush and includes a description of the different successional stages and associated species contributing towards the communities. Reference is however also made to the south-eastern Cape dunes by Heydorn and Tinley (1980), Tinley (1985) and Weisser and Cooper (in preparation) in their broad summaries of various coastal ecological aspects.

# CHAPTER 2

## SITE AND ENVIRONMENTAL PARAMETERS

### 2.1 GEOLOGY

The great majority of the geological formations encountered along the East London Coast belong to the Karoo System (Table 1 ). The sediments which have been grouped as the Beaufort Series are mainly of fluvial origin and were laid down after the Permo-Carboniferous Glaciation during the warmer Permian and Triassic periods (Truswell, 1977). These were later invaded by igneous material during the Jurassic period and in places have subsequently been overlaid by more recent deposits.

#### The Beaufort Series

The Beaufort spans the Palaeozoic-Mezozoic boundary, with the latter era being the age when reptiles were dominant in the animal world (Truswell, 1977). The group is therefore rich in reptilian, and to a lesser extent, amphibian fossils. Although it is difficult to place time lines into the Karoo succession, different stages of the Beaufort have been identified using palaeontological evidence supported by the lithological characteristics of the various strata.

A biostratigraphic zonation was first proposed towards the end of the last century and has subsequently been modified to the five zones currently accepted (Du Toit, 1926). The distribution in time of certain key reptiles which prevailed within the periods shown is also

| | | | | | |
|---|---|---|---|---|---|
| SYSTEM | KAROO | | | | |
| SERIES | STORMBERG | BEAUFORT | | | ECCA |
| STAGE | | UPPER | MIDDLE | LOWER | |
| PERIOD | | EARLY TRIASSIC | LATE PERMIAN | MIDDLE PERMIAN | |
| ERA | | MESOZOIC | PALEOZOIC | | |
| PALEONTOLOGICAL ZONES | | *Cynognathus*<br>*Lystrosaurus* | *Daptocephalus*<br>*Cistecephalus* | *Tapinocephalus* | |

TABLE 1. GEOLOGICAL TIME SCALE AND PALEONTOLOGICAL ZONES OF THE BEAUFORT SERIES OF THE KAROO SYSTEM.

illustrated in Table 1. The lithological limits of each stage of the Beaufort do not correspond exactly to the limits of the time periods and the Middle Stage for example includes both the Late Permian and Early Triassic.

Reptilian fossils discovered along the coast include those from within the Lower Cistecephalus horizon - for example Dicynodon grimbeeki, Oudenodon baini and Pristerodon spp. - and have therefore been associated with the Lower Beaufort Stage (Mountain, 1945, 1974). No fossils have been found in the Middle Beaufort beds of the area. Fossils of the fern Dicroidium lancifolia, known to occur in the Burgersdorp beds of the Upper Beaufort, have been collected at Cintsa and fossils of several Glossopteris spp. (common to the Lower Beaufort) have been found at various localities along the coast (Mountain, 1974; Du Toit, 1926).

The Lower Beaufort Stage

The bulk of the coastline sediments belong to the Lower Beaufort. Its lower limit is not visible since the underlying Ecca does not crop out anywhere in the area. It can however be distinguished from the latter by the absence of dark grey sandstone and shale and the presence of reddish mudstone (Mountain, 1945). Its upper limit is also somewhat vague since the Middle Beaufort is only positively known to occur in a few areas.

The rock types include argillaceous mudstone and fine-to coarse-grained sandstones. The colour of the mudstone varies and includes red, purple, blue, grey and green varieties. With exposure, the mudstones fracture into small irregular blocks and the deposits tend to break up into rough boulders in contrast to the sandstones which weather into smooth platforms. Some of the small sandy bays could quite possibly have formed where the mudstones have been weathered more rapidly than adjacent sandstone headlands. According to Mountain (1974) the red mudstones are not that common but outcrops have been noted at East London, Haga Haga, Kwenxura River Mouth and at Cintsa (See Plate 1 ).

Sandstone outcrops, some of which contain calcareous concretions, occur frequently. A coarse pink variety containing pebbles can be found on either side of the Bulura River mouth and at Kidds Beach

### The Middle Beaufort Stage

The Middle Beaufort is relatively thin compared to the Lower Stage and outcrops have only been identified at Kidds Beach and Kwelera. Marais and Johnson (1965) associate the pinkish pebble-containing sandstone at Kidds Beach with the Middle Beaufort Katberg Formation. Its colour also distinguishes it somewhat from the typical blue-grey Lower Beaufort sandstone.

### The Upper Beaufort Stage

The only beds encountered along the coast of this stage are those overlying the Middle Beaufort at Kwelera. The rocks typical of the Upper Beaufort are maroon, purple and greenish-grey mudstones

PLATE 1. Mudstone outcrop at Cintsa West.

occurring in the upper and lower parts of the sequence (Marais and Johnson, 1965).

Karoo Dolerite

Several examples of doleritic intrusions into the sediments of the Beaufort Series can be found along the East London coast. They commonly follow an east-west trend and appear to reach their southern limit at the Kiwane River, which is approximately 20 km south-west of Kidds Beach. Truswell (1977) gives the southern limit of the Karoo dolerites as the line corresponding to the Cape Fold Belt.

The age of these intrusions has not been determined with any certainty but it is likely that they formed at the beginning or middle of the Jurassic Epoch (Du Toit, 1926; Truswell, 1977).

The two forms assumed by the dolerite are the broad, slightly inclined sheets and the narrow dykes, which show far greater angles of dip.

The dolerite sheets consist mainly of plagioclase and augite and are medium to coarse grained. Examples can be seen at Cape Morgan, the cliffs at Double Mouth, Reef Point near Cintsa, Kwelera River Mouth, Nahoon Point, Hood Point and Igoda Mouth.

The dykes tend to be slightly finer grained than the sheets and exhibit a glomeroporphyritic texture due to clusters of plagioclase feldspar crystals (Mountain, 1945). Du Toit (1926) considers the dyke erruption to be later than that of the sheets since in many cases they do not merge with the latter but cut through them. The dykes, which vary in width between 2 and 15m, appear to be concentrated to the north of East London and few are found to outcrop in the south. An example of a relatively wide dyke is visible at Double Mouth with other examples occurring south of Reef Point, at Nahoon River Mouth, Fullers Bay and at several other localities. (See Plate 2).

Metamorphism of the invaded sediments, in particular the mudstones, has occurred over a period of time with the altered material often resembling an igneous type of rock itself (Mountain, 1974). The mudstones have been altered to lydianite and the sandstones, which principally contain quartz, become very hard quartzite (Schwarz, 1912). Any calcareous concretions have been converted to siliceous concretions and an example of this can be observed below the dolerite sheet at Hood Point.

Veins in dolerite of mobilized sediment occur widely in the East London area, for example at Gonubie River Mouth (Mountain, 1974). Veins of granitized sediment or granophyre, consisting of quartz and feldspar can be found in the dolerite sheet at Hood Point and a wider vein of similar material occurs at Keightleys Krantz at Morgan Bay (Mountain, 1936, 1974). Du Toit (1926) explains the formation of granophyre dykes as being due to the solidifying of the siliceous residue remaining from the crystallizing of the dolerite in the contraction rifts of the rock mass.

The occasional boulder beaches encountered along the coast are a result of the weathering of the dolerite masses which break up along

PLATE 2. Dolerite boulders at Cintsa West.

the typical cross-jointing found in them. The boulders can be confused with the darker sandstone rocks containing heavy minerals which also have a tendency to weather spheroidally .

The reddish-brown sands of some of the older fixed dunes have been associated with weathered dolerite, with the colour being derived from oxidized iron-containing minerals such as magnetite and ilmenite. Mountain (1945) notes the absence of these red sands south of the Kiwane River Mouth which, as stated earlier, is the southern limit of the dolerite intrusions.

Coastal Limestone

Heydorn and Tinley (1980) note the general absence of limestone along the south-eastern Cape coast while Mountain (1945) considers deposits to be restricted to localities south of East London. These are very poorly exposed with none evident within the study area, although an outcrop of a friable, yellowish type does occur fairly close to the Igoda River Mouth. Other deposits could be covered by overlying calcareous sandstone.

Calcareous Sandstone

In many areas the Beaufort sediments and Karoo dolerites are overlaid by Quaternary calcareous sandstone. It has formed through the consolidation of dunes by calcite which recrystallizes from the calcium carbonate contained in shell fragments (Mountain, 1945, 1966, 1974). Where the rock exhibits a criss-cross bedding, the parent material is of aeolian origin and it is referred to as aeolianite or

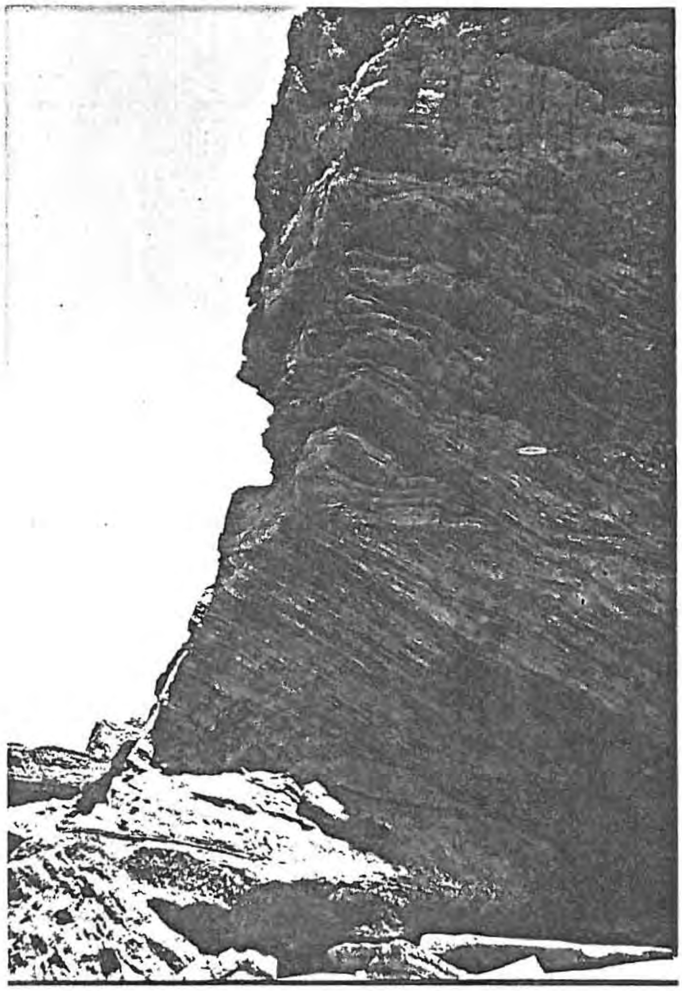


PLATE 3. Dune rock or aeolianite.

dune rock (See Plate 3). Where the bedding is horizontal it is probable that the material is of aqueous origin either in the form of a lagoonal or beach deposit.

There is an interesting outcrop at Bats Cave near East London which rests upon a pebble layer above a dolerite intrusion. Middle Stone Age implements have been collected from this layer and casts of human footprints and tracks of hyena and birds have been found in one of the strata. On the basis of this evidence, Mountain (1966, 1974) aged this deposit as belonging to the upper Pleistocene time and radiocarbon dating of some of the shell material gave a result of 29090 (+410 -390) years B.P. (SR-83).

The occurrence of peculiar solution hollows in the dune rock platforms at Bonza Bay have been attributed by Mountain (1936, 1937) to chemical weathering.

## 2.2 DUNE SOILS

### 2.2.1 Introduction

According to the broad divisions of the soils of the South African coastal margin, the East London soils are described as being derived from the Beaufort series and dolerite of the Karroo System (Van der Merwe, 1962; Harmse, 1978). Van der Merwe (1962) classifies the coastal dunes as belonging to the arenosol order of soils and groups those situated between Mossel Bay and Bazaruto Island as the eastern, higher rainfall group of fersiallitic dunes. A further sub-division is made by McLachlan et al. (1981) who distinguish between beach sands with low and high $CaCO_3$ contents. The former occur on the south-east coast, south to the Kei River, while the latter extend between East London and the Orange River. The dunes in the study area thus fall within the transition zone of sands with high and low calcareous concentrations.

Edaphic succession has resulted in the development of two soil types which can be classified according to the South African binomial system of Macvicar et al. (1977). Most of the dune soils fall within the description given to the Motopi or Langebaan series of the Fernwood form but certain duplex soils, corresponding to the Oakleaf form, have developed in some of the older dune valleys. In the latter case structural development in the neocutanic B horizon is quite conspicuous.

The oldest fixed dunes were laid down during the late Pleistocene, while those still in a dynamic state of erosion and accretion are a product of Recent times (Meissner, 1977; Tinley, 1985).

### 2.2.2 Physical characteristics of the dune soils

The East London dune sands are comprised of between sixty and ninety-five percent of the lighter quartz minerals, with most of the balance being made up of calcite, derived from shell material (Meissner, 1977). Heavy minerals such as ilmenite, rutile and zircon can account for between 0,2 and 3 percent of the sand volume (Tinley, 1985).

Through the winnowing action of the wind, considerable sorting of the sand grains has occurred, with the heavier and coarser material having been deposited closest to the sea and the lighter, finer fraction transported further inland (also found by Willis et al. (1959) and Barbour et al. (1973). A gradient in particle size also generally occurs within the dunes from the crest into the dune core. Finer material is found close to the soil surface, while the grains become more coarse deeper in the profile (Tinley, 1985). Due to the large number of air spaces between the grains and low clay and humus contents, young dune sands are extremely porous and have an inherent low field capacity due to the rapid rate of moisture percolation (Boorman, 1977; Barbour et al., 1973). This is one of the major physical characteristics of dune sands which has a great influence on the chemical processes which take place within them. The effects of a low field capacity are thought to be reduced by the formation of dew within the dune mass (Salisbury, 1952; Boorman, 1977; Tinley, pers. comm.) since the poor conductive properties of sand and the rapid loss of heat from the surface layers could establish the necessary temperature gradients for this to occur.

### 2.2.3 Analysis of grain size

An analysis of the relative distribution of the various grain sizes of dune sand was made from a series of soil samples taken across a vegetated dune at Kwelera, north of East London. Fig. 2 indicates the positions of the five sample sites as well as the deflation hollow situated in the wake of a parabolic dune which originated at

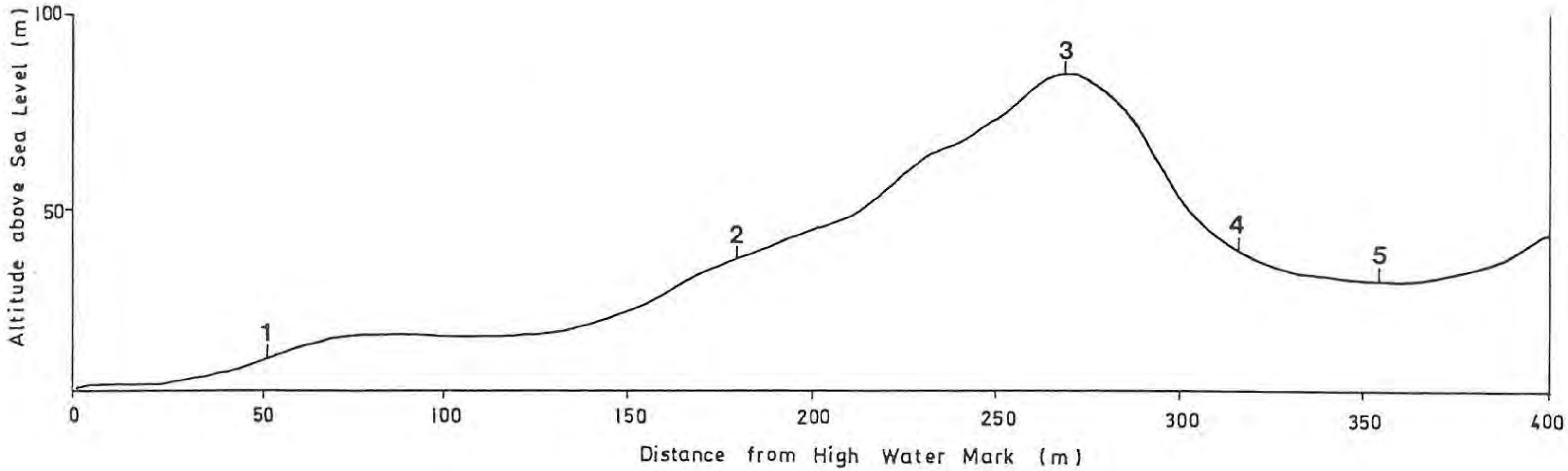



Fig. 2.
Position of the five soil sample sites at Kwelera.

Sunrise-on-Sea in the south. Composite samples were taken from two depth intervals within the five soil profiles, which were located between 80 and 1000 m inland of the high water mark. The depth intervals were defined as the surface layer (0-15 cm) and sub-surface layer (16-60 cm) and the analysis was made for both layers at each site. The cumulative percentages of sand retained in the sieve size 180 microns or bigger were then compared with one another.

Results and discussion

In all cases, apart from site No. 5, the sub-surface layers contained a greater fraction of coarse sand than the surface layers (See Table 2). At Site No. 1 for example, the cumulative percentage of coarser grains was 95 percent in the case of the deep sample, compared to 76 percent in the surface layer. These results were expected since with time, finer wind-blown sand would tend to accumulate on top of the less mobile coarse material.

A progressive decrease in the percentage of coarse sand was found to occur in the surface layer with increasing distance from the sea, between sites 1 and 3. Site no. 4, which was located at the margin of the deflation hollow contained slightly coarser surface material, while a high percentage was recorded for site no. 5 (Table 2). The decrease in grain size can be explained in terms of the sorting action of the wind, which was discussed above. It is likely that with the passage of the parabolic dune, most of the fine sand was removed from within the deflation hollow, exposing previously buried coarser sand.

| | SAMPLE DEPTH (cm) | |
|---|---|---|
| | 0 - 15 | 16 - 60 |
| SITE No. | | |
| 1 | 76 | 95 |
| 2 | 52 | 54 |
| 3 | 50 | 65 |
| 4 | 52 | 60 |
| 5 | 70 | 67 |

TABLE 2. CUMULATIVE PERCENTAGES OF SAND RETAINED IN THE SIEVE SIZES 180μ AND BIGGER FOR A SERIES OF SOIL SAMPLES TAKEN ACROSS THE KWELERA DUNES.

This is possibly the reason for the high value recorded for site no. 5 (70 per cent), since it was situated within this deflated area.

### 2.2.4 The process of soil development

In the formative stages, dunes appear to be heaps of apparently inert sand possessing few characteristics indicative of their ability to support forest communities. Under the combined influences of environmental and biotic factors, the chemical and physical properties (particularly moisture holding capacity) become modified and a soil develops which is closely associated with the vegetation it supports.

Pedogenesis within the dunes is only really initiated once they have been partially fixed by vegetation (Willis et al., 1959; Salisbury, 1925). The process of soil development follows an almost universal pattern, which has been described by Chapman (1976), Willis et al. (1959), Walker et al. (1983), Boorman (1977), Wilson (1960) and Tinley (1985). Two major factors involved, are the eluviation of basic cations from the topsoil and their subsequent accumulation in the sub-soil layers and the reverse roles played by calcium and humus in determining the soil pH. Calcium is initially responsible for creating the alkaline soil conditions but through the weak acidic properties of rain is rapidly leached out of the upper profile. The vegetation simultaneously plays an indirect role in site acidification through the production of humus and humic acids which retain the $H^+$ ions in the soil solution and aid in the solubilization of calcium. The pH values of the East London dune sands for example vary between

9,4 in the embryo dunes and 7,2 in the topsoil of densely forested sites.

The dune soils of the Eastern Cape contain substantial reserves of weatherable minerals (Gray, pers.comm.) and through laterization lose appreciable quantities of basic cations from the upper profile. Carbonates and sesquioxides of aluminium and iron accumulate at lower levels and clay (predominantly kaolin) can form with time in the older dunes (Tinley, pers.comm.). Sand removals between the Quinera lagoon and the township of Gonubie have exposed a relatively deep section through one of the previously vegetated dunes, illustrating the state of profile development (Plate 4 ). The orthic A-horizon is quite evident above the paler beige sand of the subsoil which in turn overlies the buried calcareous concretions which have resulted through the leaching process described. Although no analysis was carried out, the texture of the deepest soil indicated the definite presence of a clay fraction. No evidence of podzolisation, such as reported by Walker et al. (1983), Thompson and Hubble (1979) and Thompson (1981) for the Cooloola dunes in Australia, was found in any excavated soil pits or in the reports of borehole drillings made by Meissner (1977) and can be attributed to the comparatively low rainfall of the area.

Soil development within the dunes is still in a phase of progressive succession and is likely to remain so for a considerable time. This is due to the relatively young age of the system and predominantly subclimax state of the plant communities. Although the nutrient loss

PLATE 4. Soil profile through a dune at Quinera.

from the stabilized dunes through mineralization and leaching in all probability exceeds the rate of accretion by atmospheric nutrients (salt spray), the nutrient pool is presently positively inclined towards the requirements of the vegetation. Deep rooted woody species are capable of recycling part of the lower profile accumulation of nutrients and return this through litter fall to the humic surface layers and by so doing maintain a fertile medium for perpetuating the established or developing communities. Evidence for this can be seen in the ability of the forest to recover after fire where secondary succession produces communities resembling close facsimiles of the original forest. It is anticipated however that retrogressive succession and nutrient deficits within the soil could set in if the forests were subjected to repeated fires or stock pressure. In this case the soil surface could eventually become excessively leached and, in the absence of an effective replenishment mechanism, become incapable of supporting either forest or its precursons.

The results of a detailed soil analysis are discussed in the following section.

## 2.3 PRINCIPAL COMPONENT ANALYSIS OF THE DUNE SOIL CHARACTERISTICS

### 2.3.1 Introduction

Gauch (1982) describes Principal Component Analysis (P.C.A.) as an objective ordination technique for projecting a multidimensional cloud of points into a space of fewer dimensions (for example two). The

Principal Component axes about which the points are scattered maximize the variance accounted for by the points and allow an easier insight into and interpretation of a multivariate set of data. Details of the application and theory of P.C.A. are also given by Seal (1964) and Kendall (1957).

One of the uses of a P.C.A. ordination of environmental data is the graphic illustration it gives of the existence of a possible environmental gradient, should such a gradient exist, since any strong directions of variation in a data matrix are likely to be reflected by the analysis (Shimwell, 1971). Palmer (1981), Huntley and Birks (1979) and Bosch (1977, 1978) are a few of the many to have employed this technique in order to explain gradients in soil characteristics and it was therefore considered appropriate to use it in this study.

The information for the two-way data matrix of samples x soil chemical characteristics was collected across a dune system from a site with no soil development to one where profile development had progressed relatively far.

### 2.3.2 Description of the study area

The site chosen for the study was the beach and area of dune forest at Morgan Bay. Samples were collected at four different sites from three profile depths. The first site was located on an embryo littoral dune, the second on a sea-facing dune slope, the third on a landward slope and the fourth at the bottom of a dune valley (See Fig. 3).

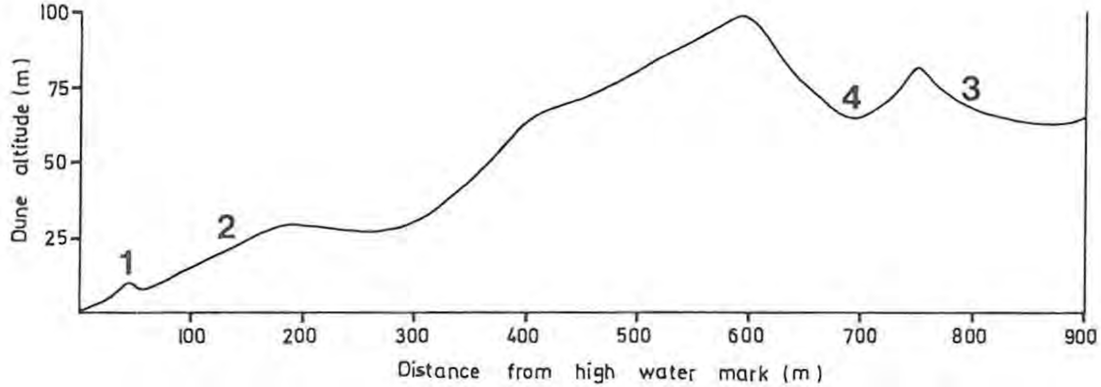



Fig. 3.
Position of the four soil sample sites at Morgan Bay.

The beach vegetation consisted of scattered primary colonizers such as Arctotheca populifolia and Ipomoea brasiliensis and the dune sand was still very mobile, with the recent accumulation having taken place. Relatively dense thicket and forest occupied the sea- and land-facing slopes and the valley vegetation consisted of climax dune forest made up of far fewer, but larger canopy trees. (A detailed description of this vegetation is given in Ch. 5). A considerable amount of eroded material, originating from the valley sides, was noted to have accumulated on the floor of the valley.

### 2.3.3 The collection of soil samples

A soil pit of 1,5m in depth was excavated at each of the four sites in order to obtain a clear assessment of the profiles. No profile development was evident in the beach pit and due to the mobile nature of the dune sand and lack of vegetation, no accumulation of organic matter had occurred in the upper soil layer. Slight traces of organic matter were noted lower in the profile and probably originated from roots or buried and decayed drift-line material. The profiles of the pits on the sea-and land-facing slopes were very similar, with the A-horizons measuring some 20-25cm deep. From the profile of a valley pit, it appeared that a buried A-horizon existed at approximately 1m below the surface, with the upper A-horizon comparable to those of the other slopes. At all sites, apart from the beach, the A-horizon was underlain by regic sand which varied in colour from light grey to beige.

Soil samples were collected at depths of 10, 50 and 100cm. At each site four initial samples were collected from the four sides of the pit at the three sample depths. These were mixed thoroughly before a single composite sample was taken for analysis from each of the various depths.

### 2.3.4 Principal component analysis of the soil data

The soil samples were analysed for eight variables. These were pH, percentage organic carbon, sodium, potassium, calcium, magnesium, cation exchange capacity (C.E.C.) and the soil S-value (sum of the base cations). The results are given in Table 3.

The computer programme COMP 1, written by L.Orlóci, was used to ordinate the samples by means of a P.C.A. of the correlation matrix of the soil characteristics. The data was untransformed. (See Table 4).

The percentage of the total variance accounted for by the first seven principal components is given in descending order in Table 5. The first and second principal components account for 77,6 and 12,4 per cent of the data variance respectively and with a cumulative total of 90 per cent of the variance, were the most promising to use for plotting the data. (Plots using the first and third Principal Components and using the three axes of the first three Principal Components did not provide better graphical illustrations of a site/soil gradient).

The component scores for the sample sites were used to plot the points about the first and second Principal Component axes (Fig 4). Four groups of sample points can be identified on the plot.

| SAMPLE SITE | SOIL VARIABLES (Concentrations in meq./100 gm.) pH | % C | Na | K | Ca | Mg | S-Val | C.E.C. |
|---|---|---|---|---|---|---|---|---|
| A1 | 9,40 | 0,00 | 0,41 | 0,18 | 7,81 | 0,60 | 9,00 | 0,85 |
| A2 | 9,40 | 0,00 | 0,41 | 0,18 | 9,11 | 0,45 | 10,15 | 0,78 |
| A3 | 9,50 | 0,01 | 0,52 | 0,19 | 11,46 | 0,58 | 12,75 | 0,44 |
| B1 | 8,20 | 1,49 | 1,01 | 0,21 | 30,83 | 5,04 | 37,09 | 5,80 |
| B2 | 9,20 | 0,08 | 0,37 | 0,14 | 13,30 | 0,66 | 14,47 | 1,23 |
| B3 | 9,40 | 0,02 | 0,28 | 0,15 | 12,80 | 0,50 | 13,73 | 1,80 |
| C1 | 8,70 | 0,44 | 0,72 | 0,22 | 13,36 | 0,66 | 14,96 | 3,36 |
| C2 | 8,90 | 0,34 | 0,46 | 0,15 | 15,69 | 0,33 | 16,63 | 2,30 |
| C3 | 9,30 | 0,06 | 0,52 | 0,13 | 10,64 | 0,41 | 11,70 | 1,00 |
| D1 | 8,20 | 1,40 | 0,92 | 0,18 | 21,40 | 1,37 | 23,87 | 2,12 |
| D2 | 8,90 | 0,20 | 0,48 | 0,17 | 14,54 | 0,66 | 15,85 | 2,15 |
| D3 | 9,00 | 0,32 | 0,41 | 0,12 | 19,61 | 0,70 | 20,84 | 2,91 |

A = BEACH
B = SEAWARD SLOPE
C = LANDWARD SLOPE
D = DUNE VALLEY

1 = 10 cm.
2 = 50 cm.
3 = 100 cm.

TABLE 3. SOIL VARIABLES RECORDED ACROSS A DUNE SYSTEM AT MORGAN BAY.

SOIL VARIABLES

| | pH | % C | Na | K | Ca | Mg | S-Val | C.E.C. |
|---|---|---|---|---|---|---|---|---|
| pH | 1 | -,948 | -,875 | -,375 | -,852 | -,674 | -,847 | -,796 |
| % C | | 1 | ,920 | ,418 | ,891 | ,787 | ,900 | ,751 |
| Na | | | 1 | ,624 | ,745 | ,754 | ,776 | ,674 |
| K | | | | 1 | ,203 | ,457 | ,268 | ,363 |
| Ca | | | | | 1 | ,850 | ,995 | ,873 |
| Mg | | | | | | 1 | ,898 | ,811 |
| S-Val | | | | | | | 1 | ,882 |
| C.E.C. | | | | | | | | 1 |

TABLE 4. CORRELATION COEFFICIENTS BETWEEN THE EIGHT SOIL VARIABLES USED FOR THE ORDINATION OF THE MORGAN BAY DUNE SOILS.

| COMPONENT | PERCENTAGE OF TOTAL VARIANCE ACCOUNTED FOR BY EACH COMPONENT |
|---|---|
| 1 | 77,62 |
| 2 | 12,38 |
| 3 | 5,65 |
| 4 | 2,98 |
| 5 | 0,78 |
| 6 | 0,43 |
| 7 | 0,16 |
| 8 | 0,00 |
| TOT: | 100,00 |

TABLE 5. THE PERCENTAGE OF TOTAL VARIANCE ACCOUNTED FOR BY EACH OF THE PRINCIPAL COMPONENTS.

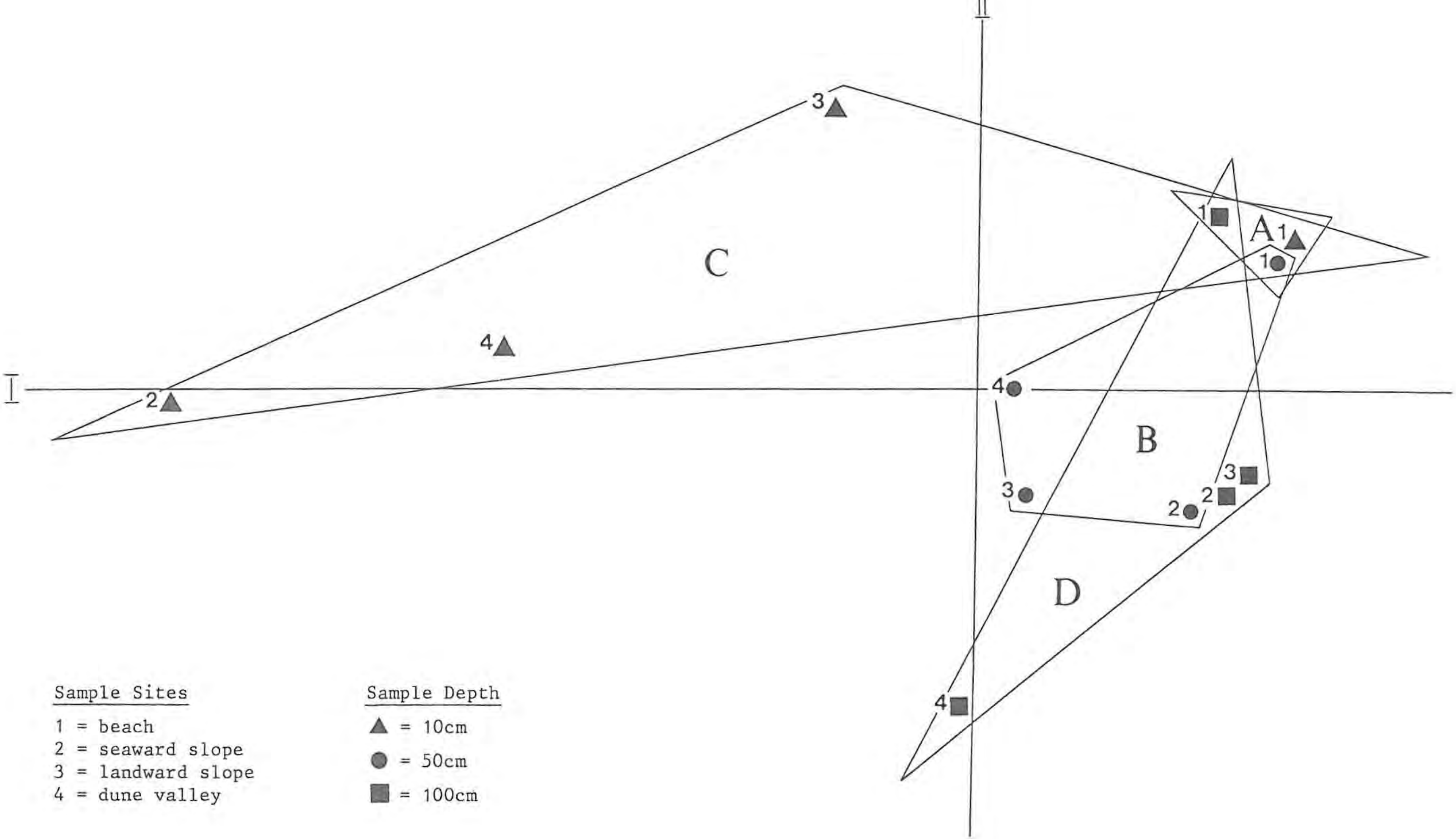



Fig. 4. P.C.A. ordination of the Morgan Bay dune soil characteristics.

Group A

This group is made up of the three samples collected from the beach site. The group as a whole is fairly isolated from the other points on the plot which would seem to indicate that the beach soil characteristics must differ fairly significantly from those elsewhere. Although there is a small gradient evident on the plot, from the upper soil sample towards the lower profile, the close proximity of the points to one another indicates the large degree of similarity in soil characteristics throughout the profile.

Group B

This consists of the group of mid-profile samples, with the two most dissimilar samples being those taken from the beach and the dune valley. Within the group, and in terms of the first Principal Component axis, the latter two points occur at the extremes of the plot and the distribution of the remaining points between them establish an interpretable gradient which is discussed later.

Group C

This is a distinct group of points which are widely distributed across the first Principal Component axis. All were samples taken from the A-horizon or upper part of the soil profile and the relatively big differences in soil characteristics between them have established the gradient which is evident on the plot. The two samples which differ the most are those taken from the beach and the seaward dune slope.

Group D

This group includes the samples taken from the lower profiles of the four sites.

### 2.3.5 Discussion of the soil gradients

The anticipated gradients in soil characteristics across the Morgan Bay dunes were expected to follow closely the vegetational successional trend since several researchers have found this to be so with dune soils (Salisbury, 1952 ; Willis et al., 1959 ; Chapman, 1976). In descending order of progression, this would be from the climax dune valley forest to the communities of the landward and seaward slopes, followed by the pioneer beach vegetation.

Within Group B, the mid-profile samples, the soil gradient did in fact correspond to the pattern described above and progressed from the beach site where no soil development was evident towards the valley site where a more complex soil had developed in association with the climax forest (Fig. 5). In Table 6, the first Principal Component displays high percentage loadings for the soil factors pH, percentage organic carbon, Ca and soil S-value. Decreased loadings were recorded for Na, Mg, K and C.E.C. and they were not therefore considered responsible for establishing the soil gradients along the first Principal Component axis. The percentage organic carbon recorded for Group B increased landwards from the beach towards the climax forest and associated with this was a corresponding decrease in soil pH - which is strongly negatively correlated with organic carbon (See Table 4). The increase in organic carbon (from colloidal humus) provides an increased source of $H^+$ which dissociates from the carboxyl (COOH) groups of humic acids. The adsorption of these ions by the humus

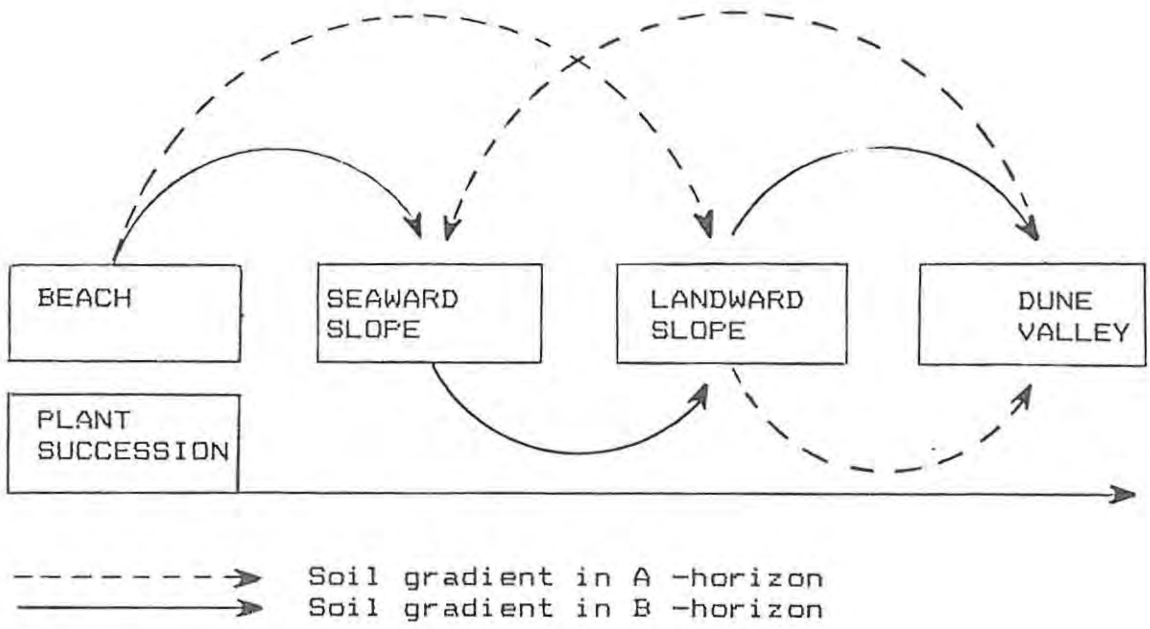



Fig. 5.
Associated vegetational and dune soil successional gradients recorded at Morgan Bay.

LOADING OF SOIL FACTOR (%).

| COMPONENT | pH | % C | Na | K | Ca | Mg | S-Val | C.E.C. |
|---|---|---|---|---|---|---|---|---|
| 1 | 13,74 | 14,73 | 13,15 | 3,73 | 14,25 | 12,88 | 14,81 | 12,72 |
| 2 | 0,02 | 0,00 | 8,55 | 73,54 | 9,71 | 0,01 | 6,11 | 2,06 |
| 3 | 23,18 | 14,10 | 11,69 | 5,60 | 0,34 | 28,76 | 1,69 | 14,64 |

TABLE 6. PERCENTAGE LOADING OF EACH SOIL FACTOR FOR THE FIRST THREE PRINCIPAL COMPONENTS.

retains them in the soil and consequently lowers the pH. Generally increasing levels of active $Ca^{2+}$ along the above gradient could be expected to counteract the decrease in pH through the displacement of H+ ions. This does not however, seem to have had a major effect on the soil acidity and it appears, therefore, that the organic carbon content is a major pH-determining soil characteristic. Calcium has nevertheless played a part in establishing the sample gradient and it is suggested that with an increase landwards, in the age of the deposited dune sand, leaching and the subsequent greater accumulation of $Ca^{2+}$ lower in the soil profile also increases (Gray pers. comm.). The soil S-value which has also influenced the soil gradient increases landwards due mainly to the contribution by the increasing calcium concentrations.

The Group C gradient along the first Principal Component axis has also been created by decreasing soil pH values associated with the percentage organic carbon content which increases along the gradient. Although this group contained the best defined gradient it did not follow the same pattern as Group B (Fig 5). Compared to the lower soil horizons, the A-horizon is not the ideal dune soil layer to investigate or to establish the presence of a gradient in soil characteristics which can be linked to specific sites across a dune profile. Due to the instability of the sand substrate and often steep slopes, localized erosion or accumulation of organic matter and sand can occur and depending on where the samples are taken, the results of the analysis can differ quite significantly.

A small gradient within Group A, the three beach samples, is evident on the plot and has also been established along the first Principal Component axis. In this case the percentage organic carbon content is negligible in all three samples and the factors creating the gradient include only pH, Ca and soil S-value, all of which increase down the profile. The calcium content in the upper soil layer has been reduced through leaching and the element has accumulated lower down in the profile. This increase in calcium concentration is responsible for the increase in soil S-value and the increase in pH has also probably been brought about by the displacement of $H^+$ by active Ca.

The Group D gradient which exists along the second Principal Component axis is similar to that within Group B but has a different combination of soil characteristics responsible for its creation. From Table 6 it can be seen that the second Principal Component has high loadings for K, Ca, Na and Soil S-value and it is these soil characteristics which account for the gradient. Between the beach and valley samples, which form the two extremes on the plot, Ca and S-value increase and K decreases. No clear pattern seems to exist for sodium apart from the fact that, as could be expected, the highest value was recorded for the beach site which is influenced most by salt spray. The greater age of the deposited valley dune sand is the probable reason for the higher concentration of calcium which has had a longer period of time to accumulate in the lower soil profile.

Apart from the gradients described above, a reasonably clear general pattern exists on the plot with respect to the position of the sample points distributed along the second Principal Component axis (Fig. 6). Division I contains mainly upper profile samples, while Divisions II and III contain samples originating from progressively deeper positions in the profile. As discussed, the second Principal Component has high loadings for K, Ca, Na and Soil S-value and the mean values for these four soil characteristics within the three divisions were therefore studied (See Table 7). Potassium and sodium decreased with increasing depth of the samples in the soil profile while calcium and the S-values increased correspondingly. The decalcification of the topsoil and subsequent accumulation of this element lower in the dune profile appears to be a typical phenomenon of the study area and was noted in the analyses of other samples along this coast as well. The behaviour of sodium and potassium in the soil profile could probably be explained in terms of nutrient supply from salt spray, leaching and recycling through litter fall but the process was not studied in any detail. The characteristic reverse concentration of sodium in the topsoil and calcium in the subsoil is also described by Tinley (1985) who ascribed high pH values of the dune soils to this feature.

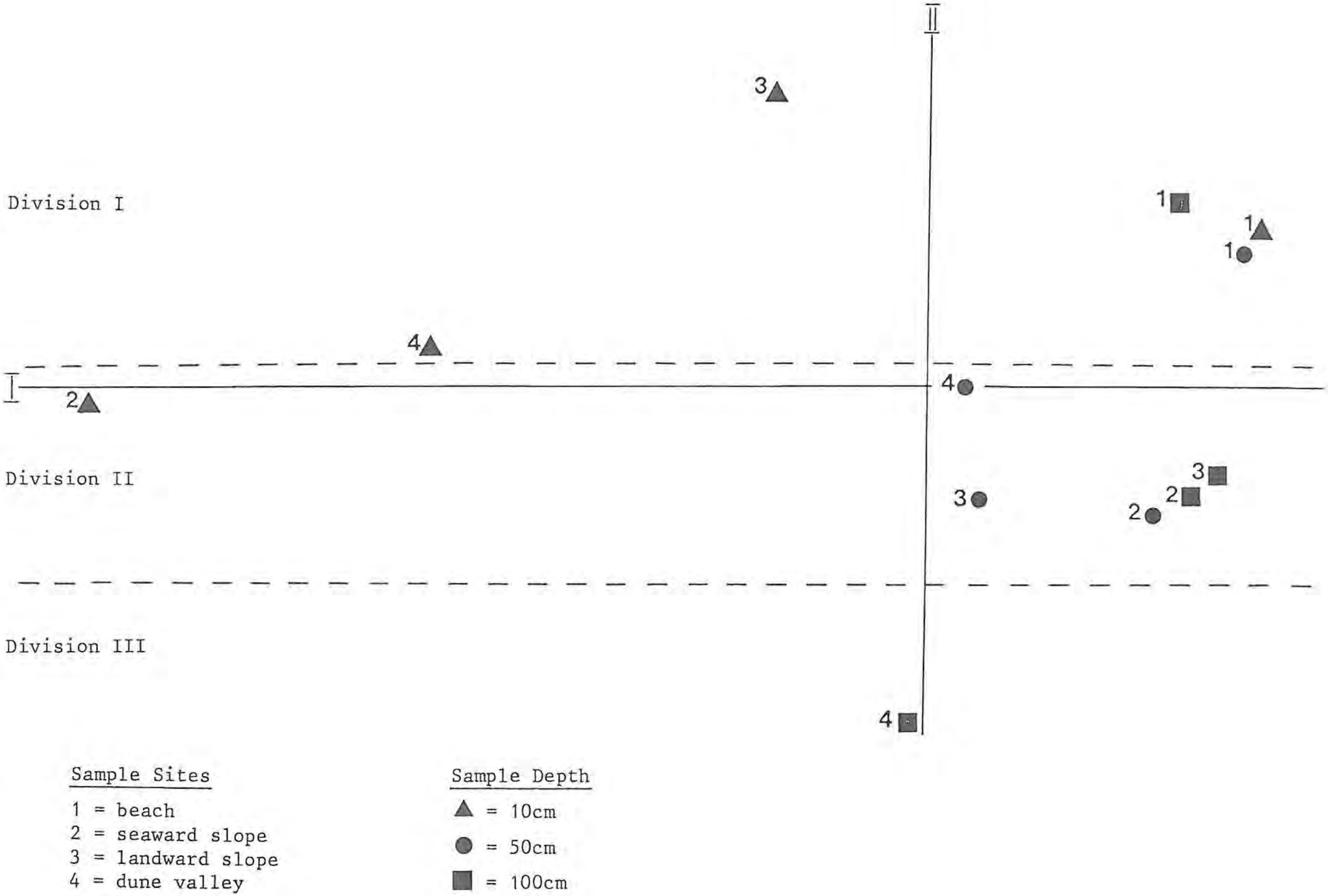



Fig. 6. P.C.A. ordination of the Morgan Bay dune soil characteristics.

| DIVISION | MEAN RECORDED VALUES FOR SOIL CHARACTERISTICS IN meq/100g. | | | |
|---|---|---|---|---|
| | K | Ca | Na | S-Val |
| I | 0,24 | 15,79 | 0,75 | 17,68 |
| II | 0,16 | 16,30 | 0,52 | 18,25 |
| III | 0,12 | 19,61 | 0,41 | 20,84 |

TABLE 7. MEAN IONIC CONTENTS OF THE SOIL SAMPLES CONTAINED WITHIN THE THREE DIVISIONS OF THE P.C.A. ORDINATION.

## 2.4. SALT SPRAY

### 2.4.1 Introduction

Of all the physical factors which influence coastal vegetation, wind-borne salt spray is possibly one of the most significant of the climatological phenomena (McAtee and Drawe, 1980).

It has been disputed in the past whether it is the mechanical effect of the wind or the deposited salt which has the greater influence on the plant communities. Oosting and Billings (1942) and others have however identified the salt component as being the important factor determining community succession, species zonation and plant growth form and recent research favours this opinion.

Salt spray originates as small droplets of water which are forced into the atmosphere by the bursting of foam bubbles (Boyce, 1954). The surf zone, which produces an abundance of foam, is therefore the biggest contributor to the salt spray reservoir. During bubble bursting and the subsequent inland transport of the spray, a gradient in cationic and cation-to-chloride ratios becomes established. Donnelly and Pammenter (1983), Clayton (1972), Ogden (1982) and Boyce (1954) attribute this to differential ion separation of the sea surface, since the ratios differ considerably from that of sea water. This process is significant when the effects of these various ions on the vegetation and soil chemistry and the total nutrient input to the dune ecosystem are considered. Such atmospheric inputs of ions are potentially quite high but it has been found that the concentration of dissolved salts in the dune soils are relatively low due to the rapid rate of leaching (Boyce, 1954; Donnelly and Pammenter 1983; Oosting and Billings, 1942; McAtee and Drawe, 1980). Only a limited amount of biological immobilization takes place and absorbed ions are returned to the soil surface through litter fall and to lower horizons through root exudation until a steady state is achieved with regard to the cycling process.

It has been found that the amount of transported spray increases proportionately with wind speed until a critical speed of approximately $7ms^{-1}$ is reached when a sudden big increase occurs (Barbour *et al.*, 1973; Boyce, 1954). This corresponds to the wind speed necessary to produce white caps and such winds are common along the East London coast.

The interaction between the coastline shape and orientation to the prevailing weather conditions greatly influence the exposure of different sites to salt spray. The degree of exposure which various sites have and the relative amounts of salt spray deposited across the dune profile have also been found to correlate well with the distribution of certain species (Lubke and Avis, 1982; Oosting and Billings, 1942; Donnelly and Pammenter, 1983). This plant zonation corresponds closely to the dune topography since the latter greatly influences the salt fallout pattern.

Any obstruction to the on-shore airflow reduces the velocity of the lower air layers and at the same time deflects the wind upwards. The windward slope of the foredunes is therefore the first zone where salt will accumulate through impact deposition and precipitation (Chapman, 1976). Due to the deflection of the wind, the leeward foredune slopes and area immediately behind the foredunes tend to be fairly sheltered and only a small amount of salt is likely to precipitate out. The next obstruction, such as the seaward slope of the mid - or reardunes, will also accumulate salt and simultaneously deflect the wind upwards, thereby affording protection to the lee areas. Salt particles continue to precipitate out over a considerable distance but in diminishing concentrations until the effects on the vegetation become minimal.

The most noticeable effect of salt spray on the dune vegetation is the asymmetric growth form of the seaward forest canopy. Boyce (1954) concludes that this is caused by oceanic chloride which enters the plant together with other deposited ions, mainly through foliar absorption. The seaward foliage and growing tips which are less sheltered than those to landward are killed off by the absorbed chloride, resulting in the formation of an often wedge-shaped canopy (Moll, 1972). During prolonged calm periods or periods when salt-laden winds do not blow, the seaward canopy can actively grow but much of the regrowth is killed off when exposed to salt spray once more. The dead twigs still fulfil an important function as salt accumulators and by so doing afford some protection to the landward canopy (Boyce, 1954). January to March are the least windy months for the East London area and the seaward canopy could develop under these favourable conditions. The new growth would however be subject to scorching during late winter and spring which is the windiest period.

The amount of salt spray which can be deposited over any particular area is largely dependant upon prevailing weather conditions as well as dune topography and orientation etc. It is therefore very difficult to determine an absolute value for the amount of salt which can be expected to be deposited within a certain period of time. An attempt can however be made to establish an expected pattern of the relative distribution of deposited salt across the dune profile and to identify certain areas which have greater or lesser exposures to salt spray. A study was therefore carried out to investigate this pattern using accepted methods to trap and measure the amount of salt deposited over one of the forest units within the study area.

### 2.4.2 The Study site

The study was carried out on the dune system between Kei Mouth and Morgan Bay. The dunes support pioneer beach communities, stunted thicket and developed forest on the older and more sheltered sites. The prevailing direction of the stronger winds is more or less parallel to the general trend of the coastline but the study area itself is slightly more exposed to the strongest and obviously most salt-laden south-westerly winds. Fig. 7 illustrates the profile of the dunes and the position of the stations at which the salt traps were placed.

### 2.4.3 Materials and methods

Various methods, such as those described by Barbour et al. (1973), Boyce (1954) and Donnelly and Pammenter (1983), can be used to trap salt. The method described by Oosting and Billings (1942) is relatively simple yet effective and was therefore chosen in preference to the others.

Each salt trap consisted of a partitioned wooden frame onto which cheesecloth strips could be tacked. Before being attached, three squares, each measuring $10cm^2$, were accurately drawn onto the cloth using marking ink, so that replicate recordings could be made at each station (Plate 5). Three similar squares were also cut from the cloth before the traps were placed out in the field, to act as a control. Six sites were chosen across the dune profile and one trap was set up

PLATE 5. Salt trap on beach at Morgan Bay.

at each, facing the prevailing wind direction. The trap situated on the beach was 1 m above the sand and the remaining traps were mounted on poles so that they just emerged above the vegetation.

After being exposed for 24 hours, the traps were taken down and the marked squares carefully cut out and placed in glass vials which were then labelled and sealed.

A standard curve for chloride, which covered the expected range of concentrations to be extracted from the cloth samples, was constructed in the laboratory. This was done by serial dilution of a 1 M NaCl solution and subsequent measurements of the conductivity using an EIL chloride electrode and T and C pH meter. A buffer, consisting of 0,5 M ammonium acetate and 0,5 M ascetic acid was added to all the solutions before measurements were taken.

The cheesecloth squares, including those used in the control, were soaked in 20 ml of buffered distilled water for ten minutes after which the leachate conductivities were measured.

2.4.4 Results and discussion

The data used in the formulation of the standard curve function is given in Table 8. A power curve was found to fit the data best and was determined using linear regression by the method of least squares.

The equation can be written as:

$$\ln y = b \ln x + \ln a$$

| CHLORIDE CONCENTRATION (Mol/litre) | ELECTRODE POTENTIAL (mv) |
|---|---|
| $10^{-8}$ | -185,7 |
| $10^{-7}$ | -194,0 |
| $10^{-6}$ | -207,0 |
| $10^{-5}$ | -208,1 |
| $10^{-4}$ | -211,2 |
| $10^{-3}$ | -233,1 |
| $10^{-2}$ | -276,5 |
| $10^{-1}$ | -330,9 |
| $10^{0}$ | -387,4 |

TABLE 8. CHLORIDE CONCENTRATIONS AND ASSOCIATED CONDUCTIVITY VALUES USED IN THE FORMULATION OF THE SALT SPRAY STANDARD CURVE FUCTION.

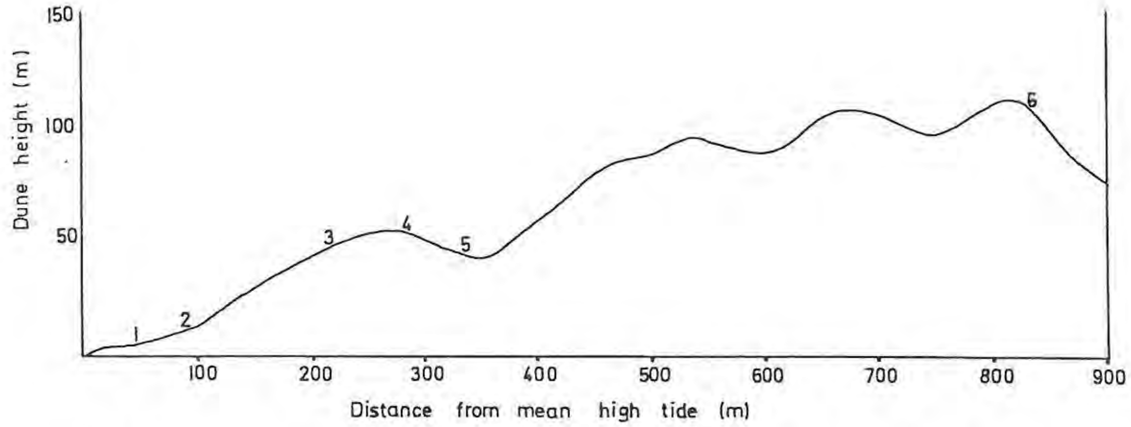



Fig. 7.
Positions of the five salt traps set up across the Morgan Bay dunes.

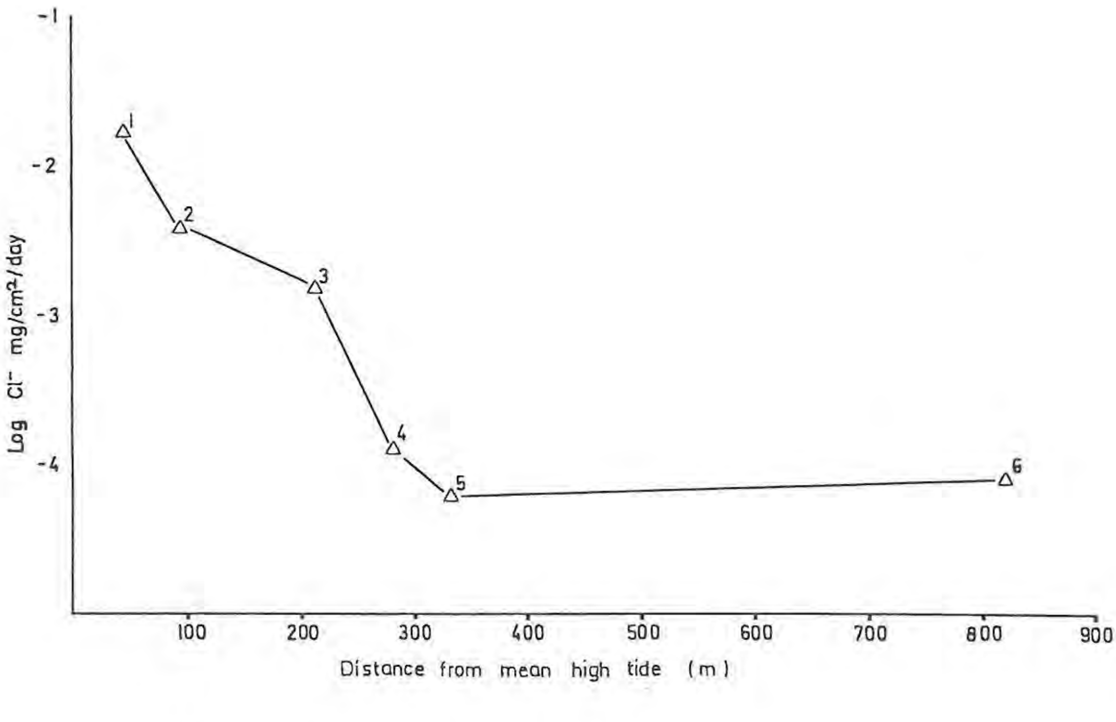



Fig. 8.
Recorded rate of salt spray fall-out at Morgan Bay

where y is the molar chloride concentration and x is the measured conductivity in mv. The regression coefficients are:

$a = 1{,}244 \times 10^{-59}$

$b = 23{,}06$

$r^2 = 0{,}87$

The above regression equation was used to determine the amount of $Cl^-$ trapped in the 24 hour period at the various stations by measuring the leachate conductivities (x - values). The results are shown in Table 9 and Fig. 8.

The results indicate that there is a rapid decline in the quantity of deposited salt with increasing distance from the sea. Station 1, which was located on the beach, accumulated by far the greatest amount of salt and in fact accounted for more than 70 per cent of the total salt intercepted across the profile. Stations 2, 3, 4 and 6 accumulated progressively less amounts of salt, with station 5 recording the lowest value. The latter amounted to 0.31 per cent of the total and was only fractionally higher than the Cl value obtained in the control.

Clayton (1972) and Ogden (1982) have reported salt inputs at sites 2,2 km and up to 20 km inland respectively but, as was the case at Station 6, the quantities become relatively insignificant. From the values obtained in this study, it would appear that the major salt fall-out zone along the East London coast is likely to be within 100 m of the

| STATION No. | DISTANCE FROM MEAN HIGH WATER MARK (m) | CONDUCTIVITY READINGS (mV) | CHLORIDE CONCENTRATION (mg/lit) | MEAN ACCUMULATED CHLORIDE (mg/cm²) | TOTAL CHLORIDE ACCUMULATED AT EACH STATION (%) |
|---|---|---|---|---|---|
| CONTROL | | - | - | | |
| | | -196,1 | 0,0323 | | |
| | | -196,5 | 0,0329 | | |
| | | | Ave: 0,0321 | [illegible] x $10^{-2}$ | - |
| 1 | 42 | - | - | | |
| | | -249,8 | 8,5910 | | |
| | | -250,1 | 8,8395 | | |
| | | | Ave: 8,7153 | 1,2430 x $10^{-2}$ | 73,35 |
| 2 | 92 | -240,0 | 3,4080 | | |
| | | -233,5 | 1,8105 | | |
| | | -229,5 | 1,2022 | | |
| | | | Ave: 2,1410 | 0,4280 x $10^{-2}$ | 10,01 |
| 3 | 208 | -225,0 | 0,7810 | | |
| | | -226,8 | 0,9230 | | |
| | | -227,4 | 0,9940 | | |
| | | | Ave: 0,8993 | 0,1900 x $10^{-2}$ | 2,58 |
| 4 | 183 | -199,1 | 0,0462 | | |
| | | -200,7 | 0,0568 | | |
| | | -203,4 | 0,0675 | | |
| | | | Ave: 0,0568 | 0,0110 x $10^{-2}$ | 0,46 |
| 5 | 333 | -197,5 | 0,0391 | | |
| | | -197,6 | 0,0391 | | |
| | | -194,5 | 0,0266 | | |
| | | | Ave: 0,0349 | 0,0070 x $10^{-2}$ | 0,30 |
| 6 | 817 | -196,1 | 0,0323 | | |
| | | -196,3 | 0,0330 | | |
| | | -198,8 | 0,0444 | | |
| | | | Ave: 0,0366 | 0,0073 x $10^{-2}$ | 0,31 |

TABLE 9. MEASURED CHLORIDE ACCUMULATIONS ON MORGAN BAY SALINITY TRAPS.

sea and that beyond 300 m it plays a decreasing role as a limiting environmental parameter. Apart from distance as a measure, various topographic zones such as seaward and leeward dune slopes, can also be identified and ranked according to the degree of salt input. Exposed foredune slopes are subjected to high salt loads and support stunted shrub and thicket communities, while the more sheltered dune valleys are capable of supporting climax forest, provided that other environmental factors are favourable. In the latter case, low salt values such as obtained in the study, are considered to play a major role in permitting the advanced development of the vegetation. Weisser (1980) describes the absence of salt spray as a factor which promotes the development of subordinate strata and an uneven canopy in tall dune forest communities on sheltered sites in Zululand.

## 2.5 CLIMATE

### 2.5.1 Introduction

Climate, as a restraint on plant growth, is most significant and determines to a great extent where plant communities can or cannot exist, since species vary in their tolerances and requirements of particular combinations of climatic parameters (Schulze and McGee, 1978).

The climate of a region is controlled by several factors, of which the most important are latitude, position relative to land and sea masses, altitude, general atmospheric circulation and ocean currents (van Zinderen Bakker, 1971; Schulze, 1965). Of the latter, the coastal setting of the study area adjacent to the Agulhas current and the south-east exposure of the coastline to the seasonal pressure systems are largely responsible for the climate which characterizes the region.

Various quantitative systems, based on different parameters and indices, have been used to classify climates. One such system, which is discussed by Schulze (1947), is that devised by Köppen, who bases his classification on rainfall and temperature averages. According to the map produced by Köppen, the East London area falls within the Cf climatic province, which is described as having a humid temperate climate with sufficient rainfall in all seasons. The provincial subtype Cfbl, occupies the coastal belt from Mossel Bay to Port St.

Johns and is further described as having a lukewarm humid climate (C = warm temperate climate - coldest months 18°C to -3°C; f = sufficient precipitation during all months; b = mean temperature of warmest month below 71.8°C; l = lukewarm, mean temperature of all months between 50°C and 71,8°C). Of the other climatic maps which have been produced for South Africa, two which provide classifications for the study area are those compiled by Poynton (1971) and Walter and Leith (1960). The former places the study area within the frost-free transition between the humid and sub-humid zones and the latter describes the climate of the area as being tropical in the north (climatic type II) and warm temperate in the south (climatic type V). The East London climate is also described by Schulze (1965) as being temperate to warm and humid with a definite summer rainy season, and by Heydorn and Tinley (1980) as subtropical, with a bimodal summer rainfall pattern.

### 2.5.2 Major climatic controls

As with the sub-continent as a whole, the coastal weather regime is dominated by the interaction between the east-moving cyclones of the circumpolar westerlies and the belt of subtropical anticylonic cells of high pressure (Schulze, 1965; Heydorn and Tinley, 1980; Tinley, 1985). The latter, which shift laterally according to season, tend to be centred off the Cape west coast and the eastern part of the country as well as over the Indian Ocean. In response to the solar control, these main pressure belts move equatorwards during winter and return southwards in summer when the oceanic highs can ridge in south of the country causing a significant increase in the easterly wind component (Tinley, 1985). A heat low pressure cell also tends to develop over the interior continental plateau during summer, replacing the continental anticyclone at the surface and thereby permitting the influx of moist marine air off the Indian Ocean.

The proximity of the sea to the study area has a moderating effect on the climate, which is accentuated by the presence of the off-shore Agulhas current. This is the southern continuation of the warm South Equatorial and Mocambique currents and serves to extend subtropical conditions further down the coast. The presence of this current is reflected by the bank of cumulo-nimbus thunderclouds above it, which are visible out over the sea on most days. The effect of the marine air tends to reduce the incidence of very cold winter weather and also fulfils a cooling function during the summer months. In addition the contrast in sea surface temperature of this current and the inshore circulations is a major factor which conditions the air masses affecting the local climate (Tinley, 1985).

### 2.5.3 Wind

The predominance of winds with an easterly component (anticyclonic) and a westerly component (cyclonic) change in accordance with the seasonal movement of the major pressure systems (Heydorn and Tinley, 1980; Schulze, 1965). Topographical features along the East London coast and winds resulting from differential warming rates of land and sea air appear to play an insignificant role in modifying the above regime. As with most coastal stations, the winds often tend to be of high velocity and play an important role in the formation of dunes, the transport of salt spray and the dispersal of seed and fruits.

In summer, the stronger winds blow from the east-north-east while in winter, the pattern is reversed with the winds prevailing from the west and west-south-west. The frequencies of winds from various quarters are shown in Tables 10 and 11. The west-south-westerly winds are the most common (13.0%) followed by the summer east-north-easterly (11.1%). The major wind sector is from south-west to west with a frequency of 37.8%. The month of August and the spring months are generally the windiest of the year while the months with the most calm periods are January to March. The months which are least windy in terms of velocity are April to June (Table 12). The seasonal wind roses for East London are illustrated in Fig.9.

It is of interest to note that the strong winds during the summer growing season of the forest communities are slightly on-shore from the east-north-east, and that the deposition of salt spray on the seaward vegetation is likely to be great during this period.

2.5.4 Land and sea breezes

Although not as well developed as in areas such as the Namib and Natal coasts sea, and to a lesser extent land breezes do contribute towards the south-eastern Cape coastal climate.

Both breezes have their origins in temperature gradients between adjacent air masses situated over the land and sea which become

| | CALM | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 10,7 | 0,8 | 3,8 | 10,4 | 19,0 | 5,3 | 4,6 | 2,8 | 3,8 | 2,9 | 7,7 | 8,4 | 10,9 | 4,6 | 1,7 | 1,2 | 1,5 |
| FEB | 10,1 | 1,4 | 4,1 | 12,3 | 17,6 | 3,6 | 2,8 | 1,9 | 1,7 | 2,0 | 8,0 | 10,3 | 12,7 | 6,0 | 2,6 | 1,5 | 1,4 |
| MAR | 8,8 | 1,6 | 7,4 | 12,8 | 14,6 | 2,8 | 2,6 | 1,4 | 2,2 | 2,0 | 7,0 | 8,6 | 14,1 | 7,1 | 3,2 | 1,7 | 2,3 |
| APR | 7,8 | 4,0 | 8,1 | 6,8 | 7,2 | 1,8 | 2,1 | 1,5 | 1,5 | 1,4 | 5,8 | 7,3 | 15,2 | 12,3 | 7,3 | 3,7 | 6,2 |
| MAY | 6,8 | 4,9 | 7,9 | 5,3 | 5,4 | 1,3 | 1,5 | 1,3 | 2,0 | 1,4 | 3,6 | 5,1 | 11,1 | 12,7 | 9,1 | 9,0 | 11,8 |
| JUN | 7,0 | 4,3 | 6,9 | 4,1 | 3,9 | 1,0 | 1,4 | 1,1 | 1,2 | 1,0 | 2,5 | 4,7 | 12,1 | 14,9 | 8,5 | 11,0 | 14,7 |
| JUL | 5,6 | 4,3 | 6,4 | 5,0 | 4,1 | 1,3 | 1,0 | 0,9 | 1,2 | 1,2 | 3,2 | 4,9 | 9,4 | 15,5 | 10,9 | 10,0 | 15,5 |
| AUG | 4,8 | 3,6 | 8,1 | 8,3 | 5,8 | 1,5 | 1,4 | 1,2 | 1,4 | 1,4 | 4,2 | 7,9 | 14,0 | 15,9 | 7,2 | 5,1 | 8,3 |
| SEP | 7,0 | 2,5 | 7,4 | 9,0 | 9,1 | 3,1 | 2,6 | 1,8 | 1,9 | 1,8 | 6,4 | 8,8 | 14,3 | 11,6 | 4,8 | 3,4 | 4,0 |
| OCT | 7,8 | 1,6 | 5,2 | 9,1 | 12,5 | 4,5 | 3,2 | 1,9 | 2,8 | 2,8 | 8,0 | 9,8 | 15,2 | 9,1 | 3,2 | 1,7 | 1,8 |
| NOV | 6,0 | 1,5 | 4,3 | 9,7 | 17,7 | 4,7 | 2,7 | 2,0 | 2,6 | 3,0 | 8,5 | 10,4 | 13,3 | 7,2 | 3,0 | 1,4 | 2,0 |
| DEC | 7,9 | 1,2 | 3,6 | 7,1 | 15,7 | 5,6 | 3,8 | 2,4 | 3,1 | 3,1 | 10,8 | 10,2 | 13,1 | 6,9 | 2,4 | 1,6 | 1,4 |
| YEAR | 7,6 | 2,6 | 6,1 | 8,3 | 11,1 | 3,0 | 2,5 | 1,7 | 2,1 | 2,0 | 6,3 | 8,0 | 13,0 | 10,3 | 5,3 | 4,3 | 5,9 |

TABLE 10. PERCENTAGE FREQUENCY OF CALMS AND WINDS OF DIFFERENT DIRECTIONS RECORDED FOR EAST LONDON (data from published Weather Bureau statistics.)

| MONTH | SECTOR | | | % FREQUENCY |
|---|---|---|---|---|
| JAN | NE | ENE | E | 34,7 |
| FEB | NNE | NE | ENE | 34,0 |
| MAR | NNE | NE | ENE | 34,8 |
| APR | WSW | W | WNW | 34,8 |
| MAY | WSW | W | WNW | 32,9 |
| JUN | WSW | W | WNW | 35,5 |
| JUL | W | WNW | NW | 36,4 |
| | WNW | NW | NNW | 36,4 |
| AUG | SW | WSW | W | 37,8 |
| SEP | SW | WSW | W | 34,7 |
| OCT | SW | WSW | W | 34,1 |
| NOV | SSW | SW | WSW | 32,2 |
| DEC | SSW | SW | WSW | 34,1 |
| YEAR | SW | WSW | W | 31,3 |

TABLE 11. MONTHLY WIND SECTOR FREQUENCIES FOR EAST LONDON. (data from published Weather Bureau statistics)

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % FREQUENCY OF WINDS > 15 km/h | 59,2 | 60,5 | 59,3 | 54,5 | 55,0 | 57,0 | 61,9 | 66,7 | 62,5 | 61,1 | 66,3 | 60,8 |
| MEAN WIND SPEED (km/h) | 17,7 | 17,5 | 16,6 | 15,6 | 15,6 | 26,1 | 17,4 | 18,7 | 18,2 | 18,3 | 20,0 | 17,5 |

TABLE 12. MEAN MONTHLY WIND SPEEDS AND FREQUENCIES OF WINDS IN EXCESS OF 15 km/h AT EAST LONDON. (data from published Weather Bureau statistics)

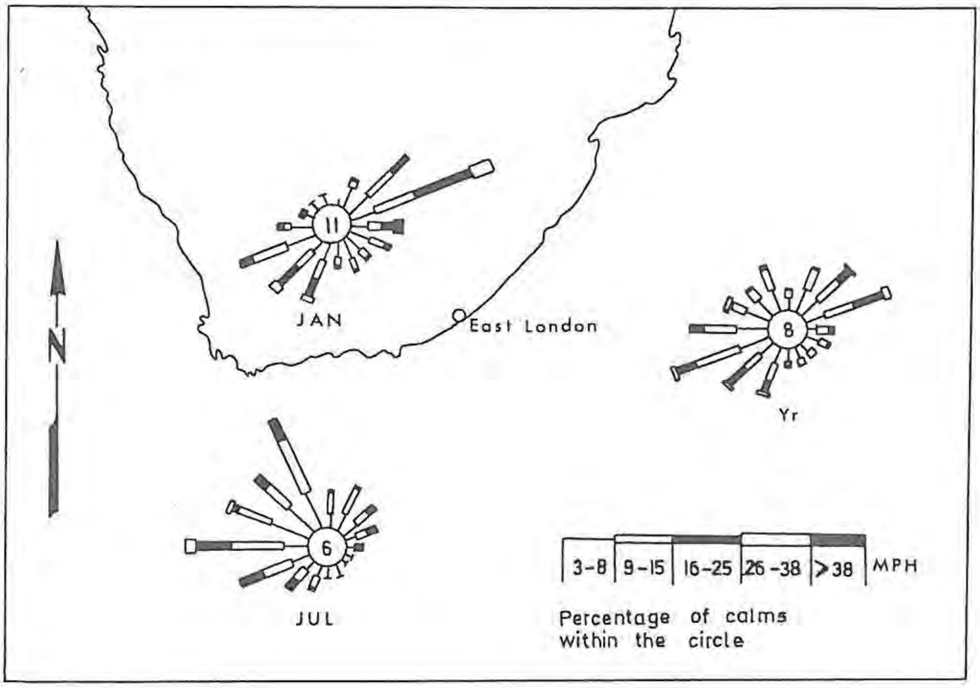



Fig. 9.
Summer, winter and annual wind roses for East London.
(from Schulze, 1965.)

established due to the differences in temperature range experienced by the two air masses. The temperature of the oceanic air is moderated by the warm Agulhas current and remains more or less constant in contrast to the land air, the temperature of which differs greatly between day and night.

The prevailing winter winds are off-shore due to the distribution of the major pressure systems and as such are not classified as land breezes. A feature of clear winter nights however is the katabatic drainage of cold inland air towards the coast. Heydorn and Tinley (1980) regard this as the noticeable land breeze for the East London area.

Although the prevailing summer winds are on-shore, this is again more as a result of the general circulation than the effect of local heating. The relatively small differences between the land and sea temperatures and the exposure to the strong prevailing westerlies is regarded by Jackson (1954) as being responsible for the weak development of the sea breeze along the south-eastern Cape coast. The typical sea breeze for East London does occur mainly in summer however and is described by Heydorn and Tinley (1980) as being a light landward air movement after the wedge of cool land air has dissipated on warming. The breeze is of fairly short duration and is rapidly overtaken by the anticyclonic Trades which strengthen during the day.

An example of the diurnal variation of wind resultants for East London is illustrated graphically in Fig. 10 and is attributed by Schulze

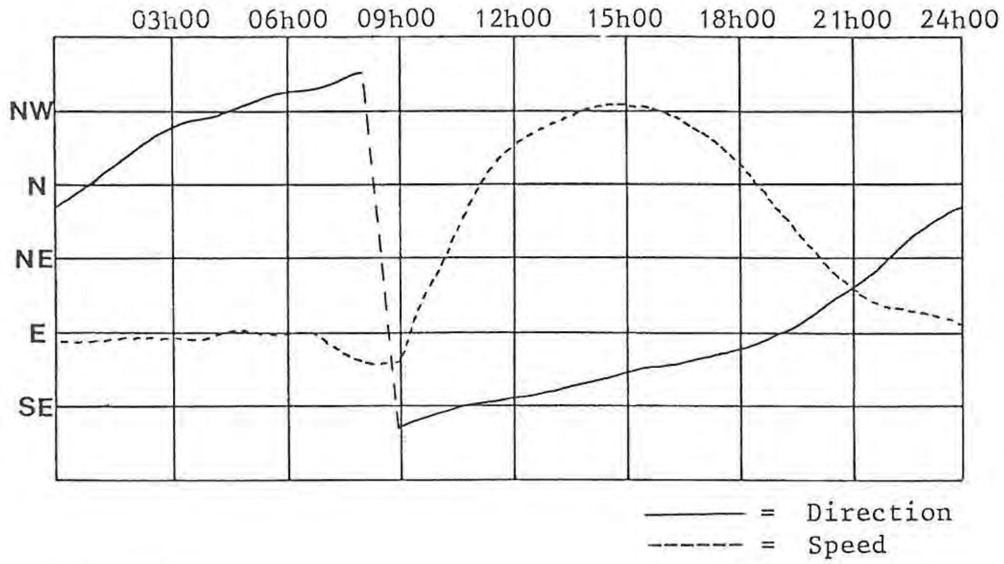



Fig. 10.
Diurnal variation of wind resultants for East London.
(after Schulze (1965))

(1965) to the effects of land and sea breezes. During the early part of the day the wind is light and off-shore and corresponds to the land breeze described above. At 09h00, as the cool land air dissipates, there is an abrupt change in wind direction to on-shore with the development of the sea breeze which in turn is later overtaken by the prevailing seasonal wind. The latter shows an increase in velocity and a general backing to the east and north-east.

### 2.5.5 Berg winds

The occurence of berg winds is of great significance to the general climate of the study area. Not only do berg wind conditions drastically modify the temperature and relative humidity regimes of the dune environment but indirectly they can be catastrophic to the dune forest communities.

Characteristics of berg winds are a sudden large increase in air temperature, a rapid decrease in relative humidity and a prevalence of turbulent airflow. The combination of these conditions has a dessicating effect on the vegetation and the risk of fire occurring in forest, which under normal conditions is considered relatively non-flammable, is very great.

Records over the past ten years indicate that for the ten fires which occurred in the dune forests, berg wind conditions prevailed during five of them. (See Table 13). The remaining fires occurred under a variety of weather conditions with minimal damage to the forest.

| LOCALITY AND DATE OF FIRE | AIR TEMP. AT TIME OF FIRE. (°C) | MEAN DAILY MAX. FOR MONTH (°C) | REL. HUMIDITY AT TIME OF FIRE (%) | MEAN MONTHLY REL. HUMIDITY (%) | | WIND DIRECTION | AREA BURNED (ha) |
|---|---|---|---|---|---|---|---|
| | | | | 03h00 | 14h00 | | |
| COVE ROCK * 22/6/83 | 30,0 | 20,9 | 16 | 67 | 50 | NNW | 2,0 |
| SUNRISE-ON-SEA 27/6/80 | 14,5 | 20,9 | 48 | 67 | 50 | NNW | 0,25 |
| GLEN MUIR * 16/5/80 | 36,7 | 22,6 | 11 | 69 | 58 | NNW | 5,0 |
| ROOIWAL 16/5/80 | 25,5 | 22,6 | 18 | 69 | 58 | NNW | 3,0 |
| CAPE MORGAN 18/6/75 | 29,0 | 20,9 | 19 | 67 | 50 | NNW | 7,0 |
| GULU WEST 12/2/83 | 21,0 | 25,6 | 59 | 77 | 71 | SW | 1,0 |
| CAPE MORGAN 29/12/82 | 24,0 | 24,0 | ? | 71 | 71 | S | 1,0 |
| CAPE MORGAN 7/7/76 | ? | 21,0 | ? | 61 | 50 | W | 2,0 |
| NYARA WEST 5/8/72 | ? | 21,3 | DRY | 69 | 59 | SW | 4,0 |
| CAPE MORGAN 11/7/72 | ? | 21,0 | ? | 61 | 50 | SW | ? |

* = Fires which caused significant damage to the forest.

TABLE 13. RECORD OF THE TEN FIRES KNOWN TO HAVE OCCURRED ALONG THE EAST LONDON COAST BETWEEN 1972 AND 1983 AND ASSOCIATED WEATHER CONDITIONS. BERG WINDS PREVAILED DURING THE FIRST 5 FIRES LISTED.

Two main sets of synoptic conditions are necessary for the formation of a berg wind. A high pressure cell, usually with weak initial pressure gradients, must be situated over the interior plateau of the country and a trough of low pressure, usually preceeding a cold front, must be situated off the coast. As the front moves up the coast a transition region is created between the two pressure systems in which strong pressure gradients develop parallel to the coast (Tyson, 1964). The wind which flows across the pressure gradient blows from the interior in an off-shore direction but can however be influenced by local circulation patterns and sea-breezes in particular. The air mass which originates from a relatively warm inland source becomes compressed as it descends to the coast, thereby increasing its temperature further and the result is the anomalous situation of an extremely hot wind occurring often in mid-winter.

Berg winds occur in all months of the year but are most frequent during the winter in the period April to September (which increases the mean temperature for these months). The reason for this seasonal pattern is the northwards shift in the high pressure belt, described earlier, and the presence of an almost constant cell of high pressure over the sub-continent (Schulze, 1965). The synoptic conditions required for the formation of berg winds are thus considerably more favourable than in summer.

The synoptic chart shown in Fig. 11 illustrates the distribution of the pressure systems which resulted in the berg wind at East London on

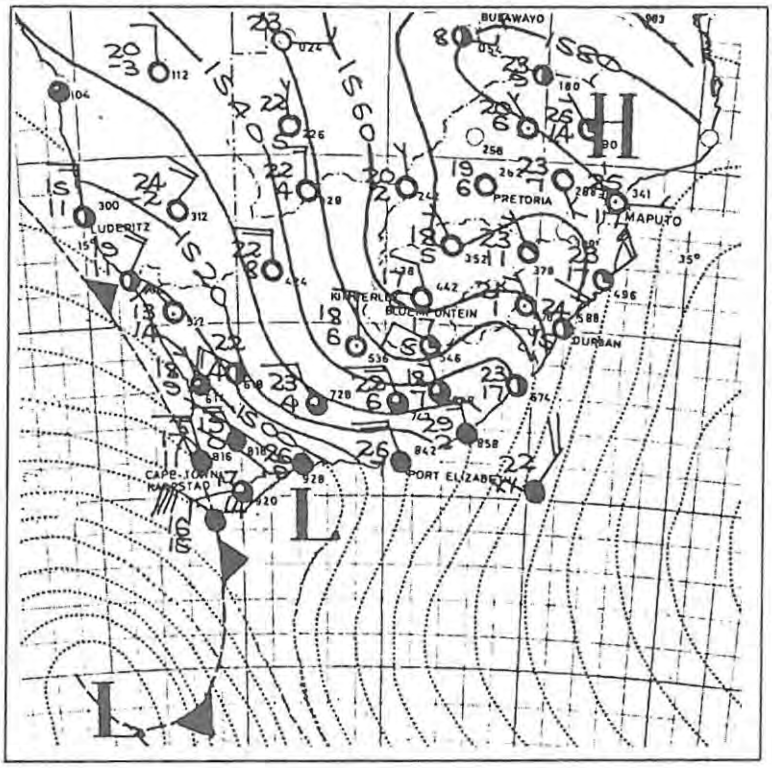



Fig. 11.
Synoptic conditions prevailing at the time of the Berg Wind on the 21st of June, 1983. (data from unpublished Weather Bureau records).

the 22nd June 1983. The cells of high and low pressure are clearly visible, as well as the pressure gradients aligned more or less parallel to the coastline. The development of the berg wind and the passage of the typical post berg wind cold front can be seen from the data in Table 14. Temperatures increased steadily up to a maximum of 30,1°C and associated with this was a corresponding decrease in relative humidity. The berg wind peaked at 16h00 with the wind blowing from the northerly sector at a strong 8,5 m $s^{-1}$ . Shortly after this there was a fairly rapid change in wind direction to the seasonal westerly which brought with it cooler, moister conditions.

| DATE | 21/6/83 | 22/6/83 | | | | 23/6/83 | | |
|---|---|---|---|---|---|---|---|---|
| TIME | 22h00 | 04h00 | 10h00 | 16h00 | 22h00 | 04h00 | 10h00 | 16h00 |
| TEMPERATURE (°C) | 22,0 | 22,9 | 24,9 | 30,1 | 25,1 | 16,1 | 17,9 | 18,7 |
| REL.HUMIDITY (%) | 34 | 30 | 28 | 16 | 19 | 85 | 46 | 49 |
| WIND DIRECTION | 340 | 320 | 010 | 350 | 310 | 240 | 250 | CALM |
| WIND SPEED (m/s) | 4,0 | 8,0 | 8,4 | 8,5 | 5,0 | 6,5 | 6,3 | - |

TABLE 14. CLIMATIC CONDITIONS WHICH PREVAILED DURING THE DEVELOPMENT OF THE BERG WIND AT EAST LONDON ON 22 JUNE 1983. (data from unpublished Weather Bureau records).

### 2.5.6 Temperature

Although temperature alone is not regarded as a significant factor in determining major regional vegetation formations, its indirect influence on water availability is of primary importance (Van Riper, 1971). On a meso- and micro-scale it can however play a major part in determining floristic variations, and within plant communities it can directly influence growth rates, the timing of phenophases etc. (Werger, 1978). Critical temperature indices such as summer maxima, winter minima or ranges are considered to be of greater significance to plant distributions than means (Werger, 1978). Within the dune communities it is felt that temperature does in fact contribute indirectly towards the establishment of the floristic gradients which exist on the various aspects of the dune profiles.

Along the south-east coast, subnormal temperatures are associated with increased cyclonic activity, cloudy weather and minimum insolation (Schulze,1965). Hotter weather on the other hand occurs throughout anticyclonic conditions, when clear skies and optimum insolation result in temperature rises. Cold snap weather can however occur after the passage of a depression south of the country and prior to the advance of an anticyclone (Board, 1962).

From Table 15 it can be seen that the annual variation of mean temperatures at East London is retarded, with the maximum occuring in February and the minimum in August. This is influenced by the delay in the heating up and cooling off of the ocean surface, which experiences temperature extremes during the same months (Board, 1962).

| MONTH | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN DAILY MAXIMA (°C) | 25,2 | 25,6 | 24,7 | 23,5 | 22,6 | 20,9 | 21,0 | 21,3 | 21,4 | 21,6 | 22,8 | 24,0 |
| MEAN DAILY MINIMA (°C) | 17,9 | 18,3 | 17,5 | 15,1 | 12,0 | 10,5 | 10,2 | 11,2 | 12,5 | 14,2 | 15,4 | 16,7 |
| MEAN DAILY RANGE (°C) | 7,3 | 7,3 | 7,2 | 8,4 | 9,0 | 10,4 | 10,8 | 10,1 | 8,9 | 7,4 | 7,4 | 7,3 |

TABLE 15. MEAN MONTHLY MAXIMA, MINIMA AND TEMPERATURE RANGES RECORDED FOR EAST LONDON. (data from published Weather Bureau records.)

Minimum temperatures tend to be relatively stable due to the ameliorating influence of the sea and Agulhas current but the maxima can show large fluctuations due to Berg wind incidence, cold front effects and high cloud cover variability (Schulze, 1965; Tinley, 1985). Mean daily temperature ranges differ from month to month and are greatest in July when both hot Berg winds and cold spells can prevail (Table 15). The smallest temperature range occurs in March.

The characteristics of the coastal climate are emphasized when the temperature statistics for East London are compared with those for King William's Town, which is subjected to a greater continental rather than a marine influence (Table 16). It can be seen that King William's Town is hotter in all months of the year except for July, but has lower mean daily minima. The difference between the greatest and the least daily maxima in East London is 4,7 °C while in King William's Town it is 7,8°C. It is thus clear that as far as the temperature is concerned, the coastal vegetation is subjected to far smaller ranges in temperature and less pronounced extremes than inland areas.

Dune topography affects the local temperature regimes experienced by the vegetation. Seaward slopes tend to experience a more equitable climate than landward slopes due to their aspect and proximity to the moderating sea air. Landward slopes tend to be both hotter during the day due to aspect and colder at night due to the chilling effect of katabatic cold air drainage from the hinterland. Although it is a

| | | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum (°C) | EAST LONDON | 25,2 | 25,6 | 24,7 | 23,5 | 22,6 | 20,9 | 21,0 | 21,3 | 21,4 | 21,6 | 22,8 | 24,0 |
| | KING WILLIAM'S TOWN | 28,5 | 28,7 | 27,4 | 25,8 | 23,8 | 21,7 | 20,9 | 22,9 | 23,7 | 24,4 | 25,6 | 27,1 |
| Mean Daily Minimum (°C) | EAST LONDON | 17,9 | 18,3 | 17,5 | 15,1 | 12,8 | 10,5 | 10,2 | 11,2 | 12,5 | 14,2 | 15,4 | 16,7 |
| | KING WILLIAM'S TOWN | 16,1 | 16,7 | 15,5 | 12,4 | 8,9 | 5,9 | 5,5 | 7,1 | 9,5 | 11,9 | 13,6 | 14,9 |
| Mean Daily Range (°C) | EAST LONDON | 7,3 | 7,3 | 7,2 | 8,4 | 9,8 | 10,4 | 10,8 | 10,1 | 8,9 | 7,4 | 7,4 | 7,3 |
| | KING WILLIAM'S TOWN | 12,4 | 12,0 | 11,9 | 13,4 | 14,9 | 15,8 | 15,4 | 15,8 | 14,2 | 12,5 | 12,0 | 12,2 |

TABLE 16. COMPARISON OF AVERAGE TEMPERATURES BETWEEN (COASTAL) EAST LONDON AND (INLAND) KING WILLIAM'S TOWN. (data from published Weather Bureau statistics.)

rare occurrence, pockets of cold air can accummulate at the landward base of the dune slopes during winter and form frost in spite of being close to sea (Ward, 1980; Heydorn and Tinley, 1980).

### 2.5.7 Comparison of site-related temperature differences

Temperature variations within the dune forest were assessed by means of simultaneous comparative recordings for three slope aspects. The site chosen for the study was the Kwelera dune forest and the positions of the recording stations are indicated in Fig. 12. Thermohygrograph no. 1 (Th.1) was situated on the seaward slope with a SE aspect, Th.3 was situated on the landward slope with a NW aspect and Th.2 was situated on the dune crest.

The recording instruments used were three Thies Model 620 Gottingen thermohygrographs (temperature ranges -10°C to 50°C), each of which was placed within a specially constructed weather screen. Stevenson screens could unfortunately not be obtained for the study and the results cannot therefore be regarded as absolute. They are however considered to be entirely adequate for comparitive purposes. At each site, the screens were placed under the forest canopy at a standard height of 25cm above the ground for the sake of uniformity. The low canopy height on the dune crest (± 2m) precluded mounting them much higher than this. Continuous temperature recordings were kept over a period of four days.

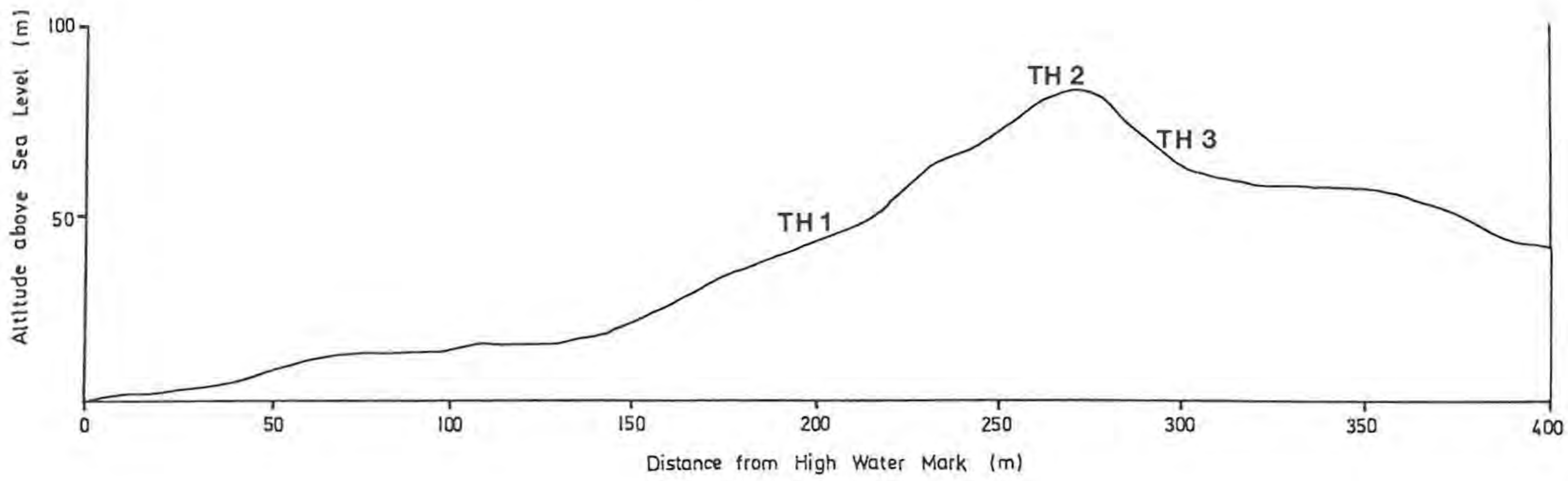



Fig. 12.
Positions of the three thermohygrographs across the Kwelera dune profile.

Results and discussion

The daily temperature cycles as recorded by the thermohygrographs for the study period are shown in Fig. 13 and the recorded absolute maximum, minimum and temperature ranges are represented in Fig. 14. The following conclusions can be drawn from these results:

(a) The landward slope recorded higher temperatures on all days than either of the other two sites for the duration of the study.

(b) The temperature maxima were identical for the seaward slope and dune crest on one of the days but were higher on the latter site for the remainder of the period.

(c) No great temperature difference existed between the recorded minima for the three sites, although the seaward slope did tend to be slightly cooler.

(d) The landward slope experienced the greatest daily temperature range, followed by the dune crest.

The patterns described above are considered to be representative of the expected summer and winter regimes. In winter however, it is possible that the landward slope will record lower temperature minima than the other sites, which will possibly widen its temperature range. It would appear therefore that if temperature alone is considered, the landward vegetation experiences the most harsh climate of the three

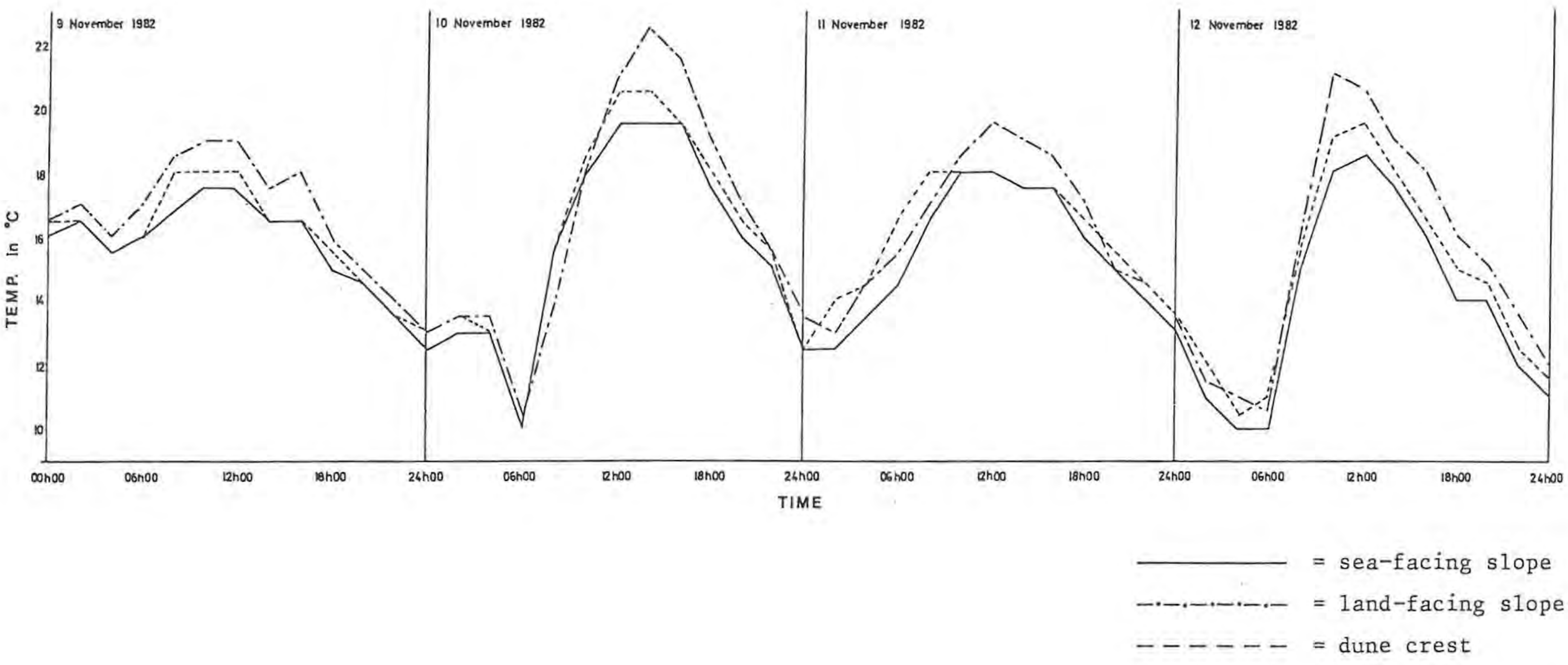



Fig. 13. Diurnal temperature cycles recorded over a four day period at three sites across the Kwelera dune profile.

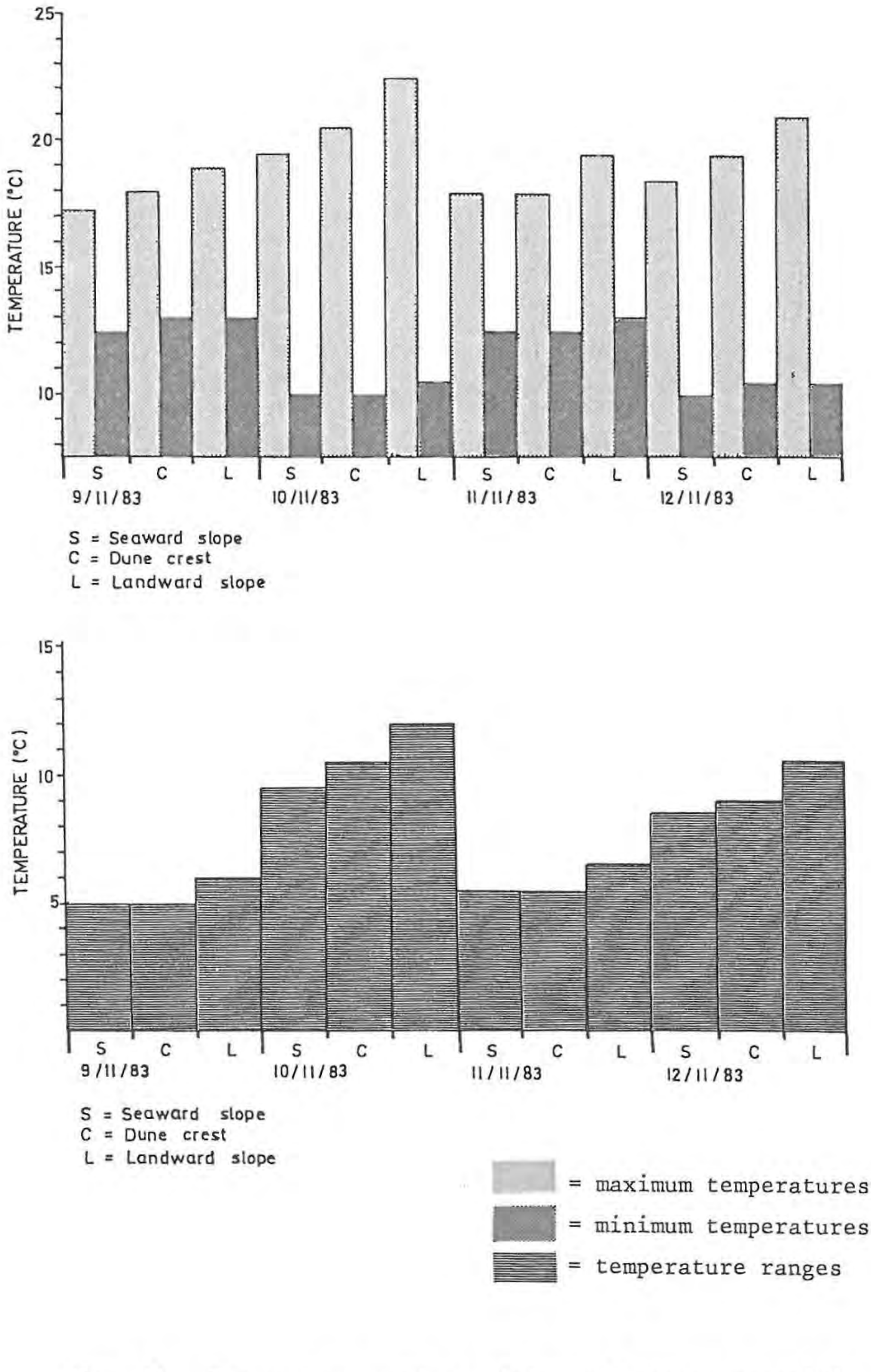



Fig. 14. Temperature maxima, minima and ranges recorded over a four day period at three sites across the Kwelera dune profile.

sites and could be subjected to a degree of moisture stress particularly on the steeper dune slopes. This is sometimes quite evident in the relatively sparse nature of the vegetation, which formed part of the basis for mapping these communities separately during the vegetation survey.

### 2.5.8 Precipitation

Water, as an essential agent for physiological and chemical processes within plants is considered to be the most important climatic variable influencing major vegetational changes (Van Riper, 1971).

The two forms of moisture inputs along the East London coast are from rainfall and fog. The rainfall is primarily influenced by the distribution and interaction of the major pressure systems while fog is associated with the development and longshore movement of coastal lows (Heydorn and Tinley, 1980). East London has characteristics of both bimodal and summer rainfall distribution patterns with the spring and autumn rainfall peaks separated by a dry winter and midsummer period. In the longterm however, these dry periods are relatively mild (Tinley, 1985).

The Climate Diagram for East London was constructed using the Weather Bureau statistics, according to Walter and Leith (1960). The mean monthly temperature curve is drawn to the scale of one unit being equivalent to 10°C while the scale of the mean monthly rainfall curve is based on one unit to 20mm of rain (Fig. 15). The entire year can

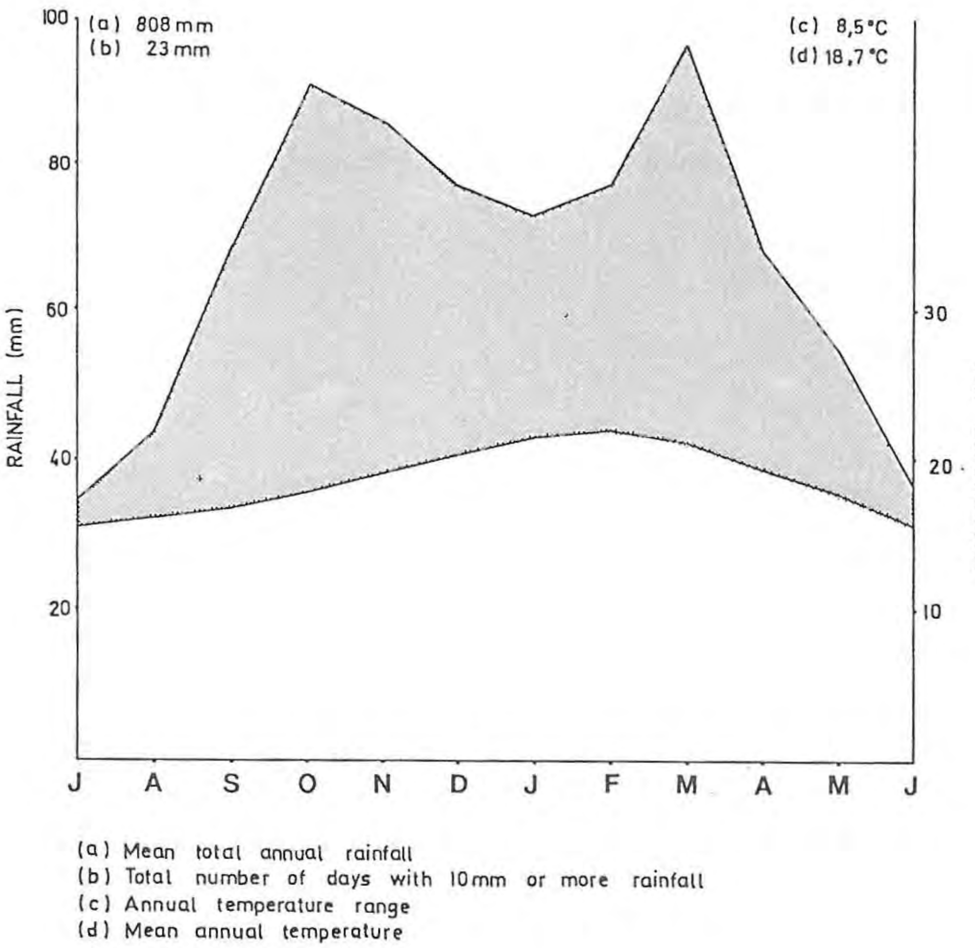



Fig. 15.
The Climate Diagram for East London. (data from published Weather Bureau statistics recorded over 67 years).

be classed as humid since in no month does the mean rainfall curve drop below the temperature curve.

Droughts are generally associated with prolonged anticyclonic activity, while moist conditions originate from two sources. The first are the cyclonic frontal rains which begin in spring. These are followed shortly afterwards by the tropical anticyclonic influence to the east, which interacts with the interior heat low and advects moist air off the Indian Ocean onto the land. With the equatorwards shift of the pressure belts in winter, the heat low is dissipated and dry conditions prevail once more.

Fog is most common during summer and autumn and is formed when warm moist air brought in by the coastal lows off the Agulhas current, condenses as it crosses the cold inshore waters. Heydorn and Tinley (1980) reported an incidence of fog at East London on a total of 44 days during 1979.

The colder inshore waters off East London are also responsible for the infrequency of shoreline rains, unlike Natal where the land-sea junction records a high rainfall. The warm water is however relatively close in at Kei Mouth and, combined with the orographic effect of the steeper shoreline, is partly responsible for the higher rainfall received in this area.

The rainfall statistics for the study area are given in Table 17. The data for East London is based on longterm published figures while that

| | J | F | M | A | M | J | J | A | S | O | N | D | Yr (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAST LONDON (67) | 73 | 77 | 97 | 68 | 55 | 36 | 35 | 44 | 69 | 91 | 86 | 77 | 808 |
| GONUBIE (9) | 74 | 76 | 105 | 72 | 41 | 28 | 10 | 38 | 48 | 107 | 74 | 72 | 745 |
| KWENXURA (8) | 76 | 65 | 126 | 53 | 36 | 23 | 10 | 23 | 119 | 119 | 82 | 130 | 855 |
| HAGA HAGA (27) | 89 | 97 | 133 | 91 | 56 | 38 | 38 | 72 | 94 | 93 | 97 | 86 | 984 |
| KEI MOUTH (84) | 63 | 133 | 115 | 84 | 79 | 13 | 32 | 62 | 119 | 83 | 139 | 83 | 1005 |
| QOLORA (23) | 84 | 112 | 134 | 93 | 58 | 37 | 48 | 84 | 80 | 99 | 116 | 79 | 1024 |

TABLE 17. MEAN RAINFALL RECORDED FOR THE EAST LONDON COAST. FIGURES IN BRACKETS INDICATE PERIOD IN YEARS, FOR WHICH RECORDS WERE KEPT. (data from published and unpublished Weather Bureau records.)

for the other areas was obtained from unpublished Weather Bureau records. It is apparent that the rainfall gradient increases northwards from East London, with Kei Mouth receiving in excess of 200 mm more rain than East London - this statistic can be considered to be reliable since the data for Kei Mouth covers a period of 84 years. The statistics for Qolora, which is situated approximately 10 km north of Kei Mouth, have been included to emphasize the trend described above.

Rainfall records were kept for part of the duration of the study at five sites along the coast. Two rain gauges were located at each station (apart from Rooiwal) in order to measure the rainfall on both sea- and land-facing slopes. The monthly averages of the combined values for the five areas are shown in Table 18, and bear little resemblance to the longterm statistics. This was due to the exceptionally dry conditions which prevailed throughout this period, with most areas receiving less than half of the expected rainfall. Although an increasing trend can be interpreted from south to north along the coast, the figures for Rooiwal and Cove Rock do not correspond to this pattern. In the latter case however, a single shower, not received at any of the other stations, accounted for approximately 25 per cent of the entire annual rainfall. The recorded data cannot therefore be used reliably to support the interpretation of vegetational gradients but does serve to illustrate the climatic variability which can periodically occur.

| | J | J | A | S | O | N | D | J | F | M | A | M | Yr (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GULU | 23 | - | - | - | - | - | - | 10 | 36 | 17 | 34 | 30 | 150 |
| COVE ROCK | - | 4 | 6 | 71 | 153 | 38 | 27 | 25 | 34 | 13 | 33 | 14 | 418 |
| CINTSA | 34 | 110 | - | - | - | - | - | 20 | 17 | 4 | 35 | 32 | 252 |
| ROOIWAL | 34 | 68 | 3 | 65 | 92 | 34 | 24 | 40 | 56 | 16 | 38 | 23 | 493 |
| CAPE MORGAN | 15 | 65 | - | 6 | 104 | 15 | 9 | 42 | 16 | 23 | 54 | 28 | 377 |

TABLE 18. RAINFALL RECORDED WITHIN THE STUDY AREA BETWEEN JUNE 1982 AND MAY 1983.

The diurnal frequency and density of the rainfall for East London is shown in Fig. 16. Although the density, at rainfall per hour, shows very little diurnal variation, the frequency reaches a maximum between 19h00 and 20h00. This could be of significance to the vegetation since the moisture could be absorbed and exploited more beneficially by the soil and vegetation in the form of an increased number of light showers at a time when evaporation losses would be considerably reduced. Heavy showers tend to cause considerable erosion and the result is increased run-off losses due partially to the observed water-repellent nature of the dune soil (Plate 6 ). This phenomenom is discussed by Chapman (1964) and Tinley (1985) who attribute it to the presence of substances such as plant waxes in the soil and organic skins coating the sand particles.

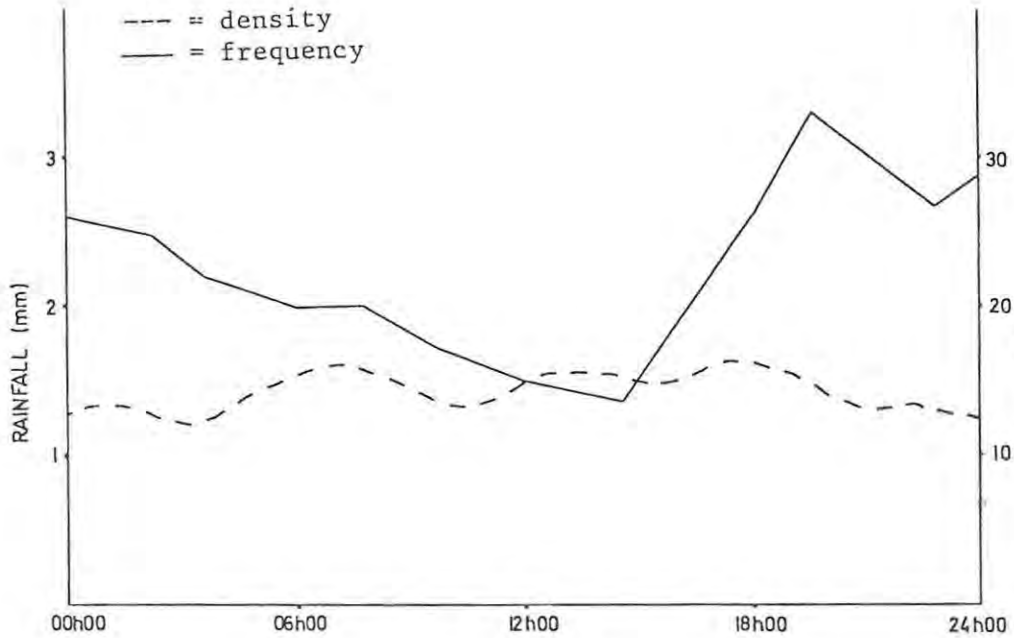



Fig. 16.
Diurnal variation of precipitation. (after Schulze (1965)).

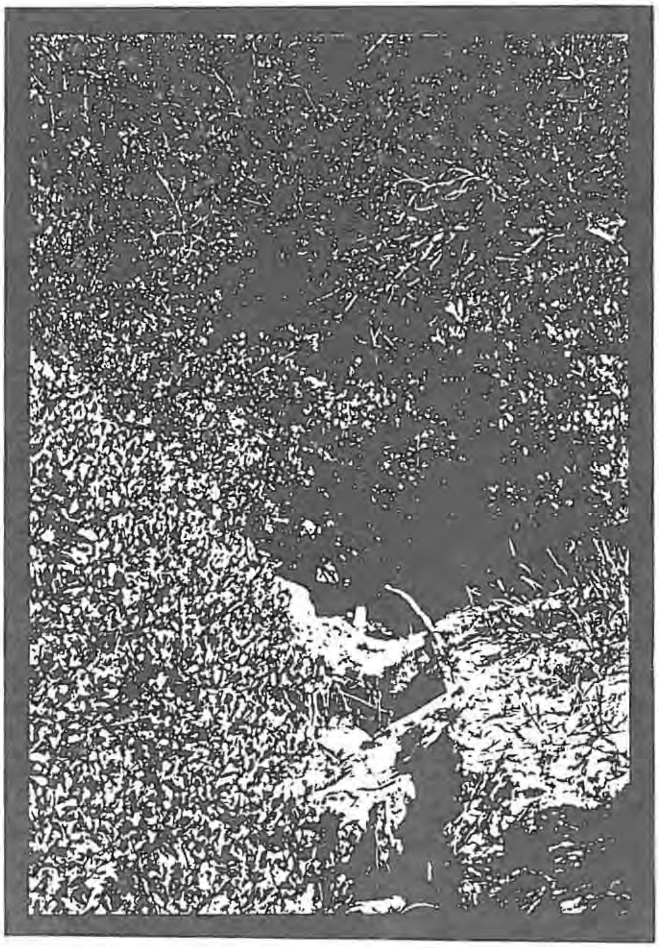


PLATE 6. Erosion caused through water repellance by dune soil.

2.5.9 Insolation

The energy balance of all ecosystems is ultimately dependant upon solar radiation and the influence which it has on water balance relations can be of particular significance in the study of vegetational successional trends. It is important therefore that the sunshine distribution pattern within the study area should be briefly described.

Seasonal cloud distribution is the climatic index most closely associated with the amount of radiant energy received by the dune plant communities. The monthly and annual values of the relative duration of sunshine, expressed as a percentage of the maximum possible and as a frequency in days is shown in Table 19. June, with the number of sunshine hours representing 79% of the maximum possible, is the most sunny month, while December is the lowest with a value of 52%. The actual number of hours of sunshine in December is however greater than in October when only 6,8 mean daily hours are recorded. The mean annual duration of sunshine at East London is 61% of the possible maximum - which is relatively high for a coastal station according to Schulze (1965). The Natal coast for example, receives only 55% of the posssible maximum and has a mean daily hour value of 6,6 compared to the 7,4 hours recorded at East London. Schulze and McGee (1978) attribute the low Natal coast value to the high atmospheric water vapour content associated with the warm Mocambique current, but although a cumulus cloud bank is often visible over the

| MONTH | DAILY HOURS | | MEAN AS % OF POSSIBLE | MEAN NO. OF DAYS | |
|---|---|---|---|---|---|
| | MAXIMUM POSSIBLE | MEAN | | COMPLETELY OVERCAST | SUN 90-100% |
| JAN | 14,1 | 7,6 | 54 | 1,8 | 3,7 |
| FEB | 13,3 | 7,3 | 55 | 2,4 | 5,2 |
| MAR | 12,5 | 7,1 | 57 | 1,6 | 4,9 |
| APR | 11,3 | 7,2 | 64 | 1,3 | 8,8 |
| MAY | 10,4 | 7,3 | 70 | 0,8 | 12,1 |
| JUN | 10,0 | 7,9 | 79 | 0,3 | 15,1 |
| JUL | 10,3 | 7,8 | 76 | 0,4 | 13,7 |
| AUG | 11,0 | 7,6 | 69 | 0,5 | 10,5 |
| SEP | 11,9 | 7,5 | 63 | 1,2 | 6,9 |
| OCT | 12,8 | 6,8 | 53 | 3,1 | 3,3 |
| NOV | 13,8 | 7,6 | 55 | 2,1 | 3,1 |
| DEC | 14,2 | 7,4 | 52 | 1,6 | 2,8 |
| YEAR | 12,1 | 7,4 | 61 | 17,1 | 90,1 |

TABLE 19. SUNSHINE PATTERN AT EAST LONDON.(data from published Weather Bureau records.)

Agulhas current off East London, its influence on the general cloudiness of the area is not very great.

According to Heydorn and Tinley (1980) the south-eastern Cape coast receives winter radiant flux densities below 110 x $10^5$ $Jm^{-2}$ $day^{-1}$ and summer values of approximately 230 x $10^5$ $Jm^{-2}$ $day^{-1}$, when the sun is in its southernmost position.

Dune topography plays a major role in modifying the insolation regimes for the different dune aspects. For a greater part of the year, and especially in mid-winter, north-facing slopes intercept considerably more sunlight than those with a southerly aspect or the dune crests although in mid-summer however, the latter can receive more direct sunlight than gentle, north facing slopes (Ward, 1980). The above trends are described by Schulze and McGee (1978), Schulze (1975) and Drummond and Vowinckel (1957) and could also be partly deduced from temperature patterns which were recorded in the field within the study area.

The East London coastline has a north-east/south-west orientation and the two major dune aspects are north-west and south-east. Relatively more sunshine is therefore received by the land-facing slopes, particularly in winter, and consequently they are hotter and drier than the sea-facing slopes. The microclimate across the dune profile can thus differ considerably with regard to temperature and evaporation of precipitated moisture.

The amount of sunshine which penetrates the vegetation strata to the soil surface varies according to the dominant species or successional

| SPECIES | LIGHT INTENSITY AS % OF FULL SUNLIGHT |
|---|---|
| *Scaevola plumieri*, well developed | 7,81 - 12,5 |
| *Passerina rigida*, up to 1m tall | 4,41 - 28,82 |
| *Chrysanthemoides monilifera* | 4,69 - 18,75 |
| *Eugenia capensis*, clump 1m tall | 1,21 - 2,08 |
| *Brachylaena discolor* | 4,21 |
| *Mimusops caffra*, 3m tall | 1,19 - 2,25 |
| Early dune forest, canopy 4,5 - 5,5m tall | |
| (i) above *Isoglossa woodii* (0,75m tall) | 1,88 - 3,44 |
| (ii) below *I. woodii* (0,75m tall) | 0,31 - 0,78 |

TABLE 20. LIGHT INTENSITIES UNDER DIFFERENT TYPES OF DUNE VEGETATION IN NATAL (after Ward, 1980).

stage of the community. Although data was not recorded locally, the values determined by Ward (1980) and shown in Table 20 can however probably be interpreted as being typical for most dune communities.

# CHAPTER 3

# SUCCESSION AND ZONATION

## 3.1 INTRODUCTION

Dune succession is perhaps one of the processes to which both recent and older concepts of succession can be applied with relative ease. Primary succession in particular appears to follow a definite sequence which creates the species and community zonation typical of the East London coast, and in fact of most dune systems.

Several authors have described dune succession and the general pattern which has been identified, of colonisation and development towards a climax community, appears basically to be universal. A situation of progressive stabilisation of the dunes by vegetation does not necessarily have to represent a successional sequence of one community progressing to the next (Willis et al., 1959), but it often is the case. Edaphic factors for example, such as a high water table in dune slacks, can halt a particular community from progressing beyond its existing floristic and possibly structural status but the vegetation can however continue to increase the stability of the site. Chapman (1976) discusses succession as it applies to some European and American situations and describes the principal seral communities. Kumler (1969) documented the community succession from the sand dunes to forest on the Oregon-coast and Barbour et al. (1973) describe the process up to a pre-climax stage at Bodega Head, U.S.A. In the South

African context, Tinley (1985) gives a precise description of dune succession and Moll (1968, 1969, 1972), Weisser (1980) and Weisser and Backer (1983) amongst others, have described the successional chronology and development of dune vegetation in Natal.

## 3.2 CONCEPTS OF SUCCESSION AND THEIR APPLICATION TO THE DUNE SITUATION

Several concepts and models of succession have been developed to date, with the most recent approaches being refinements of older ones, considered to be too rigidly simplistic to apply in many natural situations.

Clements (1916, 1936) was one of the first to formulate the concept of community succession, and his model is today regarded as the 'Classical Approach'. Clementsian succession assumes that a series of species suites succeed one another on a particular site until a climax community develops which can reproduce itself indefinitely. At each stage the site environment (soil, microclimate, competition pressure etc.) is modified, making it less favourable for the existing species suite and more favourable for the one following. This model is very applicable in dune succession where early stages play an essential role in stabilising mobile sand, enriching the soil and creating a more sheltered environment for other plants to become established. For example, Scaevola plumieri, by fulfilling its stabilising function and inevitably reducing the amount of mobile sand on which it thrives, is eventually suppressed and gives way to secondary stage plants.

Egler (1954) referred to the classical successional patterns as **relay floristics** and hypothesized that the final community is determined largely by initial floristic composition. Each species will, as it develops, restrict for a while subsequent species from assuming dominance without actually facilitating their entry into the community. This concept has limited application to primary dune succession where climax and sub-climax forest elements are definitely not abundant or even present in early seral stages and cannot become established without the assistance of the latter. During the transition phase between the open shrub and closed dune scrub stages, opportunistic forest species can however establish themselves as dormant elements which florish once a suitable environment has been created for them.

Connell and Slatyer (1977) consolidated earlier views and suggested that most successions can follow three patterns which are described as the **facilitation**, **inhibition** and **tolerance** pathways. The implications of the **inhibition** pathway are similar to those described by Egler (1954) and it is the **facilitation** pathway which would apply in primary dune succession. Once again, it is the earlier sequences which are essential in assisting the entry and development of later stages. The **tolerance** pathway implies that later sequences develop irrespective of the presence or absence of earlier stages.

Noble and Slatyer (1981) regard a knowledge of specific life history characteristics of key component species - such as the ability of members of the Strand Plant Community to grow ahead of accumulating sand and their resistance to salt spray - as an important means of understanding successional processes. The part played by surviving propagules (in the case of secondary succession) and adjacent communities in supplying seed for the colonization process is also regarded as significant.

## 3.3 SUCCESSIONAL ZONATION

Along the East London coast the model or 'ideal' dune plant succession is comprised of four zones, each seral to the one following. (See Fig. 17(a)).

### The dune pioneer zone or strand plant community

This is found closest to the sea and is made up for the most part of grasses and succulent leafed herbs which are mostly wind and water dispersed. These plants have a stoloniferous or sympodial growth form which enables them to grow ahead of accumulating sand. Efficient root systems bind the sand and partially fix it thus creating the first embryonic dunes. The ability of these plants and their seedlings to withstand periodic inundation by sea water is another reason for their success as pioneers. Soil development in this zone is minimal and the little organic matter, consisting often of decayed driftline material, is efficiently exploited by the plant roots.

The community structure is simple, with the single field layer reaching 0,5 - 1m in height. Typical or key species include Ipomoea

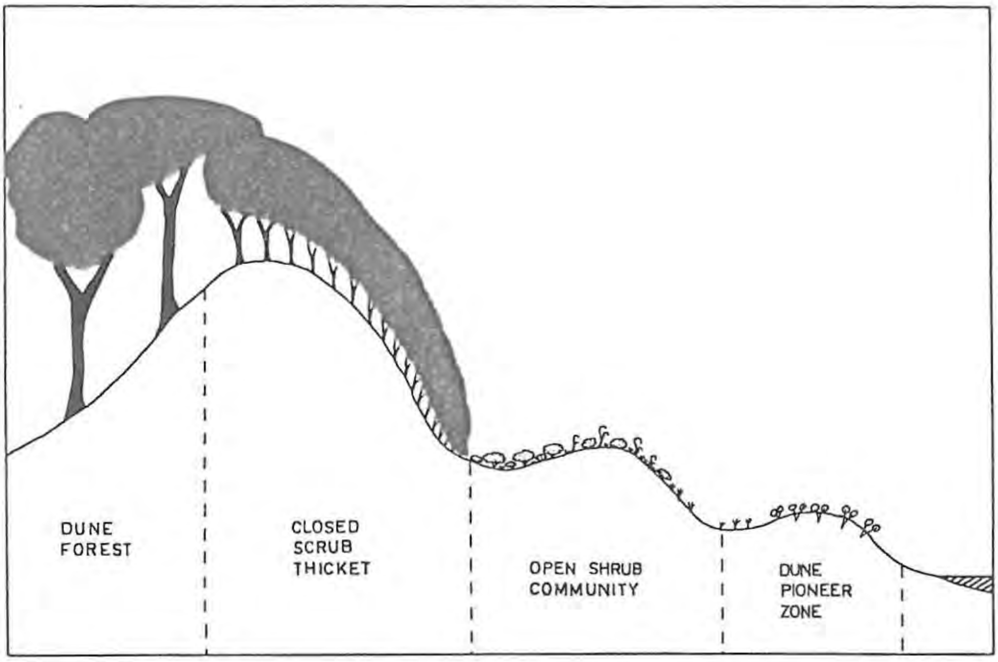



Fig. 17(a).
Schematic representation of the model successional sequence of dune vegetation illustrating the four typical seral zones.

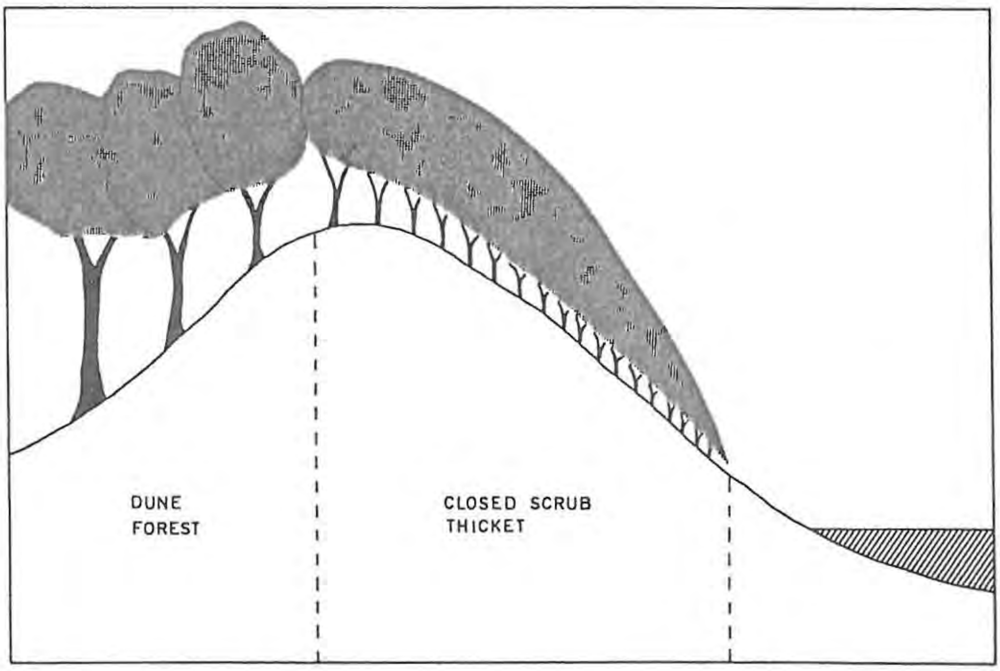



Fig. 17(b).
Schematic representation of the successional sequence more commonly encountered along the East London coast illustrating the two later seral zones.

brasiliensis, Scaevola plumieri , Arctotheca populifolia, Gazania rigens, var. uniflora and Erharta villosa. (See Plate 7 ).

As protection against sand movement and salt spray increases the habitat becomes modified. Shrubs and creepers establish themselves and a more complex community develops.

The open shrub community

Species diversity increases landwards, with a more woody shrub component becoming evident. Weisser and Cooper (in preparation) refers to this community as Passerina Scrub, after the ubiquitous diagnostic species Passerina rigida. It is generally two-layered with the field layer measuring approximately 0-0,5m and the shrub layer 0-2,5m in height. Creepers such as Cynanchum natalitium, Rhoicissus digitata and Rhynchosia caribaea link the two strata. Other species typical of the East London area include Helichrysum cymosum, Senecio littoreus, Imperata cylindrica, Metalasia muricata, Myrica cordifolia, Chironia baccifera, Chrysanthemoides monilifera and Stoebe plumosa. Occasional strand plants also occur in this community.

Bush clump nuclei develop in the more sheltered areas, where the second stage plants are able to overtop the pioneer vegetation and create perch sites (Tinley, 1985). Seed from the adjacent scrub community is introduced and the bush clumps merge to form the following seral stage. (See Plate 8 ).

The closed dune scrub or scrub thicket community

This community contains a mixture of woody and half-woody species,

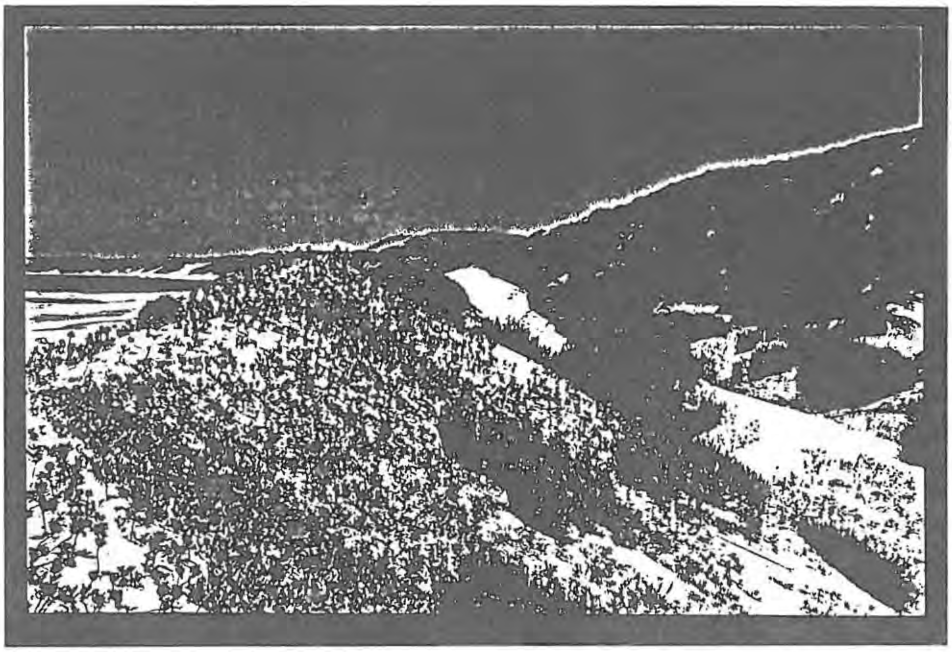


PLATE 7. Embryo hummock dune with pioneer plant community.

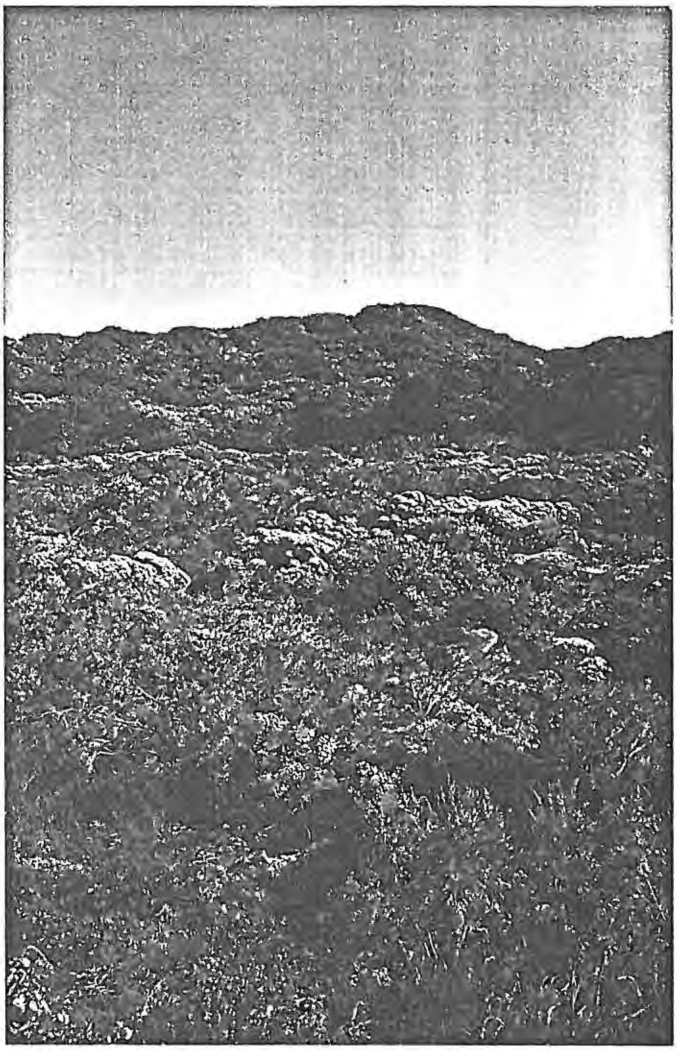


PLATE 8. Open shrub community.

many of which are present in the climax dune forest. Structurally it can be defined as being a thicket with a population of multistemmed individuals having a very compact canopy. The frequent deposition of sand in the form of a sand rain is responsible for stimulating the stem branching and also for suppressing the development of a ground layer in this zone. Strelitzia nicolai is a common emergent not affected by salt spray but the remainder of the canopy often has the typically pruned appearance which was described in the previous chapter. Subordinate strata are usually absent due to the shading effect of the canopy, the height of which varies between 1 and approximately 4 m.

Typical members of this community include Metalasia muricata, Chrysanthemoides monilifera, Maytenus procumbens, Mimusops caffra, Brachylaena discolor, Euclea natalensis, Pterocelastrus tricuspidatus, Allophylus natalensis, Cassine aethiopica, Maytenus heterophylla and Ficus burtt-davyii.

The littoral thicket or dune forest community

Edaphic succession within the dune soil increases its humus content and makes it more capable of supporting a climax forest community. Emergents appear in the more sheltered sites such as dune valleys and the development of subordinate strata including a ground layer is stimulated by the increased light penetration. The shrubs of the preceeding seral stage become overtopped by the tree elements and the vegetation is gradually transformed into taller thicket or forest.

Climax, or the most developed forest, usually occurs only in the dune valleys, with the landward vegetation, particularly on the north-facing slopes, seldom progressing beyond the thicket state.

Canopy height varies between 8 and 15m, with an intermediate layer at 2,5 - 7m. The latter is often difficult to distinguish from the canopy but can be identified by the presence of typical understorey species such as Acokanthera oblongifolia. Common canopy species include Mimusops caffra, Sideroxylon inerme, Dovyalis rotundifolia, Allophylus natalensis, Cassine aethiopica, Maytenus heterophylla, Euclea racemosa and Euclea natalensis. Climax dune valley forest in addition contains species such as Erythrina caffra, Diospyros natalensis, Harpephyllum caffrum, Schotia latifolia, Teclea natalensis, Zanthoxylum capense and even Podocarpus falcatus and P. latifolius. Sub-canopy species include Carissa bispinosa, Psychotria capensis, Acokanthera oblongifolia, Cassine papillosa, Deinbollia oblongifolia, Dracaena hookerana and juvenile canopy individuals. Isoglossa woodii can be a locally common field layer species measuring up to 1.5 m in height and often becoming so dense that few other species are able to become established in this stratum. Venter (1972) and others report of a similar situation in Natal where pure stands of I. woodii or Phymatodes scolopendria can occur to the exclusion of all other species.

The psammosere or ideal succession described above and illustrated in Fig. 17 (a) can seldom be seen as such in the field. Apart from ecotonal effects which can disguise the basic community zonation, the successional trend is often multi dimensional in reaction to secondary disturbances. Generally the communities consist of a vegetational mosaic of primary and secondary origin which only broadly conforms to the zonation model. Although the climax and pre-climax communities are least susceptible to disturbance, the early sequences can in many instances be completely eliminated by a reversal in successional direction (e.g. through a blow-out formation). The schematic profile of the forest dune illustrated in Fig.17 (b) portrays the situation more commonly encountered along the East London coast, where the forest or thicket stage immediately adjoins the beach. The situation which is also described by Moll (1972), arises due to the removal of the Pioneer and Open Shrub zones by wind and tidal erosion (See Plate 9).

Where this happens a narrow fringe community can develop which is comprised of a mixture of pioneers, creepers and dwarf thicket elements. These are characteristically fleshy-leaved through chloride induced hypertrophy (Boyce, 1954) and include Carpobrotus edulis, Ipomoea brasiliensis, Passerina rigida, Chrysanthemoides monilifera, Maytenus procumbens and Mimusops caffra.

## 3.4 A ZONATION STUDY ALONG THE EAST LONDON COAST

### 3.4.1 Introduction

A brief study on vegetational zonation within the early dune forest development sequences was carried out at one of the few sites along

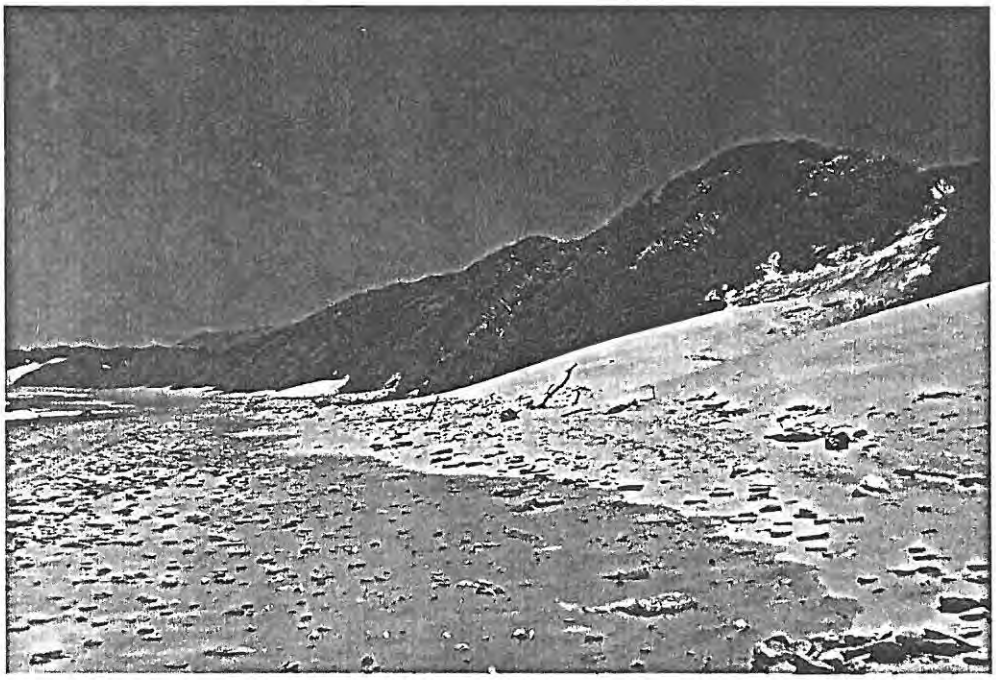


PLATE 9. Seaward dune thicket with early seral stages absent.

the East London Coast where the full successional spectrum is relatively well represented.

Zonation studies within dune systems have been carried out by many researchers both abroad and in South Africa and the phenomenon in most cases has been attributed to the combined influences of various environmental gradients (Oosting and Billings, 1942; Hobbs and Grace, 1981; van der Valk, 1974; Donnelly and Pammenter, 1983; Lubke, 1983; Lubke and Avis,1982). Although no environmental parameters were measured in this study, it was however accepted that similar gradients exist to those discussed earlier - for example the salt spray fall-out pattern, soil characteristic gradients, etc. The zonation of forest tree species is covered to a certain extent in a later chapter and one of the aims of this study was therefore to concentrate on successional or environmentally induced zonation within the Pioneer and Open Shrub communities.

### 3.4.2 The study area

The area chosen for the study is located between the Cintsa and Bulura River mouths at latitude 28°07'S and longitude 32°52'E and measures some 2 ha in extent. It supports both pioneer and more developed plant communities and is the best apparent example along the East London Coast of an ideal successional sequence.

Although the geology does not differ significantly from that found elsewhere, it is probably the sandstone base to the dunes, exposed along the land-sea interface, which has prevented erosion of the narrow beach adjoining the primary dunes. A nearby dolerite dyke situated a few hundred metres to the north has probably also contributed towards the conservation of the vegetation of this site.

From the dune profile, which is illustrated in Fig. 18, the main features of the area which can be identified are the two youngest primary dunes separated by a dune slack, an 'older' dune slack or trough and the lower slope of the major thicket-supporting dune.

### 3.4.3 Sampling procedure

The vegetation of the area was subjectively divided into three zones on the basis of visible physiognomic and floristic differences ( Fig. 18 and Plate 10 ).

Zone I consisted of the youngest foredune which supported mainly first stage pioneer vegetation.

Zone II included a mature dune slack community as well as second stage open shrub vegetation.

Zone III was made up of a "senescent" dune slack community and second stage vegetation which contained noticeably more woody elements than the above two zones.

Ten $1m^2$ quadrats were randomly sampled within each zone and the number of rooted individuals, the percentage aerial cover of each species and the height of the vegetation strata was recorded. Although the

DUNE SPECIES OF THE PIONEER AND LATER SERAL ZONES AND ASSOCIATED COVER VALUES (%).

| | | | |
|---|---|---|---|
| Open Sand | 32,6 | 37,4 | 20,7 |
| Scaevola plumieri | 1,2 | | |
| Ipomoea brasiliensis | 2,0 | | |
| Cynanchum natalitium | 4,2 | 0,5 | |
| Chrysanthemoides monilifera | 38,0 | | 2,5 |
| Allophylus natalensis | 0,1 | | 2,0 |
| Passerina rigida | 2,0 | 22,9 | 1,0 |
| Rhus crenata | 6,7 | 14,3 | 19,2 |
| Myrica cordifolia | 11,5 | 1,2 | 12,0 |
| Scutia myrtina | 1,2 | 0,3 | 0,8 |
| Chironia baccifera | 0,5 | 7,9 | 0,2 |
| Tarchonanthus camphoratus | | 0,1 | |
| Rhoicissus digitata | | 0,7 | 0,2 |
| Helichrysum cymosum | | 0,7 | 6,6 |
| Scirpus nodosus | | 2,6 | 2,0 |
| Metalasia muricata | | 10,3 | 15,7 |
| Senecio littoreus | | 1,0 | 0,9 |
| Brachylaena discolor | | 0,1 | 0,3 |
| Euclea natalensis | | | 13,5 |
| Mariscus congesta | | | 0,4 |
| Pterocelastrus tricuspidatus | | | 0,8 |
| Rhynchosia caribaea | | | 0,3 |
| Mimusops caffra | | | 0,4 |
| Maytenus nemorosus | | | 0,3 |
| Grewia occidentalis | | | 0,1 |
| Cassine aethiopica | | | 0,1 |
| Total Cover (%) | 67,4 | 62,6 | 79,3 |

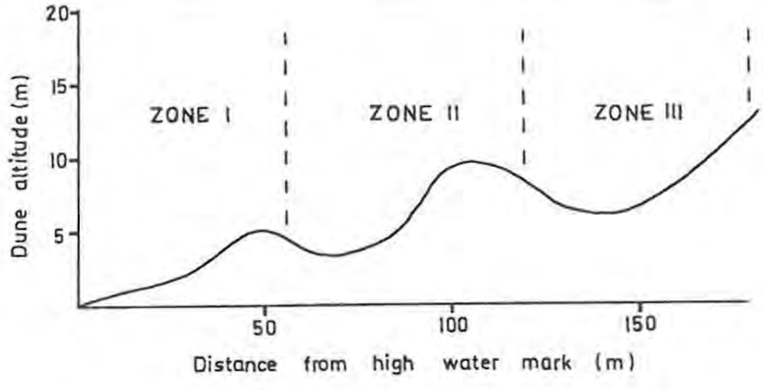



Fig. 18.
Profile across an accreting dune system illustrating the three major vegetational zones.

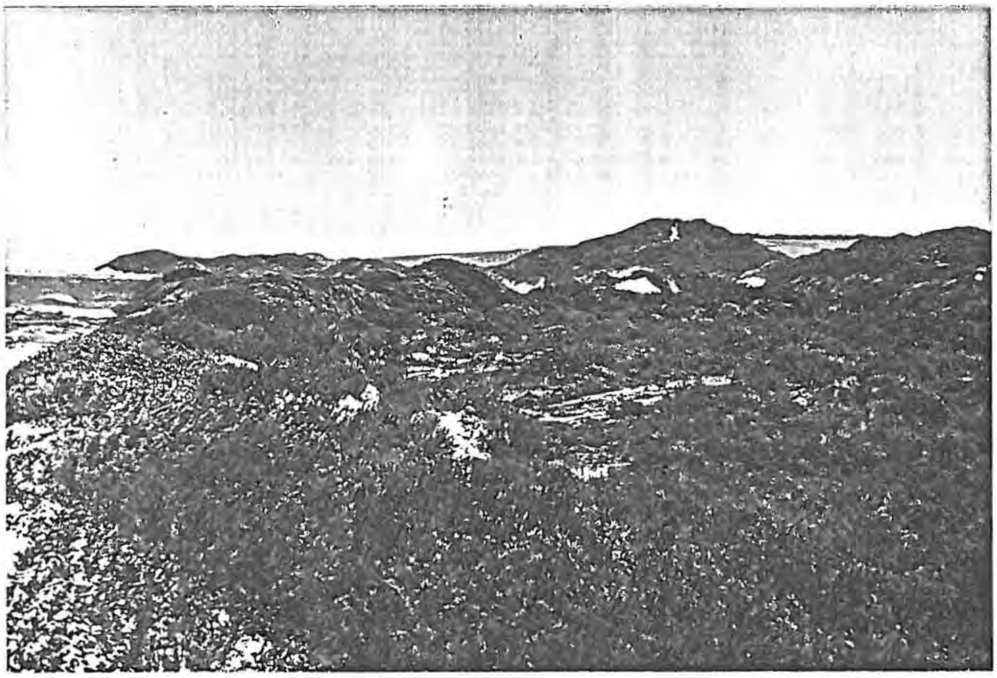


PLATE 10. Community zonation within early successional dune vegetation.

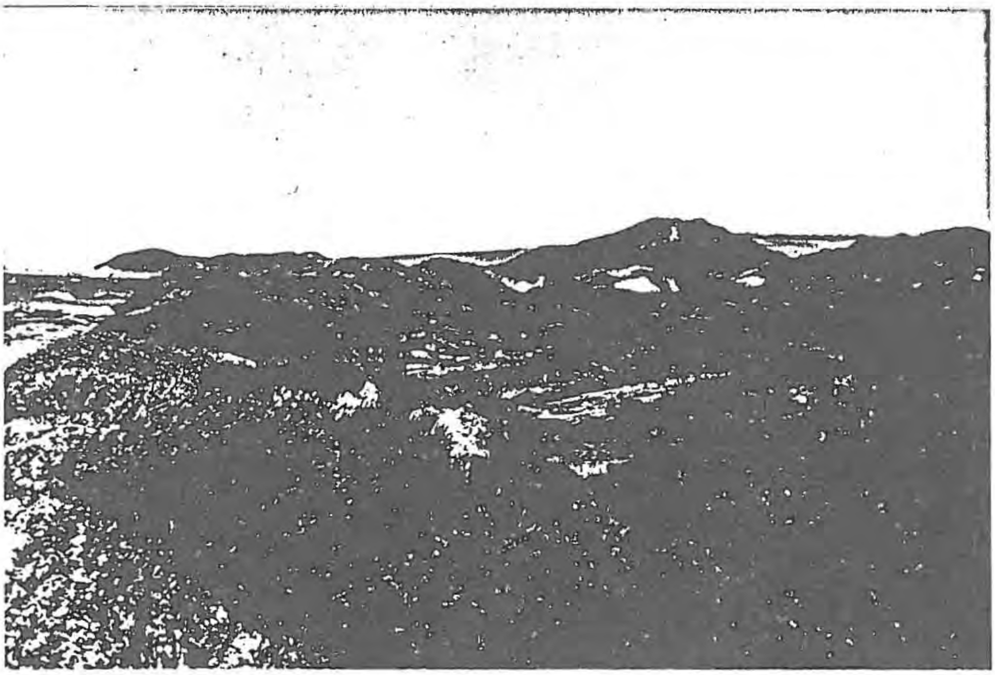


PLATE 10. Community zonation within early successional dune vegetation.

sampling intensity was relatively low, it was considered to be entirely adequate for the purposes of the study and heavier sampling would not have produced significantly better or more easily interpretable results.

3.4.4 Results

A total of twenty five species were recorded for the entire area, some of which were exclusive to one or two zones and others common throughout. The results which are illustrated in Fig. 18 indicate that landwards, there is an increase in species diversity and a prevalence of woody species.

Only ten species occurred in Zone I with Chrysanthemoides monilifera and Myrica cordifolia having the highest cover values. The common pioneers Scaevola plumieri and Ipomoea brasiliensis were also recorded.

Zone II contained thirteen species, with Passerina rigida, Rhus crenata, Metalasia muricata and Chironia baccifera having the highest cover values. A perched water table above the sandstone platform is probably responsible for the presence of Scirpus nodosus which is a common dune slack species. Helichrysum cymosum also occurred in the slack area and the indications were that in time, with the accumulation of more sand, Scirpus nodosus would eventually be replaced by shrub elements. Brachylaena discolor and Tarchonanthus camphoratus were of the few woody thicket species recorded in this zone but both had low cover values. Generally, the vegetation was very typical of the Open Shrub community described earlier.

The greatest number of species occurred in Zone III, with twenty one having been recorded. Typical scrub thicket species found included Euclea natalensis, Mimusops caffra, Pterocelastrus tricuspidatus, Grewia occidentalis and Cassine aethiopica. The highest cover values were obtained for Metalasia muricata and Rhus crenata, indicating that although in a relatively advanced stage in the succession, the vegetation had still retained much of its Open Shrub character. Scirpus nodosus was present in the "senescent" dune slack but had a lower cover value than in the younger slack of Zone II. The cover value for Helichrysum cymosum in this trough area and the presence of other shrub and woody species had, however, increased and the vegetation had lost much of its original slack community appearance.

In the analysis of the total vegetation cover of the area it was found that Zone III, with the initiation of the Closed Dune Scrub phase, recorded 79,3 per cent cover, followed by the primary dune with 67,4 per cent and Zone II with 62,6 per cent. Although the pioneer vegetation is often fairly sparse, the primary dune which was sampled in this case supported a relatively well established mixture of pioneer and second stage shrubs. The mean heights of the canopy and understorey which are given in Table 21, show an increasing tendency in association with the development of the vegetation towards thicket. The observed subordinate stratum will probably disappear temporarily

| | MEAN STRATUM HEIGHT (m) | |
| --- | --- | --- |
| ZONE | CANOPY | SUB-CANOPY |
| I | 0,5 | 0,12 |
| II | 1,4 | 0,22 |
| III | 1,9 | 0,28 |

TABLE 21. MEAN CANOPY AND SUB-CANOPY HEIGHTS RECORDED WITHIN THREE CONTIGUOUS EARLY SERAL ZONES BETWEEN THE BULURA AND CINTSA RIVER MOUTHS.

once the Scrub Thicket stage is reached and re-appear thereafter during the pre-climax and climax forest stages.

### 3.4.5 Discussion

There are few stretches along the east coast of South Africa (which has been described by Tinley (1985) and others as "eroding") where active deposition of sand, dune formation and stabilization is taking place. Weisser et al.(1982) and Moll (1972) have however, reported on two such areas in Natal and have described the sequences of dune and vegetation development in successional and phytochronological terms. The results of the study carried out on the East London coast, where accretion has taken place to a certain extent, have shown a similar pattern to that found by the above authors. The construction of the primary dune in Zone I was initiated by Strand pioneer species which have also provided a degree of shelter to a few second stage species. The second dune in Zone II has increased in height and has over a period of time and at the expense of the pioneer vegetation, become colonized by a more complex community which is slowly progressing towards dune thicket. The third and oldest dune which was not sampled, supports climax and pre-climax thicket and is considerably higher than the other two dunes. Should sand continue to be deposited on the beach, it is possible that further dune ridges could be formed and that the dune development sequence will be expanded.

With reference to species zonation, it is apparent that certain shrubs such as Passerina rigida, Rhus crenata and Myrica cordifolia thrive under a range of environmental conditions and occur in both juvenile and sub-climax communities. The liane Scutia myrtina can similarly survive in a variety of dune habitats. Other species however, such as Scaevola plumieri, Ipomoea brasiliensis, and Scirpus nodosus, are very much more site specific and disappear from the community when a change in environmental conditions takes place (such as a reduction in sand supply or a change in moisture regime for example). Lubke and Avis (1982) found that salt spray and soil moisture were major controlling factors affecting the distribution of Scirpus nodosus and it is likely that they have played a similar role in restricting this species to the dune slacks in the study area.

Woody species such as Brachylaena discolor, Cassine aethiopica, Euclea natalensis and Pterocelastrus tricuspidatus do occur in the Open Shrub community, with the emphasis being on their presence rather than their importance. Although they do become important individuals in later seral stages, they can nevertheless become established relatively early on in the succession but require the facilitation process described by Connell and Slatyer (1977) before achieving importance. The concept of relay floristics described by Egler (1954) would also apply to a certain extent in the study area in that elements of the final forest community are present on the site at a relatively early stage.

vegetation was carried out. Differentiating species were used to name the major community and variations of this community were identified using a number of species diagnostic of the variations. The survey results were then compared with data obtained from adjacent undamaged forest which had been sampled using a quarter point method.

### 3.5.2 Description of the study area

The area studied was a patch of vegetation approximately 1 ha in size which was in its third year of recovery after a fire which occurred during May 1980. It is situated 1,5km north-east of the Bulura River mouth and adjoins the privately-owned Glen Muir Holiday Resort.

The burnt dune community has a land-facing aspect of 310° and a slope of between 10° and 12°. It is unlikely that the climate differs significantly from that described earlier for the major study area and the soils are very similar to adjacent unburnt slopes. Slight differences in the chemical characteristics of the soil are discussed below.

During the fire the boundary fence between the State Forest and adjoining property was destroyed and has only recently been repaired. A considerable amount of grazing and browsing by cattle has taken place which is unfortunate since it must have had some effect on the natural recovery processes of the vegetation. It has also resulted in an invasion by weed species which should however become suppressed with time.

| SAMPLE DEPTH (cm) | 0 - 15 | | 60 | | 110 | |
|---|---|---|---|---|---|---|
| SITE | BURNT | UNBURNT | BURNT | UNBURNT | BURNT | UNBURNT |
| %C | 1,05 | 1,21 | 0,55 | 0,67 | 0,40 | 0,40 |
| pH | 8,70 | 8,50 | 8,90 | 8,70 | 8,90 | 8,70 |
| Na (meq/100g) | 0,63 | 0,52 | 0,24 | 0,38 | 4,05 | 0,81 |
| K " | 0,33 | 0,33 | 0,10 | 0,14 | 0,17 | 0,14 |
| Ca " | 19,99 | 20,93 | 21,62 | 20,67 | 20,79 | 26,06 |
| Mg " | 1,12 | 1,41 | 0,91 | 1,04 | 1,04 | 1,17 |
| S-Val " | 22,07 | 23,19 | 22,87 | 22,23 | 26,05 | 28,18 |
| C.E.C. " | 6,36 | 8,73 | 4,64 | 5,51 | 3,13 | 4,41 |

TABLE 22. COMPARISON OF SOIL CHARACTERISTICS BETWEEN THE BURNT AND UNBURNT DUNE THICKET SITES AT QUEENSBERRY BAY.

adsorptive capacity than clay, will obviously affect the C.E.C. of the soil.

The colloidal properties of humus are also particularly important in dune soils where leaching of base cations is rapid. These ions are held by the humus and leaching is thus reduced. The cation content values (apart from sodium) of the burnt site are lower than on the unburnt site, indicating that increased leaching has occurred.

### 3.5.4 Sampling procedure

The Braun-Blanquet or Zurich-Montpellier system as described by Poore (1955a, 1955b, 1956), Moore (1962), Werger (1974), Westhoff and van der Maarel (1978) and Gauch (1982) was used to survey the vegetation.

Poore (1956) advocates the use of this system for studies on vegetational succession and Werger (1974) notes the usefulness of the Braun-Blanquet approach to establish the status of the vegetation concerned and the status of the successional trends under the influence of a specific treatment. Since it is the latter which was of concern in the study of the burnt area, it was felt that this phytosociological method could be applied.

The importance of homogeneity is stressed by the various authors and care was therefore taken to first establish whether in fact the burnt area consisted of one or more stands of vegetation (phytocoenoses). In the major survey of the dune forests (see later) it was subjectively decided that for each forest unit the vegetation of the land-facing slopes could be classed as a single community . This was done after a thorough inspection of the vegetation in the field and a study of the available aerial photographs. It was assumed therefore, and again subjectively confirmed through visual inspection, that the recovering vegetation consisted of a single stand or community. Each plot sampled in the area would hopefully provide a typical description of the vegetation in terms of both floristic composition and structure (Werger, 1974).

In deciding on which quadrat size to use in the survey, the definition given by Hopkins (1957), that the minimal area for a quadrat is the smallest area which contains an adequate representation of an association, was used. Werger (1972) notes that the minimal area also depends on the structure of the phytocoenosis. Moll (1980a and 1980b), in his ordination studies of the Hawaan and Hlogwene dune forests, concluded that a 20 x 20m sample size provided the most useful data. This however could not be used as a guideline since the recovering vegetation could definitely not be classed as forest. With the flexibility permitted in the choice of plot size, a square plot measuring 3x3m was considered adequate (Palmer, pers.comm.).

It was decided that ten evenly distributed quadrats would be sufficient to reflect the total variety in the area, particularly since the scale of the study was relatively small. The quadrats were demarcated on the ground using four corner droppers and a nylon rope and all pertinent information was recorded on the Field Data Sheets of the Botanical Research Institute, Department of Agriculture (Plate 11).

A soil pit was excavated in each quadrat and in all cases the soil profile consisted of an orthic A-horizon over regic sand. The depth of the A-horizon varied between 20 and 30 cm. A complete floristic list was made and a cover abundance rating given to each species based on the scale devised by Barkman et al.(1964) (Table 23). The aspect of each quadrat was noted as well as the slope, which was measured either with an Abney level or a Suunto hypsometer. It was apparent that the vegetation consisted of two strata (a herb and a woody coppice layer) and the heights and percentage cover of each were recorded. There was also considerable evidence of grazing and browsing by ungulates and cattle and this too was noted on the data sheets.

### 3.5.5 Construction of the phytosociological table

A "raw table" of the data was constructed, with the rows representing all of the species recorded and the columns the relevés. This matrix was then re-arranged on a CPT 8100 Information Processing System to obtain the final phytosociological table (Table 24). The technique which is described by Werger (1974) and discussed in detail by Palmer and Lubke (1982) involves the vertical shifting of rows to group positively associated species followed by a second re-arrangement of the columns to place relevés of similar species composition together. Inspection of the table reveals several noda or table units which are discussed below.

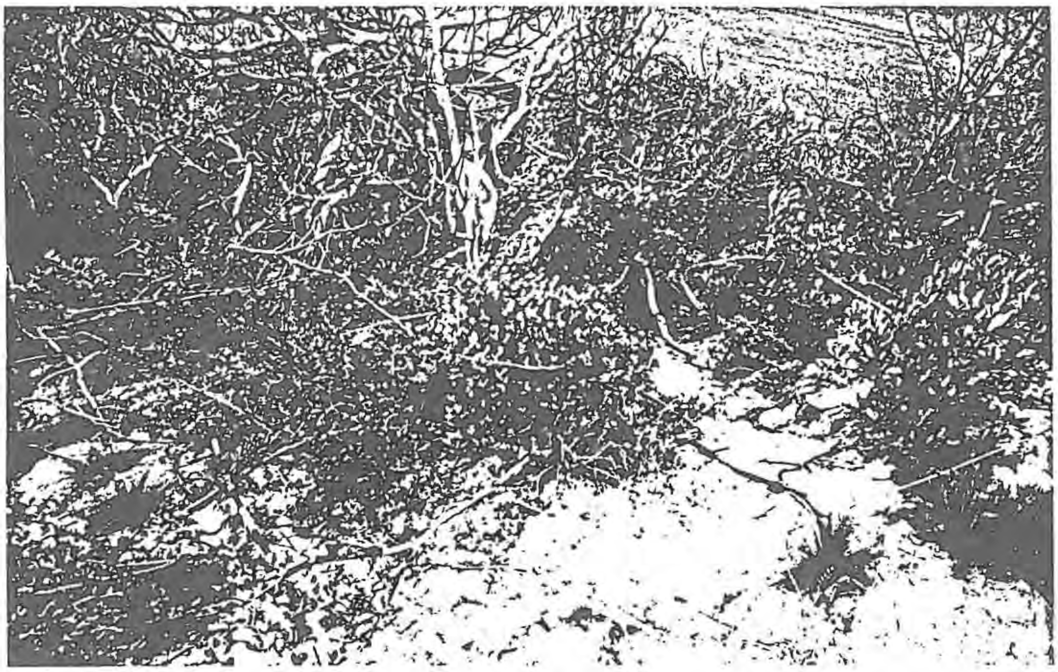


PLATE 11. Quadrat laid out in burnt dune vegetation at Glen Muir.

BRAUN-BLANQUET COVER ABUNDANCE VALUES.

r = Very rare - a single individual (negligible cover)

+ = Present but not abundant (cover < 1%)

1 = Numerous but cover < 1 %, or not so abundant but cover 1 - 5%

2m = Very numerous, covering < 5%

2a = 5 - 12% cover, independant of abundance

2b = 13 - 25% cover, independant of abundance

3 = Cover between 26 and 50%

4 = Cover between 51 and 75%

5 = Cover between 76 and 100%

TABLE 23. COVER-ABUNDANCE VALUES USED IN THE CONSTRUCTION OF THE BRAUN-BLANQUET PHYTOSOCIOLOGICAL TABLE. (Scale according to Barkman *et al*.(1964). )

| RELEVES | 9 | 10 | 2 | 1 | 4 | 3 | 5 | 7 | 6 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| SLOPE | 11 | 11 | 11 | 11 | 13 | 10 | 12 | 13 | 10 | 12 |
| ASPECT (all 310 ) | - | - | - | - | - | - | - | - | - | - |
| No. SPECIES | 14 | 13 | 13 | 18 | 12 | 11 | 17 | 14 | 14 | 10 |
| HEIGHT in metres (Shrub) | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| HEIGHT in metres (Herb) | ,5 | ,5 | ,5 | ,5 | ,5 | ,1 | ,5 | ,3 | ,2 | ,2 |
| % COVER (Shrub) | 30 | 17 | 36 | 17 | 20 | 56 | 30 | 50 | 43 | 40 |
| % COVER (Herb) | 40 | 50 | 35 | 50 | 25 | 12 | 20 | 20 | 20 | 14 |
| SPECIES | | | | | | | | | | |
| DIFFERENTIAL SPECIES OF THE | | | | | | | | | | |
| *Cassine tetragona - Euclea natalensis* variation | | | | | | | | | | |
| *Digitaria eriantha* | 2a | 1 | + | + | | | | | 2a | |
| *Cassine tetragona* | r | + | 1 | | | | | 1 | + | |
| *Mariscus congestus* | + | + | | r | r | | r | | | |
| *Mesembryanthemum aitonis* | 2m | 2a | | | | | | | | |
| DIFFERENTIAL SPECIES OF THE | | | | | | | | | | |
| *Asparagus suaveolens - Euclea natalensis* variation | | | | | | | | | | |
| *Asparagus suaveolens* | | | + | + | | | + | r | | |
| *Rhus pyroides* | | | + | r | | | | | | |
| *Zygophyllum uitenhagensis* | | | + | + | + | | | | 2a | |
| *Stipagrostis zeyheri* | | + | + | + | | | | | | + |
| DIFFERENTIAL SPECIES OF THE | | | | | | | | | | |
| *Rhus glauca - Euclea natalensis* variation | | | | | | | | | | |
| *Panicum deustum* | | | | | + | 2a | + | | | |
| *Rhus natalensis* | | | | | | r | r | | | |
| *Coccinea quinqueloba* | | | | | | r | r | | | |
| *Rhus glauca* | | | | 3 | | 3 | + | | | |
| DIFFERENTIAL SPECIES OF THE | | | | | | | | | | |
| *Mimusops caffra - Euclea natalensis* variation | | | | | | | | | | |
| *Pterocelastrus tricuspidatus* | | | | | r | | | + | | |
| *Mimusops caffra* | | | | | | | r | 2a | r | 2a |
| *Euclea racemosa* | | | | | | | 2m | 2a | | |
| *Rhus crenata* | | | | | | | | r | 1 | |
| *Ficinia acuminata* | | | | | | | | + | 2a | |
| DIFFERENTIAL SPECIES OF THE | | | | | | | | | | |
| *Olea capensis - Euclea natalensis* community | | | | | | | | | | |
| *Euclea natalensis* | 1 | 3 | 2a | + | 1 | 2a | + | 2b | 2a | 2a |
| *Olea capensis* | 1 | 1 | r | 2a | 1 | | + | + | r | 1 |
| *Carissa bispinosa* | + | + | | + | + | r | + | | | + |
| *Cassine aethiopica* | + | 1 | | + | | | + | + | 1 | + |
| GENERAL AND INFREQUENT SPECIES | | | | | | | | | | |
| *Senecio littoreus* | 1 | + | r | + | r | r | r | | | r |
| *Scutia myrtina* | 2a | | 2b | | 2a | 2b | 1 | | 2b | |
| *Brachylaena discolor* | 2a | | | r | 1 | | | | r | |
| *Rhynchosia caribaea* | + | | r | | + | 1 | + | | r | 1 |
| *Delosperma calycinum* | | r | | + | r | r | r | | | |
| *Maytenus nemorosa* | + | | | r | | | | | | |
| *Zanthoxylum capense* | | | | r | | + | | | | |
| *Allophylus natalensis* | | | | 2a | | | | | | 1 |
| *Dovyalis rotundifolia* | | | | | | | | | | 1 |
| *Capparis sepiaria* | r | | | | | | | | | |
| *Chenopodium botryodes* | | r | | | | | | | | |
| *Sideroxylon inerme* | | r | | | | | | | | |
| *Chironia baccifera* | | | | | | | | | + | |
| *Colpoon compressum* | | | | | | | | | + | |
| *Maytenus procumbens* | | | | | | | | + | | |
| *Liliaceae Burns 15* | | | | | | | | + | | |
| *Imperata cylindrica* | | | | | | | | 2a | | |
| *Chionanthus foveolata* | | | | | | | | + | | |
| *Maytenus heterophylla* | | | | | | | 1 | | | |
| *Grewia occidentalis* | | | r | | | | | | | |
| *Helichrysum cymosum* | | | r | | | | | | | |
| *Ficus burtt-davyi* | | | | 1 | | | | | | |

TABLE 24. PHYTOSOSIOLOGICAL TABLE OF THE POST FIRE *Olea capensis - Euclea natalensis* COPPICE COMMUNITY AT QUEENSBERRY BAY.

### 3.5.6 Phytosociology - Phytocoena

The Olea capensis - Euclea natalensis coppice community

The major community, consisting of four variations, was named after two of the differential species of the nodum, with Euclea natalensis and Olea capensis having constancy values of 100 and 90 per cent respectively. The two other species included, and regarded as possible diagnostics of the group are Carissa bispinosa and Cassine aethiopica. All of the named species occur in 70 per cent or more of the relevés. It is interesting to note that both important canopy and sub-canopy species are well-represented at this stage of the succession. Euclea natalensis, which is a sub-dominant of the land-facing climax canopy,is rapidly assuming a dominant position once more and Carissa bispinosa, a common sub-canopy species, is also well established. All of the species had coppiced vigorously but Cassine aethiopica and Carissa bispinosa had both been subjected to heavy browsing and had a stunted, bushy appearance compared with the upright multiple stems of the other two species.

The Cassine tetragona - Euclea natalensis variation

This variation has a field of two relevés, with the diagnostic species restricted to the lower of the two strata identified during sampling.

Cassine tetragona, which is a common scrub species of the inland forest fringe, occurs here in a dwarf form and has established itself throughout much of the burnt area. Its ability to send out suckers, which in turn root and sprout with ease, makes it one of the species well adapted to fire and post-fire colonization. Mariscus congestus and the grass Digitaria eriantha have colonised the open areas previously shaded by the forest canopy but with the envisaged development of the secondary canopy and sub-canopies the importance (cover abundance values) of these two species will inevitably diminish. As early seral colonizers, their function lies in their ability to cover the exposed soil rapidly and to bind the soil with their fibrous root systems thereby preventing erosion of the topsoil. Mesembryanthemum aitonis is also a vigorous early colonizer of burnt areas.

The Asparagus suaveolens - Euclea natalensis variation

Asparagus suaveolens ,which has two growth forms, is an interesting component since it traverses and contributes towards both strata. The two growth forms assumed by this species are related to its association with either the grasses of the open ex-canopy areas (for example Stipagrostis zeyheri) or the scaffolding of dead stems and branches of the burnt forest. Where it can obtain support it becomes a scandent, and at the time of the survey it was often found to have grown as tall as the coppice of the major species. Zygophyllum uitenhagensis, which was recorded in the vegetation of the ground layer appears to be transient and together with some of the grass species will probably disappear later in the succession.

The Rhus glauca - Euclea natalensis variation

This variation is characterized by two forest fringe species, Rhus glauca and Rhus natalensis, which have been noted as common in secondary dune scrub. The latter species also occurs in the sub-canopy strata of the climax dune forest. The grass component Panicum deustum, is a vigorous coloniser and it has been noted as a dominant ground layer element in other areas recently subjected to fire. The variation has a field of three releves.

The Mimusops caffra - Euclea natalensis variation

Four out of the five diagnostic species of this variation (Pterocelastrus tricuspidatus, Mimusops caffra, Euclea racemosa and Rhus crenata) all have well developed coppice regrowth and together have a relatively high percentage cover value of between 40 and 50 per cent in the shrub layer of relevés 6, 7 and 8. Associated with this is the low percentage cover of the herb layer of between 14 and 20 per cent. The height of the herb layer in the above three relevés is also relatively low. (20-30cm).

Ficinia acuminata is one of the few species recorded which is also a primary colonizer in the early beach vegetation and scrub of the sea-facing slopes.

General and infrequent species

The remaining species occurring in Table 24 and not included in the above noda of community variations are either too rare to be of interpretable significance in the secondary community or have so wide an ecological amplitude or distribution that they have not been regarded as diagnostic in any way. Senecio littoreus, Scutia myrtina and Rhynchosia caribaea for example all occur in a variety of dune habitats or other unassociated communities.

### 3.5.7 Discussion

One of the aims of this study was to compare the composition of the recovering secondary community with that of the adjacent undamaged forest. The principal woody species of the canopy and sub-canopy strata of the latter are listed in descending order of importance in Table 25 and when comparing this data with the constructed phytosociological table it is apparent that (inter alia) several hierarchial changes have taken place in the community.

Sideroxylon inerme, which was the dominant canopy species and which was relatively common in the sub-canopy stratum as well, has been most seriously affected by the fire and its position in the community has been reduced to the status of rare (See Table 24). Maytenus heterophylla has similarly been adversely affected and although it was noted to have been coppicing from the base of the occasional burnt tree, its status is far from being sub-dominant - as is the case in the unburnt forest. Euclea natalensis on the other hand has reacted extremely well to fire and dense coppice regrowth, which was up to 3 metres in height, was recorded at the base of all the burnt parent trees. The post-fire community is dominated by this species and it is likely that it will retain its position, having originally only had

| CANOPY SPECIES | IMPORTANCE VALUE (%) | SUB-CANOPY SPECIES | IMPORTANCE VALUE (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 19 | *Cassine aethiopica* | 18 |
| *Mimusops caffra* | 16 | *Diospyros natalensis* | 9 |
| *Maytenus heterophylla* | 14 | *Maytenus heterophylla* | 9 |
| *Euclea natalensis* | 13 | *Pavetta revoluta* | 9 |
| *Ficus natalensis* | 7 | *Euclea natalensis* | 8 |
| *Euclea racemosa* | 5 | *Carissa bispinosa* | 8 |
| *Allophylus natalensis* | 5 | *Dovyalis rotundifolia* | 7 |
| *Cassine aethiopica* | 4 | *Sideroxylon inerme* | 5 |
| *Brachylaena discolor* | 4 | *Mimusops caffra* | 4 |
| *Schotia latifolia* | 3 | *Canthium obovatum* | 4 |
| *Cordia caffra* | 2 | *Acokanthera oblongifolia* | 4 |
| *Dovyalis rotundifolia* | 2 | *Clausena anisata* | 3 |
| *Zanthoxylum capense* | 2 | *Brachylaena discolor* | 3 |
| *Diospyros natalensis* | 2 | *Ficus natalensis* | 3 |
| *Canthium obovatum* | 2 | *Bull.1* | 3 |
| *Clerodendrum glabrum* | 1 | *Zanthoxylum capense* | 2 |
| | | *Deinbollia oblongifolia* | 2 |
| | | *Olea capensis* | 2 |

TABLE 25. PRINCIPAL WOODY SPECIES OF THE CANOPY AND SUB-CANOPY STRATA OF THE UNBURNT LANDWARD THICKET COMMUNITY AT QUEENSBERRY BAY, NORTH OF THE BULURA RIVER MOUTH.

the status of being a sub-dominant forest member. Species such as Mimusops caffra, Euclea racemosa and Brachylaena discolor all appear to be well established in the secondary community and in time should achieve their previous positions in the forest population. Certain other species such as Clerodendrum glabrum, Cordia caffra and Canthium obovatum which had low original densities in the undamaged forest were not recorded at all during the survey.

The recovery of some of the typical sub-canopy species after the fire is interesting, particularly since this has occurred without the presence of a canopy. Carissa bispinosa and Cassine aethiopica which both hold significant positions in the unburnt forest sub-canopy have recovered well and are presently competing with the canopy species. It is presumed however that with time they will become overtopped and revert back to or remain in the sub-canopy stratum. Olea capensis has reacted very positively to the fire and from a previously insignificant position in the sub-canopy it now contributes considerably towards the community. The abundance of creepers and lianes which have used the dead trees for support, have in a sense created an artificial canopy producing a certain amount of shade and it is possible that this has assisted the simultaneous development of both canopy and sub-canopy elements.

With the removal of the canopy by the fire and a subsequent increase in light penetration, a herb layer has become established on the site with a mean cover value of approximately 30 per cent. This is considerably higher than the 16 per cent recorded in the unburnt forest but will probably decrease as the thicket or forest becomes more closed. (In fact, the relevés having the greatest cover values for the shrub layer also recorded the lowest herb layer values due probably to the effects of shading). (See Table 24). As discussed earlier, several of the species recorded in the herb layer are atypical of the developed forest floor and should in due course be replaced by various successor suites more adapted to shade conditions.

# CHAPTER 4

# PHENOLOGY

## 4.1 INTRODUCTION

Phenology is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces and the interrelation among phases of the same or different species (Lieth, 1974).

From the above it is apparent that it is a study which can be extremely complex and from which any hypotheses made, should possibly be regarded as speculative only unless perhaps the study has been carried out in 'greenhouse conditions'. Even in the latter case community interaction including the role and periodicity of pollinators and dispersers would necessarily be excluded. Nevertheless any phenological data collected and assessed does contribute somewhat towards the total understanding of community dynamics and it was with this intent that this brief study was carried out on certain components of the dune vegetation.

A knowledge of plant behaviour with respect to growing seasons and flowering and fruiting phenophases does also have practical management applications. Within the Eastern Cape Forest Region a considerable amount of work has been and is still being carried out on driftsand reclamation. With the current use of indigenous species for stabilizing the dunes, information has been gathered over a period of time on the seasonality and availability of seed from various species for harvesting and later use. Tinley (1985) considers it essential to have a record of the growing seasons, which, in combination with climatic information, can be used to plan planting or sowing operations.

Evolution and theories such as that of the 'old climate' (Pierce, 1984) are important aspects of phenology and have been used to explain various plant phenomena. Sideroxylon inerme and Pterocelastrus tricuspidatus for example, are two important dune thicket species of sub-tropical origin which were able to penetrate into the Cape Region during the Holocene and survive and flourish with low summer rainfalls due to their wide phenological limits (Cowling, 1983).

Levyns (1956, 1964) has described the anomalous behaviour of some of the south western Cape fynbos species such as Metalasia muricata, which exhibit an 'out-of-phase' summer growth, during periods of low rainfall and intimated that these species might have originated from the summer rainfall region. M. muricata is, at present, of relatively low importance in the latter region and the above hypothesis is therefore not necessarily correct. Biogeographical aspects and phenology are however closely linked, since it is often the flexibility of a species' phenorhythms which has enabled it to penetrate less favourable climatic regions along its migration route.

Various models have been proposed in order to predict or explain community phenorhythms but none appear to have been sufficiently holistic in their construction to be adequately reliable. Most tend to correlate phenophase activity with resource use and exclude the likely role that endogenous rhythms might play. The model of Specht (Specht et al.,1981,1983) which assumes that ecophysiological factors such as water and nutrient availability are of overriding importance in determining phenophases has been tested recently. Pierce and Cowling (1984a and 1984b) found that although it proved reliable for certain components of the south-eastern Cape fynbos communities, it did not accurately predict the vegetation behaviour on the calcium-rich dune soils. A similar model is that of Kummerow (1983) in which soil moisture and temperature or warming hours are regarded as probable determinants of phenophases and it assumes inter alia, that growth is concurrent with nutrient uptake. It can be seen that it could contradict the dry season summer growth of several species occurring in fynbos communities and it also excludes the possibility of delayed relocation of stored metabolites (Groves, 1965). Another model which has been found to conveniently fit many situations, is that of Morrow and Mooney (1974) which assumes that in many cases the vegetation adopts a "generalist strategy" of opportunistic growth whenever the combination of soil moisture, temperature and photoperiod is suitable.

## 4.2 THE STUDY AREA

The area for which data was collected corresponded to that of the major vegetation survey and included most of the dune forest units between Kei Mouth and Kidds Beach. The vegetation, which was described earlier, consists of typical strand elements and thicket or forest interspersed with scrub-thicket. Species from three major phytochoria, Cape, Tongaland-Pondoland and Afromontane, are represented and together form the cosmopolitan dune communities typical of the East London Coast. In this study recordings were limited only to the beach and dune zones and exluded phenophase information of species or individuals established on adjoining shale and sandstone derived soil suites. The soil characteristics were thus typical of coastal dunes for the region, with varying but generally high calcium contents, high pH values and varying but generally low organic contents. (See Ch. 2).

The rainfall pattern for the area is bimodal with the two peaks occurring in March and October (autumn and spring), and the winter months June and July receiving the least rainfall. The hottest months are January and February and the coolest weather is recorded during June and July. Late summer and early autumn are the least windy months in terms of velocity, with late winter and the spring months being the windiest period of the year. Further details of the climate and the moderating effect the coast has on it are discussed in Ch. 2.

A short-term summary of the rainfall and sunshine hours recorded for the area over the duration of the study was also made.

## 4.3 METHODS

Qualitative monthly assessments, with obvious subjective weaknesses, were made over a period of approximately three years throughout the study area. The project started in July 1982 and was completed in March 1985. Any species observed to be flowering or fruiting was noted and a distinction made between whether the fruit was ripe or unripe. Shoot growth and leaf development was not studied although the timing of leaf fall of Cordia caffra and Erythrina caffra, which are one of the few deciduous dune species was noted.

Only general patterns among the various species were recorded and isolated individuals which may have been observed flowering or fruiting were therefore ignored. The method posed few problems amongst the dominant or relatively common species but where rare species were involved, the later interpretation of the results was difficult. Psychotria capensis for example, which is not a very common species, was observed in fruit on only one occasion throughout the study period. This did not necessarily mean that it did not flower or fruit subsequently but due to its infrequency , it did not appear again in later reports.

In order to assist with the interpretation of the data, it was decided to differentiate between the common and rare species. A species was only regarded as common if it appeared to be a dominant or sub-dominant member of the community and if its phenophases were recorded during all three successive years. The definition of a rare or less frequent species included whether few phenophase recordings were made for it during the period. Information collected on the latter 'rare' species is given in Appendix II, which should not be regarded as complete but which can be used if necessary to supplement any future recordings for the species contained in it.

The so-called common species were categorized into Thicket or Forest individuals, Scrub Thicket species and Strand species. (See Table 26). The first group contained seventeen species and the other two six each. Bar graphs were then constructed for each group which expressed as a percentage of the total number of species, the species flowering or fruiting during each month. For this purpose the information collected over the entire study period was combined to give a monthly pattern. No differentiation was made between ripe or unripe fruit.

The results were then studied for any phenological patterns and an attempt was made to correlate the data with climatic variables such as rainfall and sunshine hours. Phenodiagrams were constructed for certain selected species and any evident patterns were discussed in terms of the effect which drought may have had on flowering or fruiting reaction.

## 4.4 RESULTS AND DISCUSSION

During the course of the study it was noted that a large degree of variety in phenophase activity exists between the various dune species and between individuals of the same species. Liversidge (1972) reported a similar situation for the Cape Recife area, where certain

| DUNE FOREST/THICKET SPECIES. | SCRUB-THICKET SPECIES |
| --- | --- |
| *Euclea racemosa* | *Olea exasperata* |
| *Cassine aethiopica* | *Colpoon compressum* |
| *Pavetta revoluta* | *Rhus natalensis* |
| *Sideroxylon inerme* | *Scutia myrtina* |
| *Allophylus natalensis* | *Rhus crenata* |
| *Mimusops caffra* | *Rhus glauca* |
| *Euclea natalensis* | |
| *Brachylaena discolor* | |
| *Tarchonanthus camphoratus* | |
| *Hippobromus pauciflorus* | STRAND SPECIES |
| *Cordia caffra* | |
| *Maytenus heterophylla* | *Chrysanthemoides monilifera* |
| *Zanthoxylum capense* | *Metalasia muricata* |
| *Olea capensis* | *Ipomoea brasiliensis* |
| *Scotia afra* | *Scaevola thunbergii* |
| *Erythrina caffra* | *Passerina rigida* |
| *Schotia latifolia* | *Stoebe plumosa* |

TABLE 26. CLASSIFICATION OF SPECIES INTO DUNE COMMUNITIES.

subtropical thicket species had regular annual cycles and others irregular intervals between flowering and fruiting. Examples of species bearing flowers or fruits for extended periods of time were also recorded. In the case of Chrysanthemoides monilifera, an almost constant level of flowering was noted throughout the year apart from a slight reduction during the spring months and an increase during late autumn and early winter. Another example is Mimusops caffra which bore ripe and unripe fruit continuously for a twelve month period during 1984/85, unlike the previous year when there was a distinct seasonality to its phenophases.

At any time of the year however, there are always some species which are either in flower or fruit and this must be mutually beneficial for both the recruitment of the various species (including reduced seed predation/destruction) and spreading or staggering competition between the pollinators and dispersers as well (Stiles, 1977; Janzen, 1969, 1970). Most of the species are dispersed by frugivorous birds which, although they do have preferences for certain species such as Maytenus procumbens and C. monilifera, will feed off other species at various times of the year (Liversidge,1972).

The dune vegetation is for the most part evergreen and only two species, Erythrina caffra and Cordia caffra can be classed as deciduous. E. caffra loses its leaves during winter and produces new foliage in spring, at the same time as Cordia caffra, which starts shedding its leaves much earlier in autumn (February). A species such as Mimusops caffra is also capable of withstanding unseasonal defoliation and produces a flush of new leaves in spring, after infestations of Zitha carnicolor caterpillars strip the trees of their leaves in late summer and autumn

The various recordings made for seventy different dune species are given in Appendix II and, as will be seen, several of these are comprised of relatively few observations. The behaviour of the important or frequent species is discussed below.

The Forest component (See Fig. 19).

The species comprising this group appear to exhibit an equinoctial bimodal pattern of flowering and fruiting. The number of flowering species increased from a low point in winter (May) to a peak in early spring (August). The pattern then showed a decreasing trend until early summer (November) when less than twenty five percent of the species were in flower. Flowering then increased to peak once more during early autumn (February) whereafter it decreased to the low winter level. The behaviour of the species with regard to fruiting showed a similar but slightly retarded pattern on the whole. Fewest species bore fruit during late autumn (April), with the percentage steadily increasing until late spring (October) when almost ninety percent of the species bore fruit. The tendency decreased towards late summer (January) when fruiting was least noticeable, after which a second but smaller peak occurred during mid-autumn (March). Tinley (1985) found much the same flowering and fruiting pattern during his observations of the Eastern Cape dune thicket and forest species.

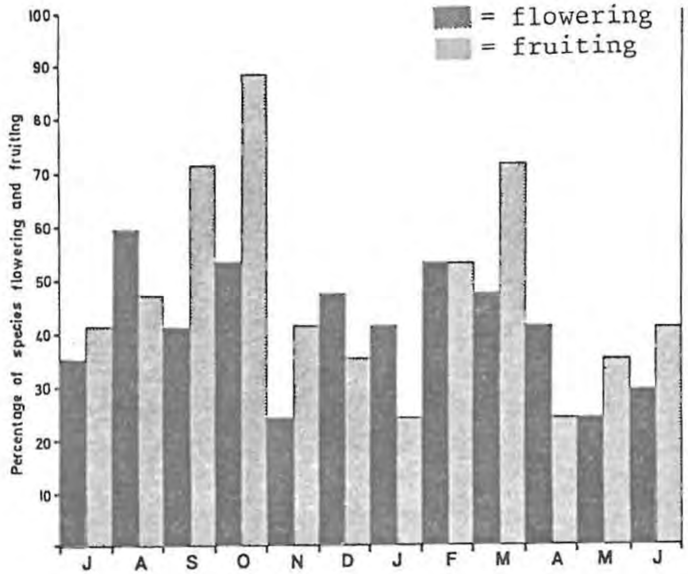



Fig. 19. Annual Phenophase response of the Dune Forest component.

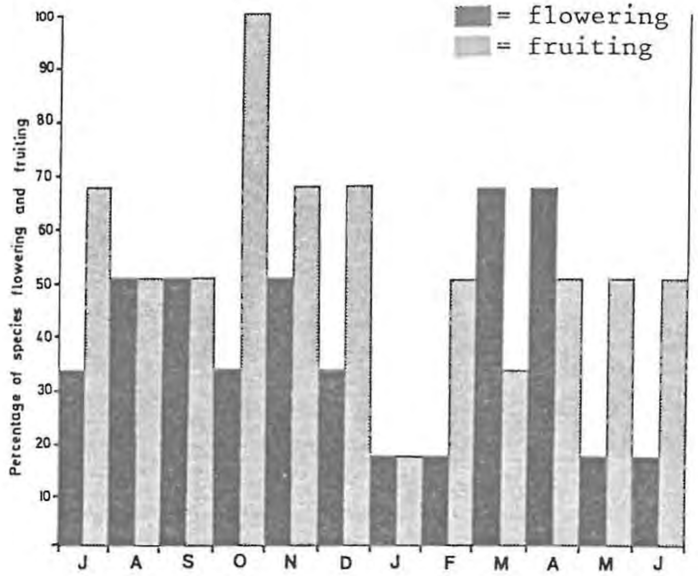



Fig. 20. Annual phenophase response of the dune Scrub Thicket component.

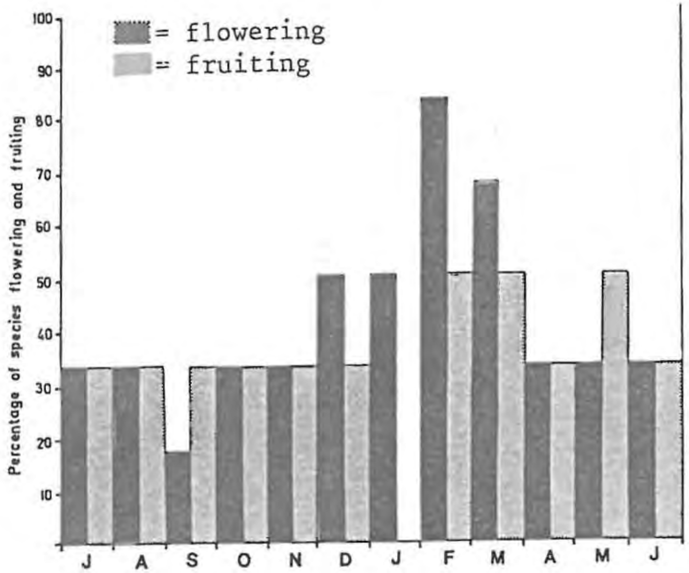



Fig. 21. Annual phenophase response of the Strand component.

The Scrub Thicket component (See Fig. 20).

The flowering and fruiting phenophases were not as well defined as in the case of the Forest species. Flowering activity was reasonably high (fifty per cent) during spring and early summer (August to November) but decreased to a low point in late summer and early autumn (January and February). A peak occurred later in autumn (March and April) when four of the six species were in flower. Immediately after this, during winter (May and June), flowering decreased to the second low level recorded for the year. During ten months of the year fifty per cent or more of the species bore fruit, with only a single peak and low point evident in the pattern. All species were observed fruiting during late spring (October), with the number decreasing until late summer (January) when only Scutia myrtina was recorded.

The Strand component (See Fig. 21).

The Strand species exhibited an interesting behaviour, with an almost constant level of fruiting and flowering activity for eight months of the year and a single developed peak in the pattern during autumn and summer. From winter through to early summer (May to November) more or less one-third of the species were in flower, after which the number of species increased to five during late summer and early autumn (December to February). The fruiting peak only developed during autumn (February and March) when fifty per cent of the species bore fruit. A second less developed peak occurred during early winter (May) before the pattern returned to the earlier level of two of the six species bearing fruit for the remainder of the year.

The fruiting behaviour of the Forest component corresponds well with the long-term annual rainfall pattern, which also peaks in October and March (Table 27). Tinley (1985) considers this equinoctial strategy to be a mechanism which can enable a species to exploit any shift in the rainfall pattern towards either a summer or a winter peak - i.e. a possible migratory adaption or simply a short-term solution to annual rainfall fluctuations. Temperature can also possibly be a limiting factor for fruiting since during the hottest period of the year fruits are least noticeable. Flowering could also be regarded as being indirectly related to rainfall in that it peaks during the appropriate season which ensures that the plants bear fruit at the climatically best possible time of the year.

Rainfall, as a stimulant and temperature, as an inhibitor also appear to play a role in the behaviour of the Scrub Thicket species. The single fruiting peak takes place in October when the highest rainfall of the year is recorded, while low fruiting levels occur during January, the hottest month. A better indicator of favourable fruiting seasons might perhaps be the soil moisture balance which, in well drained dune soils is influenced to a large extent by temperature.

The flowering and fruiting pattern of the Strand component could be interpreted as having several advantages for the species concerned. Flowering for instance occurs during the least windy months, when the risk for plants such as Scaevola plumieri and Ipomoea brasiliensis, becoming inundated with sand is lowest. Also, the abrasive effects of

| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | 77 | 97 | 68 | 55 | 36 | 35 | 44 | 69 | 91 | 86 | 77 | 808 |

TABLE 27. LONGTERM RAINFALL PATTERN FOR EAST LONDON. (data from published Weather Bureau statistics)

windblown sand on the flowers would be considerably reduced over this period. Fruiting, as with the other two vegetation components, peaks during the months with high rainfall which could have particular significance for the soil moisture balance of the young undeveloped beach soils. The high tides of the March equinox could also play a role in dispersing the fruits of some of the strand species (e.g. S. plumieri). The second fruiting peak in May occurs under windy conditions when wind-dispersed species such as Metalasia muricata and Stoebe plumosa would benefit greatly.

The results obtained in the study and the trend described for much the same area by Tinley (1985) corresponds closely to the flowering and fruiting patterns described by Liversidge (1972) for Cape Recife and Pierce and Cowling (1984a) for Cape St. Francis. Although the rainfall of the latter two areas is quite different in its seasonal distribution to the East London coast, the active reproductive phases coincide with periods when the soil moisture balance would tend to be positively inclined (i.e. due to the moderate temperatures and reasonably moist conditions of autumn and spring). The fact that the reproductive peaks in these areas do not necessarily match the rainfall peak would seem to imply that it is probable that soil moisture might be a major determining factor rather than high rainfall alone. Along the East London coast favourable (moderate) temperatures and the two rainfall peaks coincide and the resultant effect on the soil moisture balance would thus create favourable conditions for the reproductive phenophases. The model of Kummerow (1983), which is based upon soil moisture and photoperiodism appears to fit in well with the local reproductive patterns (or *vice versa*). If the long-term record of monthly sunshine hours is studied and the periodic accumulation thereof is considered, two annual peaks and low points are evident (Table 28). The greatest amount of sunshine accumulated over a three month period is in August, with a second less significant peak in January. Low accumulated levels are recorded for November, April and May. This closely matches the flowering pattern of the Forest species and also to a lesser extent that of the Scrub Thicket. From the flowering behaviour of the Strand vegetation, it would seem that this component also exploits the smaller January sunshine peak. Thus it would appear that sunshine hours might be a major stimulus for flowering initiation whilst soil moisture could play a greater role in fruit development.

During 1982/83 the study area experienced one of the worst droughts in living memory, with the recorded rainfall of 425mm being only slightly greater than half of the long-term annual mean (Table 29). Although not quantitatively studied, this resulted in considerable mortality amongst the various species (particularly the exotic, *Acacia cyclops*) or alternatively induced heavy leaf fall in species such as *Ficus natalensis* which are generally only semi-deciduous. The drought also appears to have had considerable influence on the flowering and fruiting behaviour of the dune communities and the rains which brought relief during the latter part of 1983 and early 1984 induced various phenophase reactions amongst the species. The phenodiagrams of seven

| J | A | S | O | N | D | J | F | M | A | M | J |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 705* | 715* | 703* | 672 | 664+ | 668 | 693* | 677 | 668 | 648+ | 662 | 67[illegible] |

* = Months with high accumulation.
+ = Months with low accumulation.

TABLE 28. SUMMARY OF SUNSHINE HOURS RECORDED FOR THREE MONTH PERIODS PRIOR TO AND INCLUSIVE OF MONTH INDICATED. (Data obtained from Climate Statistics for East London, Dept. of Transport.)

| J | A | S | O | N | D | J | F | M | A | M | J | TOT(mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | | | | | | 1982 | | | | | | |
| 4,1 | 100,3 | 24,1 | 52,2 | 56,4 | 40,4 | 26,5 | 41,1 | 66,8 | 172,9 | 6,1 | 37,6 | 628,5 |
| 1982 | | | | | | 1983 | | | | | | |
| 73,0 | 8,9 | 51,5 | 111,6 | 12,8 | 24,1 | 15,8 | 48,8 | 18,4 | 28,0 | 11,3 | 20,5 | 424,7 |
| 1983 | | | | | | 1984 | | | | | | |
| 201,9 | 8,4 | 80,5 | 107,0 | 103,1 | 70,1 | 46,8 | 17,2 | 70,6 | 61,8 | 31,4 | 135,8 | 934,6 |
| 1984 | | | | | | 1985 | | | | | | |
| 81,8 | 20,0 | 51,6 | 75,0 | 63,9 | 28,9 | 110,2 | 131,4 | - | - | - | - | - |

TABLE 29. SHORT TERM RAINFALL RECORD FOR EAST LONDON (Data obtained from Met. Office, D. F. MALAN AIRPORT.)

common species are shown in Fig. 22 to illustrate the observed behaviour.

Cordia caffra for example flowered for only two months in the relatively dry period of August/September 1982 and completed its fruiting by November. Either in reaction to the rains of October that year, or as a survival bid against the prevailing drought, unseasonal flowering was induced during February, only two months later. The fruiting period was yet again very short (two months) and probably not very successful. Thereafter, the usual time of flowering was retarded until after the drought was broken and heavy blooms were recorded from September to December. Fruiting was also far more successful than the previous two crops and continued for five months whilst exploiting the favourable soil moisture. With the return once more to the normal rainfall pattern, lengthy and seasonal flowering and fruiting occurred from July 1984 through to January of 1985.

Allophylus natalensis reacted slightly differently to the drought in that the normal reproductive phases did not appear to be delayed at all. After the good rains however, the following flowering season was induced earlier, during December 1983, and fruiting was only completed ten months later in September 1984. After very favourable conditions flowering began once more during February 1985 and indications are that the species has returned to its usual reproductive cycle as far as season is concerned.

During the drought Mimusops caffra flowered at much the same time of the year as usual (January), whilst the previous season's crop of

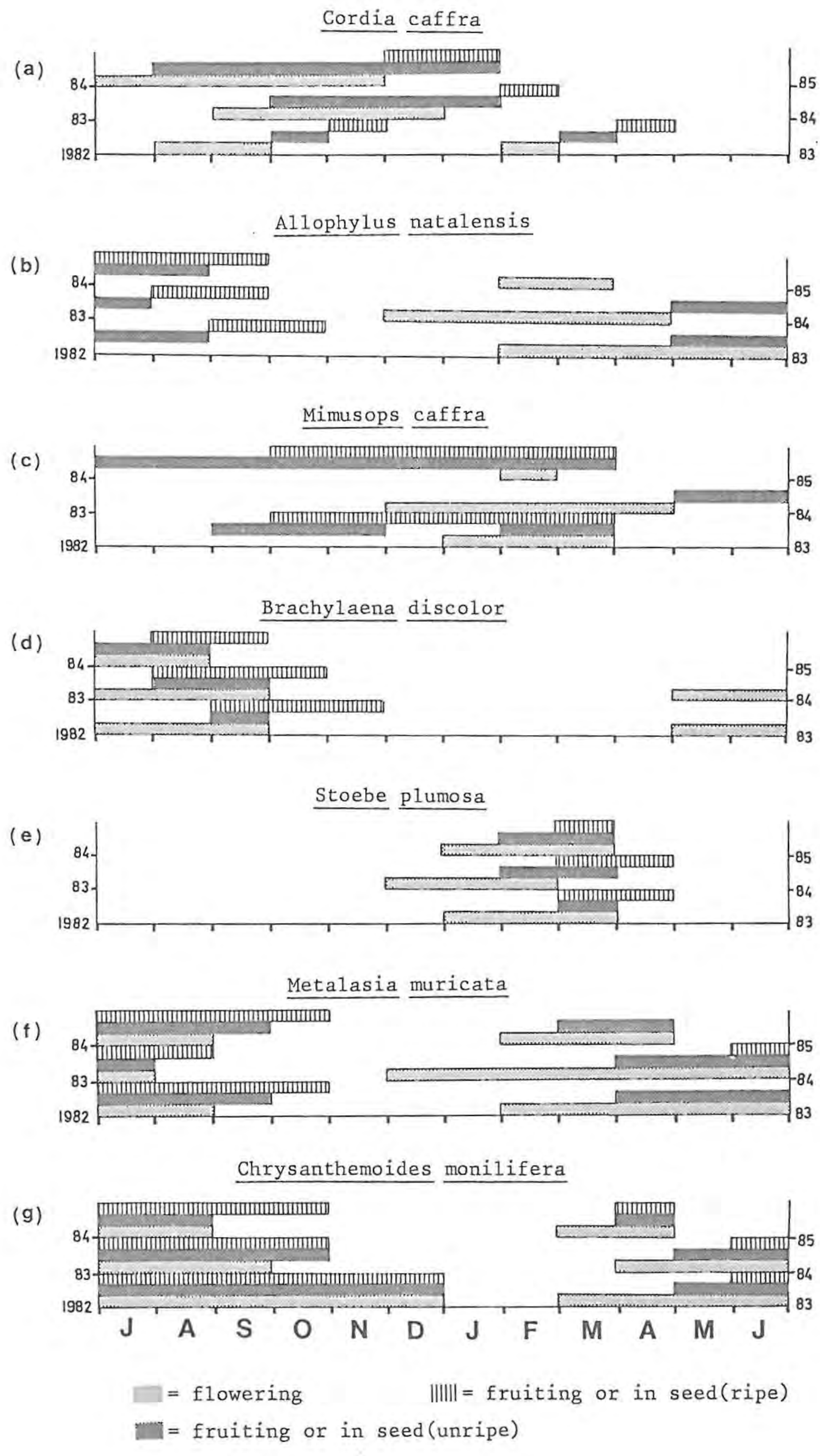



Fig. 22. Phenodiagrams of seven dune species exibiting various reactions to drought conditions.

fruit still remained on the trees. The new fruits produced subsequently could apparently not be sustained by the low rainfall and lasted for only two months before falling. Flowering was initiated once again in December 1983 after the good rains and continued for a much longer period than normal until fruit set in May of 1984. The abundance of fruits, which lasted on the trees for twelve months, was remarkable and many of the overburdened trees suffered damage in the form of broken limbs. The 1985 flowering season began in February and the reduced intensity which was observed probably again follows the return to 'normal' climatic conditions. The above survival mechanism of this species in reaction to drought must be a major reason for its dominance in the easily drought-stressed dune environment.

The flowering cycle of Brachylaena discolor did not appear to be influenced at all by the drought and started flowering in May 1983 at its usual time of the year. Fruiting took slightly longer to set, possibly due to low rainfall, but after the heavy July rains seed was ready for dispersal before the end of August. With the return to the normal rainfall pattern, flowering started once again in May 1984.

Stoebe plumosa and Metalasia muricata reacted similarly towards the drought, or rather towards the termination of dry conditions. In the case of the former species, flowering was advanced by one month and with M. muricata by two months after the good rains during the winter and spring of 1983. For some unknown reason, seed was set slightly later than usual even after the relief of the rains. Both of these species are characteristic of the well-drained early succcessional dune soils and with the development of extensive root systems their ability to efficiently exploit reduced soil moisture makes them possibly less dependent on high rainfall to be able to fruit.

Chrysanthemoides monilifera was noted to bear flowers continuously throughout the year apart from a noticeable drop in abundance during the spring and summer months, which is indicated on the phenodiagram (Fig. 22). The rainy period during 1983 stimulated flowering much earlier than usual and in December of that year an unseasonal midsummer bloom occurred which continued until the start of spring in 1984. Thereafter the pattern returned to normal. Fruiting was not significantly affected by the rainfall fluctuations.

From the above it can be seen that no general pattern existed amongst the dune species in their response to drought. Some species such as C. monilifera and M. muricata appeared to be relatively unaffected by it, whilst Cordia caffra was stimulated to produce a totally unseasonal crop of flowers and fruits. What was apparent, and this was also reported by Tinley (1985), was that the post drought rains initiated an almost immediate phenophase response which, for several species, differed from their normal cycles. This reaction appeared to be only temporary however, and with the return to a favourable rainfall pattern the species adjusted their phenophases back to what can be regarded as normal.

## 4.5 CONCLUSION

From this study, and particularly from the discussed phenophase response after prolonged drought, there is little doubt that the rainfall pattern has a marked influence on the timing of the reproductive phases of the communities studied. Although not necessarily the case on loamy or clayey soils, it is thought that the wet season coincidence of a favourable soil moisture balance and fruit production is particularly significant on the well-drained dune soils. Accumulated sunshine does in all probability also play an important role particularly with respect to the initiation of flowering periods. This was found to be the case in the Forest and Scrub Thicket components and also to a lesser extent in the Strand vegetation. Due to the fact that this variable was not studied in detail it is difficult to draw any definite conclusion. Apart from the favourable equinoctial soil moisture conditions which would seem to create the discussed fruiting peaks, the latter also coincide with exceptionally high tides which could be exploited as a dispersal mechanism by certain species. A great variability in phenophase seasonality of the dune species was observed, with elements being either in flower or fruit throughout the year. This significantly reduces interspecific competition with regard to pollinators and fruit dispersers, which in turn also benefit by this.

Models such as those of Specht et al. (1981, 1983) and Kummerow (1983) could be applicable to the dune communities but would require an in depth evaluation. The model of Morrow and Mooney (1974) which assumes that the vegetation adapts a generalist strategy of opportunistic growth whenever the combination of soil moisture, temperature and photoperiod is suitable would be convenient to test on the dune communities particularly when the spontaneous post-drought response by the various species is considered. Such a study should, however, also include aspects such as nutrient uptake, the relocation of stored metabolites and the role of pollinators and dispersers.

# CHAPTER 5

# THE VEGETATION SURVEY

## 5.1 INTRODUCTION

The study area was well known before conducting the survey, which Werger (1974) considers essential in any vegetation study. Obvious differences in the community structure and composition of the dune forests were noted and preliminary maps of the apparently different forest types were constructed with the aid of monochromatic aerial photographs taken in 1976, colour aerial photographs (Job 326) taken in 1979 and air photography carried out personally.

Although the vegetation of an area should be regarded as forming a continuum rather than a conglomerate of associations (Goodall,1954), it is often essential to impose certain explicit restrictions in order to describe or classify it. Excluding the dune areas which support the (successionally) younger shrub and scrub thicket vegetation, as well as the scrub communities which are characteristic of the dune crests, three types of forest or thicket could be differentiated in most of the units studied, on the basis of obvious physiognomic differences. These were the climax forest of the deeper and more sheltered dune valleys and the thicket communities of the land-and sea-facing dune slopes. The thicket on the sea-slopes is dense and stunted with a very closed and salt-pruned canopy whilst the valley forest is much taller, has an uneven canopy and is obviously stratified. The shorter thicket on the land-facing slopes also has an uneven canopy but has the appearance of being drier with a more sparse canopy than the above two communities. Moll (1969,1980a,1980b) described a similar situation in certain Natal dune forests where quantitative studies revealed a sub-climax sea-slope community limited by salt-spray, a pre-climax and drier north-facing community and a climax community on the flatter, moist sites.

Whilst the significance of successional processes was not ignored (Poore,1956) it was decided to concentrate the study on the above three physiognomic classes and to describe them by means of restricted sampling (sufficiently randomized), with the assumption that they were in a momentarily static state. The fairly subjective visual classification of the vegetation was supported by a quantitive ordination and classification of the sample data.

The vegetation survey which was carried out included basically only the woody tree species and cannot therefore be regarded as a description of the total floristic composition of the areas (See Appendix I). The sampling method chosen was also one which was unlikely to illustrate the significance of the less prominent species and the emphasis was placed on identifying the upper hierarchy of species dominance in each of the selected forest units.

Secondary thicket communities, such as those affected by fire were mapped separately but were not included in the survey (See Ch. 3.5).

## 5.2 Sampling procedure

The aim of any basic survey is to determine what species are present, in what quantities and how they are distributed (Boorman,1977). In order to achieve this, various sampling techniques were first evaluated before deciding upon a suitable method. The extent of the study area and the linear nature of the dune forest cordon also had to be considered. Several researchers such as Donnelly and Pammenter (1983), Lubke (1983) and Tinley (1985) have made used of belt transects across dune profiles to identify and describe the plant communities occupying them. Others have employed the Braun-Blanquet approach combined with the use of randomly distributed quadrats of various sizes to sample and quantitatively classify dune vegetation (Weisser, 1978; Moll, 1969, 1980a, 1980b). Various distance methods - such as the recording of data from Random Pairs (Breen, 1971) - have also been used and it is felt that plotless sampling can in fact have certain advantages over fixed area plots. The most obvious one is efficiency in terms of results obtained per man-hour expended. (While the demarcation and measurement of plots in inaccessible thicket can be fairly time-consuming, the establishment of a series of points, such as with the point-centred quarter method, is not).

Of the distance methods, the quarter method is considered to give the least variable results for distance determination, provides more data on tree species per sampling point and is least susceptible to subjective bias (Cottam and Curtis, 1956). Tinley (pers. comm) advocates the use of this sampling technique for obtaining acceptably reliable and rapid results, particularly where an extensive area has to be covered. The technique, which is described by Cottam, Curtis and Hale (1953), Cottam and Curtis (1956), Curtis (1959) and Curtis and Cottam (1964), has been well tested in forests of low species diversity but has not really been critically evaluated for South African conditions. It has been used with success to collect data in dune vegetation studies in Zululand by Breytenbach (1976) and Venter (1972, 1974), and in the Transvaal bushveld by Louw (1970). Rogers and Moll (1975) and McDevette (pers. comm.) consider it unsuitable however where wide species diversities occur over short distances. With the low species diversity and homogeneity of the East London Coast forest, this was not considered to be a problem and it was therefore decided to use the method.

The woody component of the forest was sub-divided vertically into two synusiae:

Canopy - defined as those individuals having their crowns exposed to full sunlight.

Sub-canopy - defined as all individuals 1.5 m in height or taller but not presently contributing to the canopy.

In general, the sub-canopy tree layer is rather ill-defined, particularly on the sea-slopes, but it becomes more apparent landwards where a degree of stratification (and even emergence) is evident

(Moll, 1972; Weisser and Cooper, in preparation). Intermediate strata are most noticeable in the climax vegetation and could be significant in a structural analysis of the forests. For the purposes of the survey, only the above differentiation was made and this provided a basis for some degree of structural comparison.

The shrubs and herb layer of the forest floor were not included in the survey to any great extent, but together were only given a percentage cover rating at the various sample points.

Within each forest unit, surveys were carried out at 15, 30 and 45 points depending on the number of physiognomic classes represented. Curves representing species vs. number of points were constructed to control the sampling intensity which, with the low species diversity, was confirmed to be adequate (See Fig. 23).

The survey lines were not compass-orientated, but followed the dune contours at approximately 5 m altitude intervals. This was done in order to accommodate any slight variations in the vegetation (particularly structural ones) up or down the dune slopes. Three lines, with 5 points per line, were therefore used to survey the thicket of the sea-and land-slopes and single lines, located in the bottom of the dune valleys were used in the case of climax forest. All points were accurately located along the survey at pre-set distances which were varied between 10, 20 and 30 m in order to reduce subjective bias (Cottam & Curtis, 1956) and to introduce some randomization into the procedure.

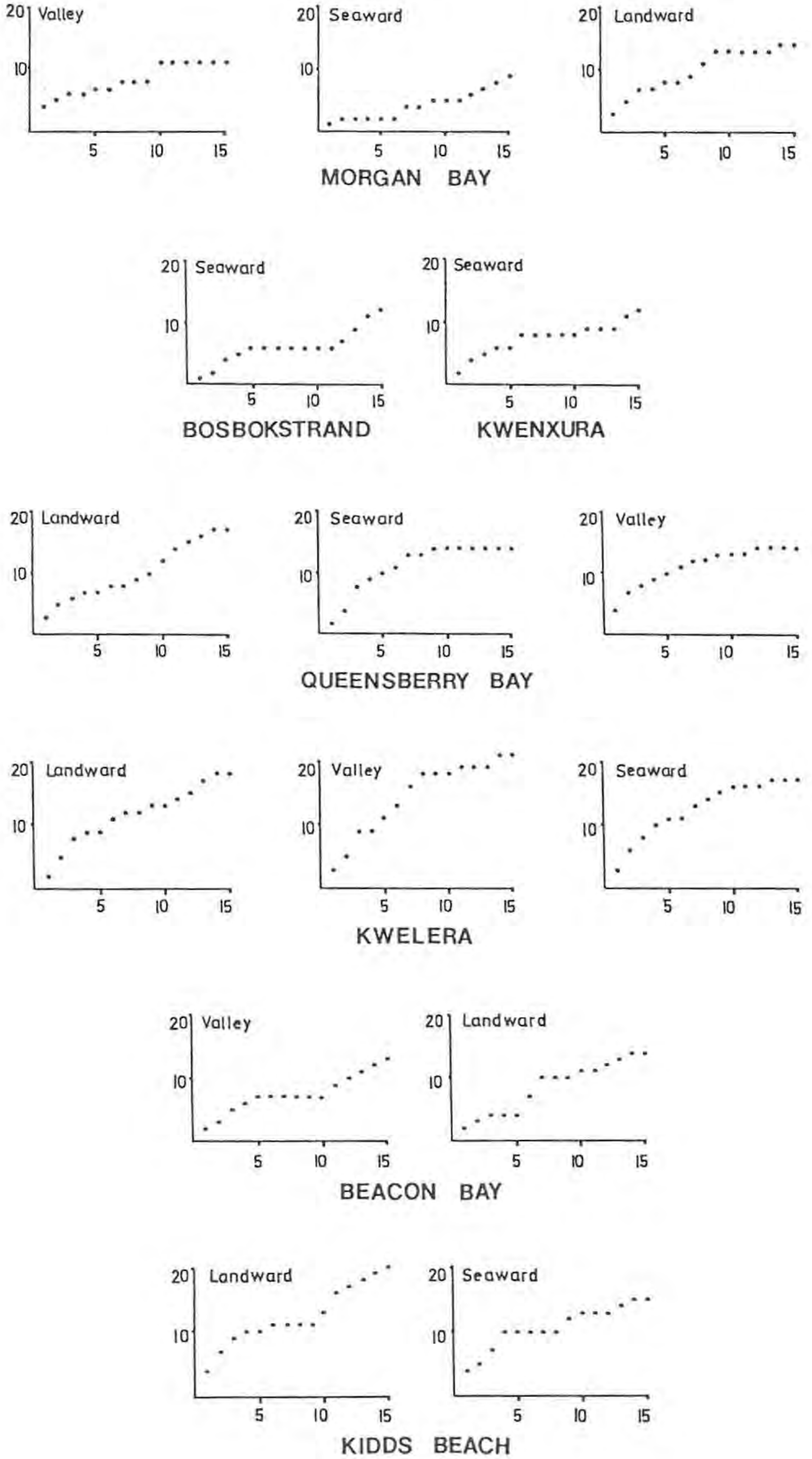



Fig. 23. Curves of the number of species recorded (y-axis) versus the number of points sampled (x-axis) within the communities of each of the seven forest units studied. (Adequacy of sampling intensity is illustrated by the decreasing curve slopes.)

The area around each point was divided into quadrants using the contour traverse as the axis and a 1 x 1 m square plot was marked out in the fourth quadrant (Fig. 24). The following information was recorded at each site:

(i) The species name of the closest individual to the point in each quadrant for both synusiae.

(ii) The distance in metres from the point to each of the eight individuals.

(iii) The diameter breast height (Dbh) in centimetres of the recorded trees (-taken at approximately 130 cm above ground level).

(iv) The tree heights in metres.

(v) The percentage cover of the combined shrub and herb layer within the 1 $m^2$ plot.

Use was made of a 3 m ranging rod to measure all distances as well as tree heights where possible. The heights of tall individuals were obtained by means of a Suunto hypsometer and a diameter tape was used to measure the stem diameters.

Tables listing all recorded species were drawn up for both synusiae in the physiognomic classes sampled for each forest unit. The following characteristics were then determined for the various species:

(i) <u>Relative Frequency</u> (F), which is the number of times a species is present, expressed as a percentage of the number of times that the total number of species are present.

(ii) Relative Density (D), which is the number of individuals of a species present, expressed as a percentage of the total number of individuals of all species present.

(iii) Relative Dominance (Do, for basal area), which is the total basal area of a species, expressed as a percentage of the total basal area of all the species. Basal areas were determined using the Dbh. values.

(iv) Relative Dominance (Dh, for heights), which is the sum of all heights recorded for a species, expressed as a percentage of the sum of the heights of all the species.

(v) Importance Value, derived from the above

$$I.V. = (F + D + Do + Dh)\tfrac{1}{4}$$

(vi) Density (D/ha), using the calculation

$$D/ha = 10000 \times D \times (\text{Mean tree distance})^{-2}$$

(vii) Basal Area (BA/ha).

$$B.A./ha = \text{Mean B.A. for species} \times D/ha$$

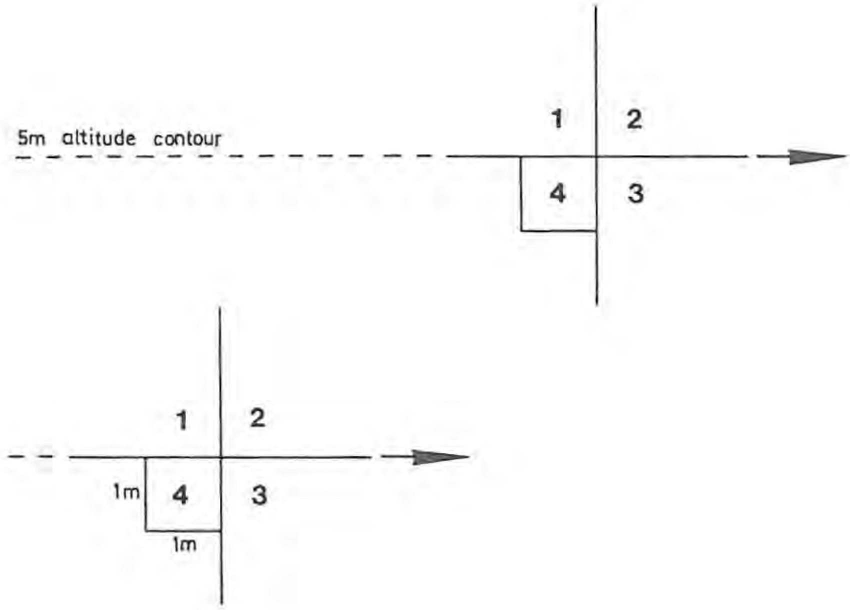



Fig. 24.
Orientation of sample quarter points. (1 - 4 represent the four quadrants and the arrow indicates the traverse axis.)

The mean heights of the canopy and sub-canopy strata were also determined for each community.

## 5.3 MULTIVARIATE ANALYSIS OF THE SAMPLE DATA

### 5.3.1 Introduction

Multivariate analysis is a technique which involves the arrangement of multivariate sets of data (such as stands comprised of species with various abundance or importance values) in order to create a degree of structure to them (Gauch, 1982). This then allows for the detection and appreciation of small differences within such data sets (Greig-Smith, 1964) and also provides a relatively objective and easy summarization of the data which facilitates the comprehension and communication thereof (Gauch, 1982). It is also regarded as a tool for generating hypotheses rather than for testing them (Gauch, 1982) and permits speculation as to why associations such as communities exist. Direct gradient analysis (which was not specifically used in this study) is often used subsequent to the initial multivariate analysis in order to link the behaviour of the vegetation to various complex environmental gradients (Kessell, 1979).

Although the ranking of species according to their levels of importance does provide a good degree of insight into the composition of the vegetation under study, the basis upon which the importance values are calculated can however be fairly subjective. In the procedures described above for example, it has been assumed at the outset that the various dune aspects support communities which differ from one another, when they might in fact be quite similar in composition. In studies of dune vegetation, where the processes of succession and adaptation are relatively distinct, the latter assumption is perhaps not too bold but would best be supported by quantitative analysis.

It was therefore decided to carry out such an analysis in order to confirm where possible the community descriptions derived from the tables of importance values and to obtain a more clear picture of the species distribution both within the various forest units as well as along the coast. Similar studies have been carried out on dune communities in Natal and Zululand by Moll (1969, 1980a, 1980b) and Venter (1972) and in other vegetation types in South Africa by (inter alia) Woods and Moll (1967) and Morris (1969).

### 5.3.2 Analysis techniques employed

Two complementary techniques, classification and ordination, were used in the study. Although both are concerned with data summarization and trend seeking (Orlóci, 1978; Gauch, 1982), the presentation of the completed analysis differs in that the former arranges the samples into discontinuous classes while the latter arranges them in the form of a continuity.

Ordination has been well described by Goodall (1954), Morris (1969), Whittaker (1967, 1973, 1978), Austin (1976) and Gauch (1982). It can be defined however, as the uni- or multi-dimensional arrangement of sample stands about abstract axes (which may correspond to one or more environmental gradients) representing an environment-induced major direction of community change. The objective of an ordination is to arrange species or sampled stands of vegetation so that similar entities are located close to one another and dissimilar entities far apart.

Of the various ordination techniques which can be employed for analyzing community data, Detrended Correspondence Analysis (DCA or DECORANA) is considered to be the most successful (Gauch, 1982). DCA results are at least as good as, and usually superior to, other ordination techniques and are best where difficult data sets involving more than one community gradient are involved (Hill and Gauch, 1980). Two major advantages of DCA are that it corrects faults such as arch distortion and compression of the first axis ends (which affect most other ordination techniques) and that it ordinates species and samples simultaneously (Gauch, 1982). The DECORANA computer program, written by Hill (1979a), was used for the study ordinations.

Gauch (1982) considers classification as a means by which differences in community composition, which are related to differences in environment and history, can be expressed. It is basically the assignment of entities into classes or groups (clusters), which produces a synthetic framework for conceptualizing communities (Gauch, 1982). Arbitrary dissections along essentially continuous community variations often have to be made, but the technique does have many practical advantages (Goodall, 1954; Whittaker, 1962, 1978). The approaches towards classification have been broadly discussed by Shimwell (1971), Whittaker (1962), Maarel (1979) and Orlóci (1978).

Of the various general purpose classifications, those which place equal emphasis on all the data (i.e. not only dominants, for example) are considered to be the least subjective. One such approach, is the Two-Way Indicator Species Analysis (TWINSPAN) which is a robust and effective polythetic divisive technique (Hill 1979b; Gauch and Whittaker, 1981). Reciprocal averaging is first used to distinguish species which characterize the axis extremes, whereafter division of the ordination axis at successive noda produces polarized clusters containing a specified small number of samples (Gauch, 1982). The TWINSPAN computer program of Hill (1979b) which was used in this study produces an arranged data matrix (similar to the Braun-Blanquet approach) which serves simultaneously as a hierarchical classification of both the samples and species. These can then be displayed in the form of dendrograms, which are made clearer by the placement of similar samples together along the ordered sample sequence.

The computer used to execute the above programs was the Control Data Mainframe (1.5 Mips) belonging to Rhodes University.

### 5.3.3 Arrangement of data for analysis

The information recorded for the trees surrounding the individual sample points was regarded as comprising a single stand. Importance values were then determined for each of the species contained in the stands as shown below.

$$I.V. = \frac{D + Do + Dh}{3}$$

where:

D = Relative density of the species in the stand.

Do = Relative dominance, with respect to basal area.

Dh = Relative dominance, with respect to height.

The stand data was thus prepared in the format of a two-way individuals-by-importance matrix. The subsequent analyses of the data were first carried out using information pertaining to the canopy and sub-canopy individually and was then followed by a third analysis where the data for both synusiae was combined. In the latter case, individuals of the same species which occurred in both the canopy and sub-canopy were coded differently in order to keep them discrete. This is considered to be necessary due to the different roles played in the community by the species in the two strata (Moll,1968,1980a). It should be noted that the classifications and ordinations were based on the above-mentioned importance values and not on relative density, abundance or cover etc.

## 5.4 The Morgan Bay Dune Forest

### 5.4.1 Site and Forest Description

The Morgan Bay dune forest, which is situated between the townships of Kei Mouth and Morgan Bay, is the most northern of the forest units studied and is also the most sub-tropical in affinity. It is the largest of the dune forest areas and measures approximately 240 ha in size. It is bordered in the south-west by the lagoon of the Incarha River (often referred to as the Morgan River) and the remainder of the forest margin follows more or less the State Forest boundaries. The latter, which also include a small area of grassland, have been used for the compilation of the vegetation map. The forest is approximately 1300 m wide at its broadest point and narrows to about 300 m towards the river. The maximum dune height is 118 m.

The main features of the undulating topography are three fairly distinct dune ridges which are aligned more or less parallel to the coastline. Two of these enclose a fairly broad expanse of sheltered valley forest and are remnant trailing arms of an ancient parabolic dune which has lost much of its original character. The third ridge which has formed through the landward movement of beach-deposited sand is not very well developed inland of the rocky shoreline to the north-east.

The dunes are partially supported by a sandstone base which is visible at low tide and by intrusive dolerite, on which the Cape Morgan lighthouse is sited. A comprehensive soil survey was carried out in the area and the results are discussed in Chapter 2. Although rainfall records for Kei Mouth are incomplete, it would appear that the area receives slightly more precipitation than East London. During the period June 1982 to May 1983, which was an extremely dry year, Kei Mouth received 372 mm of rainfall compared to the 256 mm measured at Cintsa and 428 mm at Cove Rock. A similar long term pattern also exists, with Kei Mouth receiving approximately 1000 mm and East London only 800 mm of rainfall (Published and unpublished records, Weather Bureau). Growing conditions should therefore be considerably more favourable along this northern stretch of coast.

The greatest threat to the conservation of this forest is the mining lease which has been granted to Cape Morgan Titanium Mines (Pty) Limited. As is the practice in Zululand, this type of mining operation involves the removal and complete destruction of all the dune vegetation before the heavy minerals are extracted from the sand (Weisser,1978). Mining began in 1969 when the processing plant was constructed but was stopped 3 years later due to high transport costs. Unfortunately about 35 ha of forest was disturbed during this period and damage from secondary causes, such as the fire which originated from the staff complex in 1976, has resulted to the area (See Plate 12). Steps have however recently been taken by the Directorate to attempt to cancel the lease agreement. Other damage has been caused by at least one known fire which started on the lighthouse site during 1975.

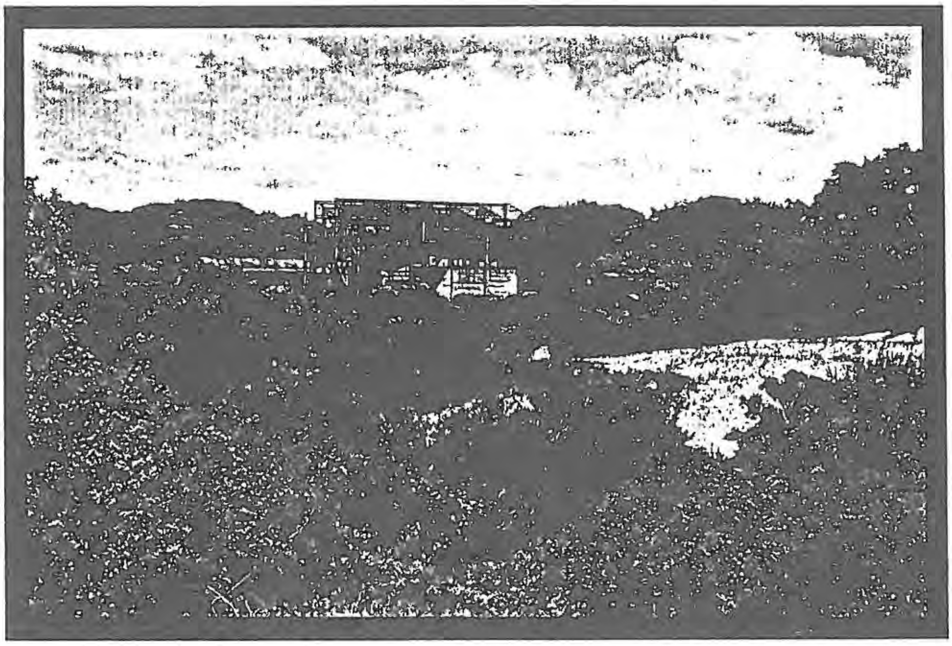


PLATE 12. Abandoned titanium mine near Morgan Bay.

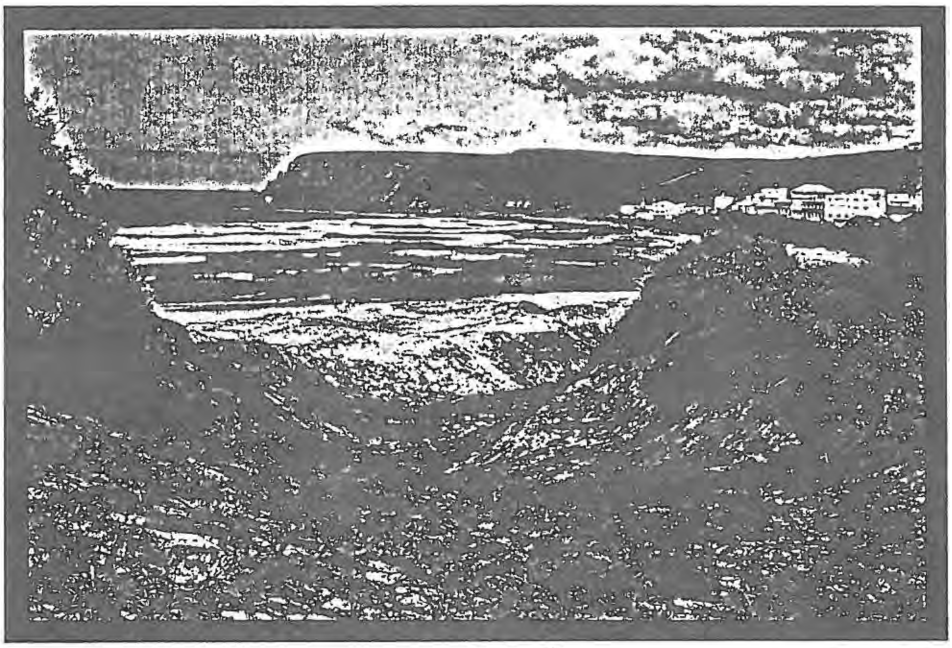


PLATE 13. Artificially stabilized blow-out at Morgan Bay.

The original throat area (near the river mouth) to the remains of the parabolic dune mentioned above is still unstable and blow-out damage caused by south-westerly winds has been repaired on two relatively recent occasions. Normal driftsand reclamation methods were used and provided the area is not disturbed, it should rehabilitate itself (Plate 13).

Utilization of the forests by the public is not great at present, although it has been suggested that a short day-walk be laid out in the area for use by holiday-makers. Vehicles are not permitted on the beach apart from on the accepted route across the Morgan River which is used for access between the townships of Kei Mouth and Morgan Bay.

The eight plant communities indicated on the vegetation map (Fig. 25) include the secondary scrub of the abandoned mine, the artificially reclaimed blow-out, mixed grassland and forest precursors, coastal scrub and grassland over dolerite, hygrophilous scrub-thicket, climax valley forest, sea-facing thicket and the forest of the landward dune slopes. Quantitative sampling was carried out only in the latter three communities.

The Mimusops caffra - Brachylaena discolor Sea-facing Thicket

The orientation of the coastline is such that this community is very exposed to the strong salt-laden south-westerly winds and signs of resultant wind-pruning are most apparent. The vegetation is protected along much of its seaward margin by a series of embryo dunes which have been colonized by Scaevola plumieri and Ipomoea brasiliensis and

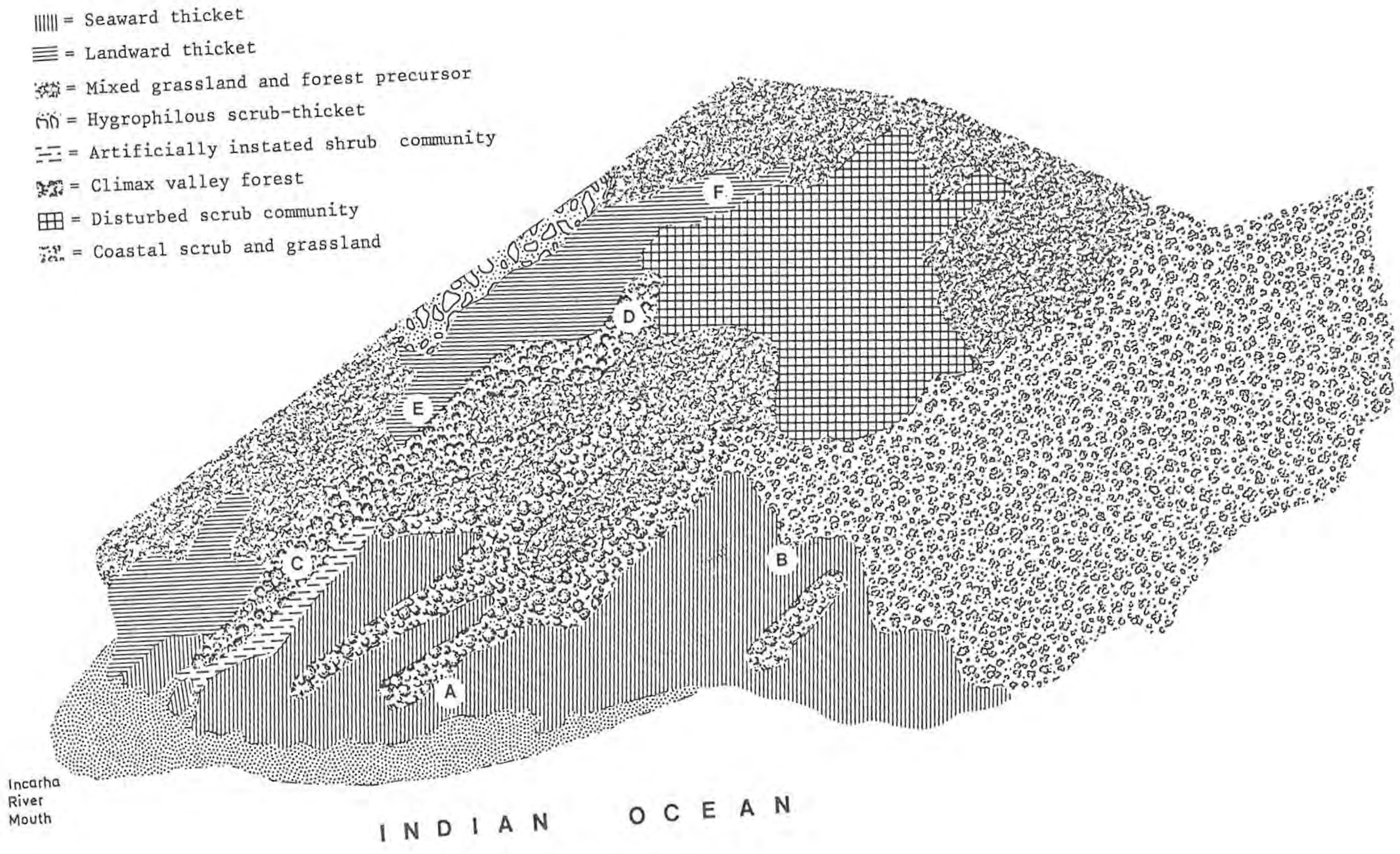



Fig. 25. The Morgan Bay vegetation map illustrating the eight major plant communities.

where it is underlain by the dolerite dike, it merges into scrub-thicket or Stenotaphrum secundatum-dominated grassland.

The fifteen points used to sample the area were distributed between the points A and B and C and D (Fig. 25).

Mimusops caffra is by far the most dominant canopy species of the community, with an importance value of 62,3 per cent and a stocking density of more than 63 per cent of the total number of canopy individuals (Table 30). Sub-dominant in the canopy stratum are Brachylaena discolor and Euclea natalensis with respective importance values of 11,4 and 6,9 per cent. The low species diversity in the canopy (only ten species were recorded) is an indication of the harsh prevailing environmental conditions, to which only a few species have been able to adapt.

Sub-canopy dominants are Euclea natalensis, Mimusops caffra and Brachylaena discolor, with importance values of 11,9 11,8 and 10,2 per cent respectively (Table 31). Sub-dominants in this stratum are Sideroxylon inerme, Allophylus natalensis and Acokanthera oblongifolia, having importance values of 7,3 6,0 and 5,9 per cent. The floristic reaction to the modification of the environment by the canopy is most noticeable, with twenty three species having been recorded in the sub-canopy and at least four of which (such as Canthium obovatum, Olea capensis, Cassine aethiopica and Pterocelastrus tricuspidatus ) could probably contribute to the canopy should the effects of salt spray become reduced - with an accreting

TABLE 30. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY SEAWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 548 | 7,97 | 62,3 |
| *Brachylaena discolor* | 101 | 0,58 | 11,4 |
| *Euclea natalensis* | 58 | 0,52 | 6,9 |
| *Maytenus heterophylla* | 43 | 0,42 | 5,2 |
| *Strelitzia nicolai* | 29 | 0,35 | 3,5 |
| *Maytenus procumbens* | 29 | 0,15 | 3,3 |
| *Allophylus natalensis* | 15 | 0,20 | 2,2 |
| *Euclea racemosa* | 15 | 0,07 | 1,9 |
| *Chionanthus foveolata* | 15 | 0,11 | 1,8 |
| *Sideroxylon inerme* | 15 | 0,03 | 1,6 |
| | 868 | 10,40 | 100,1 |

TABLE 31. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY SEAWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Euclea natalensis* | 124 | 0,31 | 11,9 |
| *Mimusops caffra* | 149 | 0,30 | 11,8 |
| *Brachylaena discolor* | 99 | 0,30 | 10,2 |
| *Sideroxylon inerme* | 149 | 0,09 | 7,3 |
| *Allophylus natalensis* | 99 | 0,03 | 6,0 |
| *Acokanthera oblongfolia* | 75 | 0,15 | 5,9 |
| *Chionanthus foveolata* | 75 | 0,06 | 5,2 |
| *Ficus burtt-davyi* | 75 | 0,02 | 4,5 |
| *Pterocelastrus tricuspidatus* | 25 | 0,21 | 4,2 |
| *Olea capensis* | 50 | 0,08 | 4,1 |
| *Dracaena hookerana* | 50 | 0,09 | 3,9 |
| *Cassine aethiopica* | 25 | 0,14 | 3,4 |
| *Maytenus procumbens* | 50 | 0,03 | 3,1 |
| *Maytenus heterophylla* | 25 | 0,11 | 3,0 |
| *Canthium obovatum* | 25 | 0,07 | 2,4 |
| *Euclea racemosa* | 50 | 0,02 | 2,4 |
| *Rhus glauca* | 25 | 0,04 | 2,1 |
| *Passerina rigida* | 25 | 0,02 | 1,8 |
| *Strelitzia nicolai* | 25 | 0,006 | 1,5 |
| *Rhus natalensis* | 25 | 0,006 | 1,5 |
| *Scutia myrtina* | 25 | 0,006 | 1,4 |
| *Rhus crenata* | 25 | 0,006 | 1,4 |
| *Carissa bispinosa* | 25 | 0,006 | 1,4 |
| | 1320 | 2,100 | 100,4 |

coastline this could be possible, with the formation of seaward dune ridges, but it is unlikely to happen in the Morgan Bay situation.

It is probable that this community will remain in a sub-climax seral state, maintained as such by wind and salt spray and that the future species composition will not deviate much from the present status. The regeneration of current canopy dominants will be through replacement by juvenile individuals which are also dominant in the sub-canopy. Euclea natalensis and Sideroxylon inerme could increase in importance in the canopy if their present high density values in the sub-canopy are considered. It is felt however that the latter species is not quite as aggressive on the seaward sites as Mimusops caffra and will not therefore displace any of the present canopy dominants.

The canopy height varied between 2,5 and 8 metres but was very even with no emergents. The calculated mean canopy height was 4,75 metres. Canopy stand density was 868 Sph having a total stem basal area of 10,4 $m^2$. The stand density of the sub-canopy population was 1320 Sph and a stem basal area of 2,1$m^2$ per hectare was recorded.

Cover values for the herb layer were low and varied between 0 and 30 per cent, with a mean value of 3,7 per cent.

The Sideroxylon inerme - Diospyros natalensis Valley Forest

The sheltered environment and more developed soils of the valley areas have produced the tallest forest community at Morgan Bay, which give the impression of being at or near to a climax stage. The presence of

Podocarpus latifolius and P. falcatus (observed, but not sampled) in the population reflect the relatively advanced stage of the community since it is unlikely that either of these species would survive in an unmodified dune habitat. The forest which was sampled had an open woodland appearance with a low stem count due either to past exploitation or natural thinning. Several rotten tree trunks were noted on the valley floor and it is possible that these resulted from wind falls during a particularly strong wind. Increased light penetration due to the decreased canopy cover and a more favourable moisture regime are factors which have contributed to the development of the dense herb layer noted.

The fifteen points used to sample the community were distributed between points C and D as indicated on Fig 25. The species diversity of the canopy stratum was relatively low with only eleven species recorded. Canopy dominants are Sideroxylon inerme and Diospyros natalensis with importance values of 34,6 and 24,3 percent and combined density values of almost 60 per cent of the total stocking (Table 32). Sub-dominant species contributing towards this stratum are Maytenus heterophylla, Cassine aethiopica and Cordia caffra with respective importance values of 10,7 7,3 and 6,5 per cent.

Of the seventeen sub-canopy species recorded, only six were juveniles of present canopy species, while a further six were species capable of achieving canopy status (Table 33). The remaining species, such as Carissa bispinosa and Dracaena hookerana, were typical sub-canopy

TABLE 32. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY VALLEY CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 69 | 7,38 | 34,6 |
| *Diospyros natalensis* | 58 | 3,41 | 24,3 |
| *Maytenus heterophylla* | 25 | 1,38 | 10,7 |
| *Cassine aethiopica* | 18 | 0,67 | 7,3 |
| *Cordia caffra* | 15 | 0,63 | 6,5 |
| *Erythrina caffra* | 7 | 1,59 | 5,2 |
| *Deinbollia oblongifolia* | 7 | 0,13 | 3,5 |
| *Strelitzia nicolai* | 7 | 0,08 | 2,6 |
| *Harpephyllum caffrum* | 4 | 0,75 | 2,5 |
| *Zanthoxylum capense* | 4 | 0,21 | 1,6 |
| *Podocarpus latifolius* | 4 | 0,07 | 1,3 |
| | 218 | 16,3 | 100,1 |

TABLE 33. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY VALLEY SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
| --- | --- | --- | --- |
| *Maytenus heterophylla* | 42 | 1,32 | 16,6 |
| *Deinbollia oblongifolia* | 49 | 0,58 | 14,0 |
| *Diospyros natalensis* | 49 | 0,32 | 11,2 |
| *Acokanthera oblongfolia* | 63 | 0,10 | 10,2 |
| *Teclea natalensis* | 35 | 0,47 | 10,2 |
| *Dovyalis rhamnoides* | 28 | 0,16 | 6,8 |
| *Dracaena hookerana* | 35 | 0,10 | 5,7 |
| *Allophylus natalensis* | 28 | 0,07 | 5,2 |
| *Cassine aethiopica* | 14 | 0,19 | 4,8 |
| *Ficus burtt-davyi* | 14 | 0,07 | 3,3 |
| *Dovyalis rotundifolia* | 14 | 0,09 | 2,9 |
| *Carissa bispinosa* | 14 | 0,02 | 2,1 |
| *Strelitzia nicolai* | 7 | 0,07 | 1,9 |
| *Scolopia zeyheri* | 7 | 0,03 | 1,7 |
| *Vepris lanceolata* | 7 | 0,004 | 1,2 |
| *Euclea natalensis* | 7 | 0,003 | 1,2 |
| *Sideroxylon inerme* | 7 | 0,003 | 1,2 |
| | 420 | 3,600 | 100,2 |

components. Dominants in this stratum were Maytenus heterophylla, Deinbollia oblongifolia and Diospyros natalensis with respective importance values of 16,6, 14 and 11,2 per cent. Sub-dominants were Acokanthera oblongifolia and Teclea natalensis with importance values of 10,2 per cent each.

If it is anticipated that regeneration of the forest will take place by recruitment from the sub-canopy, it would appear that the future status of Diospyros natalensis and Maytenus heterophylla will remain unchanged. Cassine aethiopica should also maintain its position in the canopy but Sideroxylon inerme could possibly decrease in importance if its low density in the sub-canopy is considered. Deinbollia oblongiflia could increase in importance but this is unlikely since it prefers its sub-canopy position and probably only reaches the canopy by chance through the mortality of adjacent canopy contributors. The Morgan Bay forest is the only area where Teclea natalensis has been recorded as occurring relatively frequently in the sub-canopy and although it is possible that it could eventually become a canopy member it is unlikely to be an important contributor since it is already at its southernmost distribution limit.

The canopy was very uneven and ranged in height between 6 and 15 metres, with a mean value of 9,6 metres. Emergents were Sideroxylon inerme (15 m), Cordia caffra (12,5 m) and Diospyros natalensis (12 m). The canopy stand density was 218 Sph which had a total stem basal area of approximately 16,3m$^2$. Species with the greatest DBH were Erythrina caffra (60 cm), Harpephyllum caffrum (51 cm) and Sideroxylon inerme (50 cm). The sub-canopy stocking was also comparatively low at 420 Sph, with a recorded basal area of 3,6 $m^2$.

The herb layer was dominated by grass species such as Oplismenus hirtellus and Digitaria eriantha and had cover values which ranged between 5 and 100 per cent, with a mean value of 70 per cent.

The Mimusops caffra-Maytenus heterophylla Landward Forest Community

Although the forest which was studied occupied the hotter dune slopes, with a north-west aspect, the vegetation did not have the moisture-stressed appearance typical of many such sites. A possible reason for this is the higher rainfall which the area receives and the improved moisture utilization through reduced drainage down the slope which was not particularly steep. Signs of erosion were evident however, with a small amount of soil accumulation around the bases of the trees on the lower slope. Canopy height was noted to increase considerably at the base of the dune. In places the forest merged into hygrophilous scrub (dominated by Phoenix reclinata) around the two perennial vleis adjoining the inland dune margin (Plate 14).

The fifteen points used to sample the forest were distributed between points E and F as indicated in Fig 25. Sample points were located in the vegetation of both the upper and lower dune slope.

The dominant canopy species is Mimusops caffra with an importance value of 35,5 per cent and a density of 25 per cent of the total

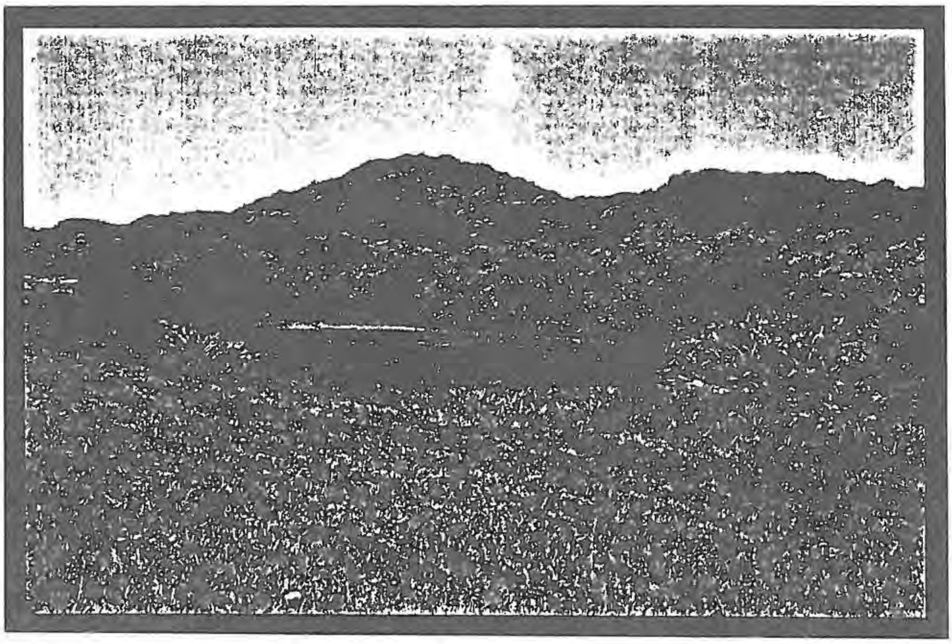


PLATE 14. <u>Phoenix reclinata</u> - dominated hygrophilous scrub at Morgan Bay.

number of stems per hectare (Table 34). Sub-dominants in this stratum are Maytenus heterophylla and Pterocelastrus tricuspidatus with importance values of 15 and 11,3 per cent respectively. Floristically interesting species which contribute to the canopy are Erythrina caffra, Harpephyllum caffrum and Phoenix reclinata. The former two species are usually associated with dune valley forest and the implication is therefore that the climatic conditions of Morgan Bay must be favourable for the development of successionally advanced forest even on the drier or hotter sites. Phoenix reclinata is an important member of sub-tropical coastal forests and although it does occur down the coast as far as Port Alfred in the dune habitat, it is definitely not common in the south and Morgan Bay is possibly the limit of where it is still of some importance in the community.

Sub-canopy dominants are Maytenus heterophylla, Psychotria capensis and Euclea natalensis with respective importance values of 15,1 11,8 and 11,6 per cent (Table 35). Sub-dominant species are Cassine aethiopica, Diospyros natalensis and Pterocelastrus tricuspidatus with importance values of 9,9 9,8 and 6,9 per cent respectively. Species diversity is slightly greater in this stratum than in the canopy, with 50 per cent of the canopy species being represented and an additional five species present which have the potential of contributing to the canopy. Mimusops caffra was not recorded at all in the sub-canopy, making the future status of this species uncertain. Maytenus heterophylla is well represented however and it is possible that this species might replace M. caffra as the canopy dominant.

TABLE 34. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY LANDWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 230 | 19,08 | 35,5 |
| *Maytenus heterophylla* | 168 | 1,91 | 15,0 |
| *Pterocelastrus tricuspidatus* | 122 | 1,29 | 11,3 |
| *Brachylaena discolor* | 92 | 1,20 | 8,5 |
| *Allophylus natalensis* | 62 | 0,54 | 6,0 |
| *Chionanthus foveolata* | 62 | 0,69 | 5,0 |
| *Sideroxylon inerme* | 30 | 0,46 | 3,0 |
| *Cassine aethiopica* | 30 | 0,26 | 3,0 |
| *Euclea natalensis* | 30 | 0,94 | 3,0 |
| *Erythrina caffra* | 16 | 1,49 | 3,0 |
| *Phoenix reclinata* | 30 | 0,37 | 2,5 |
| *Harpephyllum caffrum* | 16 | 0,20 | 1,8 |
| *Strelitzia nicolai* | 16 | 0,11 | 1,5 |
| *Ficus natalensis* | 16 | 0,06 | 1,3 |
| | 920 | 28,60 | 100,4 |

TABLE 35 DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE MORGAN BAY LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Maytenus heterophylla* | 296 | 0,60 | 15,1 |
| *Psychotria capensis* | 185 | 0,63 | 11,8 |
| *Euclea natalensis* | 296 | 0,20 | 11,6 |
| *Cassine aethiopica* | 223 | 0,32 | 9,9 |
| *Diospyros natalensis* | 296 | 0,10 | 9,8 |
| *Pterocelastrus tricuspidatus* | 111 | 0,40 | 6,9 |
| *Allophylus natalensis* | 111 | 0,24 | 6,5 |
| *Scolopia zeyheri* | 111 | 0,10 | 4,8 |
| *Carissa bispinosa* | 149 | 0,05 | 4,6 |
| *Brachylaena discolor* | 73 | 0,16 | 4,3 |
| *Sideroxylon inerme* | 111 | 0,06 | 4,1 |
| *Rhus natalensis* | 111 | 0,04 | 3,3 |
| *Olea capensis* | 38 | 0,19 | 2,8 |
| *Canthium obovatum* | 38 | 0,09 | 2,1 |
| *Turraea obtusifolia* | 38 | 0,01 | 1,3 |
| *Euclea racemosa* | 38 | 0,01 | 1,2 |
| | 2225 | 3,20 | 100,1 |

Pterocelastrus tricuspidatus, Brachylaena discolor and Allophylus natalensis are likely to retain their current canopy status, while Cassine aethiopica and Euclea natalensis could increase somewhat in importance. Diospyros natalensis which was not recorded in the canopy could eventually contribute towards it, if its present high stocking density in the sub-canopy stratum is considered. Psychotria capensis will probably remain the most important permanent sub-canopy species.

The canopy height varied between 4,5 and 11 metres, with a calculated mean height of 6,4 metres. Emergent species recorded were Strelitzia nicolai, Erythrina caffra and Mimusops caffra. The canopy stand density was measured at 920 Sph with a stem basal area of 28,6$m^2$ per hectare. Species with the greatest DBH were Mimusops caffra (70 cm) and Erythrina caffra (35 cm). The sub-canopy had a stocking of 2225 Sph and a stem basal area value of 3,2$m^2$ per hectare.

The herb layer was typically sparse for this dune aspect and although in one area the cover was as much as 80 per cent, the mean cover value was only 13,2 per cent.

### 5.4.2 Floristic and structural comparison between the seaward, valley and landward forest communities

Species diversity in the canopy stratum increases landwards, with ten of the twenty-one recorded species occurring in the seaward community, eleven in the valley forest and fourteen in the landward community. The reverse trend was encountered in the sub-canopy stratum where, of the total of thirty-two species, sixteen were represented in the landward community, seventeen in the valley forest and twenty-three in the seaward community. The site with the greatest species diversity including both strata was the seaward slope, while the valley contained the fewest species overall.

Of the five canopy species found to occur exclusively in the valley forest, only Podocarpus latifolius, Deinbollia oblongifolia and possibly Diospyros natalensis can be regarded as species which are diagnostic of the community and which could indicate the relatively advanced state of the forest. The seaward dune slope contained two exclusive species, of which only Maytenus procumbens is diagnostic of and generally exclusive to the seaward thicket. Three canopy members, Pterocelastrus tricuspidatus, Phoenix reclinata and Ficus natalensis were recorded as exclusive to the landward slope but since they have been noted to occur in other dune habitats as well they cannot be classified as diagnostic species for the Morgan Bay area.

Canopy species common to all three communities sampled were Maytenus heterophylla, Sideroxylon inerme and Strelitzia nicolai, with the first two species being of greatest importance.

Apart from the above species, five canopy species common to the seaward and landward communities are (in decreasing order of importance) Mimusops caffra, Brachylaena discolor, Euclea natalensis, Allophylus natalensis and Chionanthus foveolata. No additional species are common to the seaward and valley communities, while three species, Cassine aethiopica, Erythrina caffra and Harpephyllum caffrum are common to the valley and landward communities. Floristically, the most similar sites are the seaward and landward slopes, with less similarity between the valley and landward communities. The most dissimilar communities are those occupying the seaward and valley sites. The pattern of species overlap in the canopy between the three sites corresponds to the assumed vegetation succession which, in ascending order of development, is from the seaward slopes to the vegetation of the landward slopes, to the climax valley forest.

Within the sub-canopy stratum of the three communities, six species were found to occur throughout the area. *Maytenus heterophylla* was of greatest importance, followed by *Euclea natalensis*, *Cassine aethiopica*, *Allophylus natalensis*, *Sideroxylon inerme* and *Carissa bispinosa*. Apart from the latter species all of the above are capable of achieving canopy status. Seven species, of which only *Maytenus procumbens*, *Passerina rigida* and *Mimusops caffra* are of real significance, are exclusive to the seaward community, while five species and a further two species are exclusive to the valley and landward sites respectively. *Deinbollia oblongifolia* and *Teclea natalensis* are regarded as being significant within the valley community and *Psychotria capensis*, which generally only occurs in very sheltered sites, is a significant member of the landward community. As with the canopy stratum, the greatest overlap in sub-canopy species is between the seaward and landward communities where, apart from the six species referred to above, a further six species were common to both sites.

Structurally, the three communities differ quite significantly. The mean canopy height of the valley forest is twice that of the seaward thicket and is considerably greater than that of the forest on the landward slope. The stocking density of both the canopy and sub-canopy strata is greatest on the landward slope and least in the valley, where eighty per cent fewer trees occur. In spite of the dense crown cover of the seaward thicket, there are thirty percent fewer stems in both strata than on the landward slope. Stem basal area of the canopy individuals is greatest on the landward slope and least on the seaward site and in the sub-canopy stratum is greatest in the valley and again, least on the seaward slope.

Large differences between the herb layer cover values were recorded for the three communities. The seaward thicket floor had the lowest cover value due to the combined effects of shading by the compact canopy and the continuous deposition of sand from the beach. The landward slope also had a fairly sparse herb cover due to the instability of the slope and probably also to the hotter and drier microclimate. The valley community had the most dense herb layer, which has become established due to increased light penetration through the fairly open and uneven canopy combined with a more favourable microclimate.

### 5.4.3 Multivariate Analysis Results and Discussion

#### Classification

A classification of the canopy species is illustrated in Table 36.

TABLE 36. CLASSIFICATION OF THE MORGAN BAY CANOPY SPECIES.

VALLEY COMMUNITY (points 5–2) | LANDWARD COMMUNITY (points 30–45) | SEAWARD COMMUNITY (points 17–44)

| POINT Nos. | 5 | 10 | 37 | 39 | 7 | 9 | 13 | 14 | 11 | 15 | 3 | 4 | 6 | 1 | 8 | 12 | 2 | 30 | 33 | 42 | 16 | 19 | 21 | 31 | 35 | 32 | 34 | 36 | 40 | 28 | 29 | 41 | 43 | 45 | | 17 | 18 | 20 | 24 | 27 | 22 | 23 | 25 | 26 | 30 | 44 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zan. cap. | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pod. lat. | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pho. rec. | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Har. caf. | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Dei. obl. | | | | | 4 | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ste. nic. | | 4 | | 5 | | | | | 4 | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ery. caf. | 5 | | | 5 | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf. | | | | | 5 | 4 | 5 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. act. | | | | 4 | 5 | | | | | | | | | 4 | 4 | 5 | 5 | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | |
| Dio. nat. | | | | | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sid. ine. | 5 | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | 4 | 4 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fic. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | |
| Pte. tri. | | | | | | | | | | | | | | | | | | | 4 | | | | | 4 | 5 | 4 | 4 | 4 | 5 | | | | | | | | | | | | | | | | | |
| May. pro. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | 4 | | |
| Euc. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | 5 | | 5 | |
| Bra. dis. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | 4 | 4 | 5 | 5 | 5 | | | | | 5 | 4 |
| May. het. | | | | 4 | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | 4 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | | | | | | | | | | | | |
| Chi. fov. | | | | | | | | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | 5 | | | | | | |
| All. nat. | | | 5 | | | | | | | | | | | | | | | | | | | | | | 4 | | | 4 | | | | | | 4 | | | | 5 | | | | | | | | |
| Mim. caf. | | | | | | | | | | | | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | 5 | |

The valley community is distinguished by a number of characteristic or member species while the seaward and landward vegetation contains comparatively fewer. Sideroxylon inerme and Diospyros natalensis can be regarded as diagnostics for the climax forest and Pterocelastrus tricuspidatus and Brachylaena discolor are diagnostic of the landward and seaward communities respectively. Of the four species grouped as being common to more than one community, Mimusops caffra and Maytenus heterophylla are most significant. M. caffra would appear to be the linking element between the seaward and landward communities while M. heterophylla is ubiquitous in the landward and valley communities. If the successional sequence of development of the dune vegetation is assumed to be from the seaward site towards the valley, then M. heterophylla can be regarded as a later seral species than M. caffra. This classification is very similar to that based on the importance rankings with the exception of the landward thicket, where overlapping species (M. heterophylla and M. caffra) were used to identify the community instead of the greater differentiating species, P. tricuspidatus.

The sub-canopy community classification is illustrated in Table 37. The distinguishing species of the subordinate valley stratum are relatively few and bear little resemblance to the canopy composition. Deinbollia oblongifolia and Teclea natalensis can be regarded as possible diagnostics but as neither are likely to develope into significant canopy contributors speculation into the future canopy regeneration would have to be based upon the species common to the

TABLE 37. CLASSIFICATION OF THE MORGAN BAY SUB-CANOPY SPECIES.

| | LANDWARD COMMUNITY | | | | | | | | | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | | | | | | | | | VALLEY COMMUNITY | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 18 | 24 | 30 | 42 | 27 | 32 | 35 | 44 | 13 | 14 | 31 | 41 | 36 | 39 | 40 | 43 | 25 | 28 | 34 | 37 | 26 | 33 | 41 | 6 | 38 | 10 | 15 | 29 | 11 | 17 | 22 | 16 | 21 | 33 | 1 | 3 | 5 | 6 | 2 | 4 | 9 | 2 | 7 | 19 | 20 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scu. myr. | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pas. rig. | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gle. era. | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Olc. cap. | | | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pte. tri. | | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. nat. | | | 4 | 4 | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Era. dic. | 5 | | 5 | 4 | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | |
| Chi. fov. | | 4 | | | | | | | | | | | | | | | 5 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Car. bis. | | | | | 4 | 5 | 4 | | 5 | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sco. zey. | | | | | | | | | 5 | | 5 | 5 | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. act. | | 5 | | | | | | | | | | | 5 | 5 | 4 | 5 | | | | | | | 4 | | | | | | | | | | | | | | | | 5 | | | 5 | | | |
| Dio. nat. | | | | | | | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | 5 | | | | | | | | | | | |
| Tur. obt. | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | |
| Rhu. gla. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | |
| May. pro. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | 4 | | | | | | | | | | | | |
| Fic. bdv. | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | 5 | | | | | | | | | | | | 5 | | |
| Dra. haa. | | | | | | | | | | | | | | | | | | 5 | | | | | | | | 5 | 5 | 4 | 5 | | | | | | | | | | | | | | | | |
| All. nat. | | | | | | | | | | | | | 5 | | | | | | | 5 | | | | 5 | 5 | 5 | | | 5 | 4 | | 5 | 4 | 5 | | | | | | | | | | | |
| Can. obo. | | | | | | | | | | | | | | | | | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dov. rha. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | |
| Vep. lan. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | |
| Rhu. cre. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | |
| Tec. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | | 5 | 5 | | 5 | | |
| Dei. obl. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | 5 | 5 | 5 | | 5 | | | |
| Psy. cap. | | | | | | 5 | 5 | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Euc. nat. | 5 | | | | | 5 | | 4 | | | | 5 | 5 | | 5 | 5 | 5 | 5 | | | 5 | 5 | | 4 | | | | | | | | | | | | | | | | | | | | | |
| Sid. ine. | | | | | 5 | | | 4 | | | | | | | 4 | | | | | 4 | 5 | | 4 | | | | | 5 | | | | 5 | | | 4 | | | | | | | | | | |
| Mim. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | | | | | 4 | 5 | | | | 5 | 5 |
| Aco. obl. | | | | | | | | | | 4 | | | | | | | 4 | | | | | | | 5 | | 4 | 4 | 5 | | | | | | | | | | | | | 5 | 5 | | | |
| May. het. | | | | | | | | | | | | | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | | 5 | 5 | | | | | | | | |
| Str. nic. | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | 5 |

landward and valley sites as well. The seaward community is characterized by the importance of Allophylus natalensis and Dracaena hookerana as sub-canopy elements while Mimusops caffra appears to play a relatively insignificant role. The greatest membership of distinguishing sub-canopy species occurs in the landward community, which contains more than twice the number of such species as the seaward or valley sites. Diagnostic species here are Diospyros natalensis and Cassine aethiopica, both of which are capable of achieving canopy status. Euclea natalensis appears to be a significant sub-canopy linking element between the seaward and landward communities. The differences between this classification and the tabled importance rankings of the sub-canopy species do not appear to be too great. The arrangement of more or less contiguous stands in the table clearly indicates some trend towards the definition of site-specific sub-canopy communities.

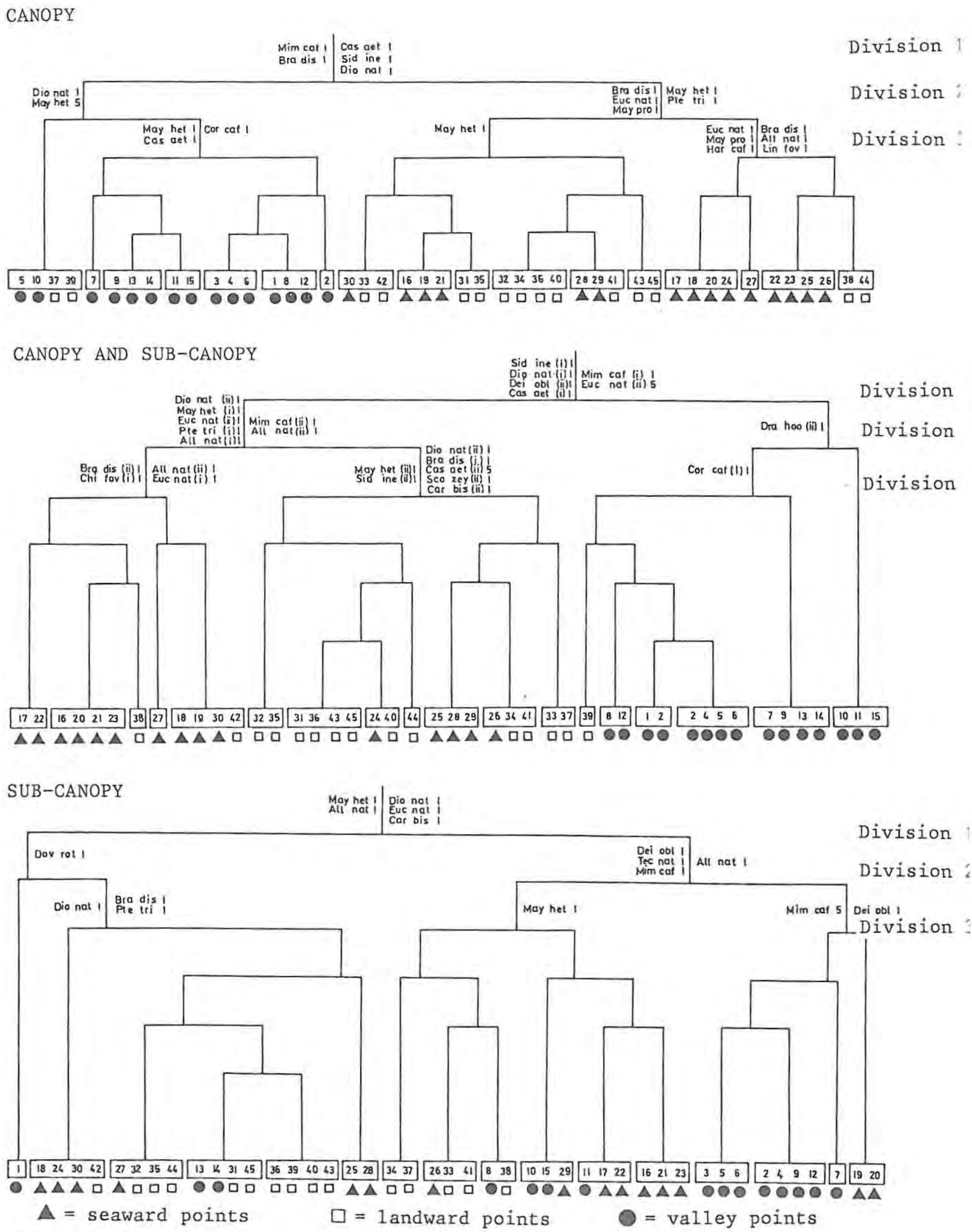
The classification including both the canopy and sub-canopy data supports the two previous classifications quite well (Table 38). It illustrates the associations between canopy and sub-canopy species occupying the various sites and permits speculation about the interaction between the two strata and possible directions of successional development of the forest. The seaward community appears to be in a state of equilibrium as far as its regeneration potential is concerned and the species of importance which are present in the sub-canopy are similar to those currently contributing to the canopy - i.e. M. caffra and B. discolor. Also present in the sub-canopy group

TABLE 38. CLASSIFICATION OF THE MORGAN BAY CANOPY AND SUB-CANOPY SPECIES.

| |SEAWARD COMMUNITY|||||||||||LANDWARD COMMUNITY|||||||||||||||||||VALLEY COMMUNITY|||||||||||||||
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|POINT Nos.|17|22|16|20|21|23|38|27|18|19|30|42|32|35|31|36|43|45|24|40|44|25|28|29|26|34|41|33|37|39|8|12|1|2|3|4|5|6|7|9|13|14|10|11|15|
|SPECIES||||||||||||||||||||||||||||||||||||||||||||||
|Mim. caf.2||||5|5|5||||5||||||||||||||||||||||||4||5||||||||||
|Rhu. gla.2|5|||||||||||||||||||||||||||||||||||||||||||||
|Tur. obt.2|||||||4|||||||||||||||||||||||||||||||||||||||
|May. pro.2||5|||4||||||||||||||||||||||||||||||||||||||||
|Fas. rig.2|||||||||4||||||||||||||||||||||||||||||||||||
|Scu. myr.2|||||||||4||||||||||||||||||||||||||||||||||||
|Rhu. cre.2||||||||||4|||||||||||||||||||||||||||||||||||
|Euc. nat.1||4||||5|5||||||||||||||||5||||||||||||||||||||||||
|Ole. cap.2||||||||5|||5|||||||||||||||||||||||||||||||||||
|Euc. rac.1||||||||||||||||||||||||4||||||||||||||||||||||
|Pte. tri.2||||||||||||5|||||||5|5|||||||||||||||||||||||||||
|Chi. fov.1||||||||5||||5||||||||||||||||5|||||||||||||||||||
|Fic. nat.1|||||||||||||4|||||||||||||||||||||||||||||||||
|Ole. exa.2|||||||||||||||5|||||||||||||||||||||||||||||||
|Euc. rac.1||||||||||||||||||||||||4||||||||||||||||||||||
|Pho. rec.1|||||||||||||||||||||||||||||5||||||||||||||||||
|Sco. zey.2|||||||||||||||5||5|5|||||||||||||||||||||||5|||||
|Can. obo.2||||||||||||||||||||||5||||5||||||||||||||||||||||
|Car. bis.2||||||||4||||||5|4||||5|||||||||||||||||||||||||5|||||
|Chi. fov.2|||||||||||||||||||4|||5|4|||||||||||||||||||||||||
|Psy. cap.2|||||||||||||5|5|||||||||||5|||5||||||||||||||||||
|Sid. ine.2||5||||||5|||||||||||||||4|||5|5||4||4|||||4|||||||||||||
|All. nat.1|||||||||||||||4|4||4|5||||||||||5|||||||||||||||||
|Pte. tri.1|||||||||||||4|5|4|4||||5||||||4||4||||||||||||||||||
|Euc. nat.2|||||||||5||||5|||5|5|5||5|4|5|5||5|||5|||4|||||||||||||||
|Pod. lat.1||||||||||||||||||||||||||||||||||||||||||||4|||
|Dov. rha.2|||||||||||||||||||||||||||||||||5||||||||||||
|Vep. lan.2|||||||||||||||||||||||||||||||||4||||||||||||
|Dov. rot.2|||||||||||||||||||||||||||||||||5|5|||||||||||
|Zan. cap.1|||||||||||||||||||||||||||||||||||||4||||||||
|Dei. obl.1|||||||||||||||||||||||||||||||||||4||||4||||||
|Aco. obl.2||||||||||||||||||||||4||5|||||||5|5||||||||5||4|4||4|
|Ery. caf.1||||||||||||||||||||||||||||||5||||5|||5|||||||||
|Cas. aet.1||||||||||||||5||||||||||||||||4|4|5|4|5|||||5||||||||
|Tec. nat.2||||||||||||||||||||||||||||||||||||5|4|5|5|5||||||
|Cor. caf.1|||||||||||||||||||||||||||||||||||||||5|4|5|5||||
|Dei. obl.2||||||||||||||||||||||||||||||||5||5|5|5|4|5||||||||
|Dio. nat.1||||||||||||||||||||||||||||||||||5|5|5|5||5|5|5|5|4||5|5|
|Sid. ine.1|||||||||||4|||||||||||||||||5|5||5|5|5|4|5||5|5||5|5|5|5|5|5|
|May. pro.1||4|||||||||||||||||||||||||4||||||||||||||||||||
|Euc. rac.2||||||5|||||||||||||||||||||||5||||||||||||||||||
|Bra. dis.2|||||||||5|5|5|4|||||||||5||||||||||||||||||||||||||
|Bra. dis.1|4|||5|||5|5|4|||||||||5|5|5||4||||||||||||||||||||||||
|Mim. caf.|5|5|5|5|5|5|||5|5|5|5|5|5|5|5|5||5||5|5|5|5|5|5|5|5|||||||||||||||||||
|Dio. nat.2||||||||||||||4|5|4|5|5|||4|||||||||5|||||||||4||5|5||||
|Cas. aet.2||||||||||||||||5|5||5|5|||||||4|||5||5||5|||||||||||
|Har. caf.1|||||||||||||||||||||4||||||||||||||||||||||5|||
|Dra. hoo.2|||||||||||||||||||||||5|4|||||||||||||||||||5|5|5|
|May. het.2|||||||5|||||||||||||||||||5|5|5|5|5||5||||5||5|||||||||
|Str. nic.2||||||||||||||||||||||||||||||||||||||||||||||5|
|Rhu. nat.2|||||||||||4|4||||||||||||||||||5|||||||||||||||
|Str. nic.1|||||||||||5|||||||||||||||||||5|||||||||||||4|4||
|Fic. bdv.2|5|5|||||||||||||||||4|||||||||||||||||||||5|||||5||
|All. nat.2|4||5||4|5|5||||||||||5||||||||||||5||5||||||||||||5|5||

are early colonizer species such as Passerina rigida, Rhus crenata and Maytenus procumbens which are indicative of the relatively inadvanced state of the vegetation. In contrast, the landward forest shows clear signs of progression, particularly through the presence of potential climax species such as S. inerme and Diospyros natalensis in the sub-canopy and these species could with time, become more significant in the canopy. The developed valley forest contains a variety of sub-canopy elements which are either capable of regenerating the canopy (such as D. natalensis) or which are typical of intermediate strata in structured forest communities (e.g. Acokanthera oblongifolia). This apparent ability of the community to maintain its present composition, combined with the presence of associated understorey species would seem to confirm its climax status.

Dendrograms, illustrating essentially the same stand clustering as the above classification tables, were used as an alternative method of presenting the TWINSPAN results (Fig. 26). The canopy and combined canopy and sub-canopy analyses produced the best differentiation between the three forest communities. In the case of the canopy synusia, the first level of division separated the valley stands from the other vegetation which in turn was split at one of the second level divisions into predominantly landward and seaward clusters. In the analysis of both synusiae, the communities were identified at the same levels of division as above. The investigation of lower level clustering could not be usefully interpreted. The differentiation of the sub-canopy communities was not indicated as explicitly by the




Importance category
1 = 0- 1%
5 = 20-100%

(i)=canopy species

(ii)=sub-canopy species

Fig. 26. Dendrograms produced from TWINSPAN of 45 sample points within the Morgan Bay dune forest. The codes at the division levels represent indicator species with the value indicating the importance category of that species in all points on the same side of the division. Lists of taxa that are represented by the codes appear in Tables 30 - 35.

dendrogram as in the above cases. The first level of division differentiated between the majority of the landward stands on the one hand and the valley and seaward stands on the other. A division at the second level in the latter case created two reasonably pure clusters of predominantly valley and seaward stands.

Ordination

Isolines have been used to delimit three groups of floristically similar stands on the ordination scatter diagram for the canopy data (Fig. 27). Group A, at the upper left extreme of the ordination, contains predominantly valley stands, Group C, at the lower right contains predominantly seaward stands and Group B, which is located between the other two groups, contains predominantly landward stands. If the group proximity is considered, it would appear that the landward and seaward vegetation is relatively closely affiliated while the valley group forms a distinctly different community.

Figs. 28(a) to (f) show the distribution of certain selected canopy species on the ordination. Fig. 28(a) illustrates the importance of Brachylaena discolor in the seaward community and to a lesser extent, in the landward community. This species appears to have little significance in the climax forest of the dune valley. Fig. 28(b) illustrates the high degree of importance of Mimusops caffra in both the seaward and landward communities. It too is of little significance as a canopy species in the climax forest. Figs. 28(c) and (d) show the significance of Sideroxylon inerme and Diospyros

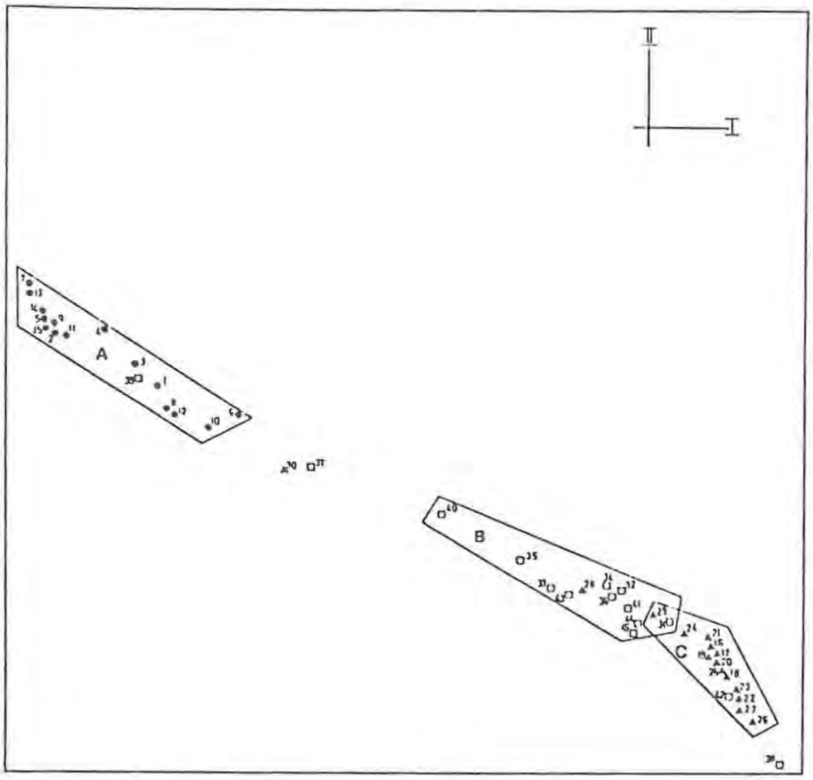


Fig. 27.
Ordination of the Morgan Bay canopy data. Group A represents the valley community, Group B the landward community and group C the seaward community.
● = valley stands
□ = landward stands
▲ = seaward stands

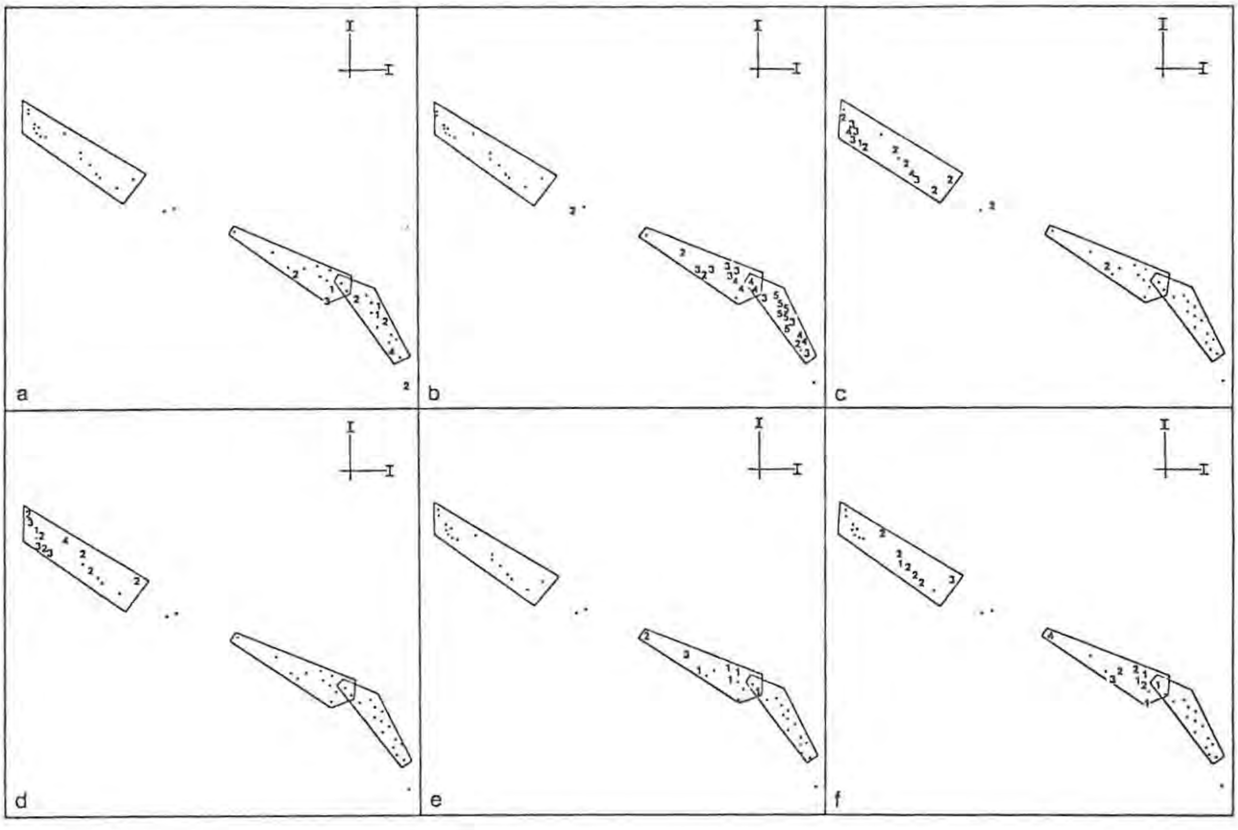



Fig. 28.
Positions on the Morgan Bay canopy ordination of (a) Brachylaena discolor, (b) Mimusops caffra, (c) Sideroxylon inerme, (d) Diospyros natalensis, (e) Pterocelastrus tricuspidatus and (f) Maytenus heterophylla.

(·-5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

natalensis in the valley community only and how they are of little or no importance on the other sites. The relative importance of Pterocelastrus tricuspidatus to the landward community only, is shown in Fig. 28(e) while Fig. 28(f) illustrates the dual role of Maytenus heterophylla as a canopy contributor to both the valley and landward communities.

The ordination of the sub-canopy elements did not provide very explicit stand groupings on the scatter diagram and it was not really possible to differentiate any sub-canopy communities on this basis (Fig. 29). This was anticipated since the various external environmental gradients would tend to have a reduced influence on this stratum, in that it is contained within a canopy-modified micro-environment. Soil gradients could nevertheless still be effective and might in fact be responsible for creating the vague groupings which are indicated on the diagram.

Figs. 30(a) to (f) illustrate the distribution of some of the sub-canopy species on the ordination. Teclea natalensis and Deinbollia oblongifolia, which are shown in Figs. 30(a) and (b), show the best grouping and are both restricted to the valley forest only. Cassine aethiopica is widely distributed on the ordination but is of greatest importance on the landward slopes (Fig. 30(c)). Diospyros natalensis, which is illustrated in Fig. 30(d) is also fairly widely distributed on the scatter diagram but was not recorded on the seaward slope. Fig. 30 (e) shows the distribution of Dracaena hookerana, which tends

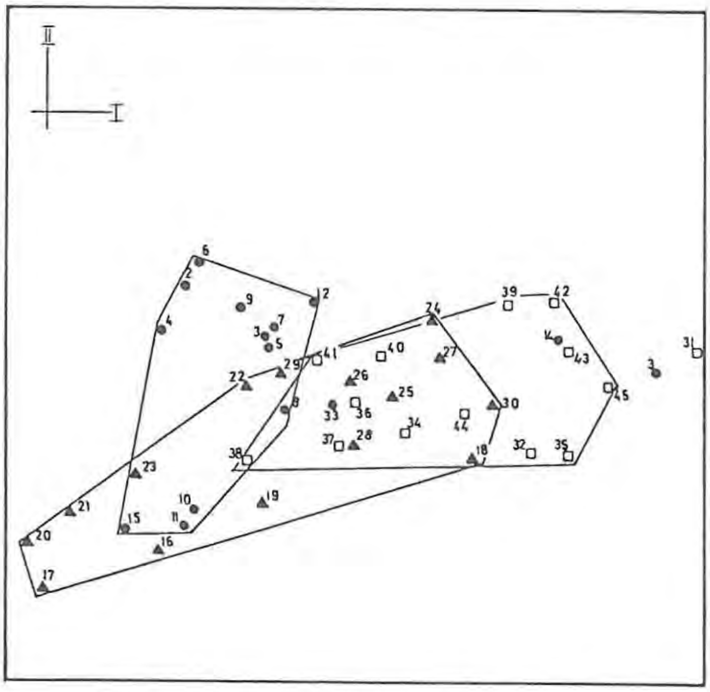


Fig. 29.
Ordination of the Morgan Bay sub-canopy data.
● = valley stands
□ = landward stands
▲ = seaward stands

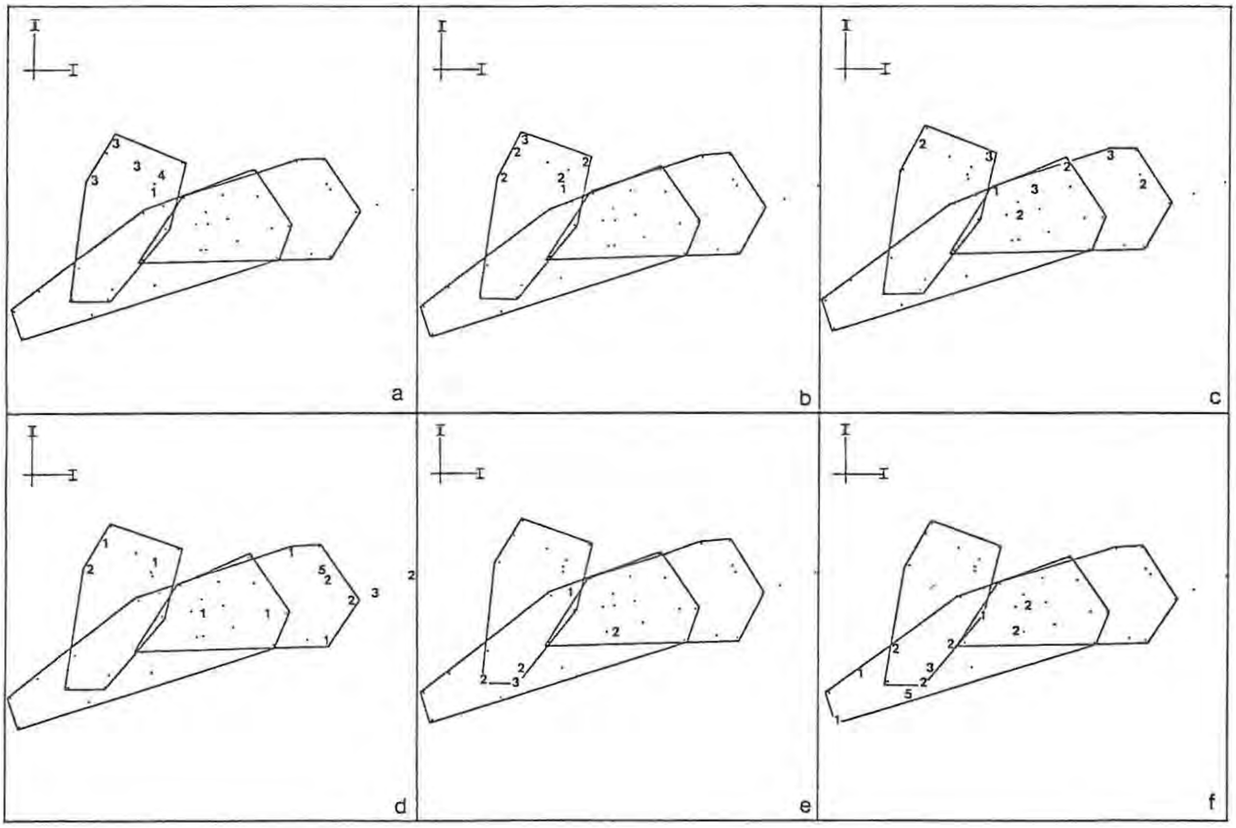


Fig. 30.
Positions on the Morgan Bay sub-canopy ordination of (a) Teclea natalensis, (b) Deinbollia oblongifolia. (c) Cassine aethiopica, (d) Diospyros natalensis, (e) Dracaena hookerana and (f) Allophylus natalensis.

(·-5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

to favour the closed seaward and valley forest, while the distribution of Allophylus natalensis indicates that although it occurs on all three sites, it is of least importance in the valley vegetation (Fig. 30(f)).

Relatively clear community groupings can be made on the ordination of the combined canopy and sub-canopy data and it is likely that this is due largely to the overriding contribution by the canopy stratum (Fig. 31). Group A consists of all of the valley stands and is quite separate from the other two groups. There is a degree of overlap between Group B, the landward community, and Group C, which is comprised of the seaward stands. Only D.C.A.- Axis I of the ordination can be used for interpreting any possible gradients and, since the two communities situated at the extremes on the plot are successionally furthest away from one another (i.e. Group C is least developed while Group A is climax forest) , the indicated gradient would appear to be a successional one. As discussed earlier, this gradient is closely related to (inter alia) the state of soil development, salt spray fall-out etc.

Figs. 32(a) and (b) illustrate the distribution of two canopy and two sub-canopy tree species on the ordination. From Fig. 32(a) it is apparent that Sideroxylon inerme as a canopy element and Teclea natalensis as a sub-canopy element are closely associated in the climax valley forest. Similarly, the impression gained from Fig. 32(b) is that Mimusops caffra and Euclea natalensis are closely

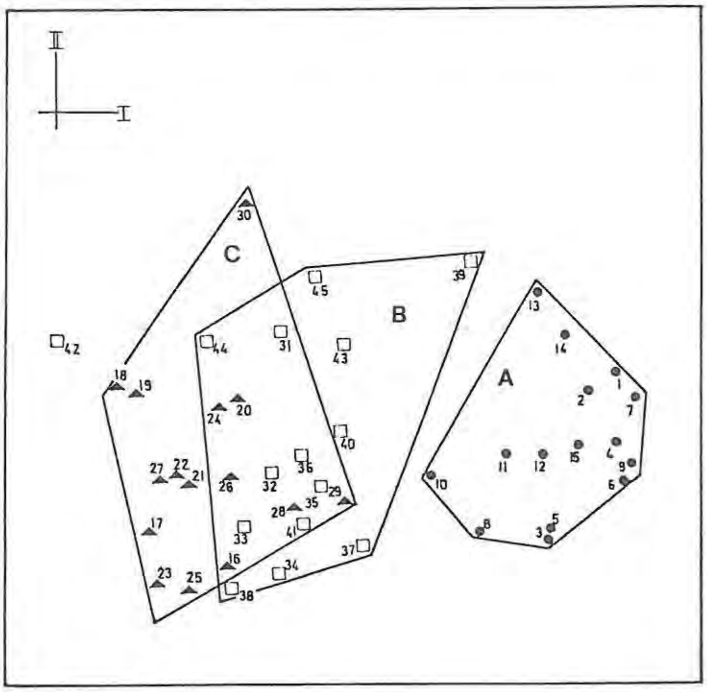



Fig. 31. Ordination of the combined canopy and sub-canopy data for Morgan Bay. Group A represents the valley community, Group B the landward community and Group C the seaward community.
● = valley stands;
□ = landward stands;
▲ = seaward stands.

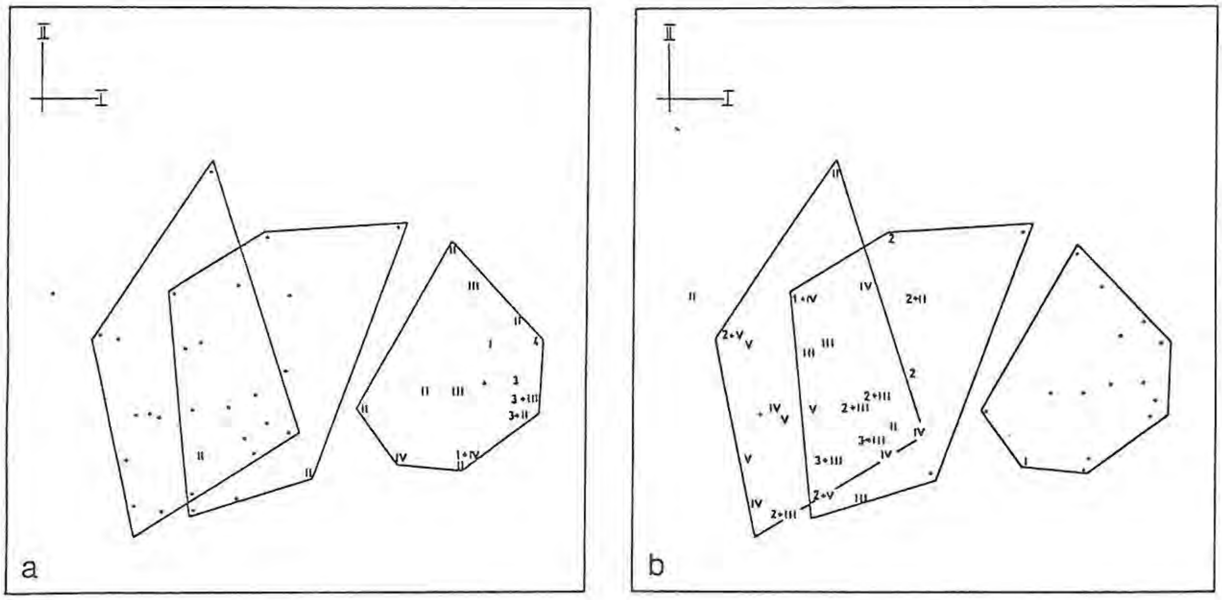



Fig. 32.
(a) Valley association of Sideroxylon inerme as a canopy species with Teclea natalensis in the sub-canopy, on the combined Morgan Bay canopy and sub-canopy ordination.
(b) Seaward and to a lesser extent landward association of Mimusops caffra as a canopy species with Euclea natalensis in the sub-canopy on the combined Morgan Bay canopy and sub-canopy ordination.

(i-v denote canopy importance ratings, where: i = 1-20%, ii = 21-40%, iii= 41-60%, iv = 61-80% and v = 81-100%.
•-4 denote sub-canopy importance ratings where: • = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60% and 4 = 61-80%.)

associated as canopy and sub-canopy elements respectively in both the seaward and landward communities.

## 5.5 THE BOSBOKSTRAND DUNE FOREST

### Site and forest description

The study area at Bosbokstrand is included in the Cape Henderson Nature Reserve, which was proclaimed during December 1983. The greater protection status was considered necessary in order to preserve the very unspoilt and undisturbed character of this part of Cintsa Bay. The forest studied is approximately 25 ha in size and stretches from the Nyara River Mouth in the south-west in a north-easterly direction until it merges into a grassy community occupying the steep hills adjoining the shoreline.

The forested dune reaches a maximum height of 60m and loses much of its typical dune appearance a short distance north of the river mouth where the wind-deposited sand forms only a shallow capping on top of the clayey hill soil. The change in vegetation corresponds closely to this change in soil properties. A series of embryo dunes, which have been colonized by pioneer species, have formed on the beach close to the river mouth but disappear northwards as the sandstone base to the dunes becomes more exposed. One of the topographical features of the area is a small gully which intersects the dune forest approximately 500m north-east of the Nyara River. A dense forest community is supported in this depression and several species atypical of the dune habitat (such as Calodendrum capense), occur here relatively close to the sea.

The inland margin of the mapped area adjoins the Bosbokstrand Holiday Resort which, apart from the chalet and camping area, is managed as a private Nature Reserve and is therefore an ideal buffer to the proclaimed Coastal Reserve. The seasonal utilization of the beach by the public is only moderately heavy due to the fairly isolated locality of the area and no immediate threat of disturbance is anticipated. The presence of vehicles on the beach has decreased since they were banned but illegal access is still obtained through privately-owned property and stricter measures will have to be enforced in future in order to eliminate the problem.

The precipitation measured on the sampled dune slope for the period June 1st 1982 to May 31st 1983 amounted to 493mm and although very little, it was in fact the highest figure of all the rainfall recording stations in the study area. The results of a soil analysis of samples collected at one point within the forest are given in Table 39. Most of the soil characteristics and the variations with an increase in soil depth corresponded reasonably well with those measured elsewhere on similar dune aspects.

The three plant communities which have been mapped separately are Grassland, Secondary Scrub and forest precursors (probably fire-induced), and Seaward Thicket (which forms the largest continuous community on the sea-facing dune slope). Sampling was only carried out in the latter community and the fifteen sample points were distributed between points A and B (Fig. 33).

| SOIL CHARACTERISTICS | SAMPLE DEPTH (cm) 20 | 80 | 100 |
|---|---|---|---|
| pH | 7,90 | 8,90 | 9,10 |
| %C | 1,25 | 0,23 | 0,28 |
| Na (meq/100g) | 0,89 | 0,65 | 0,74 |
| K " | 0,35 | 0,24 | 0,27 |
| Ca " | 8,79 | 14,68 | 14,75 |
| Mg " | 1,37 | 1,29 | 1,87 |
| S-Val " | 11,4 | 16,86 | 17,63 |
| C.E.C. " | 13,47 | 4,62 | 7,27 |

TABLE 39. SOIL CHARACTERISTICS OF SAMPLE TAKEN FROM THE BOSBOKSTRAND DUNE FOREST.

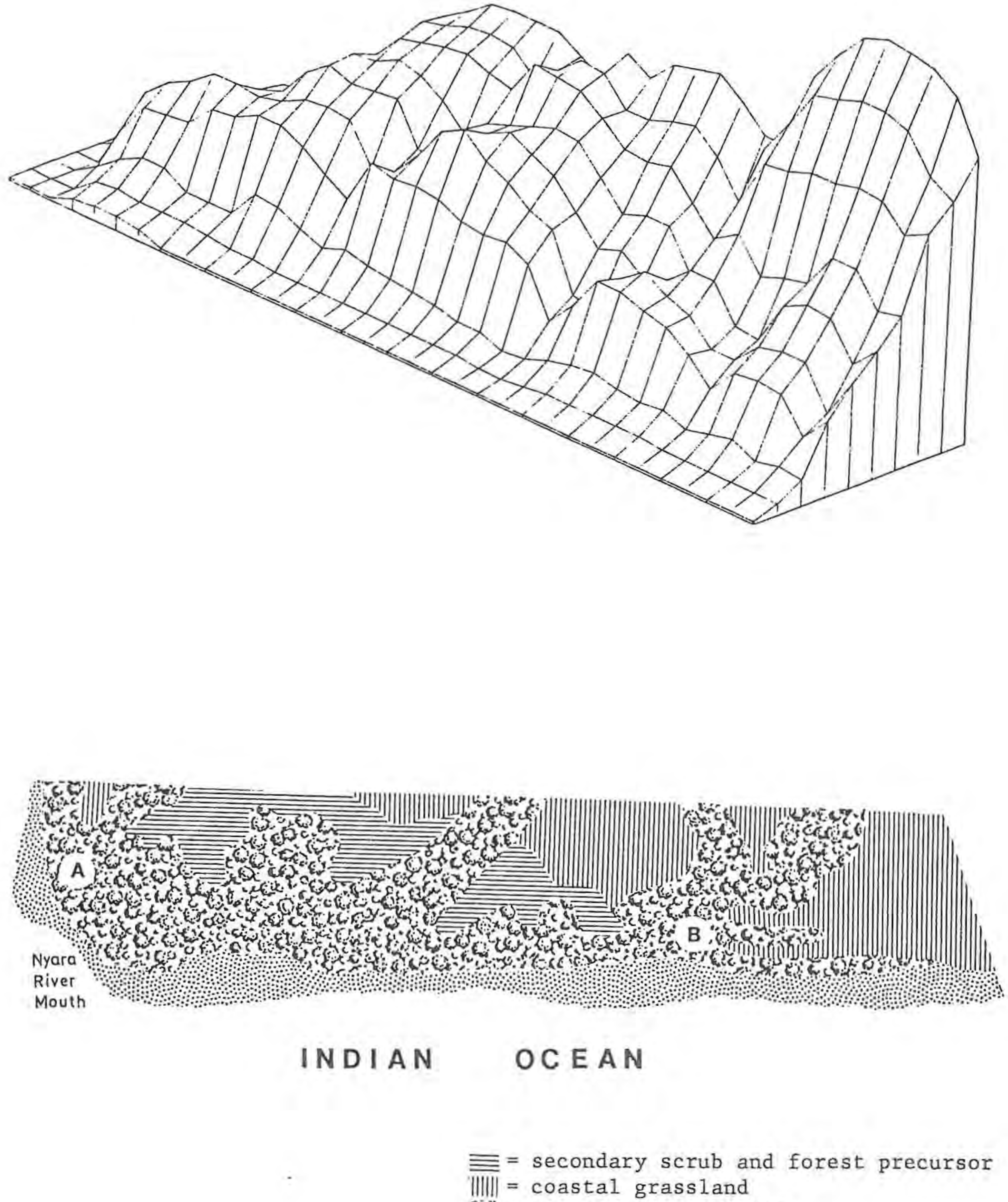



Fig. 33. The Bosbokstrand vegetation and topographical maps illustating the three major plant communities.

The Mimusops caffra - Strelitzia nicolai Sea-facing Thicket

The dominant species contributing towards the canopy are Mimusops caffra, Brachylaena discolor and Strelitzia nicolai, with respective importance values of 35,8 20,5 and 14,5 per cent (Table 40). Sub-dominants are Sideroxylon inerme, Allophylus natalensis and Canthium obovatum with importance values of 5,7 5,4 and 4,6 per cent respectively.

The sub-canopy stratum is floristically richer than the canopy with at least fifteen of the total of twenty-one species recorded capable of achieving canopy status. Typical sub-canopy species such as Acokanthera oblongifolia, Carissa bispinosa and Deinbollia oblongifolia were also recorded fairly frequently. Dominant species are Phoenix reclinata, Maytenus heterophylla and Strelitzia nicolai with respective importance values of 15,3 9,4 and 8,4 per cent. Allophylus natalensis, with an importance value of 7,6 per cent and Euclea natalensis, with an importance value of 6,6 per cent are the sub-dominant species while Brachylaena discolor and Mimusops caffra both have relatively high density values in this stratum (Table 41).

It would appear that the future composition of this community will not change much from the present situation. Most of the important canopy species are equally well represented in the sub-canopy and will be replaced by individuals from this stratum in due course. It is possible that Maytenus heterophylla and Euclea natalensis will increase somewhat in importance in the canopy while Canthium obovatum

TABLE 40. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BOSBOKSTRAND CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 127 | 1,39 | 35,8 |
| *Brachylaena discolor* | 127 | 0,27 | 20,5 |
| *Strelitzia nicolai* | 79 | 0,12 | 14,5 |
| *Sideroxylon inerme* | 24 | 0,11 | 5,7 |
| *Allophylus natalensis* | 32 | 0,04 | 5,4 |
| *Canthium obovatum* | 24 | 0,07 | 4,6 |
| *Maytenus heterophylla* | 16 | 0,03 | 3,3 |
| *Dovyalis rotundifolia* | 16 | 0,03 | 3,2 |
| *Diospyros natalensis* | 8 | 0,10 | 2,6 |
| *Cordia caffra* | 8 | 0,03 | 1,8 |
| *Euclea natalensis* | 8 | 0,01 | 1,5 |
| *Euclea racemosa* | 8 | 0,002 | 1,4 |
| | 477 | 2,202 | 100,3 |

TABLE 41. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BOSBOKSTRAND SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Phoenix reclinata* | 102 | 0,06 | 15,3 |
| *Maytenus heterophylla* | 39 | 0,06 | 9,4 |
| *Strelitzia nicolai* | 52 | 0,03 | 8,4 |
| *Allophylus natalensis* | 77 | 0,01 | 7,6 |
| *Euclea natalensis* | 90 | 0,004 | 6,6 |
| *Deinbollia oblongifolia* | 38 | 0,02 | 6,2 |
| *Sideroxylon inerme* | 25 | 0,03 | 5,7 |
| *Brachylaena discolor* | 64 | 0,002 | 5,6 |
| *Mimusops caffra* | 52 | 0,001 | 4,8 |
| *Cussonia spicata* | 25 | 0,01 | 4,0 |
| *Maytenus nemorosus* | 25 | 0,02 | 3,8 |
| *Harpephyllum caffrum* | 13 | 0,02 | 3,6 |
| *Scutia myrtina* | 38 | 0,004 | 3,6 |
| *Acokanthera oblongfolia* | 25 | 0,001 | 2,6 |
| *Cassine papillosa* | 25 | 0,001 | 2,5 |
| *Cassine aethiopica* | 13 | 0,01 | 2,4 |
| *Dovyalis rotundifolia* | 13 | 0,01 | 2,4 |
| *Diospyros natalensis* | 13 | 0,004 | 1,8 |
| *Cussonia thyrsiflora* | 13 | 0,001 | 1,4 |
| *Carissa bispinosa* | 13 | 0,001 | 1,2 |
| *Euclea racemosa* | 13 | 0,001 | 1,2 |
| | 768 | 0,300 | 100,1 |

could eventually disappear from the community if its present absence in the sub-canopy stratum is considered.

The two most interesting species which hold important positions in the community are Strelitzia nicolai and Phoenix reclinata (Plate 15). Their clumped distribution and high density in this particular forest makes them very conspicuous and a possible reason for this was investigated. Both species, especially Strelitzia nicolai (Breytenbach, 1976) prefer the more moist dune habitats and it was felt that a combination of reasonably high rainfall together with improved utilization of this moisture through reduced soil drainage could influence their distribution and frequency.

The older dunes along this coastline have a high clay content deeper in the soil profile which reduces the free drainage of moisture - which is rapid in most dune soils - and twelve soil pits were excavated at various contours throughout the forest in order to assess the depth at which the clay layer occurs.

The depth of clay-free soil was found to increase down the dune slope, where accumulation of eroded material had taken place, but at the higher contours clay was encountered within 90cm of the surface. It would appear that the dune at Bosbokstrand is relatively old and that pedogenesis has progressed further than in the younger dunes which contain very little clay. It is also likely that this factor has had some influence on the abundance of the above two species in the forest community which was studied.

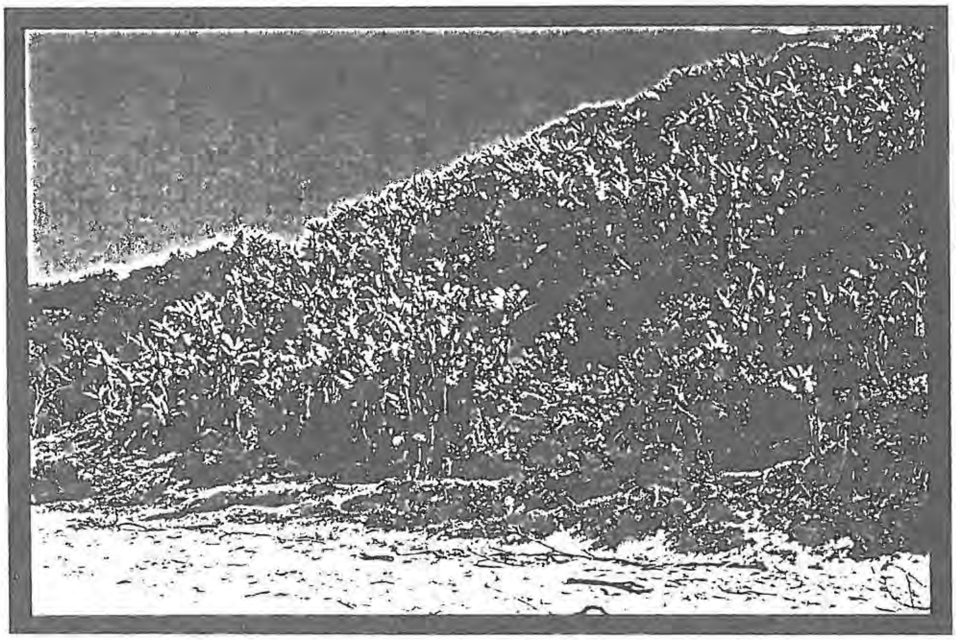


PLATE 15. Strelitzia nicolia - dominated seaward thicket at Bosbokstrand.

Strelitzia nicolai and Phoenix reclinata are fairly common elements of sub-tropical dune forests and at Bosbokstrand, are reaching their southernmost distribution limit.

The canopy varied between 3,5 and 9 metres in height and the calculated mean value was 6,5 metres. Strelitzia nicolai which is not greatly affected by salt spray contributed considerably towards the relatively high canopy, particularly as the community would generally be stunted on the exposed sea-facing site which it occupies. The canopy stand density was 477 Sph with a stem basal area of $2,2m^2$ and that of the sub-canopy 768 Sph and a stem basal area of $0,3m^2$ per hectare.

The cover values for the herb layer ranged between 0 and 80 per cent and a mean value of 22 per cent was calculated. Although lower values are generally recorded on similar dune slopes due to the often very dense canopy, the latter in this case is fairly uneven and a considerable amount of light manages to penetrate to the forest floor.

## 5.6 THE KWENXURA DUNE FOREST

### 5.6.1 Site and forest description

The forest which was studied is situated between the Kwenxura and Nyara Rivers and forms a narrow strip measuring approximately 40 ha in size. It is also included within the Cape Henderson Nature Reserve, which has the Kwenxura River as its south-western boundary. The dune topography is such that although several small patches of forest have developed in relatively sheltered conditions, most of the vegetation occupies the exposed sea-facing dune slope (Fig. 34). Landwards, the forest merges rapidly into coastal grassland, with a narrow ecotone of scrub-forest precursors such as Scutia myrtina, Rhus glauca, Passerina rigida and Allophylus natalensis . There is no well-defined land-facing slope to the main dune since the deposited sand merely forms an extension of the hills which adjoin the coastline. The seaward margin of the forest is bordered by a narrow fringe of short scrub-thicket which in turn adjoins the sandy beach. A series of embryo dunes which have been colonized by Scaevola plumieri and Ipomoea brasiliensis have developed for a short distance south of the Nyara River and probably contribute much towards the protection of the dune forest.

There are two major disturbances to the area. The first is a relatively large blow-out, which occurs close to the Nyara River and which has been partially stabilized by secondary vegetation. It does not pose any threat to adjacent farmland and no active reclamation

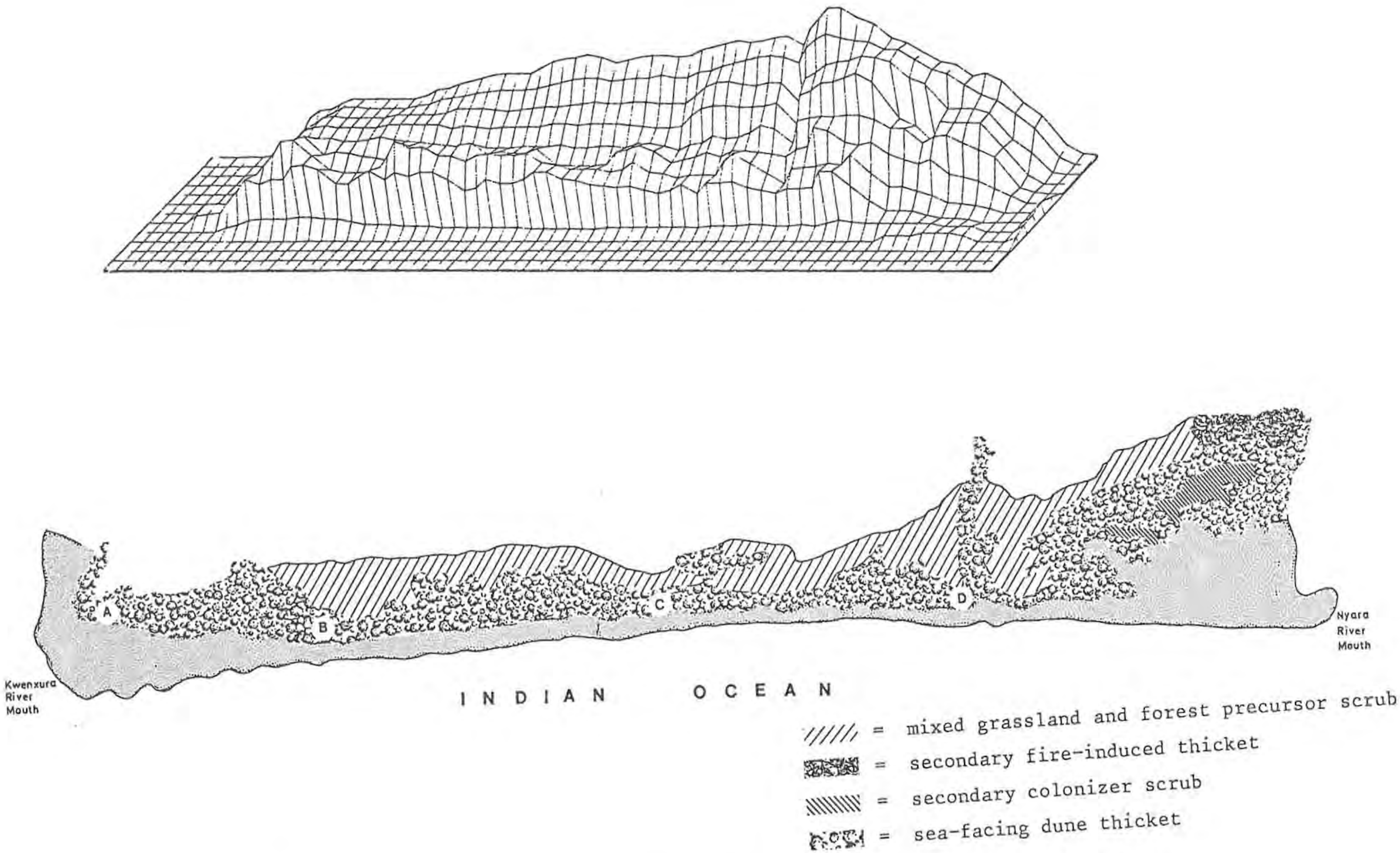



Fig. 34. The Kwenxura vegetation and topographical maps illustrating the four major plant communities.

work is considered necessary (Plate 16). The second is a badly eroded donga which cuts deeply through the main dune approximately 1 km south of the Nyara River and which probably originated through the injudicious use of a natural drainage depression as a footpath or stock route. The boundary fence should prevent any further major deterioration of the situation and with the eventual inevitable collapse of the side walls it should stabilize itself. One advantage of this donga is the profile section through the dune which it exposes (See Plate 17). The typical red colouring of the sand clearly indicates the lateritic deep weathering process which has taken place within what must be one of the older dunes along the coastline.

The only record of a fire having occurred in the area was submitted in August 1972 when a small patch of vegetation was destroyed close to the Nyara River along the inland forest margin. Recovery has been good and there are few apparent signs of any lasting damage.

Access to this forest is limited, with no public roads in the close vicinity. Since the banning of beach vehicles, only very few people walk along the stretch of beach, mainly from the Bosbokstrand Holiday Resort which is north of the Nyara River. The impact of human disturbance on the forest is therefore minimal.

The four plant communities identified and indicated in Fig. 34 are the Mixed Grassland and Forest Precursor Scrub, the Secondary fire-induced Thicket, the Secondary Scrub colonizing the blow-out and the Sea-facing Thicket. Sampling was only carried out in the latter community

PLATE 16. Unstable blow-out south of the Nyara river mouth.

PLATE 17. Lateritic weathering within the dune soil north of Kwenxura river mouth.

and the fifteen sample points used were distributed between points A and B and points C and D as indicated on the map.

The Mimusops caffra - Dovyalis rotundifolia Sea-facing Thicket

The dominant canopy species in this community is Mimusops caffra, with an importance value of 41,2 per cent and a stocking density accounting for 38 per cent of the total number of canopy individuals (Table 42). Maytenus heterophylla, Cassine aethopica and Dovyalis rotundifolia are sub-dominants in the canopy stratum, with respective importance values of 14,7 14,4 and 13,9 per cent. A total of only eleven canopy species were recorded, which is a possible indication of the harsh or exposed environment to which relatively few species are well-adapted.

The sub-canopy is far richer in species than the canopy,with seventeen having been recorded. The dominant species are Dovyalis rotundifolia, Maytenus heterophylla and Cassine aethiopica with calculated importance values of 17,8 14,6 and 14,5 per cent respectively (Table 43). Sub-dominants include Euclea natalensis and Mimusops caffra with respective importance values of 7,1 and 6,5 per cent. Species which typically occur in this stratum, such as Carissa bispinosa and Acokanthera oblongifolia, are reasonably well represented and account for approximately 13 per cent of the sub-canopy population.

It would appear that the canopy composition will, for the foreseeable future, maintain more or less the current status quo, apart from the position of Dovyalis rotundifolia which could increase somewhat in importance. All current canopy dominants and sub-dominants are well

TABLE 42. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWENXURA CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 390 | 9,70 | 41,2 |
| *Maytenus heterophylla* | 170 | 1,97 | 14,7 |
| *Cassine aethiopica* | 153 | 1,69 | 14,4 |
| *Dovyalis rotundifolia* | 153 | 1,43 | 13,9 |
| *Sideroxylon inerme* | 51 | 0,85 | 5,0 |
| *Euclea racemosa* | 17 | 0,54 | 2,2 |
| *Diospyros natalensis* | 17 | 0,38 | 2,0 |
| *Scolopia zeyheri* | 17 | 0,38 | 1,9 |
| *Allophylus natalensis* | 17 | 0,14 | 1,7 |
| *Olea capensis* | 17 | 0,16 | 1,6 |
| *Chionanthus foveolata* | 17 | 0,16 | 1,6 |
| | 1019 | 17,40 | 100,2 |

TABLE 43. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWENXURA SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Dovyalis rotundifolia* | 138 | 0,34 | 17,8 |
| *Maytenus heterophylla* | 69 | 0,49 | 14,6 |
| *Cassine aethiopica* | 110 | 0,30 | 14,5 |
| *Euclea natalensis* | 83 | 0,03 | 7,1 |
| *Mimusops caffra* | 69 | 0,06 | 6,5 |
| *Carissa bispinosa* | 55 | 0,04 | 5,2 |
| *Chionanthus foveolata* | 41 | 0,05 | 4,9 |
| *Euclea racemosa* | 41 | 0,05 | 4,5 |
| *Diospyros natalensis* | 27 | 0,11 | 4,5 |
| *Olea capensis* | 41 | 0,04 | 4,2 |
| *Acokanthera oblongfolia* | 41 | 0,02 | 3,8 |
| *Brachylaena discolor* | 27 | 0,04 | 3,3 |
| *Allophylus natalensis* | 27 | 0,04 | 3,3 |
| *Cassine papillosa* | 14 | 0,05 | 2,0 |
| *Maytenus procumbens* | 14 | 0,02 | 1,5 |
| *Pterocelastrus tricuspidatus* | 14 | 0,01 | 1,4 |
| *Rhus crenata* | 14 | 0,01 | 1,3 |
| | 825 | 1,70 | 100,3 |

represented in the sub-canopy which also contains four species, Euclea natalensis, Brachylaena discolor, Cassine papillosa and Pterocelastrus tricuspidatus, capable of achieving canopy status.

It is of interest to note that although the forest studied and the adjacent forest at Bosbokstrand are floristically similar, with species common to both present in one or the other strata, the absence of certain species is quite striking. Strelitzia nicolai and Phoenix reclinata which are important species at Bosbokstrand were not recorded at all in this forest and neither were Deinbolla oblongifolia nor Harpephyllum caffrum (usually associated with successionally advanced forests). Since the rainfall does not differ significantly between the two sites, some other factor, such as slope or the depth of the humic and relatively unweathered upper soil and the effect this has on drainage, is probably responsible for the difference in species composition. Increased soil moisture associated with a shallow depth of clay-formation in the dune was considered to be a determining factor for the presence of Strelitzia nicolai and Phoenix reclinata, and the absence of these species at Kwenxura could be as a result of a less favourable moisture regime. Several soil cores were extracted with a soil auger throughout the forest and nowhere was clay encountered within 130cm of the surface. At Bosbokstrand clay occurred within 1m on the sites where Strelitzia nicolai was well established and the presence of Deinbollia oblongifolia and Harpephyllum caffrum could also possibly be attributed to the above factor.

The mean canopy height, which was considerably lower than that measured at Bosbokstrand, was 5,1m and varied between 4 and 6,5m. No emergent species were noted. The stand density of the canopy individuals was 1 019 Sph, with a total stem basal area of 17,4$m^2$ per hectare. The density of the sub-canopy stratum was 825 Sph and a stem basal area of approximately 1,7$m^2$ per hectare was calculated.

Cover values for the herb layer, although as great as 80 per cent in some areas, were generally low, with the mean being 13 per cent and the lowest value being 1 per cent. The present exclusion of light by the dense canopy will always tend to preclude the development of a better ground cover.

## 5.7 THE QUEENSBERRY BAY DUNE FOREST

### 5.7.1 Site and Forest Description

This 7 km stretch of forest is situated between the Cintsa River in the north and the Bulura River in the south and occupies for most of its length, a single, discontinuous dune ridge. It measures approximately 105 hectares in extent, varying in width between 75 and 400 metres and has a maximum dune height of 66 metres. The two major dune aspects are sea- and land-facing, with few well developed valleys between successive dune ridges. Much of the beach and dune area is being actively eroded by tidal action and it is only near the Bulura River mouth and adjacent to the farm Beacon Valley that any signs of dune accretion are evident. The occasional primary dunes which do separate the major fixed dune from the beach are mainly colonized by Scaevola plumieri , while a narrow fringe of scrub elements such as Passerina rigida, Carpobrotus edulis and Maytenus procumbens separates the thicket from the open sand in the other areas. Where this fringe community has been eroded away, as it has been at Queensbury Bay itself, the detrimental effects of on-shore salt winds are becoming evident in the deteriorated state of the exposed forest trees. As this appears to be a natural process, there is little which can be done to prevent it.

The dunes are supported by a sandstone base, which is exposed as a platform along the intertidal zone for much of this stretch of coastline. The formation is intersected in at least one place by a narrow dolerite dike which is situated approximately 2 km south of the Cintsa River.

Of the entire study area, this forest and beach area is subjected to possibly the most intense public utilization. Eight caravan parks and chalet resorts have been established within the 7 km and at least one more is in the process of being developed. Both river mouths are well utilized by day visitors and the point off Queensberry Bay is a popular venue for surfing competitions. It is fortunate however that the beach is not also subjected to the stress of off-road vehicles since all access points have been effectively closed off. Several well-aligned and licenced footpaths provide pedestrian access to the sea from the various resorts.

Management of the area includes regular patrolling by staff based at Beacon Valley, the eradication of weeds and the restoration of disturbed dune areas. Of the alien plant species, guava is potentially the most serious invader along the landward forest margin and a successful technique has yet to be established for its eradication. Seasonal disturbance to the vegetation such as through unauthorized footpaths, sand-sliding and trampling is repaired regularly by densely packing such areas with thorn branches and if necessary, sowing indigenous seed in situ.

In mapping the vegetation, seven communities were identified (Fig. 35). They are the thicket and forest communities of the sea- and landward slopes and dune valley, a fire-induced secondary scrub

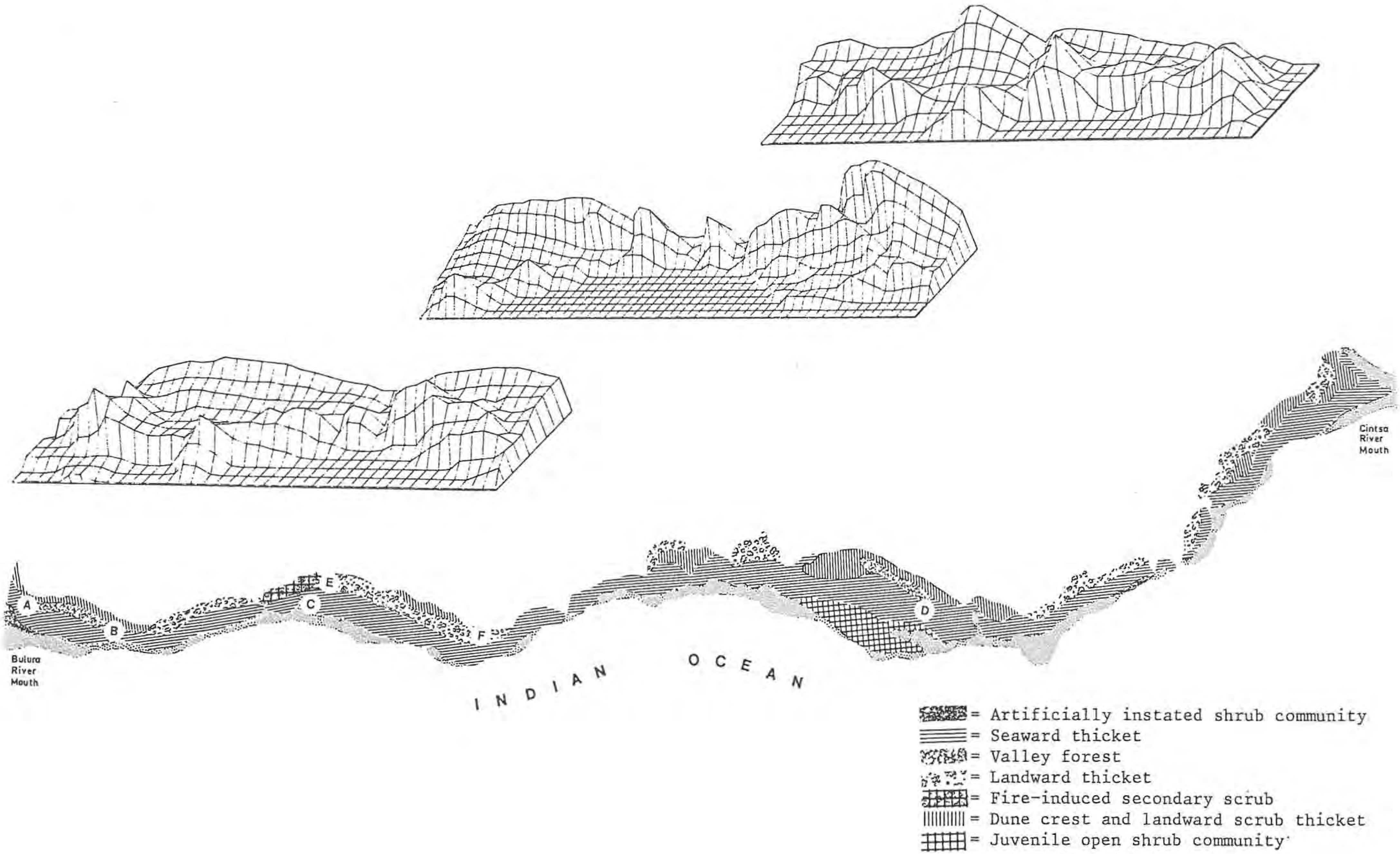



Fig. 35. The Queensberry Bay vegetation and topographical maps illustrating the seven major plant communities.

community, the vegetation of the reclaimed driftsand areas, the scrub-thicket occupying part of the dune crest and landward slope and a juvenile open shrub community represented in two areas. Sampling of the tree component was carried out only in the first three communities. Data which was recorded for the burnt area and developing seaward shrub vegetation in separate studies is discussed in Chapter 3.

The Sideroxylon inerme - Diospyros natalensis valley community

The fifteen points used to sample the valley forest were distributed between the points A and B as indicated in Fig. 35.

The dominant canopy species is Sideroxylon inerme, with an importance value of 31 per cent (Table 44). Sub-dominants in this stratum are Diospyros natalensis and Allophylus natalensis, with respective importance values of 19 and 11 per cent. Maytenus heterophylla is the dominant species in the sub-canopy stratum, with an importance value of 16 per cent, followed by Cassine aethiopica and Dovylis rotundifolia which occur as sub-dominants with importance values of 13 and 12 per cent respectively (Table 45). The latter stratum is comprised of a high per centage of potential canopy elements as well as a number of species such as Psychotria capensis and Acokanthera oblongifolia which retain their sub-canopy status. All species which are currently significant in the canopy stratum appear to be capable of regenerating themselves except for Mimusops caffra which was not recorded at all in the sub-canopy. It would appear as if Maytenus heterophylla and

TABLE 44. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY VALLEY CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 87 | 5,1 | 31 |
| *Diospyros natalensis* | 62 | 2,1 | 19 |
| *Allophylus natalensis* | 36 | 1,0 | 11 |
| *Mimusops caffra* | 15 | 1,8 | 8 |
| *Maytenus heterophylla* | 26 | 0,5 | 8 |
| *Cordia caffra* | 26 | 0,4 | 7 |
| *Zanthoxylum capense* | 10 | 0,3 | 3 |
| *Harpephyllum caffrum* | 10 | 0,2 | 3 |
| *Dovyalis rotundifolia* | 10 | 0,1 | 3 |
| *Schotia latifolia* | 5 | 0,7 | 3 |
| *Scolopia zeyheri* | 5 | 0,2 | 2 |
| *Deinbollia oblongifolia* | 5 | 0,1 | 1 |
| *Cassine aethiopica* | 5 | 0,1 | 1 |
| *Clausena anisata* | 5 | 0,04 | 1 |
| | 307 | 12,64 | 101 |

TABLE 45. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY VALLEY SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Maytenus heterophylla* | 101 | 0,86 | 16 |
| *Cassine aethiopica* | 151 | 0,32 | 13 |
| *Dovyalis rotundifolia* | 134 | 0,19 | 12 |
| *Diospyros natalensis* | 118 | 0,35 | 12 |
| *Allophylus natalensis* | 33 | 0,43 | 7 |
| *Cassine papillosa* | 84 | 0,04 | 5 |
| *Clerodendrum glabrum* | 50 | 0,11 | 5 |
| *Zanthoxylum capense* | 33 | 0,14 | 4 |
| *Scolopia zeyheri* | 33 | 0,04 | 3 |
| *Sideroxylon inerme* | 17 | 0,13 | 3 |
| *Deinbollia oblongifolia* | 33 | 0,07 | 3 |
| *Pavetta revoluta* | 33 | 0,03 | 3 |
| *Psychotria capensis* | 17 | 0,03 | 2 |
| *Chionanthus foveolata* | 17 | 0,03 | 2 |
| *Carissa bispinosa* | 33 | 0,02 | 2 |
| *Clausena anisata* | 17 | 0,03 | 2 |
| *Ficus burtt-davyi* | 17 | 0,01 | 2 |
| *Canthium spinosum* | 17 | 0,11 | 2 |
| *Acokanthera oblongfolia* | 33 | 0,01 | 2 |
| *Rhus natalensis* | 17 | 0,01 | 1 |
| *Dracaena hookerana* | 17 | 0,03 | 1 |
| | 1005 | 2,99 | 102 |

Cassine aethiopica might increase in importance as canopy contributors if their position in the sub-canopy is considered, while Diospyros natalensis and Allophylus natalensis are likely to retain their current positions. Sideroxylon inerme might decrease somewhat in importance if its relatively insignificant position in the sub-canopy stratum is considered.

The canopy height of the forest ranged between 6 and 10 m with a mean value of 7,7 m. The tallest individuals were Sideroxylon inerme, Mimusops caffra and Allophylus natalensis. The canopy stand density was 307 Sph and the measured stem basal area was 12.64$m^2$ per hectare. The sub-canopy stocking was fairly dense at 1005 Sph with a basal area of approximately 3$m^2$ per hectare. The individuals with the greatest DBH were S. inerme (64cm) and M. caffra (56 cm).

Cover values of the herb and shrub layer varied between 50 and 100 per cent. Isoglossa woodii was however very well established on the forest floor and contributed mostly towards the mean cover value of 80 per cent in this stratum.

TheMimusops caffra-Maytenus heterophylla seaward community

The fifteen sample points were distributed between points C and D as indicated in Fig. 35. The two dominant canopy species in this community are Minusops caffra and Maytenus heterophylla, with respective importance values of 32 and 22 per cent (Table 46). Sideroxylon inerme can be regarded as a sub-dominant member, having an importance value of 16 per cent.

TABLE 46. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY SEAWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 300 | 6,3 | 32 |
| *Maytenus heterophylla* | 209 | 2,2 | 22 |
| *Sideroxylon inerme* | 109 | 4,8 | 16 |
| *Cassine aethiopica* | 64 | 0,8 | 6 |
| *Euclea racemosa* | 73 | 0,5 | 6 |
| *Allophylus natalensis* | 46 | 0,3 | 5 |
| *Dovyalis rotundifolia* | 27 | 0,5 | 4 |
| *Olea capensis* | 18 | 0,7 | 3 |
| *Cordia caffra* | 18 | 0,7 | 3 |
| *Brachylaena discolor* | 18 | 0,2 | 2 |
| *Euclea natalensis* | 18 | 0,02 | 1 |
| *Chionanthus foveolata* | 18 | 0,1 | 1 |
| | 918 | 17,12 | 101 |

Cassine aethiopica is the dominant contributor in the sub-canopy stratum, with an importance value of 26 per cent (Table 47). Sub-dominants are Maytenus heterophylla and Euclea racemosa with importance values of 14 and 12 per cent respectively. Carissa bispinosa and Dracaena hookerana , which are typical sub-canopy members, are relatively well represented.

It is interesting to note that Mimusops caffra was not recorded at all in the sub-canopy, making the future status of this species uncertain. M. heterophylla and S. inerme are likely to maintain their current canopy status while C. aethiopica and Euclea racemosa could increase in importance in due course if their positions in the sub-canopy stratum are considered.

The canopy of the seaward community had a stunted appearance and varied in height between 3 and 3,5 m. The mean calculated canopy height was 5,2 m and the tallest individuals were Sideroxylon inerme. The stocking density of the individuals contributing to the canopy stratum was 918 Sph, having a total stem basal area of 17,12 $m^2$ per hectare. The sub-canopy stratum contained 689 Sph and recorded a basal area of 1.35$m^2$ per hectare. The trees with the biggest DBH were Mimusops caffra (36 cm) and S. inerme (34 cm).

Cover values for the combined herb and shrub stratum varied between 0 and 70 per cent. The mean determined cover value was 22 per cent.

The Sideroxylon inerme - Mimusops caffra landward community

The fifteen sampling points were distributed between points E and F as indicated in Fig. 35.

TABLE 47. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY SEAWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 182 | 0,31 | 26 |
| *Maytenus heterophylla* | 68 | 0,26 | 14 |
| *Euclea racemosa* | 57 | 0,25 | 12 |
| *Carissa bispinosa* | 57 | 0,02 | 7 |
| *Chionanthus foveolata* | 68 | 0,02 | 7 |
| *Dracaena hookerana* | 57 | 0,09 | 7 |
| *Euclea natalensis* | 46 | 0,06 | 5 |
| *Deinbollia oblongifolia* | 12 | 0,07 | 3 |
| *Maytenus procumbens* | 12 | 0,09 | 3 |
| *Sideroxylon inerme* | 23 | 0,02 | 3 |
| *Tarchonanthus camphoratus* | 12 | 0,09 | 3 |
| *Ficus burtt-davyi* | 12 | 0,01 | 2 |
| *Mimusops caffra* | 23 | 0,01 | 2 |
| *Brachylaena discolor* | 12 | 0,004 | 2 |
| *Allophylus natalensis* | 12 | 0,02 | 2 |
| *Psychotria capensis* | 12 | 0,01 | 2 |
| *Dovyalis rotundifolia* | 12 | 0,01 | 2 |
| *Acokanthera oblongifolia* | 12 | 0,004 | 1 |
| | 689 | 1,350 | 103 |

Sideroxylon inerme and Mimusops caffra are the two dominant species with respective importance values of 19 and 16 per cent (Table 48). If the importance values alone are considered, the sub-dominant species are Maytenus heterophylla and Euclea natalensis with ratings of 14 and 13 per cent respectively. Both of the latter species however have higher density values than Mimusops caffra and could also therefore be classed as dominants. Although Cassine aethiopica is the dominant sub-canopy member with an importance value of 18 per cent, there appears to be no other clear pattern of sub-dominance (Table 49). Considering their sub-canopy status, it would appear that C. aethiopica and to a lesser extent Diospyros natalensis might increase in community importance in the future while S. inerme, M.caffra, M. heterophylla and Euclea natalensis are likely to retain their current canopy status.

The canopy of this community varied in height between 4 and 15 m and recorded a mean value of approximately 7 m. The tallest individuals were Ficus natalensis which were sampled close to Cintsa Bay. The stand density of the canopy members was 562 Sph and the stem basal area for this stratum was 22.2m$^2$ per hectare. The sub-canopy stand density was 978 Sph and the total basal area for these individuals was calculated at 1.68m$^2$ per hectare. The species with the greatest recorded DBH values were Sideroxylon inerme (40 cm) and Mimusops caffra (38 cm). The estimated ground cover values varied between 0 and 70 per cent and the mean value for this stratum was 16 per cent.

TABLE 48. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY LANDWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 93 | 5,5 | 19 |
| *Mimusops caffra* | 74 | 5,8 | 16 |
| *Maytenus heterophylla* | 93 | 1,1 | 14 |
| *Euclea natalensis* | 83 | 1,8 | 13 |
| *Ficus natalensis* | 28 | 2,2 | 7 |
| *Euclea racemosa* | 37 | 0,9 | 5 |
| *Allophylus natalensis* | 28 | 0,8 | 5 |
| *Cassine aethiopica* | 28 | 0,4 | 4 |
| *Brachylaena discolor* | 28 | 0,5 | 4 |
| *Schotia latifolia* | 10 | 0,9 | 3 |
| *Cordia caffra* | 10 | 0,6 | 2 |
| *Dovyalis rotundifolia* | 10 | 0,5 | 2 |
| *Zanthoxylum capense* | 10 | 0,4 | 2 |
| *Diospyros natalensis* | 10 | 0,4 | 2 |
| *Canthium obovatum* | 10 | 0,3 | 2 |
| *Clerodendrum glabrum* | 10 | 0,1 | 1 |
| | 562 | 22,2 | 101 |

TABLE 49. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE QUEENSBERRY BAY LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 166 | 0,27 | 18 |
| *Diospyros natalensis* | 68 | 0,23 | 9 |
| *Maytenus heterophylla* | 68 | 0,23 | 9 |
| *Pavetta revoluta* | 98 | 0,13 | 9 |
| *Euclea natalensis* | 68 | 0,18 | 8 |
| *Carissa bispinosa* | 98 | 0,07 | 8 |
| *Dovyalis rotundifolia* | 78 | 0,07 | 7 |
| *Sideroxylon inerme* | 49 | 0,07 | 5 |
| *Mimusops caffra* | 49 | 0,02 | 4 |
| *Canthium obovatum* | 29 | 0,08 | 4 |
| *Acokanthera oblongfolia* | 49 | 0,03 | 4 |
| *Clausena anisata* | 29 | 0,05 | 3 |
| *Brachylaena discolor* | 20 | 0,07 | 3 |
| *Ficus natalensis* | 29 | 0,05 | 3 |
| *BULL 1* | 20 | 0,07 | 3 |
| *Zanthoxylum capense* | 20 | 0,02 | 2 |
| *Deinbollia oblongifolia* | 20 | 0,02 | 2 |
| *Olea capensis* | 20 | 0,02 | 2 |
| | 978 | 1,68 | 103 |

### 5.7.2 Floristic and structural comparison between the valley, landward and seaward communities

Definite floristic differences exist between the three sampled communities. A total of thirty species, including both strata, were recorded in the seaward thicket and the landward and valley communities contained thirty four and thirty five species respectively. While a considerable number of species were common to all communities a pattern of exclusivity was also evident. There were five exclusive species in the seaward community, of which Euclea racemosa and Olea capensis were the most significant since they recorded the highest importance and density values. The landward community also contained five such species with Ficus natalensis and Canthium obovatum being the most significant. Of the six exclusive valley species, Harpephyllum caffrum and Cassine papillosa were of greatest importance.

The canopy height differed quite considerably between the three communities, with the valley forest being the tallest and the seaward thicket, the most stunted. The canopy and overall stocking density was lowest in the valley forest and greatest in the seaward community, with a reverse pattern evident in the sub-canopy. In the latter stratum fewest stems occurred in the seaward thicket and most in the valley forest. This was expected, since the dense canopy cover of the seaward vegetation tends to preclude the development of sub-ordinate strata while the more open nature of the climax valley forest and increased light penetration encourages such development. The combined stem basal area for both strata was greatest in the landward community and least in the valley community, although in the latter case, the basal area of the sub-canopy stratum was considerably higher than on the other sites. The ground cover was very high in the valley community due again to the greater light penetration and more moist conditions and was lowest on the hotter and less stable landward slope.

### 5.7.3 Multivariate Analysis Results and Discussion

#### Classification

On the basis of the canopy data, it was not possible to classify the sampled stands into communities or groups which corresponded exactly to the three different sites occupied by the vegetation. This could be due either to an insufficient sampling intensity, or the community homogeneity requirements not having been met - which in turn could imply that the vegetation of the valley and sea and land-facing sites is not significantly different. In spite of this, some pattern is evident in the data given in Table 50. Of the three vegetation groups identified, only one which consists of predominantly valley stands, has the appearance of representing a true community as such. Both of the other two groups are nevertheless comprised predominantly of either landward or seaward sampled stands. Diospyros natalensis, and to a lesser extent Cordia caffra, can be regarded as diagnostic species of the valley forest. Sideroxylon inerme also plays a significant role in this community but its range also extends into the

TABLE 50. CLASSIFICATION OF THE QUEENSBERRY BAY CANOPY SPECIES.

**VALLEY COMMUNITY**

| POINT Nos. | 11 | 22 | 42 | 12 | 17 | 36 | 37 | 31 | 43 | 33 | 38 | 41 | 44 | 45 | 9 | 35 | 40 | 13 | 16 | 32 | 34 | 39 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | | | | | | | | | | | | | | | | | | | | | | |
| Har. caf. | | | | | | | | | | | | | | | | | | | | 5 | 5 | |
| Dei. obl. | | | | | | | | | | | | | | | | | | | | 5 | | |
| Ole. cap. | | | | | | | | | | | | | | | | | | | 5 | | | |
| Fic. nat. | | | | | | | | | | | | | | | | | | 5 | | | | |
| Cla. ani. | | | | | | | | | | 4 | | | | | | | | | | | | |
| Zan. cap. | | | | 5 | | | | 5 | 5 | | | | | | | | | | | | | |
| Sco. zey. | | | | | | | 5 | | | | | | | | | | | | | | | |
| Chi. fov. | | 5 | | | | | | | | | | | | | | | | | | | | |
| Cor. caf. | 5 | | | | 5 | | 5 | 5 | | | | | | | | 5 | | | | | 5 | 5 |
| Dio. nat. | | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | | | | | |
| Bra. dis. | 5 | 5 | | 5 | | | | | | | | | | | | | | | | | | |
| Sch. lat. | | | | | | | | | | | | | | | | | | | | | | |
| May. nem. | | | | | | | | | | | | | | | | | | | | | | |
| Dov. rot. | | | | | | | | | | | | | | | | | | | | 5 | | 5 |
| Cas. aet. | | | | | | | | | | | | | | | | | | | | | | 5 |
| Euc. nat. | | | | | | | | | | | | | | | | | | | | | | |
| Can. obo. | | | | | | | | | | | | | | | | | | | | | | |
| Cle. gla. | | | | | | | | | | | | | | | | | | | | | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | |
| All. nat. | | | | 4 | | | | | | | | 5 | 5 | 5 | 4 | | 4 | | | | 5 | |
| Sid. ine. | 4 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | 5 |
| May. het. | | | | 5 | 4 | 5 | 4 | | 5 | | | 5 | | 5 | | | | | | | | |
| Mim. caf. | 5 | 5 | 5 | | | | | | | | | | | | 5 | 5 | 5 | | | | | |

**LANDWARD COMMUNITY**

| POINT Nos. | 6 | 14 | 15 | 19 | 28 | 18 | 23 | 10 | 21 | 4 | 5 | 7 | 3 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | | | | | | | | | | | | | | |
| Har. caf. | | | | | | | | | | | | | | |
| Dei. obl. | | | | | | | | | | | | | | |
| Ole. cap. | | | | | | | | | | | | | | |
| Fic. nat. | | | | | | | | | | | | | | |
| Cla. ani. | | | | | | | | | | | | | | |
| Zan. cap. | | | | | | | | | | | | | | |
| Sco. zey. | | | | | | | | | | | | | | |
| Chi. fov. | | | | | | | | | | | | | | |
| Cor. caf. | | | | | | | | | | | | | | |
| Dio. nat. | | | | | | | | | | | | | | |
| Bra. dis. | | | | | | | | | | | | | | |
| Sch. lat. | | 5 | | | | | | | | | | | | |
| May. nem. | | | | | | 4 | | | | | | | | |
| Dov. rot. | | | | | | 5 | 5 | 5 | | | | | | |
| Cas. aet. | 5 | 4 | 5 | 5 | 5 | 5 | | | | | | | | |
| Euc. nat. | 5 | | | | | | | 5 | 5 | 5 | 5 | 5 | | 4 |
| Can. obo. | | | | | | | | | | | | | | 5 |
| Cle. gla. | | | | | | | | | | | | | | |
| Euc. rac. | | | | | | | | | | 5 | | | | |
| All. nat. | | | 5 | 5 | 5 | | 4 | 4 | | | | | | |
| Sid. ine. | 5 | 5 | 5 | 5 | | | | | | 5 | 5 | | 5 | |
| May. het. | | 4 | 4 | | 5 | | 5 | | | 4 | 5 | 5 | 4 | 4 |
| Mim. caf. | | | | 5 | | 5 | | 5 | 5 | | | | 5 | 5 |

**SEAWARD COMMUNITY**

| POINT Nos. | 20 | 27 | 29 | 30 | 25 | 26 | 1 | 2 | 24 |
|---|---|---|---|---|---|---|---|---|---|
| SPECIES | | | | | | | | | |
| Har. caf. | | | | | | | | | |
| Dei. obl. | | | | | | | | | |
| Ole. cap. | | | | | | | | | |
| Fic. nat. | | | | | | | | | |
| Cla. ani. | | | | | | | | | |
| Zan. cap. | | | | | | | | | |
| Sco. zey. | | | | | | | | | |
| Chi. fov. | | | | | | | | | |
| Cor. caf. | | | | | | | | | |
| Dio. nat. | | | | | | | | | |
| Bra. dis. | | | | | | | 4 | | |
| Sch. lat. | | | | | | | | | |
| May. nem. | | | | | | | | | |
| Dov. rot. | | | | | | | | | |
| Cas. aet. | | | | | | | | | |
| Euc. nat. | | | | | | | | | |
| Can. obo. | | | | | | | | | |
| Cle. gla. | | | | | | | | 5 | |
| Euc. rac. | | | | | 5 | 5 | 4 | 5 | 5 |
| All. nat. | | | | | | | | | |
| Sid. ine. | | | | | | | | | |
| May. het. | 5 | 5 | 4 | 5 | 5 | 5 | | 5 | 5 |
| Mim. caf. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | |

landward thicket as well and in this case cannot be regarded as a diagnostic. The group of landward stands is characterized by Euclea natalensis, and Cassine aethiopica, while Euclea racemosa is the only differentiating species of any significance in the group of seaward stands. Mimusops caffra and Maytenus heterophylla are ubiquitous in all three of the sites sampled while Sideroxylon inerme and Allophylus natalensis are common to both the valley and landward vegetation.

The classification of the sub-canopy stand data is illustrated in Table 51. The three groups identified conform only broadly to the three sites which were sampled but this was not unexpected for this stratum. A clear association between site and species is only really evident for the valley and seaward vegetation and in the case of the group of predominantly landward stands, the four differentiating species contained therein cannot be regarded as being significantly diagnostic. As with the canopy stratum, Diospyros natalensis is clearly characteristic of the valley sub-canopy while Cassine papillosa and Chionanthus foveolata also appear to have a similar site distribution. In the case of the seaward vegetation, the sub-canopy floristic composition appears to show a more clear association with the site than is the case with the canopy individuals. Here, Euclea natalensis, Euclea racemosa and Mimusops caffra appear to have possible diagnostic status. Of the five sub-canopy species common to all three sites Maytenus heterophylla and Cassine aethiopica are the most significant. Carissa bispinosa, although recorded throughout the area appears to have a slight preference for the landward site.

TABLE 51. CLASSIFICATION OF THE QUEENSBERRY BAY SUB-CANOPY SPECIES.

| | VALLEY COMMUNITY | | | | | | | | | | | | | | | LANDWARD COMMUNITY | | | | | | | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 4 | | 4 | 3 | 3 | 3 | 1 | 3 | 4 | 4 | | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | | | 3 | 3 | 1 | 4 | | 1 | 1 | 4 | 3 | 3 | | | 2 | 2 | | 1 | 2 | | 1 | 2 | 2 | 2 |
| | 5 | 9 | 0 | 1 | 2 | 3 | 5 | 6 | 1 | 2 | 3 | 7 | 0 | 3 | 8 | 4 | 8 | 1 | 6 | 8 | 9 | 4 | 5 | 1 | 9 | 0 | 4 | 2 | 3 | 7 | 5 | 5 | 7 | 1 | 8 | 5 | 6 | 7 | 2 | 1 | 6 | 9 | 0 | 2 | 4 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tur. obl. | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cla. gla. | | | | 5 | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap. | | | | 4 | 5 | | | | 4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Can. spi. | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| All. nat. | | | 5 | | | | | | | 5 | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pav. rev. | | | | | | | 5 | | 4 | 4 | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | |
| Dio. nat. | 5 | 5 | 4 | | 5 | 4 | | 4 | 5 | | 5 | | | | | | | | | | | | | | 4 | 5 | | | | | | | | | | | | | | | | | | | |
| Cla. ani. | | 4 | 5 | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| Chi. fov. | | | | | | | | | | | 4 | 4 | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Ole. cap. | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | |
| Fic. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | |
| Tar. cam. | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zan. cap. | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | | | | | | 5 | | | | | | | | | | | | |
| Bra. dis. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 | |
| Sco. zey. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | | | | | | | | | | | | |
| Mim. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | 5 | | 5 | 4 | | | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | 5 | 5 | | 5 |
| May. pro. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | |
| Sul. ill. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | |
| Euc. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | 4 | 5 | 4 | 5 | 5 | | | | | |
| Dei. obl. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | 5 | 5 | | 4 | | | | | | | | | | | | |
| Cas. aet. | | | | | | | | | | 5 | | | | 5 | | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | | 4 | 5 | 5 | 5 | 5 | 4 | 5 | | 4 | 5 | 4 | 4 | | | | 5 | 4 | 5 | 5 | |
| Car. bis. | 4 | | | | | | | | | | 4 | 5 | 5 | | | 4 | | | | 4 | 5 | | 4 | | 4 | | 4 | | | | | | | | | | | 5 | | | 4 | 4 | | | |
| May. het. | | | | 5 | | 5 | | | | | | | | | 5 | | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | 5 | 5 | 4 | | | | | | | | |
| Sid. ine. | | | | | | | | 5 | | | 4 | 5 | | | | 5 | 4 | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | |
| Dov. rot. | | 5 | 4 | 4 | | 4 | | 5 | | | | | 5 | | | | | | | | | 4 | 4 | 4 | 4 | | | 5 | | | 5 | | 4 | | | | | | | | | | | | |
| Aco. obl. | | | | | | | 5 | 4 | 4 | | | | | | | 4 | | 5 | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| Psy. cap. | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | 5 | | | |
| Can. obo. | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | 4 | | | | | | |
| Dra. hoo. | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | 5 |
| Fic. bdv. | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | |

In the classification of the combined canopy and sub-canopy data, relatively good groupings of site-associated sample stands were obtained, particularly in respect of the valley and landward vegetation (Table 52). The latter communities each contained a number of species in both strata which could be regarded as either differential or diagnostic and their significance has already been discussed. It is interesting to note that of the species grouped as being common to all three communities, the sub-canopy individuals are most prominent. Environmental factors are likely to be less variable for the subordinate strata members than in the canopy and it is felt that this is an important linking element be between the three sites sampled. Mimusops caffra is shown in the classification to be common to the seaward and landward sites and of little significance overall in the valley community. This tends to support the belief that it is not an important species in climax dune forest in spite of its dominant position in sub-climax thicket.

Ordination

The ordination of the canopy sample data produced reasonably clear site-associated groupings of stands on the scatter diagram (Fig 36). Group A (the seaward stands) and Group B (the valley stands) show the least floristic affinity for one another in terms of DCA-Axis I, while Group C (the landward stands) in its centrally plotted position appears to have some affinity for both. The elevated position of Group C in terms of the DCA-Axis II indicates however that the landward vegetation does have some floristic identity of its own which

TABLE 52. CLASSIFICATION OF THE QUEENSBERRY BAY CANOPY AND SUB-CANOPY SPECIES.

| | VALLEY COMMUNITY | | | | | | | | | | | | | | | | LANDWARD COMMUNITY | | | | | | | | | | | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. : | 32 | 39 | 31 | 33 | 38 | 43 | 9 | 40 | 41 | 13 | 17 | 37 | 47 | 35 | 34 | 44 | 11 | 42 | 14 | 15 | 19 | 4 | 5 | 16 | 36 | 28 | 10 | 23 | 6 | 22 | 18 | 1 | 7 | 8 | 21 | 12 | 20 | 25 | 26 | 29 | 2 | 3 | 24 | 27 | 30 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zan. cap.1 | | |5| | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | |
| Dei. obl.1 |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cla. ani.1 | | | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Can. spi.2 | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fic. nat.1 | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fic. nat.2 | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sco. zey.1 | | | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Har. caf.1 |5| | | | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fic. bdv.2 | | | | | |5| | | | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tur. obt.2 | | | | | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sco. zey.2 | | | | | | | | | | | |5| | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cle. gla.2 |5| |5|5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dei. obl.2 | | | | | | | | | |4|5|4|5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dio. nat.1 | | |5|5|5|5|5|4|5| | | |5| |5|5| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf.1 | |5|5| | | | | | | |5|5| |5|5| |5| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap.2 |5| |5| | | | | |4| | | | | | | | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zan. cap.2 | | | | | | | | | | | |5| | | |5| | | | | | | | | | |4| | | | | | | | | | | | | | | | | | |
| Cla. ani.2 | | | | | | |4|5| | | | | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | |
| Dio. nat.2 |5|4| |4| |5|5|4|5| | | | | | | | | | | | | | | |4| |5| | | | | | | | | | | | | | | | | | |
| Dov. rot.2 | |4|4|4| | |5|4| | | |4|5|4| | | | | | | |4|4| |5| | | | | | | | | | | | | | | | |5| | | |5|
| Tar. cam.2 | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | |
| Can. obo.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | |
| Bul. ill.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | | |
| May. nem.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |4| | | | | | | | | | | | | | |
| Chi. fov.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | | | | |
| Bra. dis.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5|5| | | | | | | | | | | | | | | |
| Sch. lat.1 | | | | | | | | | | | | | | | | |5|5| | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. aet.1 | |5| | | | | | | | | | | | | | | | |4|5|5| | | | |5| | |5| |5| | | | | | | | | | | | | | |
| Euc. nat.1 | | | | | | | | | | | | | | | | | | | | | |5|5| | | |5| |5| | | |5|4| | | | | | | | | | | |
| Bra. dis.1 | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | |5| |4| | | |5| | | | | | | | | |
| Mim. caf.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |4| | |4|5| |5| | | | | | | | | | |
| Aco. obl.2 | | | | | | | | | | | | | | | | |5| |4|5| | | | |4| | | | | | | | | | | | | | |4| | | | | |
| Ole. cap.1 | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | | | | | | | | | | |
| All. nat.2 | | | | | | | |5| | | | | | | | | |5| | | | | | | | | |5| | | | | | | | | | | | | | | | | |
| Pav. rev.2 | | | | | | | | |4| | | | | | | |5|4| |5| | | | | | | | | | | | | | | |5| | | | | | | | | |
| Sid. ine.2 | | | | | | | | | | | | | | | | | | |5| | | | | |5|4| | | | | | | |5| | | | | | | |4| |5| |
| May. pro.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | |
| Ole. cap.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | |
| Cle. gla.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | |
| Euc. rac.2 | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | | | | | | | |5|5| | | | |5| | |
| Dra. hoo.2 | | | | | | | | | | | | |4| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |5|5|5|
| Euc. rac.1 | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | | |4| | | | | | |5|5| |5| |5| | |
| Psy. cap.2 | | | | | | | | | | | | | |5| | | | | | |5| | | | | | | | | | | | | | | | | | | | | | | | |
| All. nat.1 | | | | | | | |4|5| | | |5|5|4|5| | | |5|5| | | | |5|4|4| | | | | | | |4| | | | | | | | | |
| Dov. rot.1 |5|5| | | | | | | | | | | | | | | | | | | | | | | | |5|5| | |5| | | | | | | | | | | | | | |
| Sid. eni.1 |5|5|5|5|5|5|5|5|5|5|5|5|5| | |5|4|5|5|5|5|5|5|5|5| | | |5|5| | | | | | | | | | | | |5| | | |
| Dov. rot.2 | |4|4|4| | |5|4| | | |4|5|4| | | | | | | |4|4| |5| | | | | | | | | | | | | | | | |5| | | |5|
| May. het.2 | |5|5|5|5| | | | | | | | |5| | |5| | | | |5|5|4| |5| | | | |5| | |5| | | |5|4|5| | | | | |
| Cas. aet.2 | | | | | | | | | |5|5| |4|5|5|5|4|5|5| |4|5|5|5| |5|4|5|5|5|5|4| |5| | |5|4|4|5|5| | | | |
| May. het.1 | | | | | |5| | |5| |4|4|5| | | | | |4|4| |4|5| |5|5| |5| | | | |5|4| |5|5|5|5|4|5|4|5|5|5|
| Car. bis.2 | |4| | | |4| | | | | | | | | |4| | |4| |4| |4| | | | | |4| |4| |5| | | | | | |5| |4| |5|5|
| Mim. caf.1 | | | | | | |5|5| | | | | | |5| |5|5| | |5| | | | | |5| | |5|5|5| |5|5| |5|5|5|5| |5| |5|5|
| Can. obo.2 | | | | | | | | | | | | | | | | | | | | | | | | | | |5| | | | | | | | |4| | | | | | | | | |
| Chi. fov.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |5| |5| | | | | | | | | | | | |4|5|4| |
| Euc. nat.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |4|4|5|5|5| |4|5| | | | | | |

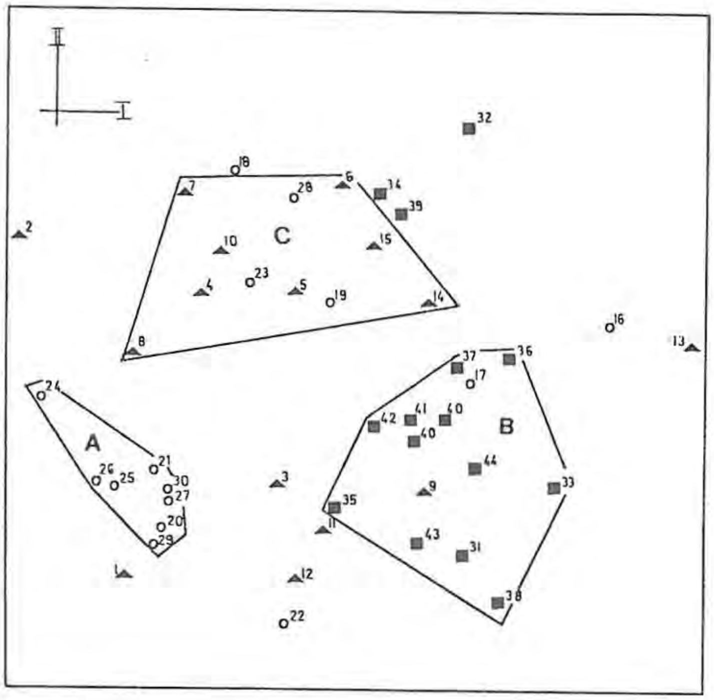



Fig. 36.
Ordination of the Queensberry Bay canopy data. Group A represents the seaward community, Group B the valley community and Group C, the landward community.
o = seaward stands
■ = valley stands
▲ = landward stands

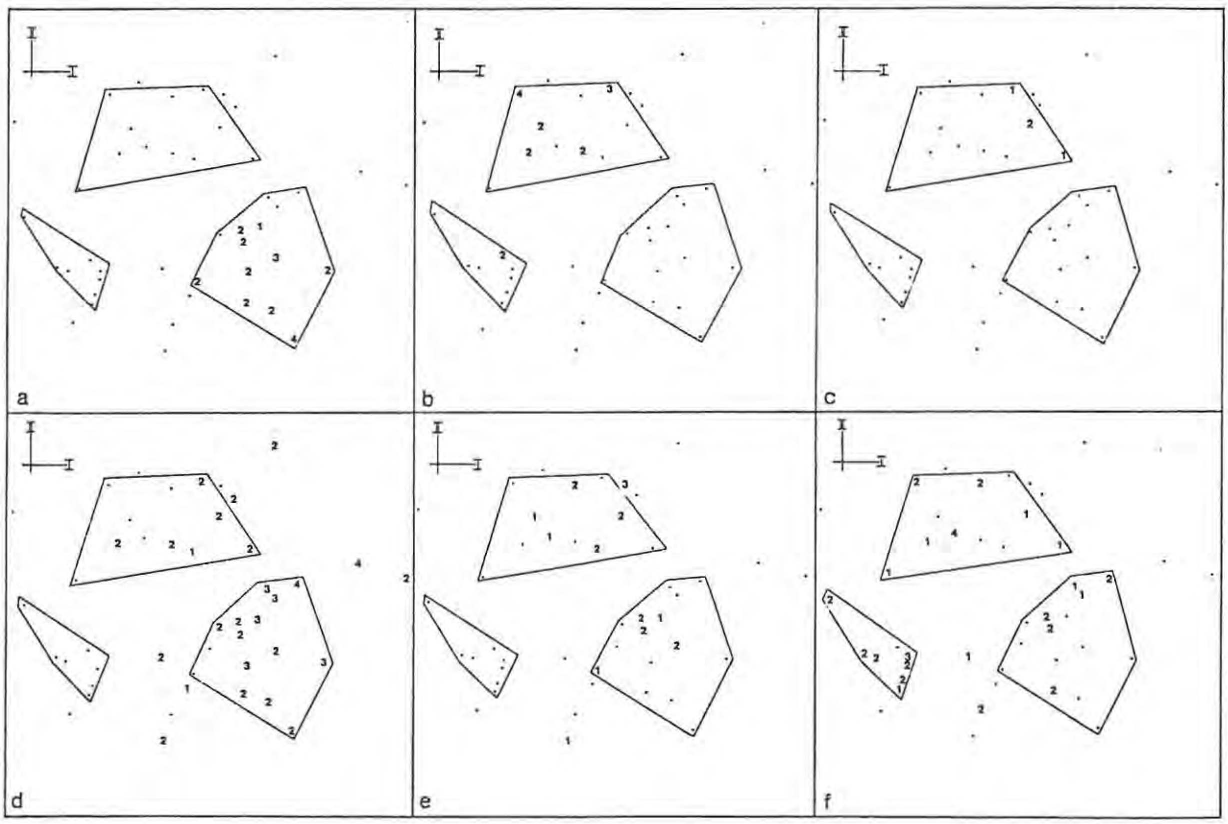



Fig. 37.
Positions on the Queensberry Bay canopy ordination of (a) *Diospyros natalensis*, (b) *Euclea natalensis*, (c) *Cassine aethiopica*, (d) *Sideroxylon inerme*, (e) *Allophylus natalensis* and (f) *Maytenus heterophylla*.

(·-4 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60% and 4 = 61-80%)

could distinguish it as a community. The significance of certain differentiating canopy species which are responsible for the creation of the above groups, as well as linking or common species is illustrated in Figs. 37(a) to (f).

The plot of Diospyros natalensis on the ordination (Fig 37(a) indicates its exclusive association with the valley site, while similar but less explicit patterns are also evident for Euclea natalensis and Cassine aethiopica in the case of the landward vegetation (Figs. 37(b) and (c)). The contributing role played by Sideroxylon inerme, and to a lesser extent Allophylus natalensis, in the canopy composition of the valley and landward forest is shown in Figs. 37(d) and (e). Fig. 37(f) illustrates the common distribution of Maytenus heterophylla on all three sites which were sampled.

The sub-canopy ordination did not produce clearly defined or dissociated community groups on the scatter diagram (Fig. 38). The floristic associations between samples from the various sites appeared to be only broadly related, particularly in the case of the seaward vegetation (Group C), of which a number of outlier samples are evident on the ordination. Species which can be regarded as important in the creation of the groups shown in Fig. 38 are relatively few and are discussed briefly below.

The distributions of Diospyros natalensis and Cassine papillosa on the ordination (Figs. 39(a) and (b)) indicate that they contribute quite significantly towards the composition and identity of the valley sub-

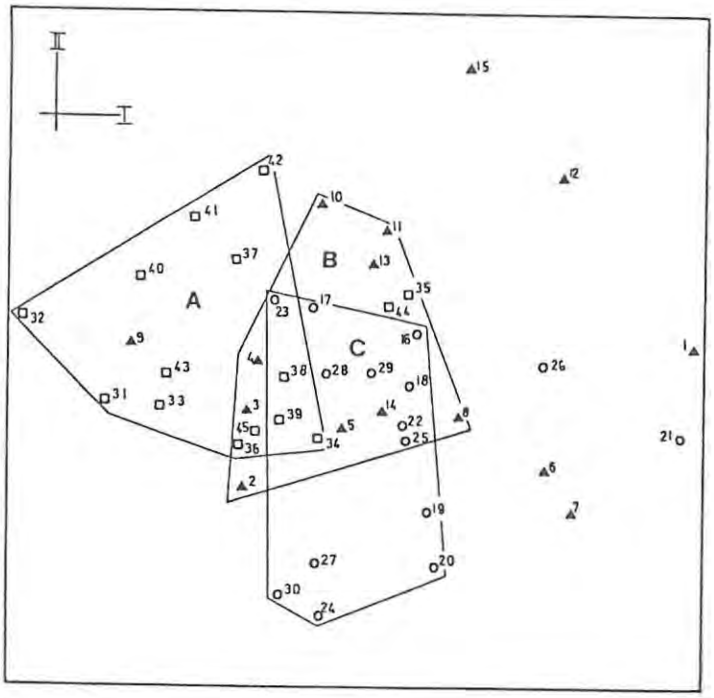


Fig. 38.
Ordination of the Queensberry Bay sub-canopy data. Group A represents the valley community, Group B the landward community and Group C the seaward community.
□ = valley stands
▲ = landward stands
○ = seaward stands

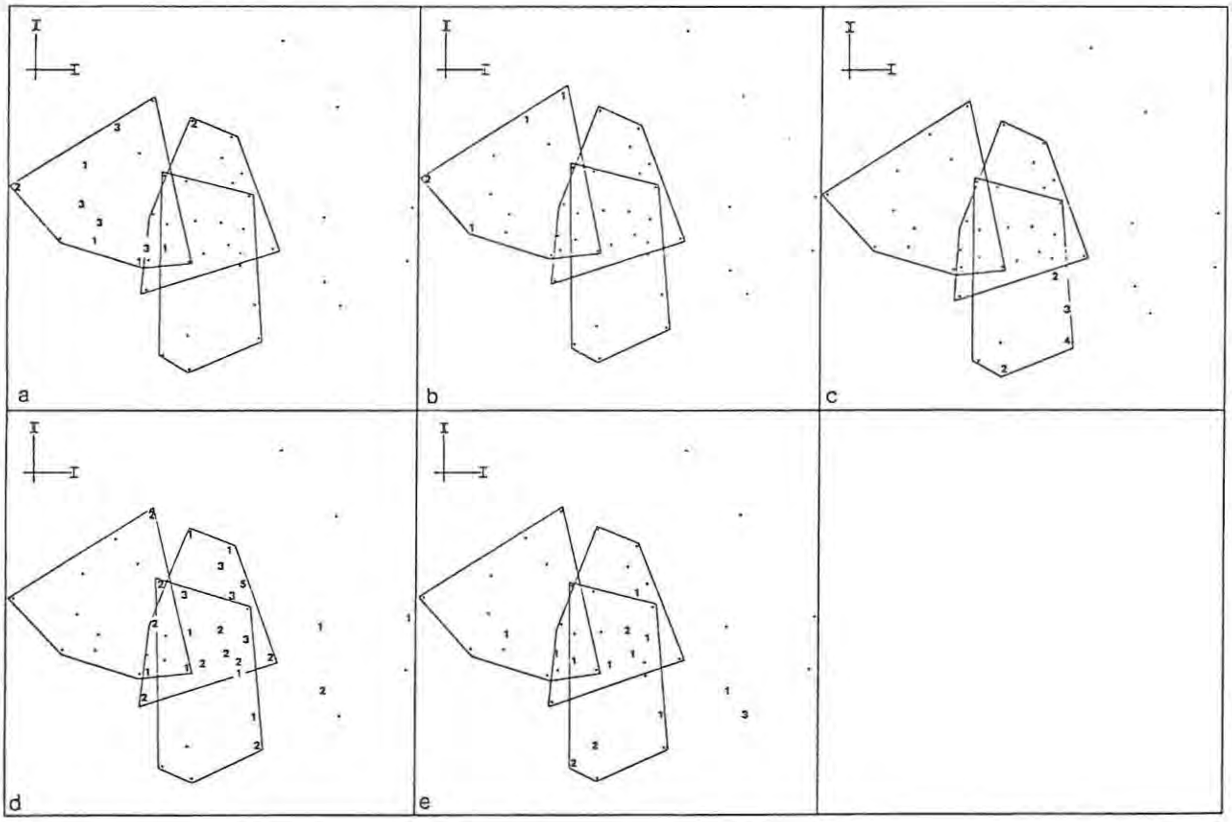


Fig. 39.
Positions on the Queensberry Bay sub-canopy ordination of (a) Diospyros natalensis, (b) Cassine papillosa, (c) Euclea racemosa, (d) Cassine aethiopica and (e) Carissa bispinosa.

(·-5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

canopy stratum. Euclea racemosa is also shown in Fig. 39(c) to play a similar role in the case of the seaward vegetation. Cassine aethiopica and Carissa bispinosa act as differentiating species in the case of the sea- and landward thicket which distinguish the latter from the sub-canopy stratum of the climax valley forest (Figs. 39(d) and (e)).

The ordination of the combined canopy and sub-canopy data provided much the same type of stand groupings as those described for the individual strata (Fig. 40). Overall, these groups could be described as representing site-related communities with a certain degree of floristic continuity between them - as is evident on the ordination. As with the other dune forest areas studied, certain species are definitely more restricted to specific sites than others which might reflect either a degree of environmental intolerance or simply a successional feature, or both. Diospyros natalensis is the best example at Queensberry Bay of a species which occurs only in sheltered climax forest. Sideroxylon inerme on the other hand was found to occur mainly in the valley and sub-climax landward communities but was infrequent in the seaward thicket while Maytenus heterophylla showed little preference for any particular community and was relatively common throughout. The behaviour of these and other species has however been discussed earlier.

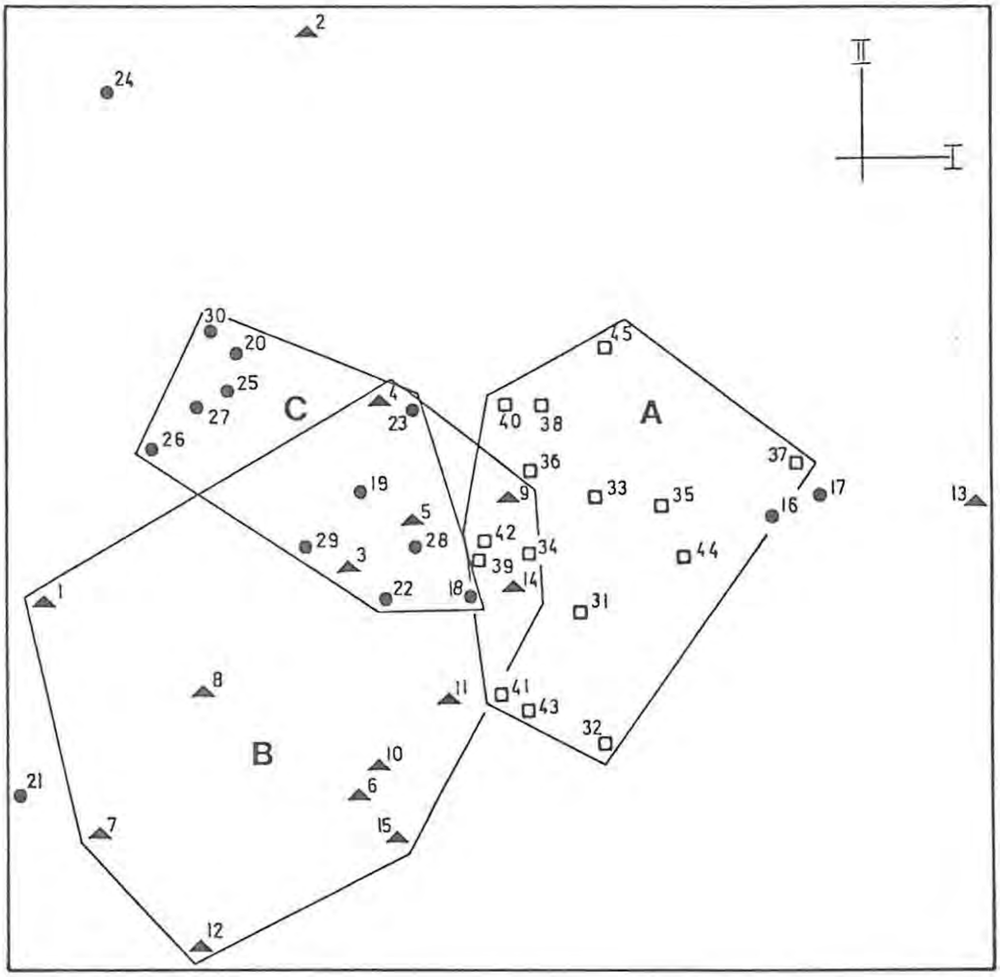



Fig. 40.
Ordination of the combined canopy and sub-canopy data for Queensberry Bay. Group A represents the valley community, Group B the landward community and Group C, the seaward community.

□ = valley stands
▲ = landward stands
● = seaward stands

## 5.8 THE KWELERA DUNE FOREST

### 5.8.1 Site and Forest description

The woody plant communities at Kwelera are in general in a pristine state and include possibly the finest example of developed dune forest along the entire East London coast. The area was proclaimed as a Nature Reserve during 1984 in order to afford it a greater protection status and it is one of the three such reserves along this stretch of coast.

The area is bordered in the north by the Kwelera River and in the south by the Gonubie River and measures some 200 ha in extent. It is comprised of approximately 120 ha of forest, with most of the remaining area covered by coastal grassland.

The Kwelera Village, which was excised from State Forest land in 1925 is enclosed by the Nature Reserve and the township of Sunrise-on-Sea and the Rainbow Valley Holiday Resort adjoin part of the landward boundary of the forest. Much of the remaining area, inland of this boundary, has been cleared of indigenous vegetation for agriculture and it is obvious that the forests were at one time considerably more extensive.

Much of the coastline here is rocky, with a very narrow apron of sand adjacent to the forest. Active erosion by the sea has however undermined the seaward dune slope in the south, close to Rainbow Valley, and exposed a pebble and boulder beach which was previously covered with sand.

The topography of the area is interesting, in that the forested dune valley, which is indicated in Fig. 41, is in fact the 'floor' or wake zone behind an old parabolic dune which originated as a breach in the longitudinal barrier dune close to Sunrise-on-Sea. One of the remnant trailing arms of the parabolic dune has more or less fused with the seaward barrier dune, while the other arm can still be distinguished as a slight ridge landwards of the valley. The head of the dune which was moved north-eastwards by the south-westerly winds is now quite insignificant and has been stabilized by scrub-thicket vegetation. The dune system reaches a maximum height of 70 m and varies in width between 100 and 700 m.

Management of this area has included: The erection of fencing along the landward boundary, assisting the restoration of the disturbed sub-canopy stratum between the Gonubie River and Rainbow Valley by packing the forest floor with thorn branches and the provision of picnic facilities at Kwelera point. Regular patrols are carried out by Forest Guards who are based in the Reserve.

The following plant communities can be distinguished and have been mapped as such in Fig. 41. The forest of the sea-facing slope of the

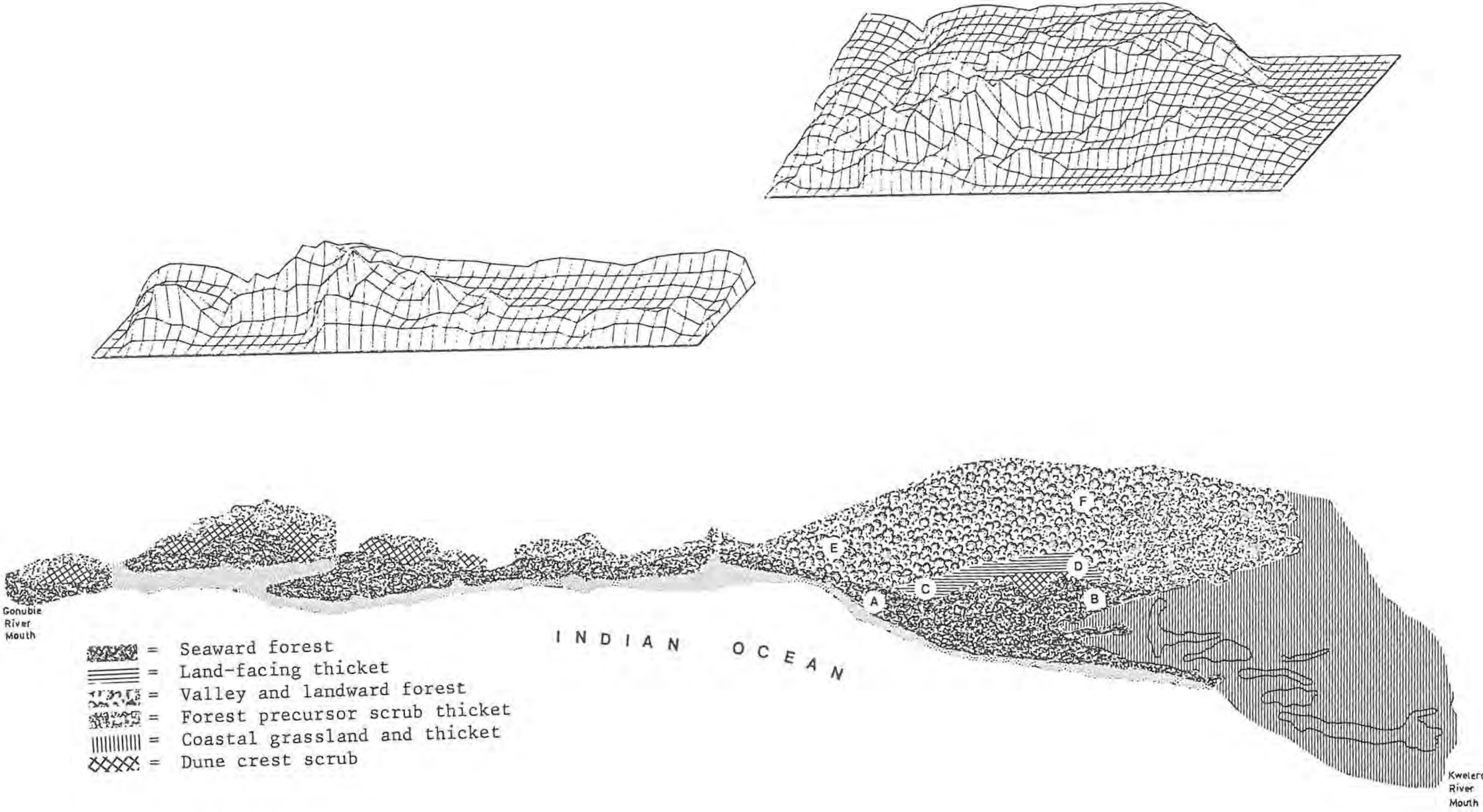



Fig. 41. The Kwelera vegetation and topographical maps illustrating the six major plant communities.

barrier dune, a land-facing thicket community, valley and landward forest, forest precursor scrub-thicket, coastal grassland with thicket patches and a small dune crest community. Sampling was only carried out in the first three communities.

The Mimusops caffra - Maytenus heterophylla seaward community

The fifteen points used to sample this community were distributed between points A and B as indicated in Fig. 41.

No distinct pattern of species dominance appeared from the sampling data of the canopy stratum. Of the four species having the highest importance values, Mimusops caffra and Maytenus heterophylla can possibly be regarded as dominants with values of 14 and 12 per cent respectively, while Sideroxylon merme and Cassine aethiopica can be classed as sub-dominants (Table 53). The relatively low density value of Schotia latifolia (72 Sph) precludes sub-dominance status for this species.

The margin of dominance retained by M. caffra in the canopy stratum is considerably less than for similar seaward communities to the north of Kwelera. Also associated with this are the relatively higher density and importance values of the lower hierarchy species.

The sub-canopy stratum is dominated by C. aethiopica with an importance value of 24 per cent, with Dovyalis rotundifolia and

TABLE 53. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA SEAWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Mimusops caffra* | 159 | 2,54 | 14 |
| *Maytenus heterophylla* | 127 | 2,34 | 12 |
| *Sideroxylon inerme* | 95 | 3,17 | 11 |
| *Cassine aethiopica* | 94 | 1,19 | 10 |
| *Schotia latifolia* | 72 | 3,37 | 10 |
| *Dovyalis rotundifolia* | 94 | 0,40 | 7 |
| *Euclea natalensis* | 51 | 1,19 | 6 |
| *Chionanthus foveolata* | 72 | 1,39 | 6 |
| *Acokanthera oblongfolia* | 51 | 0,99 | 5 |
| *Diospyros natalensis* | 31 | 0,99 | 4 |
| *Cassine papillosa* | 31 | 0,79 | 3 |
| *Cordia caffra* | 31 | 0,20 | 3 |
| *Tarchonanthus camphoratus* | 31 | 0,40 | 3 |
| *Maytenus procumbens* | 20 | 0,20 | 2 |
| *Zanthoxylum capense* | 20 | 0,40 | 2 |
| *Euclea racemosa* | 20 | 0,20 | 2 |
| *Pterocelastrus tricuspidatus* | 20 | 0,04 | 1 |
| | 1019 | 19,80 | 101 |

Acokanthera oblongifolia occupying sub-dominant positions (Table 54). From its relatively insignificant sub-canopy status, it would appear that M. caffra does not have a particularly high regenerative capacity in this community and it could be replaced by C. aethiopica or Maytenus heterophylla in the future. D. rotundifolia could also increase somewhat in community importance if its relatively high density in the sub-canopy is considered. Most of the other canopy elements are adequately represented in the sub-canopy stratum and appear to be capable of retaining their current canopy status.

It is of interest to note that the typical sub-canopy species Acokanthera oblongifolia is a sub-dominant in this stratum, which is uncommon for the dune forests north of Kwelera. Usually both the dominant and sub-dominant positions in these communities are retained by juvenile canopy species.

The height of the forest canopy varied between 4 and 13 m and the calculated mean value was 6.2 m. The tallest species were Schotia latifolia and Diospyros natalensis. The stand densities of the canopy and sub-canopy strata were 1019 and 935 Sph respectively, with the canopy individuals contributing a stem basal area of 19.8m$^2$ and the sub-canopy individuals 1.76m$^2$ per hectare. Species with the greatest Dbh were Schotia latifolia (38cm) and Sideroxylon inerme (33cm).

Cover values for the herb and shrub layer ranged between 2 and 60 per cent with a mean value of 34 per cent.

TABLE 54. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA SEAWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 212 | 0,50 | 24 |
| *Dovyalis rotundifolia* | 140 | 0,22 | 13 |
| *Acokanthera oblongfolia* | 75 | 0,18 | 10 |
| *Euclea natalensis* | 75 | 0,05 | 7 |
| *Maytenus heterophylla* | 66 | 0,11 | 7 |
| *Deinbollia oblongifolia* | 28 | 0,25 | 6 |
| *Allophylus natalensis* | 47 | 0,09 | 5 |
| *Diospyros natalensis* | 66 | 0,02 | 5 |
| *Maytenus procumbens* | 28 | 0,05 | 4 |
| *Carissa bispinosa* | 28 | 0,02 | 3 |
| *Mimusops caffra* | 28 | 0,04 | 3 |
| *Olea capensis* | 28 | 0,04 | 3 |
| *Schotia latifolia* | 19 | 0,04 | 2 |
| *Brachylaena discolor* | 19 | 0,02 | 2 |
| *Pterocelastrus tricuspidatus* | 19 | 0,02 | 2 |
| *Scolopia zeyheri* | 19 | 0,02 | 2 |
| *Rhus glauca* | 19 | 0,04 | 2 |
| *Dracaena hookerana* | 19 | 0,05 | 2 |
| | 935 | 1,76 | 100 |

The Cassine aethiopica - Mimusops caffra thicket of the land-facing slope

The fifteen points used to sample this community were distributed between points C & D as indicated in Fig. 41.

The thicket of the relatively steep land-facing dune slope is dominated in the canopy stratum by Cassine aethiopica, which has an importance value of 23 percent (Table 55). Sub-dominant species, which all had similar density values, were Mimusops caffra, Brachylaena discolor and Maytenus heterophylla. C. aethiopica is also by far the most dominant species in the sub-canopy stratum and has an importance value of 24 per cent (Table 56). The sub-dominants in this stratum are Sideroxylon inerme and Dovyalis rotundifolia, with importance values of 11 and 10 per cent respectively. Most of the typical sub-canopy species, such as Acokanthera oblongifolia, Carissa bispinosa and Dracaena hookerana all recorded low importance values.

It would appear that C. aethiopica is likely to remain dominant in the community, if its current regenerative potential in the sub-canopy is considered. The reduced status of M. caffra in the latter stratum however would seem to indicate that this species is likely to become less significant in the community in the future, while both Dovyalis rotundifolia and Sideroxylon inerme could increase somewhat as canopy contributors. Most of the remaining canopy species are reasonably

TABLE 55. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA LANDWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 405 | 2,73 | 23 |
| *Mimusops caffra* | 147 | 3,34 | 13 |
| *Brachylaena discolor* | 147 | 1,61 | 10 |
| *Maytenus heterophylla* | 147 | 1,29 | 10 |
| *Dovyalis rotundifolia* | 107 | 0,64 | 7 |
| *Sideroxylon inerme* | 107 | 0,97 | 7 |
| *Euclea racemosa* | 77 | 1,29 | 6 |
| *Diospyros natalensis* | 77 | 0,97 | 6 |
| *Canthium obovatum* | 46 | 0,48 | 4 |
| *Pterocelastrus tricuspidatus* | 46 | 0,32 | 3 |
| *Chionanthus foveolata* | 46 | 0,16 | 3 |
| *Schotia latifolia* | 31 | 0,97 | 3 |
| *Maerua cafra* | 31 | 0,32 | 2 |
| *Ficus burtt-davyi* | 31 | 0,48 | 2 |
| *Olea capensis* | 31 | 0,16 | 2 |
| *Tarchonanthus camphoratus* | 31 | 0,32 | 2 |
| *Euclea natalensis* | 31 | 0,05 | 1 |
| | 1538 | 16,10 | 104 |

TABLE 56. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 310 | 0,52 | 24 |
| *Sideroxylon inerme* | 169 | 0,21 | 11 |
| *Dovyalis rotundifolia* | 142 | 0,14 | 10 |
| *Euclea natalensis* | 142 | 0,09 | 9 |
| *Schotia latifolia* | 100 | 0,32 | 9 |
| *Maytenus heterophylla* | 71 | 0,11 | 6 |
| *Euclea racemosa* | 71 | 0,06 | 5 |
| *Rhus glauca* | 71 | 0,09 | 5 |
| *Mimusops caffra* | 43 | 0,11 | 4 |
| *Scutia myrtina* | 71 | 0,02 | 4 |
| *Rhus natalensis* | 71 | 0,02 | 4 |
| *Dracaena hookerana* | 29 | 0,04 | 2 |
| *Canthium obovatum* | 29 | 0,07 | 2 |
| *Tarchonanthus camphoratus* | 29 | 0,01 | 2 |
| *Carissa bispinosa* | 29 | 0,01 | 2 |
| *Maytenus undata* | 29 | 0,01 | 2 |
| *Acokanthera oblongfolia* | 29 | 0,01 | 1 |
| *Diospyros natalensis* | 29 | 0,01 | 1 |
| | 1464 | 1,85 | 103 |

well represented by juvenile individuals in the subordinate stratum and appear capable of perpetuating their current contributive roles.

The measured height of the canopy was fairly low, varying between 3,5 and 7 m, and averaged at only 5 m. The tallest individuals were Mimusops caffra and Canthium obovatum. The stocking density of the canopy stratum is 1538 Sph, with a stem basal area of 16,1m$^2$, and the density in the sub-canopy stratum is 1464 Sph, having a basal area of 1,85m$^2$. Species with the greatest Dbh were M. caffra (26cm) and Schotia latifolia (21cm).

The combined cover value of the herb and shrub layer varied between 1 and 15 per cent, but overall the cover was sparse, having a mean value of 2.6 per cent.

The Sideroxylon inerme - Schotia latifolia valley forest

The fifteen sampling points used in this survey were distributed along the line EF as indicated in Fig. 41.

Sideroxylon inerme and Schotia latifolia are the current dominant species in the canopy stratum and have importance values of 13 and 12 per cent respec-tively (Table 57). The sub-dominants are Diospyros natalensis and Euclea racemosa with respecive importance values of 11 and 10 per cent. Other interesting canopy members are Podocarpus falcatus and Erythrina caffra which occur only in advanced dune forest

TABLE 57. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA VALLEY CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 81 | 3,29 | 13 |
| *Schotia latifolia* | 81 | 3,65 | 12 |
| *Diospyros natalensis* | 81 | 1,58 | 11 |
| *Euclea racemosa* | 67 | 1,81 | 10 |
| *Mimusops caffra* | 32 | 3,16 | 8 |
| *Maytenus heterophylla* | 52 | 1,36 | 8 |
| *Cassine papillosa* | 32 | 0,90 | 7 |
| *Harpephyllum caffrum* | 19 | 1,13 | 4 |
| *Euclea natalensis* | 19 | 0,90 | 4 |
| *Pterocelastrus tricuspidatus* | 19 | 0,45 | 3 |
| *Scolopia zeyheri* | 19 | 0,68 | 3 |
| *Brachylaena discolor* | 19 | 0,23 | 3 |
| *Acokanthera oblongfolia* | 19 | 0,45 | 3 |
| *Podocarpus falcatus* | 19 | 0,68 | 3 |
| *Allophylus natalensis* | 19 | 0,45 | 3 |
| *Cassine aethiopica* | 13 | 0,45 | 2 |
| *Erythrina caffra* | 13 | 0,68 | 2 |
| *Cordia caffra* | 13 | 0,23 | 2 |
| *Euclea schimperi* | 13 | 0,45 | 2 |
| *Erythroxylum emarginatum* | 13 | 0,07 | 1 |
| | 646 | 22,60 | 104 |

communities on very sheltered sites. Cassine papillosa, with an importance value of 17 per cent, is the dominant species in the sub-canopy stratum and the sub-dominant species here are S. inerme and Acokanthera oblongifolia with respective importance values of 11 and 9 per cent (Table 58).

The elevated status of C. papillosa as a sub-canopy member is unique to the Kwelera forest since it does not feature significantly elsewhere along the coast and it is possible that its contribution towards the canopy might increase in the future. It is not anticipated that many other changes will take place in the composition of the community if the sub-canopy regenerative potential is considered. S. inerme and Diospyros natalensis are likely to retain their dominant and sub-dominant positions, as is Schotia latifolia which is reasonably well represented by juveniles in the sub-canopy stratum. E. racemosa could however decrease in canopy importance if its apparent sub-canopy absence is considered.

On average, the canopy was approximately 8 m high but varied between 5 and 12 m, with E. racemosa being the tallest individual recorded. The canopy stocking density was calculated at 646 sph which accounted for a total stem basal area of 22,6m$^2$. The density of the sub-canopy individuals was 406 Sph with a basal area of 1,4m$^2$. Species with the greatest Dbh were Mimusops caffra (49 cm) and Harpephyllum caffrum (34 cm).

TABLE 58. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KWELERA VALLEY SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine papillosa* | 67 | 0,25 | 17 |
| *Sideroxylon inerme* | 33 | 0,25 | 11 |
| *Acokanthera oblongfolia* | 33 | 0,15 | 9 |
| *Diospyros natalensis* | 33 | 0,03 | 7 |
| *Cassine aethiopica* | 20 | 0,15 | 7 |
| *Euclea natalensis* | 28 | 0,04 | 6 |
| *Allophylus natalensis* | 20 | 0,13 | 6 |
| *Maytenus heterophylla* | 20 | 0,08 | 6 |
| *Deinbollia oblongifolia* | 20 | 0,08 | 6 |
| *Podocarpus falcatus* | 20 | 0,03 | 4 |
| *Schotia latifolia* | 12 | 0,08 | 4 |
| *Carissa bispinosa* | 20 | 0,01 | 4 |
| *Dovyalis rotundifolia* | 12 | 0,01 | 3 |
| *Cussonia thyrsiflora* | 8 | 0,03 | 2 |
| *Olea capensis* | 8 | 0,01 | 2 |
| *Euclea schimperi* | 12 | 0,01 | 2 |
| *Mimusops caffra* | 8 | 0,003 | 2 |
| *Brachylaena discolor* | 8 | 0,01 | 2 |
| *Cordia caffra* | 8 | 0,03 | 2 |
| *Vepris lanceolata* | 8 | 0,003 | 1 |
| *Erythroxylum emarginatum* | 8 | 0,003 | 1 |
| | 406 | 1,400 | 104 |

The shrub and herb layer recorded cover values of between 1 and 50 per cent, with a mean value of 30 per cent.

### 5.8.2 Floristic and structural comparison of the seaward, land-facing and valley vegetation

All three sites exhibited some degree of similarity with respect to their upper hierarchy species and this makes it difficult to classify the vegetation with confidence into three distinct communities. Mimusops caffra for example, which is typically dominant in sea- and land-facing communities north of East London, was found to be quite significant in the Kwelera valley vegetation as well. The reverse pattern also appears to be true, with Sideroxylon inerme and Schotia latifolia (generally dominant in valley forest only), also assuming relatively significant positions on both other sites. In the case of the valley vegetation however, it was characterized by the presence of species such as Diospyros natalensis, Harpephyllum caffrum, Podocarpus falcatus and Erythrina caffra which all tend to be restricted only to well developed forest communities on the most sheltered sites.

Of the sub-canopy species, Cassine papillosa proved to be the most prominent in distinguishing its association with the valley vegetation, while Acokanthera oblongifolia appeared to be equally significant on the cooler valley and seaward sites but not in the landward vegetation. Diospyros natalensis, although present in the sub-canopy stratum of all three of the sampled stands, was of relatively greater significance in the valley vegetation and this would seem to reinforce its possible diagnostic valley status.

The same number of canopy and sub-canopy species were recorded on the seaward and land-facing sites while the valley vegetation exhibited a slightly greater diversity in both strata. This fact, together with the presence of some of the species discussed above could be indicative of the near climax state of the valley community compared with the other vegetation sampled.

Clear structural differences between the three communities could be interpreted from the sample data. The canopy of the valley forest was considerably taller than that of either of the other two communities and the trees, although fewer in number, also contributed the highest stem basal area. The landward community was the most stunted and thicket-like in appearance and in spite of its very high stem density, had the lowest stem basal area. The seaward community also had a relatively high stem density and the site supported only a slightly lower stem basal area than in the case of the valley. A less favourable moisture regime is a likely contributing factor which has resulted in the creation of the thicket occupying the steep and excessively drained landward slope. The very low cover values of the ground layer on the latter site would also seem to confirm this since the cooler seaward and valley sites support comparatively dense shrub and herb layers.

### 5.8.3 Multivariate Analysis Results and Discussion

Classification

The classification of the Kwelera forest based on the composition of the canopy is given in Table 59. The sample groupings only broadly conform to the indicated site associations and definite community descriptions cannot be reliably made on the basis of this stratum only. Although no diagnostic species can be isolated from those included in the landward group, Sideroxylon inerme and Schotia latifolia appear to identify the valley forest and Mimusops caffra and Dovyalis rotundifolia the seaward thicket. Maytenus heterophylla is shown to be common to both the landward and seaward sites while Diospyros natalensis is reasonably well represented on the relatively sheltered landward site as well as in the valley.

The classification table of the sub-canopy elements was only just adequate to distinguish the three sample groups which could be associated with specific sites (Table 60). The valley group displayed the best community characteristics and contained two species, Cassine papillosa and Diospyros natalensis, which could be regarded as diagnostics within the stratum. The group of landward samples contained no species which were specifically representative of only

TABLE 59. CLASSIFICATION OF THE KWELERA CANOPY SPECIES.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LANDWARD COMMUNITY | | | | | | | | | | | | | | | | VALLEY COMMUNITY | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | | | | | | | | | | | |
| POINT Nos. | 28 | 29 | 1 | 17 | 19 | 35 | 15 | 20 | 33 | 4 | 44 | 3 | 6 | 9 | 11 | 38 | 21 | 22 | 24 | 25 | 26 | 30 | 23 | 27 | 32 | 34 | 41 | 18 | 7 | 12 | 14 | 36 | 2 | 5 | 42 | 8 | 10 | 37 | 43 | 13 | 16 | 31 | 39 | 45 | 40 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| All. nat. | 4 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pod. fal. | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fic. bdv. | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ole. cap. | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Euc. rac. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap. | 5 | | | | | | | | 5 | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf | | 5 | | | | | | | | | 4 | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | |
| Pte. tri. | | | | | 4 | | | | | | | 5 | | | | 5 | | | | | | | | | | | | 5 | | | 5 | | | | | | | | | | | | | | |
| Euc. sch. | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| Ery. ema. | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | |
| Cus. kra. | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| Sid. ine. | | | | | | | | | | 5 | 5 | 5 | | | | | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | |
| Sch. lat. | | 5 | | | | | | | | | | | | 5 | | | | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | | | | | |
| Euc. nat. | | | | | | 5 | | | | | | | | | | | 5 | | | | | | | | 5 | | 5 | 5 | | | | | | | | | | | | 5 | | | | | |
| Cas. aet. | | | | | | | | | | 5 | | | 5 | 5 | 5 | | | | | | | | | | 5 | | | | 5 | | 5 | 5 | 4 | 5 | | 5 | 4 | 5 | | | 5 | 4 | | | |
| Mim. caf. | | | 5 | | 5 | 5 | | | | | | | | | | | | | | | | 4 | | | | | | | | 5 | | 4 | 5 | 5 | 5 | | | | | 5 | 5 | 5 | 5 | | |
| Dov. rot. | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | 5 | 4 | 4 | 5 | 5 | 4 | | | | | | | |
| Can. obo. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | |
| Mac. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | |
| Chi. fov. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | | | | 5 | | | | | | | | | | 5 |
| Tar. cam. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 | | 5 |
| May. pro. | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | |
| Ery. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | |
| Zan. cap. | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | |
| Dio. nat. | | | | | | | 5 | 5 | 5 | | | | 5 | | 5 | 5 | 5 | | 5 | 5 | 5 | 4 | 5 | | | | | | | | | | | | | | | | | | | | | | |
| Sco. zey. | | | | | | | | 5 | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. het. | | | | 5 | 5 | | 5 | | 4 | | 5 | | 5 | 4 | | 5 | | | | | | | | 5 | | | | | | | | | | | | | 5 | | | 5 | 5 | 5 | 5 | 5 | |
| Bra. dis. | | | | | | | | | | | | 5 | | 5 | 5 | | 5 | 5 | | | | | | | | | | | | 5 | | | | | | | 5 | | | | | | | | |
| Aco. obl. | 5 | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | 5 | | | | | 5 | |
| Har. caf. | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | |

TABLE 60. CLASSIFICATION OF THE KWELERA SUB-CANOPY SPECIES.

**SEAWARD COMMUNITY**

| SPECIES / POINT Nos. | 34 | 6 | 7 | 11 | 27 | 5 | 14 | 34 | 45 | 26 | 28 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Can. obo. | | | | | | 5 | | | | | | | |
| Tar. cam. | | | | | | 4 | | | | | | | |
| Rhu. nat. | | 4 | 4 | 4 | | | | | | | | | |
| Sch. lat. | 4 | 5 | 5 | 5 | 5 | | | | | | | | |
| Mim. caf. | | | | | | | 5 | | 5 | | 5 | | |
| Car. bis. | | | | | | | | | | 4 | 5 | 4 | 4 |
| Dov. rot. | | | | 5 | 5 | 5 | 4 | 5 | 5 | 4 | | 5 | 5 |
| Dei. obl. | 5 | | | | | | | | | 5 | 5 | | |
| May. und. | | | | | | | | | | | | | |
| Euc. rac. | | | | | | | | | | | | | |
| Cor. caf. | | | | | | | | | | | | | |
| Scu. myr. | | | 4 | | | | | | | | | | |
| Sco. zey. | | | | | | | | | | | | | |
| Euc. sch. | | | | | | | | | | | | | |
| Vep. lan. | | | | | | | | | | | | | |
| Ery. ema. | | | | | | | | | | | | | |
| Cus. thy. | | | | | | | | | | | | | |
| Pte. tri. | | | | | | | | | | | | | |
| Ole. cap. | | | | | | | | | | | | | |
| Pod. fal. | | | | | | | | | | | | | |
| Cas. pap. | | | | | | | | | | | | | |
| Dio. nat. | | | | | | | | | | | | | |
| All. nat. | | | | | | | | | | | | | |
| Bra. dis. | 4 | | | | | | | | | | | | |
| Rhu. gla. | | | | | | | 5 | 5 | | | | | |
| Cas. aet. | | 5 | 5 | | 5 | | | | | 5 | | 5 | 5 |
| May. pro. | | | | | | | | | | | | | |
| Dra. hoo. | | | | | | | | | | | | | |
| May. het. | | | | | | | | | | | | | |
| Sid. ine. | | | | 5 | | | | | | | | | |
| Aco. obl. | | | | | | | | | 5 | | | | |
| Euc. nat. | | | | | | | 5 | | | | | | 4 |

**LANDWARD COMMUNITY**

| SPECIES / POINT Nos. | 1 | 3 | 9 | 12 | 37 | 39 | 10 | 29 | 2 | 31 | 35 | 42 | 8 | 30 | 4 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Can. obo. | | | | | | | | | | | | | | | | |
| Tar. cam. | | | | | | | | | | | | | | | | |
| Rhu. nat. | | | | | | | | | | | | | | | | |
| Sch. lat. | | | | | | | | | | | | | | | | |
| Mim. caf. | 5 | | | | | | | | | | | | | | | |
| Car. bis. | | | | | | | | | | | | | | | | |
| Dov. rot. | | | | 5 | 5 | | | | | | | | | | | |
| Dei. obl. | | | | | | | | | | | | | | | | |
| May. und. | | | | | | | 4 | 5 | | | | | | | | |
| Euc. rac. | | 4 | | | | | | | | | | | 5 | | | 4 |
| Cor. caf. | | | | | | | | | | | | | | 5 | | |
| Scu. myr. | | | | | | | | | 5 | | | | 5 | | | |
| Sco. zey. | | | | | | | | | | | | | | | | |
| Euc. sch. | | | | | | | | | | | | | | | | |
| Vep. lan. | | | | | | | | | | | | | | | | |
| Ery. ema. | | | | | | | | | | | | | | | | |
| Cus. thy. | | | | | | | | | | | | | | | | |
| Pte. tri. | | | | | | | | | | | | | | | | |
| Ole. cap. | | | | | | | | | | | | | | | | |
| Pod. fal. | | | | | | | | | | | | | | | | |
| Cas. pap. | | | | | | | | | | | | | | | | |
| Dio. nat. | | | | | | | | | | | | | | | | |
| All. nat. | | | | | | | | | | | | | | 5 | | |
| Bra. dis. | | | | | | | | | | | | | | 5 | | |
| Rhu. gla. | | | | 5 | | | 5 | | | | | | | | | |
| Cas. aet. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | | 5 | 4 |
| May. pro. | | | | | | | | | | | | 4 | | | | |
| Dra. hoo. | | | | | | | | | | | | | | | 5 | |
| May. het. | | | | | 4 | 5 | | | | | | | | 4 | 5 | 5 |
| Sid. ine. | 4 | 5 | 5 | 5 | | | | 5 | | | | | | | | |
| Aco. obl. | | | | | | | | 5 | | 5 | 4 | 5 | 5 | | | |
| Euc. nat. | | | | | | | 4 | | 5 | 4 | | | | | | 5 |

**VALLEY COMMUNITY**

| SPECIES / POINT Nos. | 36 | 44 | 21 | 25 | 15 | 38 | 41 | 18 | 24 | 19 | 20 | 23 | 17 | 22 | 16 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Can. obo. | | | | | | | | | | | | | | | | |
| Tar. cam. | | | | | | | | | | | | | | | | |
| Rhu. nat. | | | | | | | | | | | | | | | | |
| Sch. lat. | | | | | | | | | | | 5 | | | | | |
| Mim. caf. | | | | | | 5 | | | | | | | | | | |
| Car. bis. | | | | | | | | | | | | | | | | |
| Dov. rot. | | | | | 5 | | | | | | | | | | | |
| Dei. obl. | | | | | | | | | | | | | | | | |
| May. und. | | | | | | | | | | | | | | | | |
| Euc. rac. | | | | | | | | | | | | | | | | |
| Cor. caf. | | | | | | | | | | | | | | | | |
| Scu. myr. | | | | | | | | | | | | | | | | |
| Sco. zey. | | | | | | | 5 | | | | | | | | | |
| Euc. sch. | | | 5 | | | | | | | | | | | | | |
| Vep. lan. | | | | | | | | | | | | | | | 5 | |
| Ery. ema. | | | | | | | | 4 | | | | | | | | |
| Cus. thy. | | | | | | | | | | | | | 5 | | | |
| Pte. tri. | | | | | | | | | | | | | | | | 5 |
| Ole. cap. | | | | | | | | | | 5 | | | | | | 5 |
| Pod. fal. | | | | | | | | | | | | | 5 | 5 | 5 | |
| Cas. pap. | | | 5 | 5 | | | | | 4 | 5 | 5 | 5 | 4 | | | |
| Dio. nat. | | 4 | | | 4 | 4 | 5 | 5 | | 5 | | 5 | | 5 | | |
| All. nat. | 5 | 5 | | | | | | | | | 4 | 4 | | | | |
| Bra. dis. | | | | | | | | | | | | | | | | |
| Rhu. gla. | | | | | | | | | | | | | | | | |
| Cas. aet. | | | | | | | | | | | | | | | | |
| May. pro. | | | | | | | | | | | | | | | | 5 |
| Dra. hoo. | | 5 | | | | | | | | | | | | | | |
| May. het. | | | 5 | 5 | 4 | 5 | 5 | | | | | | | | | |
| Sid. ine. | | | | | | | | | 5 | | 4 | | 4 | 4 | | |
| Aco. obl. | | | | | | 5 | | 5 | 5 | | | | | | | |
| Euc. nat. | 5 | 5 | | 5 | 5 | | | | 5 | | | | | | 5 | |

that site but contained a few others which were significant in one of the alternative sample groups as well. Cassine aethiopica for example, was common to both the landward and seaward thicket while Sideroxylon inerme and Maytenus heterophylla occurred in the valley forest as well as the landward thicket.

The classification in which information on both strata has been included provides the best illustration of the community or compositional differences between the three sampled areas (Table 61). Distinguishing species in the valley forest occur in both strata, while in the case of the seaward thicket, the dominance of Mimusops caffra in the canopy is its most significant feature. The identity of the landward thicket appears to be determined largely by sub-canopy species such as Rhus glauca, Rhus natalensis and Schotia latifolia and to a lesser extent by Brachylaena discolor in the canopy. Sideroxylon inerme is largely responsible for the compositional links in both strata between the valley and landward communities, while Cassine aethiopica fulfils the same role between the landward and seaward thicket. Apart from Acokanthera oblongifolia, there are no species of any significance which are exclusive to both the seaward and valley sites, although Maytenus heterophylla in the canopy, and Euclea natalensis in the lower stratum, do act as linking elements between all three communities.

TABLE 61. CLASSIFICATION OF THE KWELERA CANOPY AND SUB-CANOPY SPECIES.

| | VALLEY COMMUNITY |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | LANDWARD COMMUNITY |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | SEAWARD COMMUNITY |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 28 | 29 | 34 | 18 | 38 | 22 | 41 | 21 | 23 | 24 | 25 | 30 | 15 | 17 | 19 | 20 | 4 | 37 | 44 | 3 | 9 | 6 | 7 | 11 | 26 | 27 | 32 | 33 | 10 | 12 | 14 | 5 | 43 | 45 | 16 | 31 | 36 | 2 | 8 | 42 | 11 | 13 | 35 | 39 | 40 |
| SPECIES |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ole. cap.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pod. fal.1 |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cus. thy.2 |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cor. caf.2 |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cus. kra.1 |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Euc. sch.2 |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sco. zey.2 |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ery. ema.2 |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Har. caf.1 |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bra. dis.2 |  |  | 4 |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Zan. cap.1 |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dio. nat.2 |  |  |  | 5 | 4 | 5 | 5 |  | 5 |  |  |  | 4 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cas. pap.2 |  |  |  |  |  |  |  | 5 | 5 | 4 | 5 |  |  | 4 | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| All. nat.1 | 4 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Euc. rac.1 | 5 | 5 |  |  |  |  |  |  | 4 |  |  |  | 5 | 5 | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sch. lat.1 |  | 5 | 5 |  |  | 5 | 5 |  | 5 | 5 |  | 5 |  |  |  |  |  |  |  |  | 5 |  |  |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| All. nat.2 |  |  |  |  |  |  |  |  | 4 |  |  | 5 |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |
| Dio. nat.1 |  |  |  |  | 5 |  |  | 5 | 5 | 5 | 5 | 4 | 5 |  |  | 5 |  |  |  |  |  | 5 |  | 5 | 5 |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dei. obl.2 | 5 |  | 5 |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cor. caf.1 |  | 5 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cas. pap.1 | 5 |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pod. fal.2 |  |  |  |  |  | 5 |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |
| Vep. lan.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |
| Pte. tri.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |
| May. pro.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  | 5 |
| Tar. cam.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 | 5 |
| Mae. caf.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |
| Mim. caf.1 |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 |  | 5 | 5 | 5 | 4 | 5 |  | 5 | 5 | 5 | 5 | 5 |  |
| Euc. rac.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  | 4 |  |  |  |
| Aco. obl.1 | 5 |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |
| Aco. obl.2 |  | 5 |  | 5 | 5 |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 |  |  | 5 | 5 |  |  | 4 |  |  |
| Bra. dis.1 |  |  |  |  |  | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 |  |  | 5 |  |  |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Can. obo.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Can. obo.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fic. bdv.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fic. nat.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dra. hoo.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tar. cam.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ery. ema.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Euc. sch.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ole. cap.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| May. pro.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rhu. nat.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dra. hoo.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dov. rot.2 |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  | 5 |  |  |  |  |  | 5 | 4 | 5 | 5 | 5 |  | 5 | 4 | 5 | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |
| Car. bis.2 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  | 4 | 4 |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |
| Sch. lat.2 |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  | 5 | 5 | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rhu. gla.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| Sid. ine.1 |  |  |  |  |  | 5 | 5 | 5 |  | 5 | 5 | 5 |  |  |  |  | 5 | 5 | 5 | 5 |  |  | 5 |  | 5 | 5 |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |
| Ery. caf.1 |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Pte. tri.1 |  |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sid. ine.2 |  | 5 |  |  |  | 4 |  |  |  | 5 |  |  |  | 4 |  | 4 |  |  |  | 5 | 5 |  |  | 5 |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |
| May. und.2 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cas. aet.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 |  | 5 | 5 | 5 | 5 |  | 5 | 5 | 5 | 5 | 5 | 5 |  |  |  |  |  | 5 |  | 5 |  |  | 5 | 4 | 5 | 5 |  |
| Cas. aet.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 | 5 |  | 4 | 5 | 5 | 5 |  |  | 4 |  | 4 |  | 5 | 5 |  |  | 5 | 4 | 5 | 4 | 5 |  |  |  |  |  |  |
| Chi. fov.1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  | 5 |
| Scu. myr.2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 | 5 |  |  |  |  |  |  |
| Dov. rot.1 |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  | 4 |  |  |  |  |  |  |  |  |  |  | 5 |  |  | 4 | 5 |  |  |  |  | 5 | 5 | 4 |  |  |  |  |  |
| Mim. caf.2 | 5 |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  | 5 |  |  |  |  |  |  | 5 |  |  |  |  |
| Euc. nat.1 |  |  |  | 5 |  |  | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 | 5 |  |  |
| May. het.2 |  |  |  |  | 5 |  | 5 | 5 |  |  | 5 | 4 | 4 |  |  |  | 5 | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5 |  | 5 |  |
| Euc. nat.2 |  |  |  |  |  |  |  |  |  | 5 | 5 |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4 | 4 |  | 4 |  |  |  | 5 | 4 | 5 | 5 |  |  |  | 5 |  |  |  |
| May. het.1 |  |  |  |  | 5 |  |  |  |  |  |  |  | 5 | 5 | 5 |  |  |  | 5 |  | 4 | 5 |  |  |  | 5 |  | 4 | 5 |  |  |  |  | 5 | 5 | 5 |  |  |  |  |  | 5 |  | 5 |  |

In general, the individual and combined classifications corresponded reasonably well to the basis upon which the communities were described earlier, using the tables of importance rankings. The sampling technique and/or intensity might have been inadequate to secure better site-associated sample groups in the classifications or alternatively, the floristic differences, particularly between the landward and seaward thicket might not be that great. Nevertheless a trend is evident in the data which would appear to indicate a successional gradient from sub-climax seaward thicket through to climax valley forest. The presence of species such as Podocarpus falcatus, Erythrina caffra, Harpephyllum caffrum, Diospyros natalensis and Sideroxylon inerme in the latter community confirm its serally advanced state, since most are late entry species which prefer sheltered sites and developed soils.

Ordination

The ordination of the sample stands based on the canopy data is shown in Fig.42. In terms of the first DCA-axis, the valley stands are plotted at the left extreme on the scatter diagram while the seaward and landward stands are plotted to the right. Differentiation between the latter two groups can be made in terms of the second DCA-axis, with the landward group plotted below that of the seaward stands. It is apparent from the ordination that a degree of overlap, particularly between the seaward and landward groups, does exist and this makes a

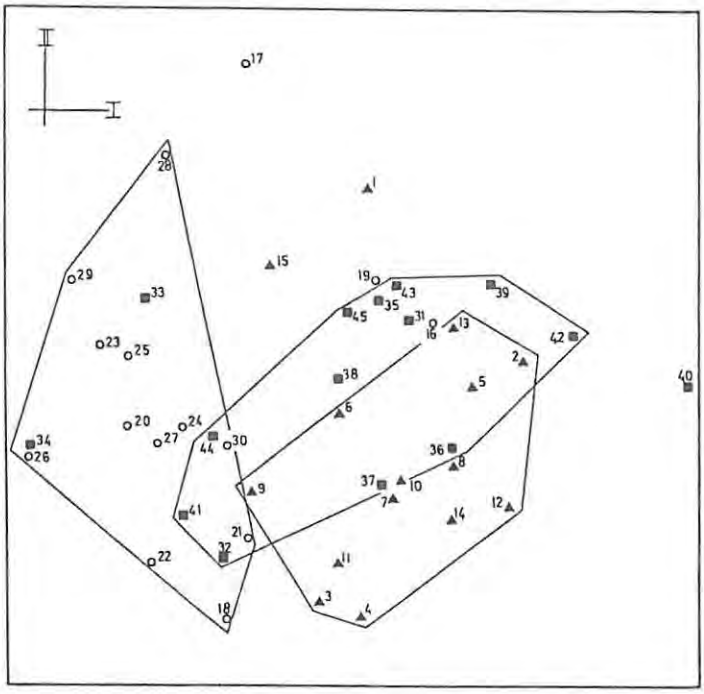


Fig. 42.
Ordination of the Kwelera canopy data.
▲ = landward stands
○ = valley stands
■ = seaward stands

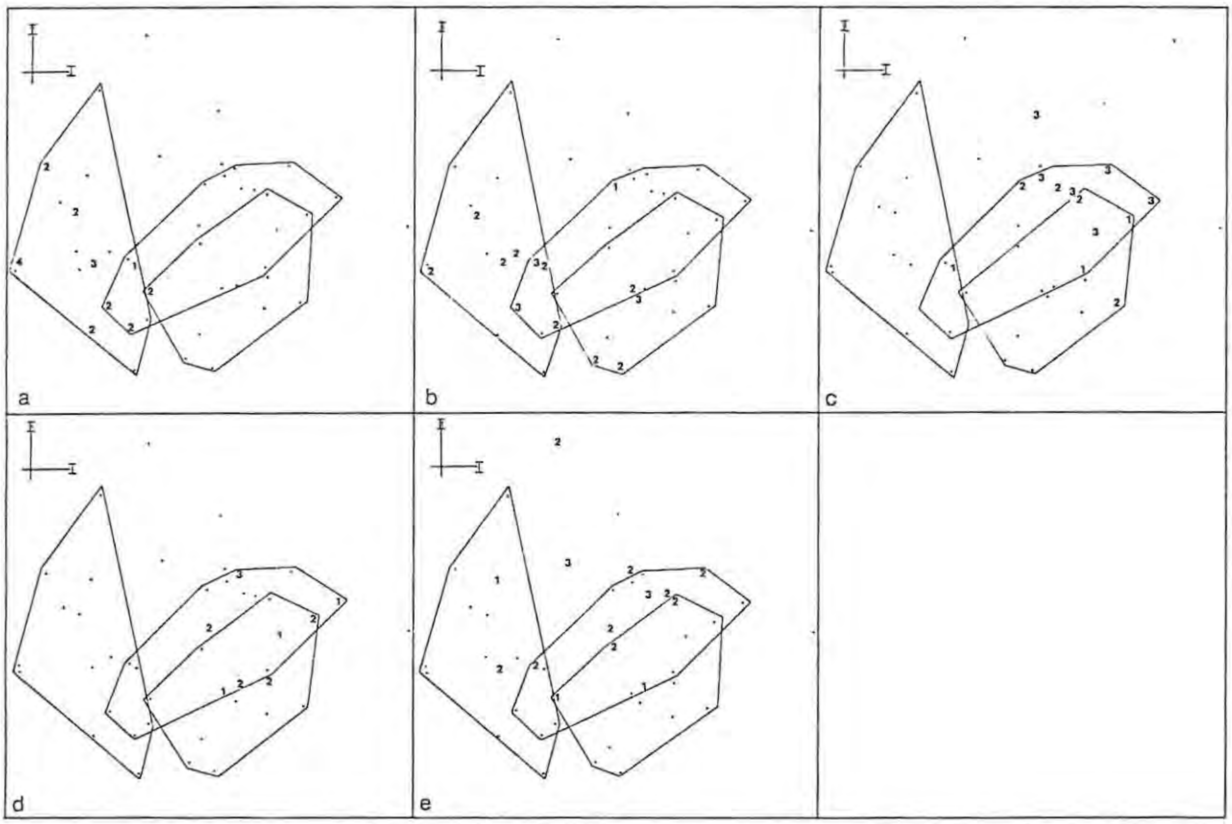



Fig. 43.
Positions on the Kwelera canopy ordination of (a) Schotia latifolia, (b) Sideroxylon inerme, (c) Mimusops caffra, (d) Dovyalis rotundifolia and (e) Maytenus heterophylla.

(·-4 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60% and 4 = 61-80%)

precise identification and description of communities difficult. The role played by various significant species in creating the ordination pattern can be seen in Figs.43(a) to (e).

Schotia latifolia is shown to occur as a canopy species almost exclusively in the valley community (Fig.43(a)) while Sideroxylon inerme also appears to favour this site and to a lesser extent, the landward slope as well (Fig.43(b)) - i.e. successionally advanced forest on sheltered sites. Mimusops caffra is as expected, an important member in the seaward community and is also shown to occur on the landward slope as well (Fig.43(c)) but is of little significance in the valley forest. Dovyalis rotundifolia is another spcies which is common in the seaward thicket canopy at Kwelera (Fig.43(d)) , while Maytenus heterophylla appears to be almost equally well represented in both the latter community and the landward thicket (Fig.43(e).

The sub-canopy ordination which is shown in Fig.44 illustrates mainly the wide variation within this stratum on each of the sites sampled. Only in the case of the landward vegetation could a relatively compact group of sample stands be isolated, which might indicate greater homogeneity between the sampled stands. The plots of Cassine papillosa and Diospyros natalensis on the ordination indicate their preference for the valley site (Figs.45(a) and (b)) while Cassine

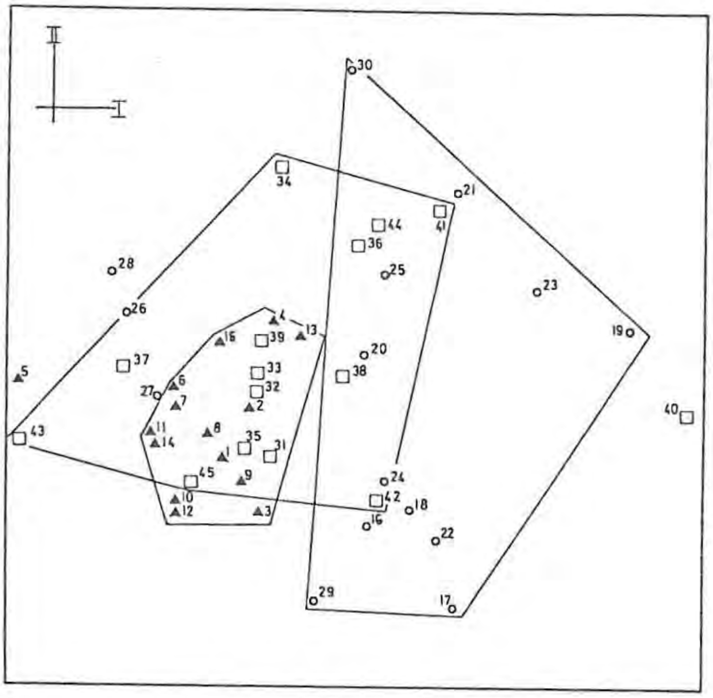


Fig. 44.
Ordination of the Kwelera sub-canopy data.
▲ = landward stands
○ = valley stands
□ = seaward stands

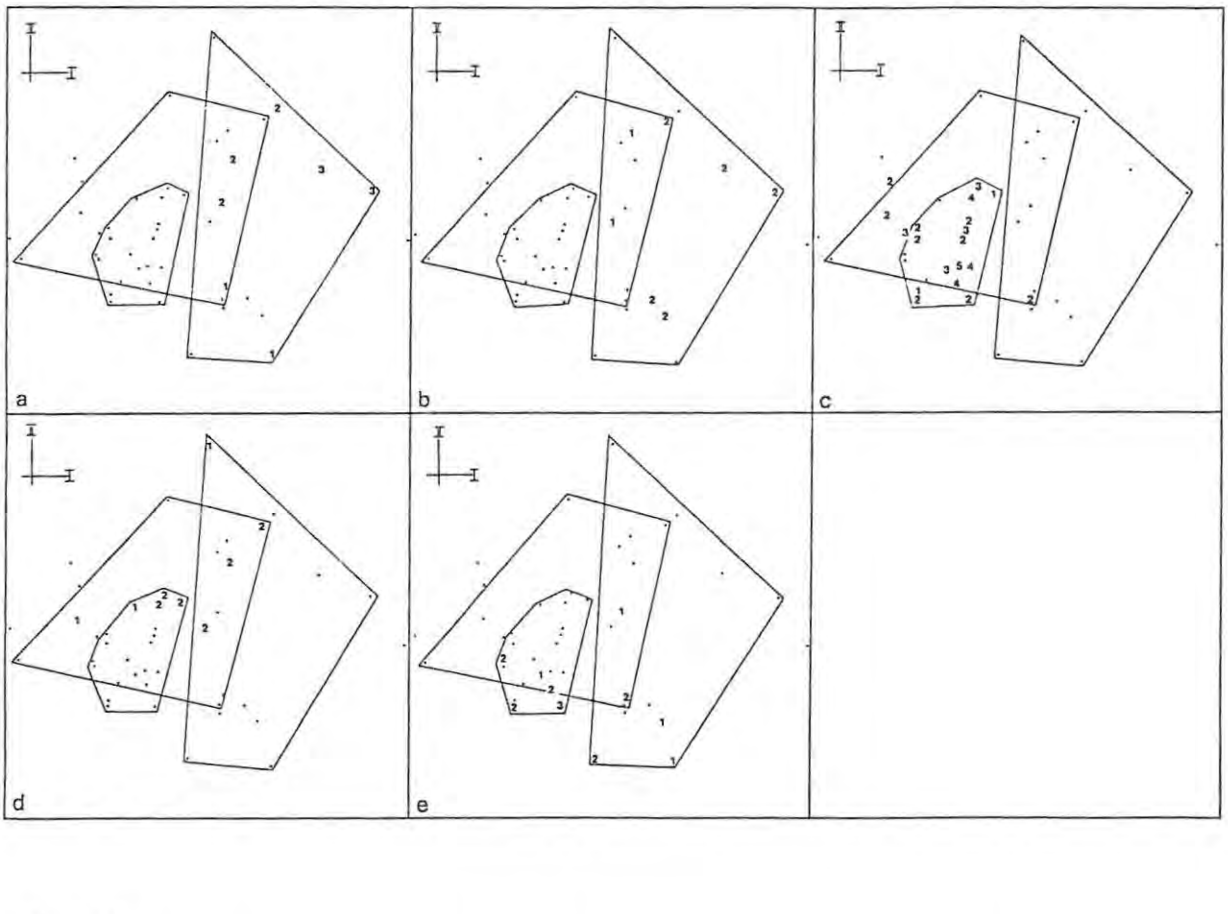



Fig. 45.
Positions on the Kwelera sub-canopy ordination of (a) Cassine papillosa, (b) Diospyros natalensis, (c) Cassine aethiopica, (d) Maytenus heterophylla and (e) Sideroxylon inerme.

(·-5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

aethiopica is shown to be relatively important in the seaward and landward thicket communities but not in the subordinate strata of the climax valley forest (Fig.45(c)). Maytenus heterophylla and Sideroxylon inerme contribute significantly towards the valley and landward sub-canopy strata but do not appear to show the same preference for the seaward community (Figs.45(d) and (e)).

The combined canopy and sub-canopy ordination which is shown in Fig.46 does not provide a particularly good graphical illustration of major community differences between the three sites sampled and the individual ordinations of the two strata were better in this respect. Nevertheless, some pattern is evident on the scatter diagram in the arrangement of the sample groups relative to the second DCA-axis. The grouped landward stands appear to be the most homogeneous but show certain similarities to the seaward group. The valley vegetation on the other hand is associated least with either of the other two groups and thus distinguishes itself as a recognizable community. The significant or diagnostic species responsible for creating the ordination groups have already been discussed.

A vague successional gradient along the second DCA-axis can also be interpreted from Fig.46, with the younger sub-climax seaward stands and the climax valley stands situated at the lower and upper axis extremes respectively. The pre-climax landward stands are located between the above two groups.

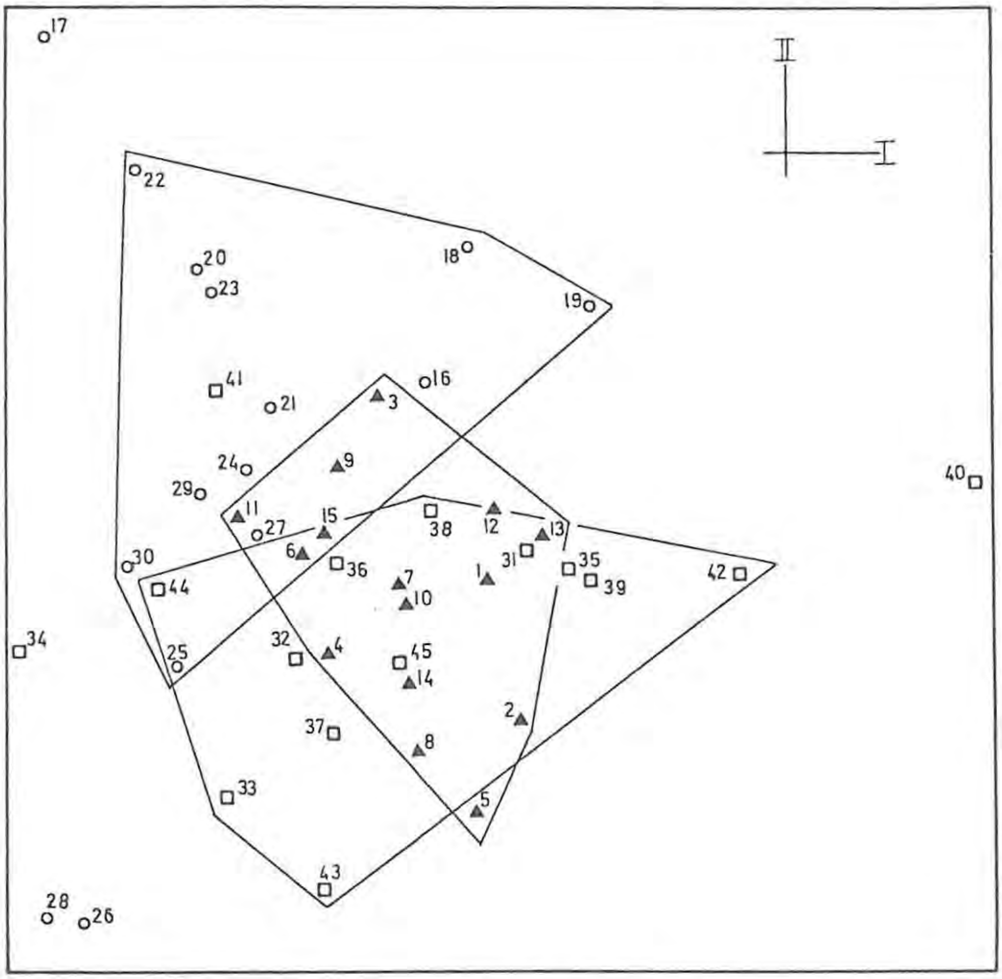



Fig. 46.
Ordination of the combined canopy and sub-canopy data for Kwelera.

▲ = landward stands
○ = valley stands
□ = seaward stands

## 5.9 THE BEACON BAY DUNE FOREST

### 5.9.1 Site and Forest Description

This is one of the smaller forest patches sampled, with the area under forest and thicket measuring approximately 38 hectares. The width of the vegetated dunes varies between 250 and 300m and the maximum dune height is 66m. The area is bordered in the north-east by the Quinera lagoon and in the south-west by the estuary of the Nahoon River.

The forest has a great potential risk of disturbance with the townships of Blue Bend and Bonza Bay adjoining much of its landward margin. This might be preferable however to the situation which prevails along the remainder of this boundary where fires in the adjoining grassland have periodically burnt up into the forest. A fire-induced fringe community seems to have developed along the forest margin, comprised of pioneer species such as Chrysanthemoides monilifera and dense coppice re-growth of species such as Euclea natalensis and Brachylaena discolor. Grewia occidentalis is also a common member of this dense scrub-thicket zone. A fire break which is burnt annually by the Directorate will do much to reduce the risk of wild fires in the future.

A very obvious sign of disturbance in the area is the scar left after sand was removed illegally from the inland base of the main dune below the Trig. beacon. This practice has been stopped and in spite of the slope being very steep , recovery by pioneer vegetation (esp. C. monilifera) has been rapid.

Several alien plant species have become established due to past dumping of garden refuse and the most vigourous of these are Melia azedarach (Syringa), Circium vulgare (Scotch Thistle), Cestrum laevigatum (Inkberry) and Lantana camara. Annual weed eradication operations should ensure that they will disappear in due course.

Beacon Bay is a popular bathing beach and the north-eastern corner of the dune forest has been used for the siting of public ablution facilities. This does not seem to have resulted in excessive damage to the vegetation but the situation will have to be monitored closely.

The beach is a wide expanse of unstable sand which has formed into a series of transverse dunes moving in a resultant north-easterly direction. Much of the vegetation on the sea-facing slope of the main dune has been scoured away and the remaining scrub-thicket community has a very stunted and tangled appearance. Isolated patches of Scaevola plumieri and Arctotheca populifolia were noted close to the high water mark but have not formed a clear line of embryo dunes. A major dune blow-out which has been caused by the north-easterly winds has been artificially reclaimed and the species which have become relatively well established in this area are C. monilifera and Passerina rigida. Off-road vehicles are not permitted on the beach.

No quantitative sampling has been carried out in this area previously but unpublished records of phenological data for certain species have been kept (Tinley, pers. comm.). In mapping the area, eight communities were identified but sampling was only carried out in the climax dune valley community and the dry forest of the landward dune slopes. The other communities which have been mapped are the eroded seaward thicket adjoining the beach, the reclaimed area, the fire-damaged communities, a small strip of riparian forest, forest precursor scrub and the dune crest communities (Fig.47).

The Diospyros natalensis - Sideroxylon inerme Valley Community.

The valley topography has provided shelter to the forest from the strong prevailing winds and drainage of precipitation to the valley floor has ensured an improved moisture regime for the vegetation. The forest which has developed can be regarded as being in a near climax state.

Fifteen points distributed between points A , B, and C were used to sample the valley forest. (See Fig.47).

Diospyros natalensis, Sideroxylon inerme, and Harpephyllum caffrum are the canopy dominants, with importance values of 24,2 24,0 and 18,1 per cent respectively (Table 62). Canopy sub-dominants are Mimusops caffra, Cordia caffra and Erythrina caffra with respective importance

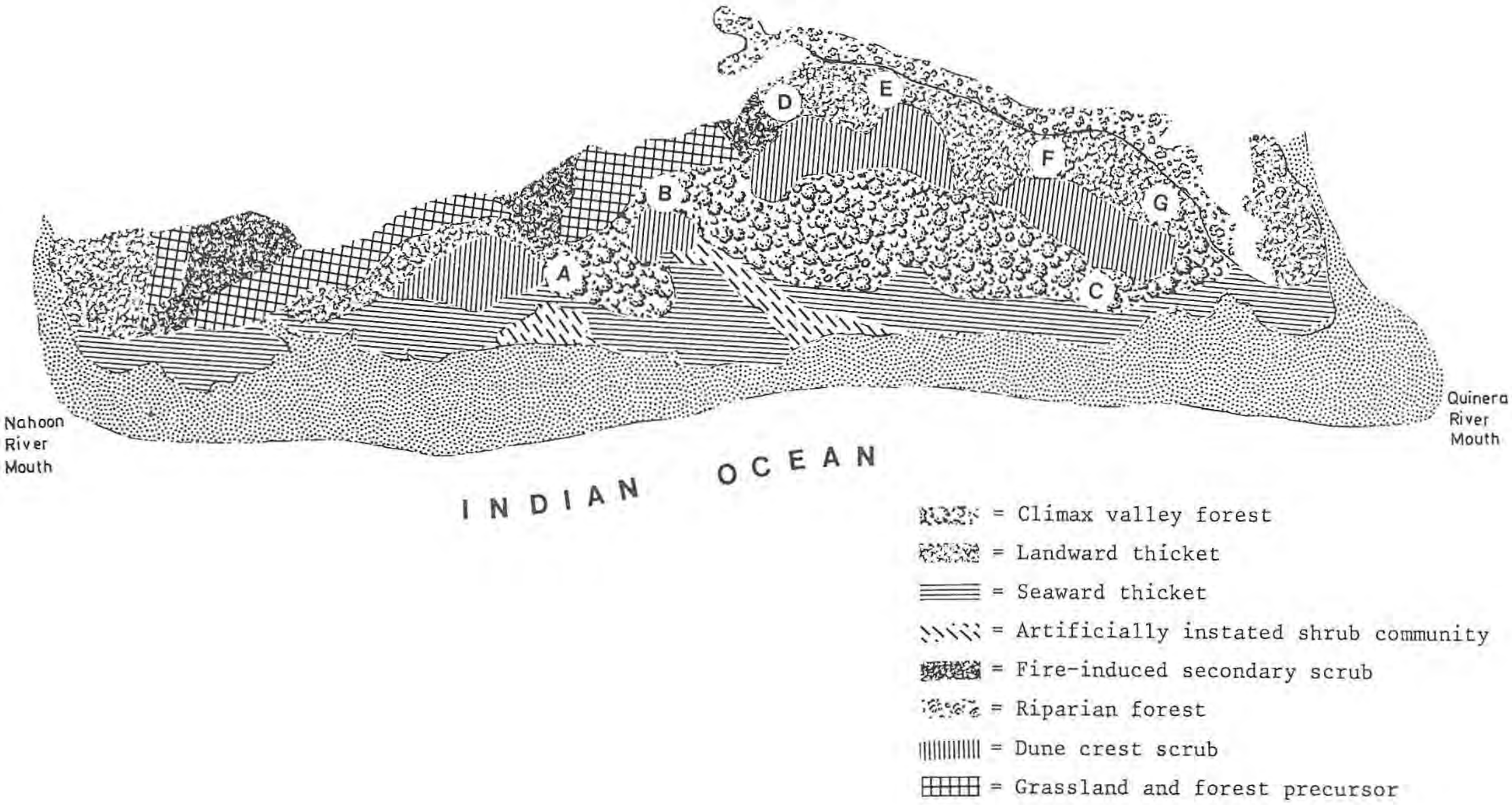



Fig. 47. The Beacon Bay vegetation map illustrating the eight major plant communities.

TABLE 62. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BEACON BAY VALLEY CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Diospyros natalensis* | 78 | 3,7 | 24,2 |
| *Sideroxylon inerme* | 73 | 4,1 | 24,0 |
| *Harpephyllum caffrum* | 49 | 2,8 | 18,1 |
| *Mimusops caffra* | 20 | 1,7 | 8,2 |
| *Cordia caffra* | 20 | 1,2 | 7,4 |
| *Erythrina caffra* | 10 | 1,6 | 5,3 |
| *Dovyalis rotundifolia* | 10 | 0,28 | 3,1 |
| *Cassine aethiopica* | 10 | 0,10 | 2,6 |
| *Chionanthus foveolata* | 5 | 0,17 | 1,5 |
| *Cassine papillosa* | 5 | 0,05 | 1,5 |
| *Scolopia zeyheri* | 5 | 0,10 | 1,5 |
| *Zanthoxylum capense* | 5 | 0,06 | 1,4 |
| *Maytenus heterophylla* | 5 | 0,07 | 1,4 |
| | 295 | 15,93 | 100,2 |

values of 8,2 7,4 and 5,3 per cent. All other canopy species have considerably lower importance values.

A high percentage of the species recorded in the sub-canopy stratum were juvenile canopy species but typical sub-canopy species also obtained high importance values. The sub-canopy dominants include only one typical canopy species, Cassine aethiopica, which had an importance value of 30,5 per cent. The other sub-canopy dominants are Acokanthera oblongifolia and Deinbollia oblongifolia, with importance values of 14,1 and 9,2 per cent respectively (Table 63). Sub-dominants in this stratum include Dovyalis rotundifolia, Cordia caffra, Pavetta revoluta and Sideroxylon inerme, with respective importance values of 8,4 5,7 5,6 and 4,9 per cent. It is of interest to note that Harpephyllum caffrum and Diospyros natalensis are of relatively little importance in the sub-canopy and that no individuals of Mimusops caffra were recorded.

The above situation makes it difficult to anticipate the future composition of the community. It would appear however, that Mimusops caffra will eventually become less important and possibly disappear and that Sideroxylon inerme, Harpephyllum caffrum and Cordia caffra will maintain more or less their present status. Cassine aethiopica could become more important but it is felt that it will remain dominant in the sub-canopy and not necessarily displace other canopy

TABLE 63. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BEACON BAY VALLEY SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 180 | 1,23 | 30,5 |
| *Acokanthera oblongfolia* | 154 | 0,13 | 14,1 |
| *Deinbollia oblongifolia* | 103 | 0,13 | 9,2 |
| *Dovyalis rotundifolia* | 39 | 0,36 | 8,4 |
| *Cordia caffra* | 52 | 0,08 | 5,7 |
| *Pavetta revoluta* | 52 | 0,05 | 5,6 |
| *Sideroxylon inerme* | 26 | 0,21 | 4,9 |
| *Harpephyllum caffrum* | 26 | 0,11 | 4,7 |
| *Allophylus natalensis* | 26 | 0,09 | 3,9 |
| *Rhus natalensis* | 26 | 0,01 | 2,8 |
| *Cassine papillosa* | 26 | 0,02 | 2,8 |
| *Maytenus heterophylla* | 13 | 0,05 | 2,0 |
| *Vepris lanceolata* | 13 | 0,01 | 1,7 |
| *Maytenus procumbens* | 13 | 0,01 | 1,4 |
| *Chionanthus foveolata* | 13 | 0,005 | 1,3 |
| *Diospyros natalensis* | 13 | 0,005 | 1,3 |
| | 775 | 2,500 | 100,3 |

species. The future status of Diospyros natalensis uncertain, vis a vis its present dominance in the canopy and almost complete absence in the sub-canopy. It is possible that regeneration of this species only takes place in openings in the forest such as those created by tree-falls and that it does not occur in general as a sub-canopy individual. Support for this view was noted at Kei Mouth where young plants were found growing close to parent trees, in areas which were relatively unshaded.

The canopy height of the forest ranged between 5,5 and 14,5 m, with a mean value of 9,7m. The tallest individuals were Sideroxylon inerme and Harpephyllum caffrum. The canopy stand density was 295 Sph and the total stem basal area for this stratum was 15,93 $m^2$ per hectare. The sub-canopy had a stocking of 775 sph and a calculated basal area of approximately 2,5$m^2$ per hectare. Species with the greatest Dbh were Erythrina caffra (55cm) and Sideroxylon inerme (50cm).

Cover values recorded for the herb layer varied between 10 and 90 per cent, with a mean value of 60 per cent.

### The Mimusops caffra - Schotia afra Landward Community

The dune slope sampled was relatively steep and unstable and considerable signs of erosion, root exposure and tree-fall were evident. Accumulation of eroded material had taken place on the lower slopes and an increase in canopy height in this zone was noted.

Generally the community had a stunted appearance, due probably to moisture stress and growth conditions appeared to be much less favourable than in the dune valley.

Fifteen sampling points were used, with seven of them located between points D and E and eight between F and G (Fig.47 ).

The canopy dominants are Mimusops caffra, Schotia afra and Cassine aethiopica with respective importance values of 35,8 12,5 and 10,5 per cent (Table 64). Canopy sub-dominants are Euclea racemosa, Sideroxylon inerme and Brachylaena discolor, having importance values of 6,5 6,4 and 6,3 per cent respectively. The remaining canopy species, apart from Chionanthus foveolata, all had relatively low density and importance values.

The major sub-canopy dominant is Cassine aethiopica, with an importance value of 41,1 per cent and a density of almost 40 per cent of the total Sph (Table 65). Sub-canopy sub-dominants include Euclea natalensis, Olea exasperata, Mimusops caffra, Sideroxylon inerme and Brachylaena discolor (none of which are typical sub-canopy species) and importance values of 6,2, 5,9, 5,0, 4,9 and 4,5 per cent were recorded for them respectively.

It would appear that it is unlikely that the future community composition will diverge much from its present status. Cassine

TABLE 64. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BEACON BAY LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V (%) |
|---|---|---|---|
| *Cassine aethiopica* | 783 | 0,89 | 41,1 |
| *Euclea natalensis* | 131 | 0,05 | 6,2 |
| *Olea exasperata* | 131 | 0,09 | 5,9 |
| *Mimusops caffra* | 98 | 0,06 | 5,0 |
| *Sideroxylon inerme* | 98 | 0,06 | 4,9 |
| *Brachylaena discolor* | 65 | 0,10 | 4,5 |
| *Pavetta revoluta* | 65 | 0,07 | 3,9 |
| *Euclea racemosa* | 33 | 0,13 | 3,4 |
| *Olea capensis* | 65 | 0,04 | 3,3 |
| *Cassine tetragona* | 65 | 0,03 | 3,2 |
| *Ficus burtt-davyi* | 65 | 0,02 | 2,9 |
| *Dovyalis rotundifolia* | 65 | 0,02 | 2,9 |
| *Scutia myrtina* | 65 | 0,02 | 2,8 |
| *Chionanthus foveolata* | 65 | 0,03 | 2,6 |
| *Rhus glauca* | 33 | 0,01 | 1,6 |
| *Eugenia capensis* | 33 | 0,01 | 1,6 |
| *Allophylus natalensis* | 33 | 0,01 | 1,5 |
| *Acokanthera oblongfolia* | 33 | 0,01 | 1,5 |
| *Turraea obtusifolia* | 33 | 0,01 | 1,5 |
| | 1959 | 1,66 | 100,3 |

TABLE 65. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE BEACON BAY LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 783 | 0,89 | 41,1 |
| *Euclea natalensis* | 131 | 0,05 | 6,2 |
| *Olea exasperata* | 131 | 0,09 | 5,9 |
| *Mimusops caffra* | 98 | 0,06 | 5,0 |
| *Sideroxylon inerme* | 98 | 0,06 | 4,9 |
| *Brachylaena discolor* | 65 | 0,10 | 4,5 |
| *Pavetta revoluta* | 65 | 0,07 | 3,9 |
| *Euclea racemosa* | 33 | 0,13 | 3,4 |
| *Olea capensis* | 65 | 0,04 | 3,3 |
| *Cassine tetragona* | 65 | 0,03 | 3,2 |
| *Ficus burtt-davyi* | 65 | 0,02 | 2,9 |
| *Dovyalis rotundifolia* | 65 | 0,02 | 2,9 |
| *Scutia myrtina* | 65 | 0,02 | 2,8 |
| *Chionanthus foveolata* | 65 | 0,03 | 2,6 |
| *Rhus glauca* | 33 | 0,01 | 1,6 |
| *Eugenia capensis* | 33 | 0,01 | 1,6 |
| *Allophylus natalensis* | 33 | 0,01 | 1,5 |
| *Acokanthera oblongfolia* | 33 | 0,01 | 1,5 |
| *Turraea obtusifolia* | 33 | 0,01 | 1,5 |
| | 1959 | 1,66 | 100,3 |

aethiopica could eventually replace Mimusops caffra as the canopy dominant but it is unlikely that the latter species will disappear from the community since it is fairly well represented in the sub-canopy stratum. The future status of Schotia afra is not very clear since it was not recorded at all in the sub-canopy. Similar to the view expressed on Diospyros natalensis in the valley forest, it is also possible that this species requires forest openings in order to re-establish itself and that otherwise it is not widely distributed in the sub-canopy. It appears to have a clumped distribution in the forest and several individuals were recorded within close proximity to one another during sampling - at one point for instance, three of the four canopy trees listed were Schotia afra. It is felt therefore that this species will maintain its present status, particularly when the high incidence of tree-fall on this dune slope is taken into account. Considering its present position in the sub-canopy stratum, Olea exasperata could increase somewhat in importance in the community in the future. Although an important canopy individual of the dune fynbos and moisture stressed dune crest communities in the region, this species seldom grows beyond 4m in height and it is unlikely therefore, that it would ever become an important canopy species in the forest which was sampled.

The mean canopy height was approximately 5m and the tallest individuals measured were Schotia latifolia (8m) Schotia afra (7m), Brachylaena discolor (7m) and Diospyros natalensis (7m). The canopy stand density was 1190 sph, with a stem basal area of 18,71m$^2$ per hectare. The stocking of the sub-canopy stratum was very high at 1959 sph but the actual stem basal area was fairly low and measured only 1,66m$^2$ per hectare. Species with the greatest Dbh were Mimusops caffra (37cm) and Schotia afra (29 cm).

The herb layer was very sparse and recorded cover values ranged between 0 and 20 per cent. The mean cover value was 4 per cent.

### 5.9.2 Floristic and structural comparison between the valley and landward forest communities

From the data it is apparent that floristic and structural differences do exist between the two communities sampled.

The landward slope contained a total of fourteen canopy species and a further ten species in the sub-canopy, which was slightly higher than the totals for the valley forest. Six canopy and seven sub-canopy species were common to both communities, with Mimusops caffra, Cassine aethiopica and Sideroxylon inerme being of greatest importance.

Seven canopy species were found to occur exclusively in the valley, of which Erythrina caffra and Harpephyllum caffrum were interpreted as being the most significant indicators of the near climax state of the forest. Of the eight species exclusive to the landward canopy, only

Olea exasperata and Schotia afra can possibly be regarded as diagnostics of this drier site.

Deinbollia oblongifolia, Vepris lanceolata and Harpephyllum caffrum are important sub-canopy species which are exclusive to the valley, whilst Scutia myrtina and Olea exasperata can be regarded as significant differential members characterizing the landward sub-canopy. Acokanthera oblongfolia was the only species, which is typically associated with subordinate forest strata, occurring in the landward sub-canopy.

The most obvious structural difference between the two communities is the height of the canopy which, in the valley, is almost five metres taller than that of the landward slope. The stocking density and stem basal area of both strata also differ significantly between the valley and landward communities. The valley site is occupied by 75 per cent fewer canopy trees and 60 per cent fewer sub-canopy individuals than the landward slope. The total stem basal area of the latter, however, is only 10 per cent higher than in the valley indicating that the climax forest consists of far fewer, but much larger members, which probably have a greater total forest biomass.

The ground cover values of the herb layer within the two sampled communities differed considerably. The moister valley environment supported a relatively dense ground layer compared to the landward slope where the herb cover was very sparse. Although moisture is probably the over-riding factor influencing the herb layer, the angle of the dune slope and the subsequent erosion of the topsoil possibly also plays a physical role in reducing ground cover.

### 5.9.3 Multivariate Analysis Results and Discussion

Classification

A classification of the canopy species is illustrated in Table 66. The climax valley forest is characterized by the diagnostic species *Sideroxylon inerme* and *Diospyros natalensis* while *Cassine aethiopica*, *Euclea racemosa* and *Mimusops caffra* distinguish the landward thicket. *Dovyalis rotundifolia* is shown to be equally common to both communities but is of relatively little significance overall. Although *S. inerme* has been identified as a species diagnostic of the valley community, it does nevertheless contribute to a much lesser extent towards the landward canopy. *M. caffra* plays a similar minor role in the valley forest canopy and the possible significance of this has already been discussed. This classification reflects the description based on the importance rankings quite well, with the exception of the apparently reduced significance of *Schotia afra* as a landward diagnostic.

The classification of the sub-canopy stratum shows a reasonably clear differentiation between the sampled valley and landward vegetation.

TABLE 66. CLASSIFICATION OF THE BEACON BAY CANOPY SPECIES.

| | VALLEY COMMUNITY | | | | | | | | | | | | | | | LANDWARD COMMUNITY | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 27 | 30 | 23 | 24 | 16 | 19 | 20 | 22 | 29 | 21 | 25 | 26 | 28 | 17 | 18 | 7 | 8 | 12 | 13 | 3 | 2 | 4 | 5 | 14 | 1 | 9 | 10 | 15 | 6 | 11 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tur. obt. | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | |
| Sch. lat. | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | |
| Pte. tri. | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | |
| Ole. exa. | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | |
| Euc. nat. | | | | | | | | | | | | | | | | | | | | | 5 | | 4 | | | | | | | |
| Sch. afr. | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | 5 | 5 |
| Euc. rac. | | | | | | | | | | | | | | | | | 5 | | | | | | | | 5 | 4 | 5 | | | |
| Chi. fov. | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | | |
| Bra. dis. | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | 5 | |
| Dov. rot. | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 |
| Cas. aet. | | 4 | | | | | | | 4 | | | | | | | 5 | 5 | 5 | 5 | | | | | | | | 5 | | | |
| Mic. caf. | | | | | | | | | | 5 | 5 | | | 5 | 5 | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | |
| May. het. | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | |
| Zan. cap. | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | |
| Oco. zey. | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | |
| Ery. caf. | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | |
| Cas. pap. | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf. | | | 5 | 5 | | | | | | 5 | | | | | 5 | | | | | | | | | | | | | | | |
| Dio. nat. | 5 | | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | 5 | 5 | | | | | | | | | | | |
| Sid. ine. | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 5 | 4 | 5 | 5 | 5 | | | | | | | | | | | | |
| Har. caf. | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | | | | |

In Table 67, nine of the fifteen landward sample stands have been grouped together, with Euclea natalensis, Mimusops caffra and Olea exasperata in particular, representing possible diagnostic species of the community. The species which are best represented in the group of predominantly valley stands and which could be regarded as diagnostics are Acokanthera oblongifolia, Deinbollia oblongifolia and Pavetta revoluta. Cassine aethiopica shows an apparent lack of preference to either community and is common to both.

The combined classification of both the canopy and sub-canopy data once again shows the compositioal differences between the valley and landward communities quite clearly (Table 68). The positive valley or climax association by canopy species such as Harpephyllum caffrum, Sideroxylon inerme and Diospyros natalensis and sub-canopy species such as Acokanthera oblongifolia and Pavetta revoluta are highlighted in the table. Similarly, the sub-climax landward preference by Mimusops caffra and Euclea racemosa as canopy members and by Euclea natalensis and Olea exasperata in the sub-canopy is also well illustrated.

Ordination

The two groups which have been delineated on the canopy ordination in Fig.48 are comprised of the majority of the landward stands on the left (A) and the valley stands on the right (B). The relatively wide

TABLE 67. CLASSIFICATION OF THE BEACON BAY SUB-CANOPY SPECIES.

| | VALLEY COMMUNITY | | | | | | | | | | | | | | | | | | | | | LANDWARD COMMUNITY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 16 | 19 | 22 | 29 | 17 | 13 | 21 | 25 | 30 | 7 | 10 | 12 | 26 | 8 | 11 | 23 | 24 | 20 | 27 | 18 | 28 | 4 | 5 | 6 | 9 | 14 | 1 | 3 | 2 | 15 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap. | | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. pro. | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. het. | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf. | 5 | | | | 5 | | | | | | | | 4 | | | | | | | | | | | | | | | | | |
| Dei. obl. | 5 | 5 | 5 | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | |
| Dic. nat. | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | |
| Har. caf. | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | |
| Dov. rot. | | | | | | 4 | 5 | | 5 | | | 4 | 4 | | | | | | | | | | | | | | | | | |
| Pav. rev. | | | | | | 5 | | 4 | 4 | | | | | | | | | | | 5 | 5 | 4 | | | | | | | | |
| All. nat. | | | | | | | | | | | | | | | | 5 | 4 | | | | | | | | | | | | 5 | |
| Aco. obl. | | | 5 | 5 | | | | | | | | | | 5 | | 4 | 5 | 4 | 4 | 5 | 5 | | | | | | | | | |
| Vep. lan. | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | |
| Rhu. nat. | | | | | | | | | | | | | | | | | | | | 5 | 4 | | | | | | | | | |
| Sid. ine. | | | | | | | | | | | | | 5 | 5 | 5 | | 5 | | | | | 4 | | | | | | | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | |
| Eug. cap. | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | |
| Tur. obt. | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | |
| Chi. fov. | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | |
| Rhu. gla. | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | |
| Fic. bdv. | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 4 | | | | |
| Ole. exa. | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 | 5 | | | |
| Euc. nat. | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | 5 | | | | 5 | |
| Scu. myr. | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | |
| Mim. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | 5 |
| Ole. cap. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Cas. tet. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Cas. aet. | | | | | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | | | 5 | 5 | 5 | 5 | | 5 | | 5 |
| Bra. dis. | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | 5 | | |

TABLE 68. CLASSIFICATION OF THE BEACON BAY CANOPY AND SUB-CANOPY SPECIES.

VALLEY COMMUNITY (points 17 to 27) | LANDWARD COMMUNITY (points 8 to 4)

| SPECIES / POINT Nos. | 17 | 16 | 19 | 20 | 22 | 29 | 18 | 21 | 25 | 28 | 26 | 7 | 12 | 13 | 30 | 23 | 24 | 27 | 8 | 11 | 10 | 1 | 3 | 5 | 14 | 2 | 6 | 9 | 15 | 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May. pro.2 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. het.2 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap.1 | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cas. pap.2 | | | 5 | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| Vep. lan.2 | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. het.1 | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. nat.2 | | | | | | | 5 | | | 4 | | | | | | | | | | | | | | | | | | | | |
| Har. caf.2 | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | |
| Sco. zey.1 | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | |
| Dei. obl.2 | | 5 | 5 | | 5 | | | 4 | | | | | | | | | | | | | | | | | | | | | | |
| Cor. caf.2 | 5 | 5 | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | |
| Cor. caf.1 | | | | | | | 5 | 5 | | | | | | | | 5 | 5 | | | | | | | | | | | | | |
| Ery. caf.1 | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | |
| Dov. rot.2 | | | | | | | | 5 | | | 4 | | 4 | 4 | 5 | | | | | | | | | | | | | | | |
| Aco. obl.2 | | | | 4 | 5 | 5 | 5 | | | 5 | | | | | | 4 | 5 | 4 | 5 | | | | | | | | | | | |
| Har. caf.1 | | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | | | | | | |
| Dio. nat.1 | | | | 5 | 5 | 5 | | 5 | 5 | | 5 | | 5 | 5 | | 5 | 5 | 5 | | | | | | | | | | | | |
| Zan. cap.1 | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | |
| Tur. obt.1 | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | |
| Sch. lat.1 | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | |
| Dio. nat.2 | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | |
| Pav. rev.2 | | | | | | | 5 | | 4 | 5 | | | | 5 | 4 | | | | | | | | | | | | | | | 4 |
| Sid. ine.1 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | | | | | 5 | 5 | | 5 | 5 | 5 | | 5 | | | | | | | | | | | |
| Sch. afr.1 | | | | | | | | | | | | | | | | | | | 5 | 5 | | | | | | | 5 | | | |
| Chi. fov.1 | | | | | | | | | | | | | | | 5 | | | | | | 5 | | | | | | | | 5 | |
| Euc. rac.1' | | | | | | | | | | | | | | | | | | | 5 | | 5 | 5 | | | | | | 4 | | |
| Pte. tri.1 | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | |
| Ole. exa.1 | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | |
| Rhu. gla.2 | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | |
| Scu. myr.2 | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | | | | | | |
| Fic. bdv.2 | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | | | | |
| Ole. exa.2 | | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | 5 | | | | | |
| Mim. caf.2 | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | | | | | | 5 | |
| Euc. nat.1 | | | | | | | | | | | | | | | | | | | | | | | | 4 | | 5 | | | | |
| Euc. nat.2 | | | | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | 4 | 5 | | |
| Bra. dis.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | 5 | |
| Tur. obt.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | |
| Ole. cap.2 | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 | |
| Cas. tet.2 | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 | |
| Euc. rac.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Eug. cap.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Sid. ine.2 | | | | | | | | | | | 5 | | | | | | 5 | | 5 | 5 | | | | | | | | | | 4 |
| Bra. dis.2 | | | | | | | | | | | | | | 4 | | | | | | | | | 5 | | | | | | | |
| Dov. rot.1 | | | | | | | | | | | | | | | 5 | | | 5 | | 4 | | | | | | | 5 | | | |
| Chi. fov.2 | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | |
| All. nat.2 | | | | | | | | | | | | | | | | | 5 | 4 | | | | | | | | 5 | | | | |
| Cas. aet.1 | | | | | | 4 | | | | | | 5 | 5 | 5 | 4 | | | | 5 | | 5 | | | | | | | | | |
| Mim. caf.1 | 5 | | | | | | 5 | 5 | 5 | | | | | | | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Cas. aet.2 | 4 | | | 5 | | | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | 5 | | 5 | 5 | 5 | | 5 | 5 | 5 | |

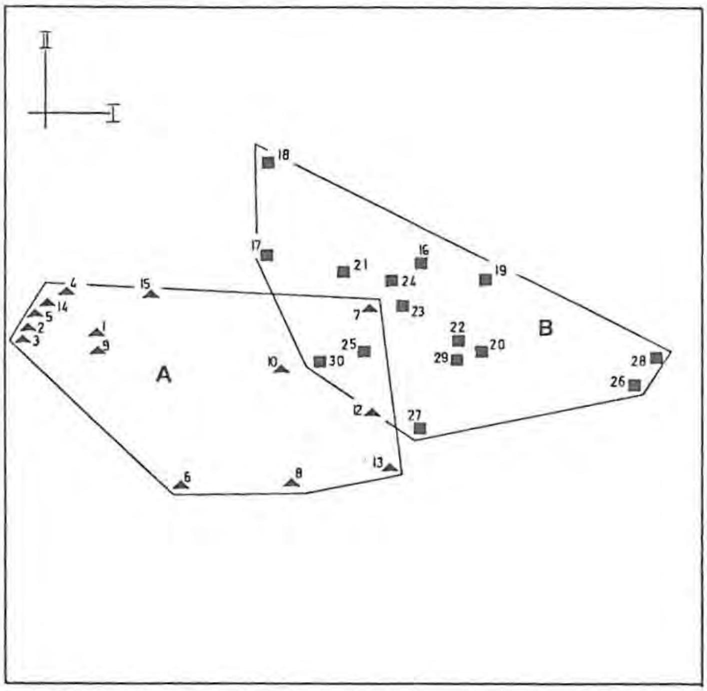



Fig. 48.
Ordination of the Beacon Bay canopy data. Group A represents the landward community and Group B, the valley community.
▲ = landward stands
■ = valley stands

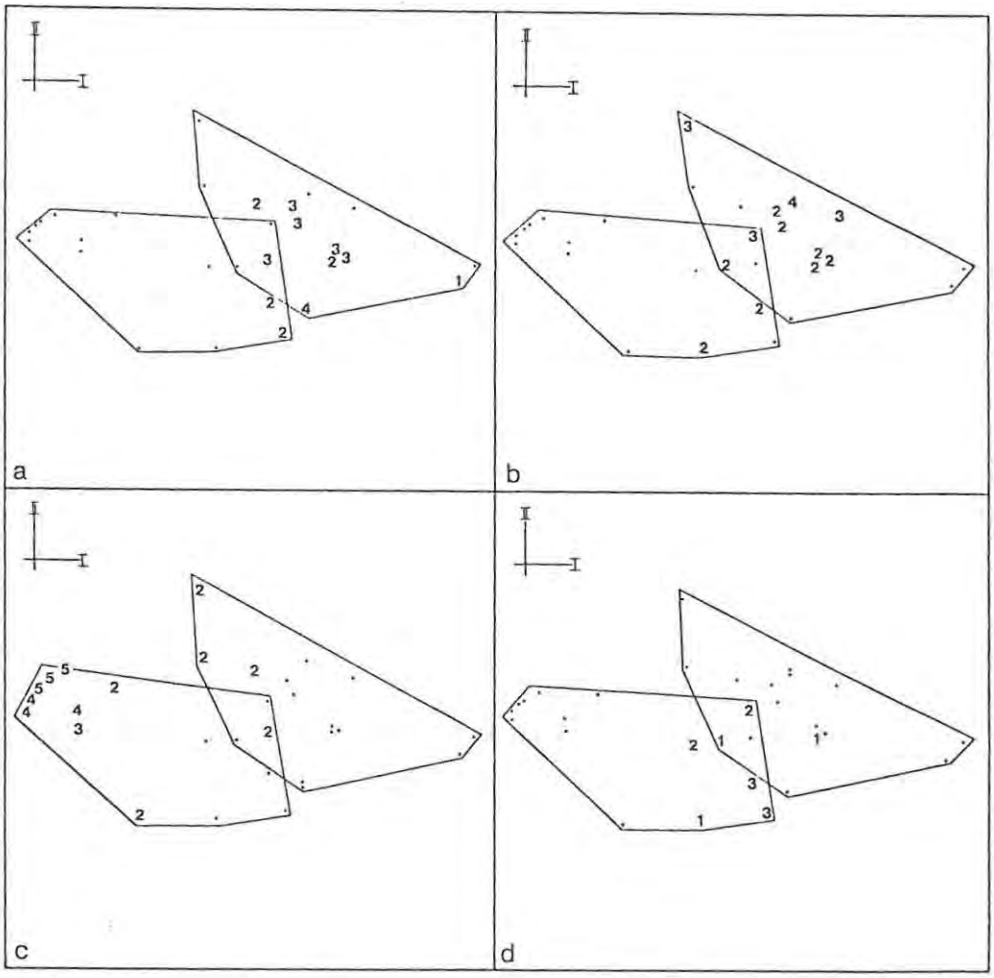



Fig. 49.
Positions on the Beacon Bay canopy ordination of (a) Diospyros natalensis, (b) Sideroxylon inerme, (c) Mimusops caffra and (d) Cassine aethiopica.
(·–5 denote importance ratings where: · = 0%, 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80% and 5 = 81–100%)

floristic differences between these two communities are reflected in the axis-I polarization of the plotted stand clusters. The significance of selected dominant and sub-dominant species in creating this pattern is illustrated in Figs.49(a) to (d).

Figs.49(a) and (b), show the importance of Diospyros natalensis and Sideroxylon inerme in the climax valley community, which would seem to indicate their preference for the sheltered site and better developed soils. The distribution of Mimusops caffra (Fig.49(c)) on the other hand indicates its tolerance of the less favourable conditions typical of the drier and unstable landward slope. Cassine aethiopica appears to be slightly more flexible in its site requirements and although it shows a slight preference for the landward site, it does nevertheless also occur in the valley forest as well (Fig.49(d)).

The sub-canopy ordination also shows two groups of stands on the scatter diagram (Fig.50). Those representing the valley sub-canopy comprise Group A and are plotted to the right while most of the landward stands are included in Group B on the left of the diagram. The distribution on the ordination of some of the important species which contribute towards the differentiation of the two communities are illustrated in Figs.51(a) to (d). Acokanthera oblongifolia quite clearly shows a preference for the valley site (Fig.51(a)), while Euclea natalensis and Olea exasperata appear to occur in the landward

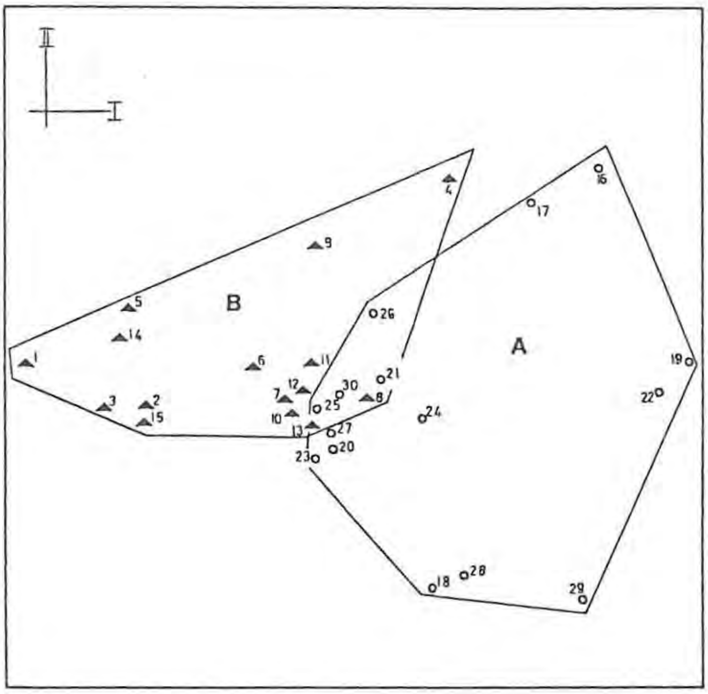



Fig. 50.
Ordination of the Beacon Bay sub-canopy data. Group A represents the valley community and Group B, the landward community.
o = valley stands
▲ = landward stands

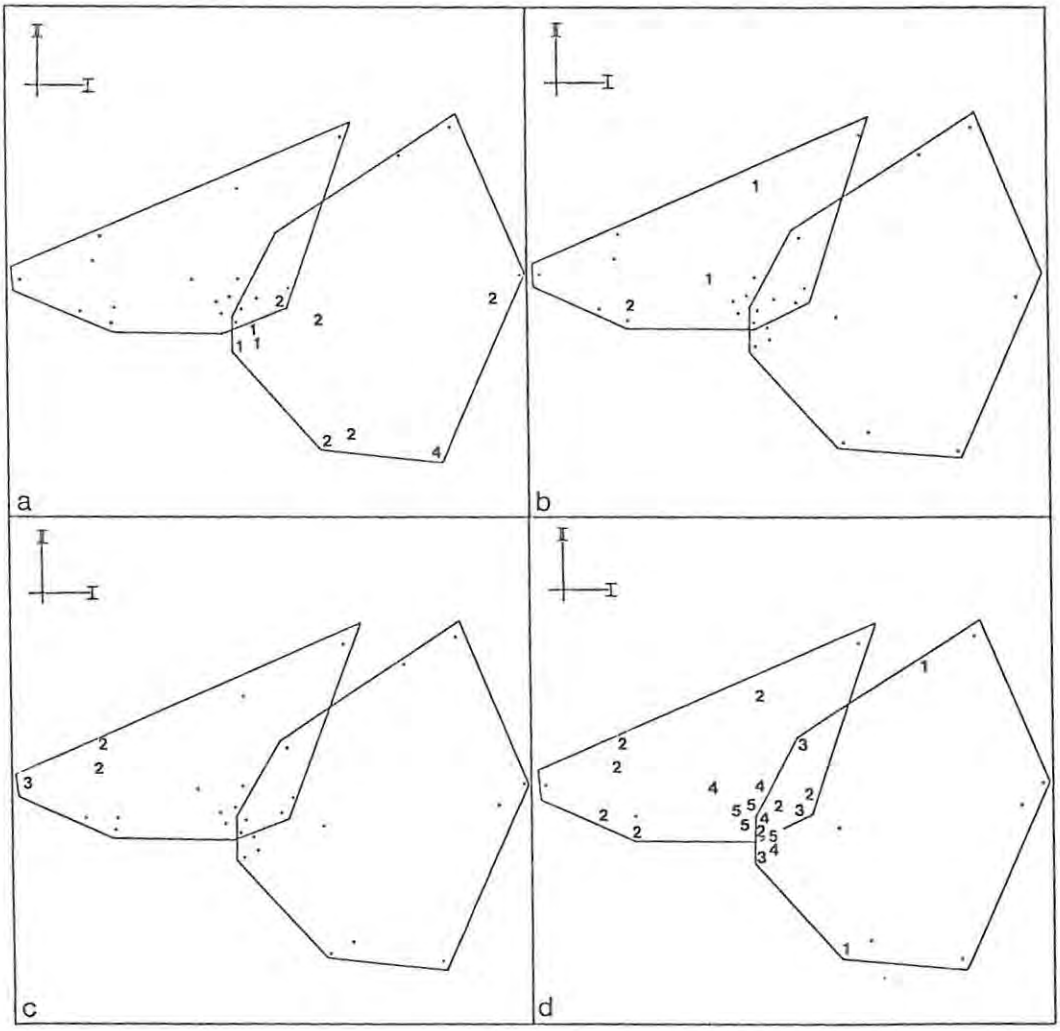



Fig. 51.
Positions on the Beacon Bay sub-canopy ordination of (a) Acokanthera oblongifolia, (b) Euclea natalensis, (c) Olea exasperata and (d) Cassine aethiopica.
(·–5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%. 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

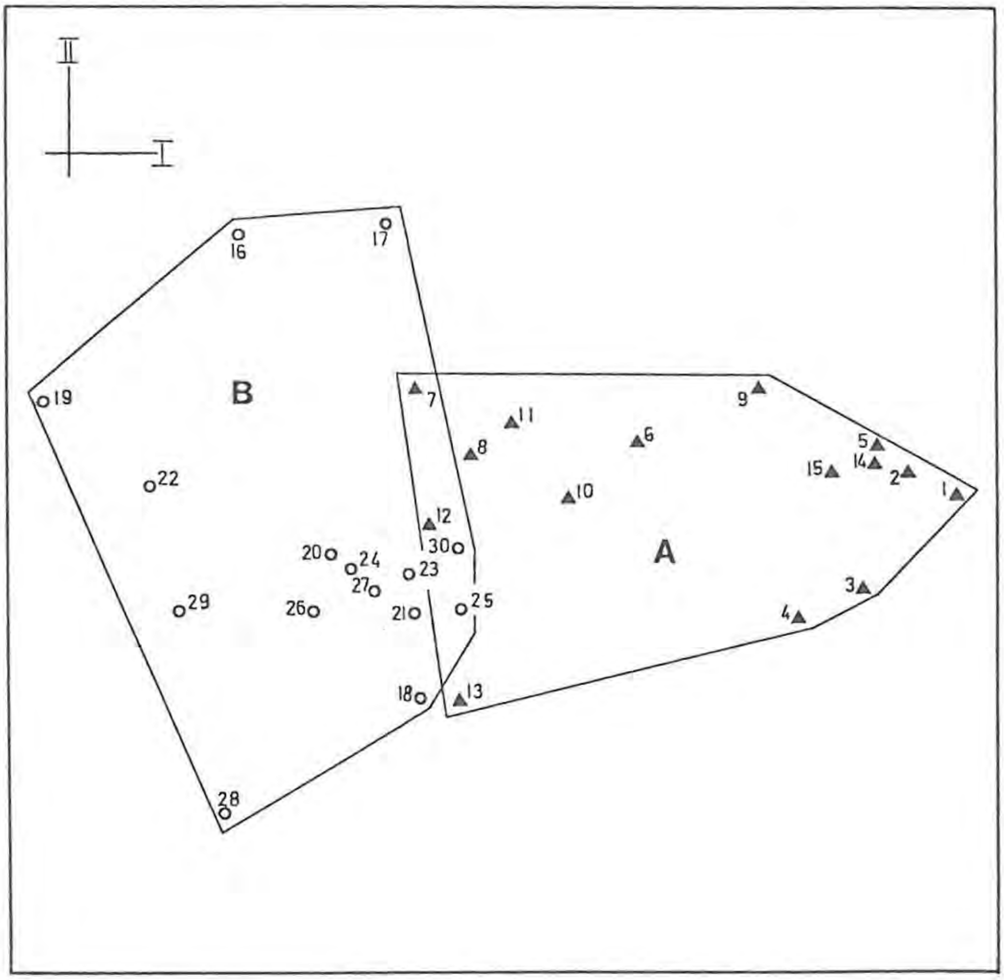



Fig. 52.
Ordination of the combined canopy and sub-canopy data for Beacon Bay. Group A represents the landward community and Group B, the valley community.

▲ = landward stands
o = valley stands

community only (Figs.51(b) and (c)).The wide distribution of Cassine aethiopica in both communities is evident from Fig.51(d).

The ordination of the sample stands where information for both strata has been included, shows a clear pattern on the scatter diagram (Fig.52). The distribution of the points relative to Ordination axis-I has resulted in a general polarization and grouping of the landward stands to the right (Group A) and valley stands to the left (Group B). The significance of certain species which contribute towards the creation of this pattern has been discussed above.

## 5.10 THE KIDDS BEACH DUNE FOREST

### 5.10.1 Site and Forest Description

The Kidds Beach dune forest, which measures approximately 105 ha in extent, stretches between the Gulu River Mouth in the north and the Mcantzi River and Kidds Beach Township in the south. As with most of the other forest patches, it occupies for much of this distance a single dune ridge which is intersected at regular intervals by parabolic dune breaches aligned in an east-west direction which have been stabilized either naturally or artificially (in one instance) by vegetation.

Public utilization of the beach and forest is relatively high, particularly at Gulu where there is a popular picnic site used by day visitors. Access to the beach is also gained by vehicles along the edge of the tidal Gulu River mouth and little can be done to prevent this until the vehicle ban is extended south of East London. The Kidds Beach township is at present almost eighty per cent developed and it is likely that with the proposed extensions, the coast will be subjected to greater pressures in the near future.

Past management of this area has included driftsand stabilization south of the Gulu River mouth. This has involved the use of both indigenous and exotic species and the current and ongoing aim is to eventually replace the latter.

Four plant communities can be distinguished (Fig. 53). They are the thicket zones of the landward and seaward dune slopes, the mixed grassland and scrub-thicket along much of the landward margin and the artificially instated community of the reclaimed driftsand areas. Sampling was carried out in the first two communities only.

The Cassine aethiopica - Mimusops caffra seaward community

The fifteen points used to sample this community were distributed between A and B as indicated in Fig. 53. The dominant canopy species is Cassine aethiopica with an importance value of 28 per cent and a stocking density of almost twice that of Mimusops caffra, the sub-dominant in the community (Table 69). The latter species had an importance value of 20 per cent and for the first time was not

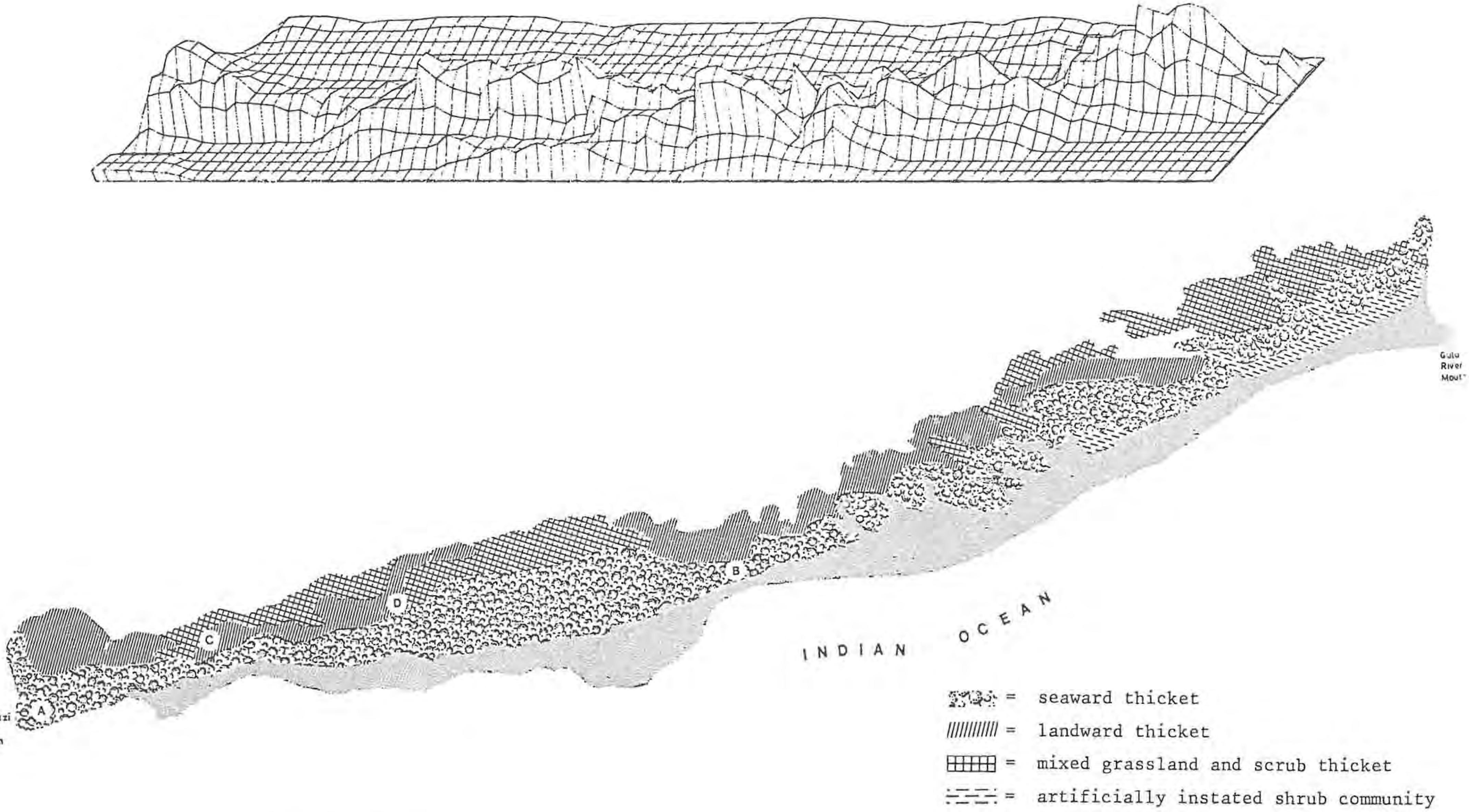



Fig. 53. The Kidds Beach vegetation and topographical maps illustrating the four major plant communities.

TABLE 69. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KIDDS BEACH SEAWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 500 | 7,20 | 28 |
| *Mimusops caffra* | 260 | 6,70 | 20 |
| *Sideroxylon inerme* | 166 | 5,96 | 14 |
| *Maytenus heterophylla* | 166 | 1,55 | 9 |
| *Chionanthus foveolata* | 116 | 0,52 | 5 |
| *Apodytes dimidiata* | 83 | 1,04 | 5 |
| *Dovyalis rotundifolia* | 83 | 0,78 | 5 |
| *Allophylus natalensis* | 50 | 0,78 | 4 |
| *Pterocelastrus tricuspidatus* | 33 | 0,26 | 2 |
| *Acokanthera oblongfolia* | 33 | 0,05 | 2 |
| *Brachylaena discolor* | 33 | 0,07 | 2 |
| *Canthium obovatum* | 33 | 0,52 | 2 |
| *Maerua cafra* | 33 | 0,13 | 2 |
| *Euclea natalensis* | 33 | 0,26 | 2 |
| *Maytenus procumbens* | 33 | 0,08 | 2 |
| | 1655 | 25,90 | 104 |

recorded as a seaward dominant. Other significant members of the canopy stratum were Sideroxylon inerme and Maytenus heterophylla.

The sub-canopy stratum is dominated by Acokanthera oblongifolia and Dovyalis rotundifolia with respective importance values of 20 and 19 per cent (Table 70). Cassine aethiopica is the sub-dominant species with an importance value of 16 per cent, while Mimusops caffra is relatively insignificant with an importance value of only 3 per cent.

The sample data appears to reflect the decreasing role played by Mimusops caffra quite well since, at Kidds Beach, this species is close to its southernmost distribution limit. Its sub-dominant position is also somewhat insecure considering its low regenerative potential from the sub-canopy stratum. Cassine aethiopica is, as described above, the new canopy dominant and is likely to retain this position since it is well represented in the sub-canopy as well. Visual impressions are that this pattern persists for some distance south of Kidds Beach until Sideroxylon inerme acquires the dominant position. The high stocking density of Acokanthera oblongifolia in the sub-canopy is somewhat unusual since in dune thicket, it is generally the juvenile canopy species which record the highest values.

The canopy varied in height between 3 and 6,5 m and on average, was 4,7 m high, with the tallest species being M. caffra and S. inerme. The stand density of the canopy members was 1655 Sph which accounted

TABLE 70. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KIDDS BEACH SEAWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Acokanthera oblongfolia* | 280 | 0,14 | 20 |
| *Dovyalis rotundifolia* | 201 | 0,18 | 19 |
| *Cassine aethiopica* | 145 | 0,24 | 16 |
| *Sideroxylon inerme* | 55 | 0,05 | 5 |
| *Chionanthus foveolata* | 33 | 0,05 | 4 |
| *Dracaena hookerana* | 33 | 0,06 | 4 |
| *Maytenus heterophylla* | 33 | 0,06 | 4 |
| *Olea capensis* | 33 | 0,02 | 3 |
| *Maytenus nemorosus* | 33 | 0,01 | 3 |
| *Mimusops caffra* | 33 | 0,03 | 3 |
| *Allophylus natalensis* | 22 | 0,05 | 3 |
| *Euclea racemosa* | 33 | 0,04 | 3 |
| *Euclea natalensis* | 33 | 0,01 | 2 |
| *Carissa bispinosa* | 22 | 0,01 | 2 |
| *Scutia myrtina* | 22 | 0,01 | 2 |
| *Maerua cafra* | 22 | 0,01 | 2 |
| *Diospyros natalensis* | 22 | 0,01 | 2 |
| *Clausena anisata* | 22 | 0,01 | 2 |
| *Cassine tetragona* | 22 | 0,01 | 2 |
| | 1099 | 1,00 | 101 |

for a total stem basal area of 25,9$m^2$/ha. In the sub-canopy stratum the density was slightly lower at 1099 Sph and the recorded stem basal area here was approximately 1$m^2$/ha. Species with the greatest Dbh were once again S. inerme (32 cm) and M. caffra (28 cm).

Cover values for the herb and shrub layer varied between 1 and 90 per cent with a mean value of 17 per cent.

**The Cassine aethiopica - Apodytes dimidiata landward community**

The fifteen points used to sample this community were distributed between points C and D as indicated in Fig. 53.

Cassine aethiopica was by far the most dominant canopy member, with an importance value of 25 per cent and a density value of more than twice that of the sub-dominant species (Table 71). Mimusops caffra and Apodytes dimidiata are subdominants with respective importance values of 15 and 11 per cent. The latter species has a somewhat higher stocking rate than M. caffra and for this reason it was used as a differentiating species in naming the community. Dominance in the sub-canopy stratum is shared between Sideroxylon inerme, Cassine aethiopica and Diospyros scabrida which have respective importance values of 14 and 13 per cent (Table 72). Acokanthera oblongifolia is a sub-dominant species in this stratum and has an importance value of 10 per cent.

TABLE 71. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KIDDS BEACH LANDWARD CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Cassine aethiopica* | 630 | 2,94 | 25 |
| *Mimusops caffra* | 230 | 3,32 | 15 |
| *Apodytes dimidiata* | 295 | 0,98 | 11 |
| *Pterocelastrus tricuspidatus* | 230 | 0,84 | 9 |
| *Chionanthus foveolata* | 115 | 0,42 | 5 |
| *Olinia ventosa* | 69 | 0,98 | 5 |
| *Schotia latifolia* | 46 | 1,96 | 5 |
| *Maytenus undata* | 69 | 0,42 | 4 |
| *Sideroxylon inerme* | 69 | 0,28 | 3 |
| *Maytenus heterophylla* | 69 | 0,28 | 3 |
| *Pavetta revoluta* | 69 | 0,28 | 3 |
| *Euclea natalensis* | 46 | 0,28 | 2 |
| *Olea capensis* | 46 | 0,03 | 2 |
| *Tarchonanthus camphoratus* | 46 | 0,14 | 2 |
| *Rhus longispina* | 46 | 0,14 | 2 |
| *Canthium obovatum* | 46 | 0,42 | 2 |
| *Scolopia zeyheri* | 46 | 0,14 | 2 |
| *Rhus glauca* | 46 | 0,06 | 1 |
| *Olea exasperata* | 46 | 0,06 | 1 |
| *Acokanthera oblongfolia* | 46 | 0,03 | 1 |
| | 2305 | 14,00 | 103 |

TABLE 72. DENSITY, BASAL AREA AND IMPORTANCE VALUES FOR THE KIDDS BEACH LANDWARD SUB-CANOPY SPECIES.

| SPECIES | D/HA (Sph) | BA/HA ($m^2$) | I.V. (%) |
|---|---|---|---|
| *Sideroxylon inerme* | 467 | 0,40 | 14 |
| *Cassine aethiopica* | 467 | 0,38 | 14 |
| *Diospyros scabrida* | 542 | 0,25 | 13 |
| *Acokanthera oblongfolia* | 257 | 0,36 | 10 |
| *Pterocelastrus tricuspidatus* | 188 | 0,28 | 7 |
| *Dovyalis rotundifolia* | 257 | 0,15 | 7 |
| *Olea capensis* | 256 | 0,10 | 6 |
| *Chionanthus foveolata* | 188 | 0,05 | 4 |
| *Euclea natalensis* | 188 | 0,05 | 4 |
| *Maytenus undata* | 188 | 0,05 | 4 |
| *Rhus glauca* | 113 | 0,08 | 3 |
| *Carissa bispinosa* | 113 | 0,05 | 3 |
| *Olea exasperata* | 75 | 0,05 | 2 |
| *Apodytes dimidiata* | 75 | 0,08 | 2 |
| *Rhus natalensis* | 75 | 0,03 | 2 |
| *Diospyros natalensis* | 75 | 0,03 | 2 |
| *Rhus longispina* | 75 | 0,03 | 2 |
| *Mimusops caffra* | 75 | 0,03 | 2 |
| *Dracaena hookerana* | 75 | 0,05 | 2 |
| | 3749 | 2,50 | 103 |

It is likely that C. aethiopica will maintain its dominant canopy position since it is also well represented in the sub-canopy, unlike M.caffra which could be replaced in due course by species such as Pterocelastrus tricuspidatus or S. inerme. As in the case of the seaward community, the typical sub-canopy species A. oblongifolia was found to be unusually common in this stratum. Diospyros scabrida was also an interesting species which was recorded for the first time at Kidds Beach and which had the highest stocking rate of any of the sub-canopy species.

The measured canopy height varied between 2,5 and 6 m and on average was 4,1 m, with the tallest individuals being Schotia latifolia, Olinia ventosa and Mimusops caffra. The stocking density of the canopy individuals was high at 2305 Sph which together, contributed a stem basal area of approximately $14m^2$/ha. The sub-canopy stocking was also exceptionally high with 3749 trees having been recorded per hectare with a combined basal area of 2,5 $m^2$. Species with greatest Dbh were Schotia latifolia (25 cm) and Mimusops caffra (21 cm).

The cover values of the combined shrub and herb layer varied between 1 and 40 per cent but on average was relatively low at only 5.4 per cent.

### 5.10.2. Floristic and Structural comparison between the seaward and landward communities

Floristically, the two thicket areas are quite similar. Both have identical canopy dominants and it is only in the lower hierarchy species that differences in relative levels of importance occur. Pterocelastrus tricuspidatus and Apodytes dimidiata for example appear to be far more significant on the hotter landward site than within the seaward community where in turn, Sideroxylon inerme and Maytenus heterophylla hold higher community positions. The landward thicket contains a wider diversity of canopy species than that of the seaward site, which could possibly be expected due to the absence of salt spray. Species such as (inter alia) Olinia ventosa, Schotia latifolia and Rhus longispina which were recorded in the landward thicket are absent in the seaward community. Both communities recorded the same number of species in their sub-canopy strata, but both floristic and hierarchical differences were evident. Most apparent was the significance of P. triscuspidatus and in particular, Diospyros scabrida, in the landward thicket, which were not recorded at all on the seaward site. Differentiation between the two communities can therefore only really be made on the basis of the compositions of both strata and by taking into account the less common species as well. Ideally, a more intensive quadrat sampling operation should be employed to establish the community identities more clearly.

The two sampled areas differed quite considerably with regards to certain structural features of the vegetation. The landward community had true thicket characteristics and was shorter, contained many more stems per hectare in both strata and accounted for a much lower stem basal area than the seaward community. The latter was comprised of fewer, but much larger trees and although the definitions of thicket and forest were not adhered to, it had a more forest-like appearance. The hotter and generally drier conditions of the steep landward slope compared to those affecting the seaward community are probably responsible for the major structural differences which were encountered. The lower cover values of the landward ground layer vegetation which has been retarded in its development through light exclusion, moisture stress and unstable soil surface conditions would also tend to support this.

### 5.10.3 Multivariate Analysis Results and Discussion

Classification

The classification of the canopy data which is illustrated in Table 73, provides two relatively good groups of site-associated sample stands. It is quite apparent that Mimusops caffra and Cassine aethiopica are significant species which are common to both sites and that the two communities must be differentiated on the basis of the lower order species. Sideroxylon inerme and Maytenus heterophylla are differential species of the seaward community and at least one of them should preferably have been used in the identification of the

TABLE 73. CLASSIFICATION OF THE KIDD'S BEACH CANOPY SPECIES.

SEAWARD COMMUNITY (point nos. 7 to 15) — LANDWARD COMMUNITY (point nos. 22 to 29)

| POINT Nos. | 7 | 30 | 4 | 5 | 13 | 14 | 16 | 23 | 8 | 11 | 12 | 2 | 6 | 15 | 22 | 24 | 17 | 9 | 21 | 3 | 20 | 26 | 1 | 18 | 10 | 19 | 27 | 25 | 28 | 29 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mae. caf. | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| All. nat. | | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dov. rot. | | | 5 | | | | | | 4 | | 4 | | | | | | | | | | | | | | | | | | | |
| Sid. inv. | | | 5 | | 5 | 5 | 5 | 5 | | 5 | 5 | | | | | | | | | | | | | | | | | | | |
| May. het. | | | | | | | | | | 5 | 4 | 5 | 5 | 5 | | 5 | 5 | | | | | | | | | | | | | |
| Sra. dis. | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | | | | |
| May. pro. | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | |
| Rhu. lon | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | |
| Eug. cap. | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | |
| Rhu. gla. | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | |
| Ole. exa. | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | |
| Ole. cap. | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | |
| Sch. lat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Tar. cam. | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | |
| Aco. obl. | | | | | | | | | | | | | | | | | | 4 | | | | 4 | | | | | | | | |
| May. und. | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 4 | |
| Oli. ven. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Can. obo. | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | | | |
| Pte. tri. | | | | | | | 4 | | | | | | | | | 5 | | | | | | | 4 | 5 | | 5 | 5 | | | |
| Apo. dim. | | | | | | | | 5 | | | | | | | | | 5 | 5 | 5 | 5 | 5 | | | | | | | 5 | | |
| Sco. zey. | | 5 | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | |
| Euc. nat. | | | | | | 4 | | | | | | | | | | | 5 | | | | | | | | | | | | | |
| Chi. fow. | | | | | | | | | | | | 5 | | 5 | 5 | 5 | | | 5 | | | | 4 | | | | | | | |
| Cas. aet. | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 5 | 5 | 5 | | | 5 | 5 | | | | 4 | | 5 | 5 | 5 | 5 | 5 | 5 |
| Mim. caf. | | | | 5 | 5 | | 5 | | 5 | | 5 | 5 | 5 | | 5 | | | | | 4 | | | 5 | | | | | | 5 | |

community which was made on the basis of the importance rankings. Similarly, Apodytes dimidiata and Pterocelastrus tricuspidatus are differential species of the landward community and the former was in fact used in the community description on the basis of its importance and density values. Little can be said about the less frequent species which have been included in the two communities but from the sample data it would appear that the canopy of the landward thicket has a wider floristic diversity than that of the seaward slope.

The sub-canopy classification also provided two relatively good groups of site-associated stands (Table 74). The landward thicket contains a greater number of significant differential species than the seaward community and the most important of these is Sideroxylon inerme. The best differential species in the seaward sub-canopy is Acokanthera oblongifolia, while the two species shown to be most common on both sites are Cassine aethiopica and Dovyalis rotundifolia.

The classification including data from both strata distinguishes the two sampled areas from one another quite well (Table 75). There is clearly a large degree of similarity between the two communities considering the number of species common in both strata. In this respect, the significance of Cassine aethiopica etc. has already been discussed. From the table however, it would appear that the differential species of the landward community are more significant in

# TABLE 74. CLASSIFICATION OF THE KIDD'S BEACH SUB-CANOPY SPECIES.

| | LANDWARD COMMUNITY | | | | | | | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 23 | 25 | 27 | 16 | 21 | 10 | 19 | 1 | 3 | 20 | 22 | 2 | 17 | 28 | 7 | 15 | 26 | 6 | 10 | 14 | 29 | 9 | 4 | 5 | 11 | 13 | 8 | 24 | 30 | 12 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ole. exa. | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Apo. dim. | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. gla. | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. nat. | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | |
| Pte. tri. | | 5 | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | |
| Euc. nat. | | | | | | 5 | 5 | | 5 | | 5 | | | | | | | | | | | | | | | | | | | |
| Chi. fov. | | | | | 5 | 5 | | 5 | 5 | 5 | | | | | | | | | | | | | | | | | | | | |
| Ole. cap. | | | 5 | | | 5 | | | | | | 5 | | 5 | | | | | | 4 | | | | | | | | | | |
| Sid. ine. | | | | 5 | 5 | 5 | 5 | 5 | | | | | 5 | 5 | 5 | | | | 5 | | 5 | | | | | | | | | |
| Cas. tet. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| All. nat. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Rhi. lon. | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | |
| Euc. rac. | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | |
| Cla. ani. | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | |
| Mae. caf. | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | |
| May. het. | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | 5 |
| Scu. myr. | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | |
| Mim. caf. | | | | | | | | | | | | | | | 5 | 5 | 5 | | | | | | | | | | | | | |
| Aco. obl. | | | | | | | | | | | | | | | | | | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | |
| May. nem. | | | | | | | | | | | | 5 | | | | 5 | | | | | | | | | | | | | | |
| Dio. nat. | 5 | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | |
| Dra. hoo. | | | 5 | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | 5 |
| Car. bis. | 4 | | | | | | | | | | | | | | | | | 5 | | | 4 | | | | | | | | | |
| May. und. | | 5 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | |
| Dio. sca. | | | | 5 | 5 | | | | | 5 | 5 | | | | | | 5 | | | | | | | | | | | 5 | 5 | |
| Cas. aet. | 5 | 5 | | | | | | 5 | | 5 | 5 | 5 | | | 5 | 5 | 5 | 5 | 5 | 5 | | | | | | | | | | |
| Dov. rot. | 5 | 5 | 5 | | | | | | 5 | | 5 | | | | 5 | 5 | | | | | | | 5 | 5 | 4 | 5 | 5 | 5 | 5 | |

TABLE 75. CLASSIFICATION OF THE KIDD'S BEACH CANOPY AND SUB-CANOPY SPECIES.

| | LANDWARD COMMUNITY | | | | | | | | | | | | | SEAWARD COMMUNITY | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POINT Nos. | 18 | 19 | 27 | 3 | 16 | 22 | 24 | 20 | 26 | 28 | 29 | 17 | 25 | 1 | 2 | 15 | 21 | 7 | 10 | 6 | 9 | 14 | 23 | 30 | 4 | 5 | 11 | 13 | 8 | 12 |
| SPECIES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. gla.1 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Eug. cap.1 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ole. exa.1 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| May. pro.1 | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ole. exa.2 | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. gla.2 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cus. kra.2 | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rhu. nat.2 | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| May. und.2 | | | 5 | | | | 4 | | | | | | 5 | | | | | | | | | | | | | | | | | |
| Pte. tri.2 | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | |
| Ole. cap.1 | | | | | | | | | | | | | 4 | | | | | | | | | | | | | | | | | |
| Sch. lat.1 | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | |
| May. und.1 | | | | | | | | | | 4 | | | 5 | | | | | | | | | | | | | | | | | |
| Oli. ven.1 | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | | | | | | |
| Tar. cam.1 | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | |
| Rhu. lon.1 | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | |
| Rhu. lon.2 | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | |
| Euc. nat.2 | 5 | 5 | | 5 | | 5 | | | | | | | | | | | | | | | | | | | | | | | | |
| Dio. sca.2 | | | | | 5 | 5 | 5 | 5 | 5 | | | | | | | | 5 | | | | | | | 5 | | | | | | |
| Pte. tri.1 | 5 | 5 | 5 | | 4 | | 5 | | | | | | | 5 | | | | | | | | | | | | | | | | |
| Scu. myr.2 | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | |
| May. nem.2 | | | | | | | | | | | | | | | 5 | 5 | | | | | | | | | | | | | | |
| Bra. dis.1 | | | | | | | | | | | | | | | | | | | | | 4 | | | | | | | | | |
| Dio. nat.2 | | | | | | | | | | | | | | | | | | | | | 5 | | 5 | | | | | | | |
| Sco. zey.1 | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | |
| Euc. rac.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | |
| Cla. ani.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | |
| Mae. caf.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | |
| All. nat.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 |
| Cas. tet.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |
| Mae. caf.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | |
| May. het.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 |
| Dov. rot.1 | | | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | 4 | 4 |
| All. nat.1 | | | | | | | | | | | | | | | | | | | | | | | | | 5 | 5 | | | | |
| Can. obo.1 | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | |
| May. het.1 | | | | | | 5 | | | | | 5 | | | | 5 | 5 | | | | 5 | | | | | | | 5 | | | 4 |
| Dov. rot.2 | | | 5 | 5 | | 5 | | | | | | 5 | | 5 | | 5 | | 5 | | | | | 5 | | 5 | 5 | 5 | 5 | 5 | |
| Aco. obl.2 | | | | | | | 5 | | | | 4 | | | | | | | | 5 | 5 | 5 | 4 | | 5 | 5 | 5 | 4 | 5 | 5 | |
| Sid. ine.1 | | | | | 5 | | | | | | | | | | | | | | | | | 5 | 5 | | 5 | | 5 | 5 | | 5 |
| Cas. aet.1 | | 5 | 5 | | 5 | 5 | | | | 5 | 5 | | 5 | 4 | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 5 | | |
| Cas. aet.2 | | | | | | | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | 5 | 5 | | 5 | 5 | | | | | | | |
| Mim. caf.1 | | | | 5 | 5 | 5 | | 5 | 5 | 5 | | | | 5 | 5 | | | | | 5 | | | | | | 5 | | 5 | 5 | 5 |
| Apo. dim.1 | | | | 5 | | | | 5 | | | | 5 | 5 | | | | 5 | | | | 5 | | 5 | | | | | | | |
| Ole. cap.2 | 5 | | 5 | | | | | | | 5 | | | | | 5 | | | | | | | 4 | | | | | | | | |
| Chi. fov.2 | 5 | | | 5 | | | | 5 | | | | | | 5 | | | 5 | | | | | | | | | | | | | |
| Sid. ine.2 | 5 | 5 | | | 5 | | | | | 5 | 5 | 5 | | 5 | | | 5 | 5 | 5 | | | | | | | | | | | |
| Chi. fov.1 | | | | | | 5 | 5 | | | | | | | 4 | 5 | 5 | 5 | | | | | | | | | | | | | |
| Mim. caf.2 | | | | | | | | | 5 | | | | | | | 5 | | 5 | | | | | | | | | | | | |
| Euc. nat.1 | | | | | | | | | | | | 5 | | | | | | | | | | 4 | | | | | | | | |
| Aco. obl.1 | | | | | | | | 4 | | | | | | | | | | | | | 4 | | | | | | | | | |
| Car. bis.2 | | | | | | | | | | | 4 | | | | | | | | | 5 | | | 4 | | | | | | | |
| Dra. hoo.2 | | | 5 | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | 5 |

the sub-canopy stratum while in the seaward thicket, elements from both strata are involved in differential roles.

## Ordination

From the ordination of the canopy species, it is possible to delineate two groups on the scatter diagram which each contain a number of stands associated with one or the other sampled area (Fig 54). Differentiation between the two groups can be made mainly in terms of the second DCA-axis, with the group of predominantly landward stands located above that identified as the seaward group. The role of certain important species which contribute towards this ordination pattern is illustrated in Figs. 55 (a) to (e).

The preference shown by Apodytes dimidiata for the landward thicket can be seen in Figs. 55 (b) and (c). The lack of preference for either site which is shown by Mimusops caffra and Cassine aethiopica can be seen in Figs. 55 (d) and (e).

The ordination of the stands using the sub-canopy data could not adequately differentiate the two communities and a large degree of similarity between them is evident from the group overlap which is shown in Fig. 56. Nevertheless, some pattern does exist on the scatter diagram, with the seaward and landward groups showing right and left polarizations respectively along the first DCA-axis. The position of Acokanthera oblongifolia on the ordination (Fig. 57 (a))

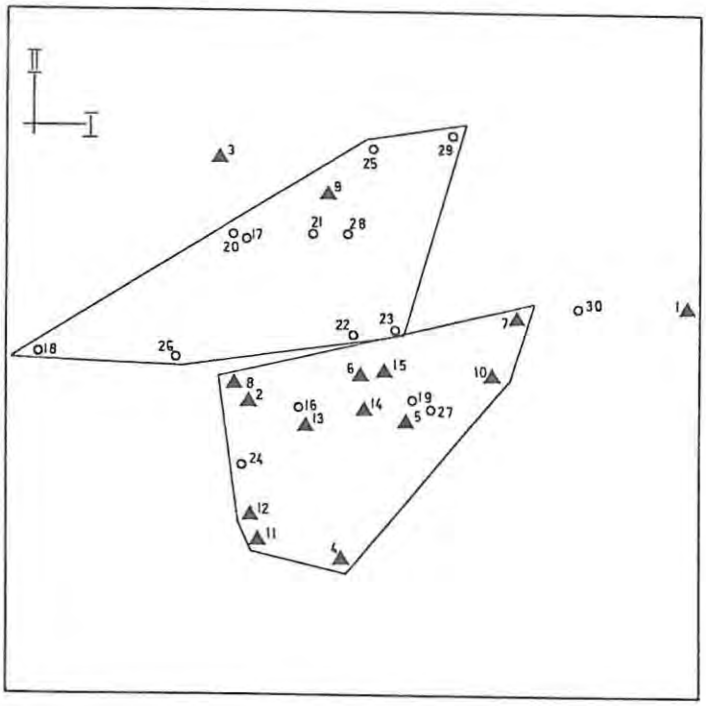


Fig. 54.
Ordination of the Kidds Beach canopy data.
o = landward stands
▲ = seaward stands

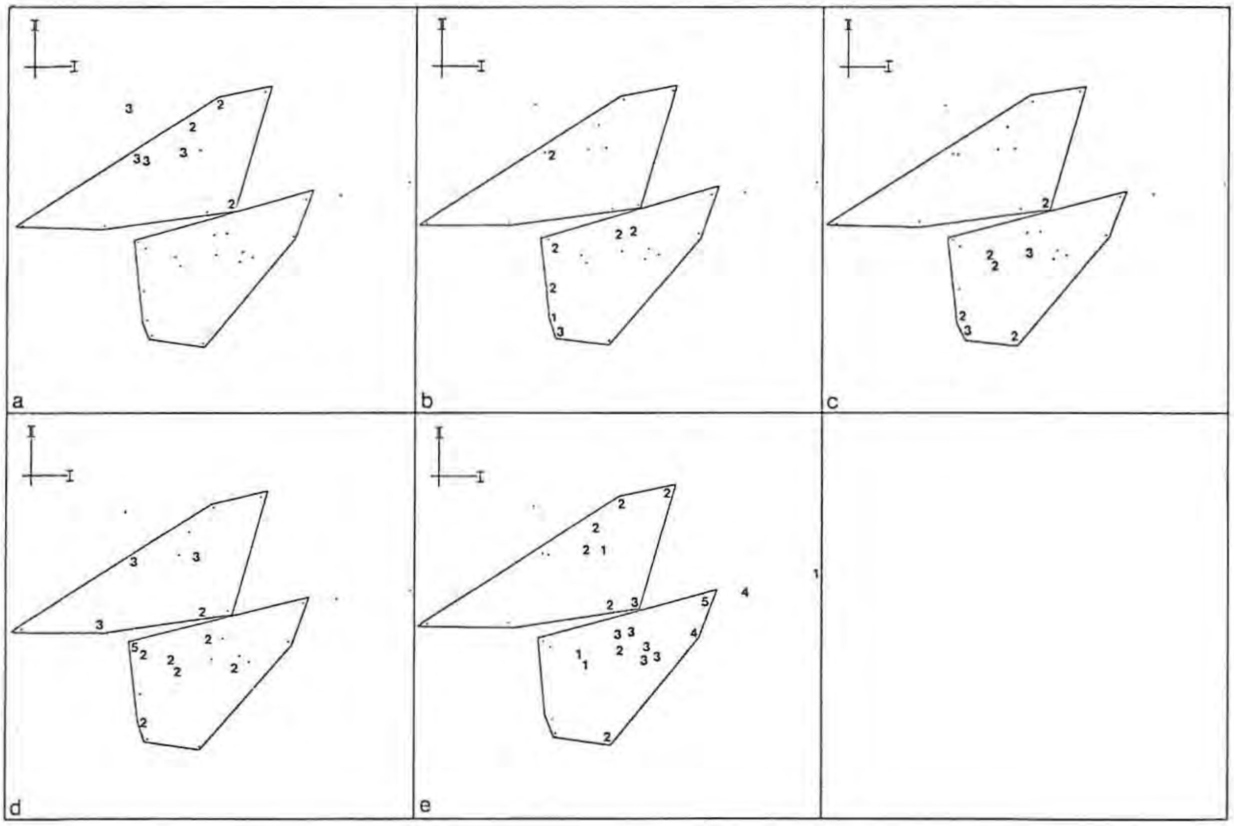


Fig. 55.
Positions on the Kidds Beach canopy ordination of (a) Apodytes dimidiata, (b) Maytenus heterophylla, (c) Sideroxylon inerme, (d) Mimusops caffra and (e) Cassine aethiopica.

(·-5 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%)

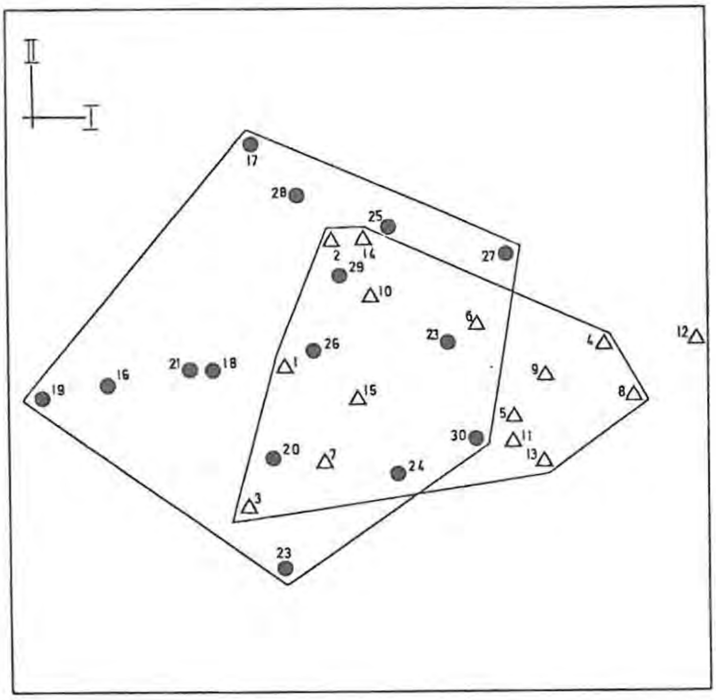



Fig. 56.
Ordination of the Kidds Beach sub-canopy data.
● = landward stands
△ = seaward stands

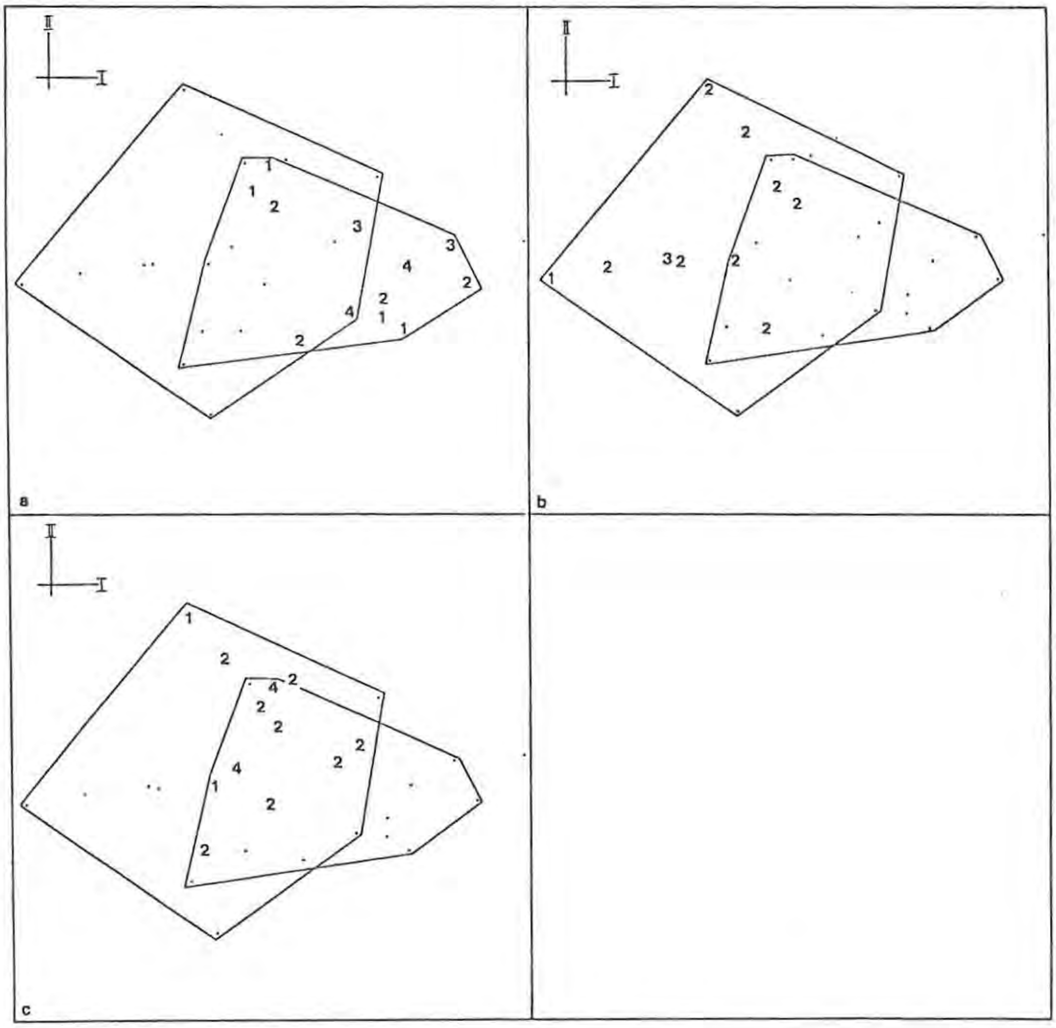



Fig. 57.
Positions on the Kidds Beach sub-canopy ordination of (a) Acokanthera oblongifolia, (b) Sideroxylon inerme and (c) Cassine aethiopica.
(·-4 denote importance ratings where: · = 0%, 1 = 1-20%, 2 = 21-40%, 3 = 41-60% and 4 = 61-80%)

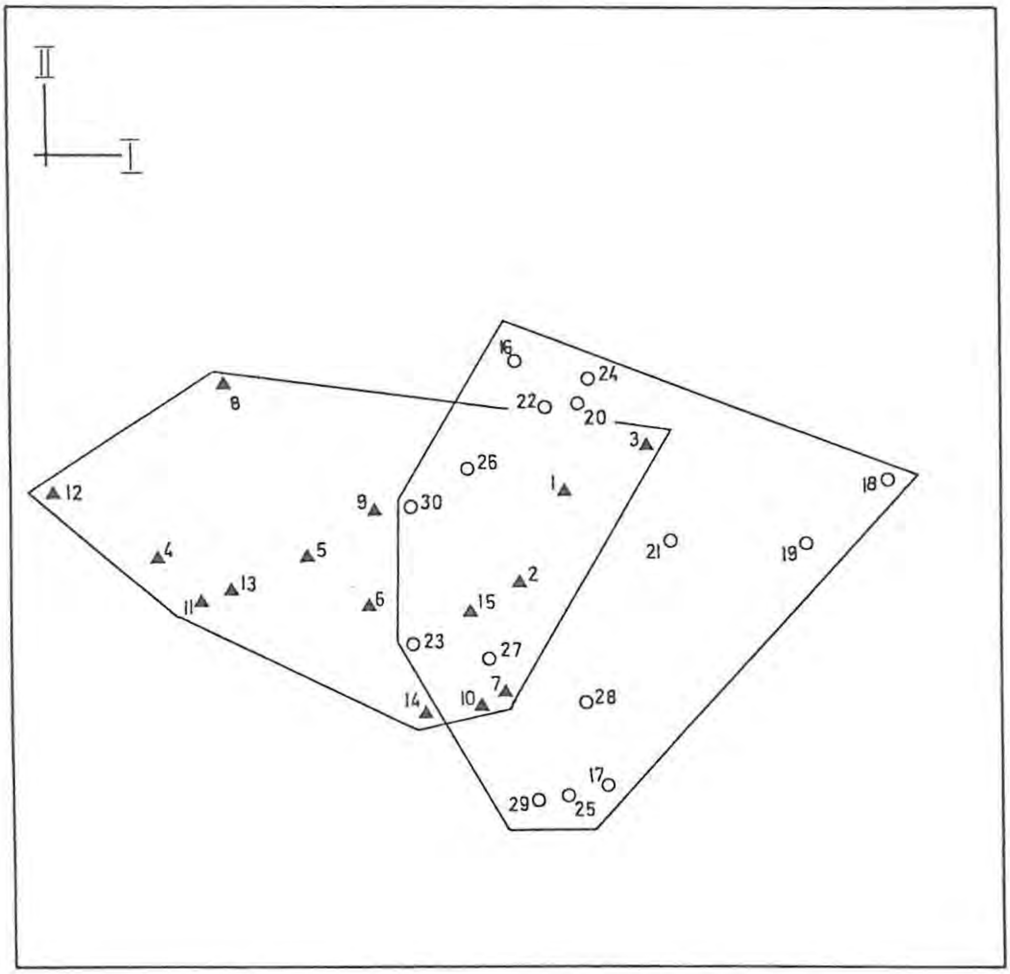



Fig. 58.
Ordination of the combined canopy and sub-canopy data for Kidds Beach.
▲ = seaward stands
o = landward stands

indicates its relative importance in the seaward community, while Sideroxylon inerme as a sub-canopy element, is shown to be more significant in the landward community (Fig. 57 (b)). As in the case of the canopy stratum, Cassine aethiopica has no particular preference for either site (Fig. 57 (c)).

The ordination including the data from both strata produced much the same pattern on the scatter diagram as that for the sub-canopy (Fig. 58). In spite of a degree of apparent similarity, some differentiation can however be interpreted between the two communities based on the polarization of the two indicated groups along the first DCA-axis. The seaward group is plotted to the left and the landward group to the right. The role of certain canopy and sub-canopy species considered to be responsible for creating this situation, has already been discussed.

## 5.11 DISCUSSION

Three of the study aims pertinent to the vegetation survey were to classify the thicket and forest into communities, to establish the more prominent patterns of dominance or importance amongst the contributing species and to establish whether gradients exist along the coastline which are a result of hierarchical changes within the various forest units.

In general, the classifications which were made were reasonably adequate to confirm the existence of communities which could be associated with particular dune sites. Much the same results were achieved with the ordination technique employed but where compositional differences were found to be less distinct, the degree of continuity between communities was illustrated more clearly. The dune valley forest was in all cases found to possess the most characteristic features distinguishing it from the other communities. Dominant valley species tended to be unique to the site and were of little or no significance on the other dune aspects. The seaward and landward communities showed certain compositional similarities (even with respect to dominant species) but could be differentiated on the basis of lower order species indicative of the state of successional advancement of the vegetation. The seaward thicket represents the earliest seral stage in the development sequence, while the taller, structured valley forest can be regarded as the climax dune community. The landward thicket appears to be transitional between the two latter communities and although it has retained certain early successional features, it also has compositional and structural links with the valley forest.

During the analysis of the sample data, the information on the canopy stratum produced the best classification and ordination results. Community variations were found to be less obvious in the case of the sub-canopy data and is a response which Moll (1980) attributes to the moderating influence of the canopy on certain external environmental variables. Analyses which included data from both synusiae followed more or less the same trend as that exhibited by the canopy.

The ordination which was carried out on the data set for the entire study area did not illustrate the presence of any significant or interpretable compositional gradients along the coast (Fig. 59). The data which was used for this analysis included the importance values allocated to the canopy species comprising each of the fifteen individual communities described during the course of the study. What is apparent from Fig. 59 however is the clustered distribution on the scatter diagram of the four different valley communities and their complete polarization away from the group of seaward and landward communities. This would seem to imply that the valleys must experience a certain uniform set of environmental or climoedaphic influences which encourages the development of forests of similar composition. In the study carried out on the salt spray fall-out rate, the lowest values were recorded for the valley site. This is a significant feature which distinguishes the valley sites from the exposed seaward slopes and must inevitably influence the forest compositions. Similarly, the state of soil development, which was shown to be considerably more advanced in the case of the valley than the other sites investigated, also must play a role in creating

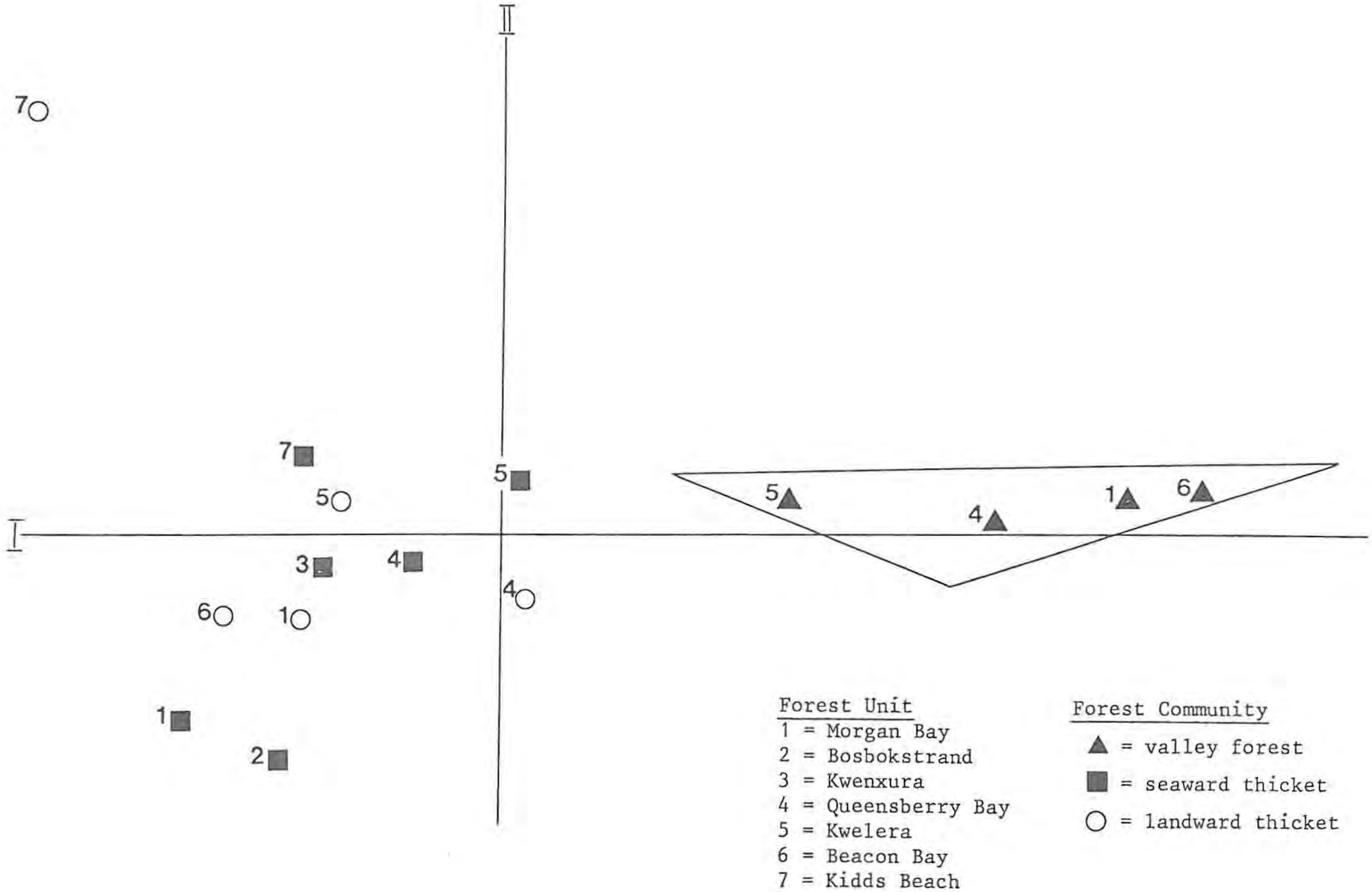



Fig. 59. Ordination of the East London coast dune communities.

favourable conditions for the establishment of climax forest species. The wide temperature ranges and high temperature maxima in particular which are experienced by the landward slopes have a negative influence on the soil moisture status and are considered to be factors which limit the development of the vegetation beyond sub-climax thicket.

The lack of significant results in the coastline gradient analysis can be ascribed inter alia to two possible reasons. The first is that the distance over which the study was carried out was not great enough either for latitudinal influences or for the rainfall gradient to be of much consequence to the species' distributions. Factors such as the dune soil characteristics and salt spray and their influence on the plant communities also do not vary much between Kei Mouth and Kidds Beach. A second reason could be the inadequacy of the data used for analysis. Each community indicated on the ordination was represented in effect by only a single (albeit composite) sample and the lack of replicates is a major shortfall. It is also unlikely that the data recorded for the numerous individual points which were sampled would have produced better ordination results. Nevertheless, the behaviour of certain species with respect to their distribution patterns did become evident during the study. The termination of a marked sub-tropical influence north of East London appears to have restricted a number of typical Natal species such as Strelitzia nicolai, Phoenix reclinata and Diospyros natalensis from becoming established at the southern extent of the study area. In contrast, other species such as Apodytes dimidiata, Schotia latifolia, Canthium obovatum and Cassine papillosa appear to be of greater significance in the south than in the north. Of the typical sub-canopy members, species common north of East London include Psychotria capensis, Teclea natalensis and Deinbollia oblongifolia while Diospyros scabrida, Maytenus undatus and Acokanthera oblongifolia tend to become more important southwards. Mimusops caffra, the canopy dominant was found to decrease in importance southwards towards its southern distribution limit and it appeared that it would be replaced by Sideroxylon inerme or Cassine aethiopica in the forest communities.

# CHAPTER 6

## Human Influences and Conservation Status

### 6.1 Introduction

Man has been associated with the coast and adjoining dune systems for many thousands of years, with Early Stone Age records of his presence, dating to the Early- and Mid-Pleistocene having been made (Maud, 1982). Subsequent subsistence cultures of hunter-gatherers frequented the shores throughout the changes in sea level during the late Pleistocene and would have made relatively little impact on the dune environment. The middens and various artifacts which are encountered on the beaches today all accumulated over the past 80 000 years (Butzer, 1972; Klein, 1972) during the Holocene or Recent periods. (See Plate 18).

A change in resource use occurred approximately 2 000 years ago when the first Iron Age cultivator-pasturalists, who were ancestral to the Bantu tribes, appeared on the eastern seaboard of Southern Africa (Tinley, 1985). In addition to harvesting shellfish, crops were established and a form of shifting cultivation took place on the enriched dune soils which were cleared of vegetation. Grassland areas adjoining the dune forests were burnt periodically to improve grazing for stock as well as to attract game and the incidence of fire in these forests would have increased dramatically.

The arrival of European settlers in the area heralded yet a different and more intense pattern of land use, with settlements and farms

PLATE 18. Strandloper midden on beach.

becoming established in contrast to the nomadic existence adopted by previous inhabitants. It is the present industrial culture, assisted by modern technology, which has however created more stress to the sensitive dune environment than any previous activities and it is a problem which faces coastal conservation managers and planners today.

## 6.2 The Management Activities of the Forestry Directorate

The management of the State Forest land is the responsibility of the Forester in charge who is supported by a staff of two Foremen, 14 Forest Guards and a labour force of 15 men. The most important management activities are discussed below.

### Patrolling

All patrolling staff are well-trained with respect to law enforcement and are instructed to apprehend any person suspected of committing an offence under the Forest Act. Apart from their basic duties which are listed above, they assist the Department of Sea Fisheries in their capacity as Honorary Inspectors with controlling the removal of shellfish and bait. Most prosecutions are related to poaching and tresspass offences.

### Fencing

Steady progress has been made with the fencing of most of the landward State Forest boundaries, the demarcation of which is considered to be of great importance. The lack of fences in the past has resulted in two major types of damage to the forests. The first is the effect of cattle, which apart from destabilizing the dune slopes, have in places created forest shells with little or no understorey and caused them literally to shrink through browsing and grazing of the forest margins. The second is the development of unauthorized footpaths in areas least suited for them, with continued trampling inevitably leading to blow-out formation. Financial limitations and the securement of a contribution towards costs by neighbouring land-owners has inevitably caused delays. In certain cases cooperation and give-and-take boundary agreements have resulted in more extensive areas of forest being included with the State-owned land.

Footpath maintenance

A consistent effort has been made to limit the number of footpaths through the dune forests to the absolute minimum. It has been necessary to compromise in certain instances especially where established holiday resorts depend on these access routes to the beach. Some twenty-two of them are registered at present and the licence-holders are financially responsible for all the necessary maintenance work. It has been found to be essential to fence in the paths throughout their length through the forests and to reclaim all previously disturbed areas. This basically involves packing the exposed forest floor with branch material and allowing a ground layer to develop, occasionally with the assistance of in situ sowing of seed. (See Plate 19).

Eradication of weeds and invader plants

A considerable amount of expenditure is incurred annually on a

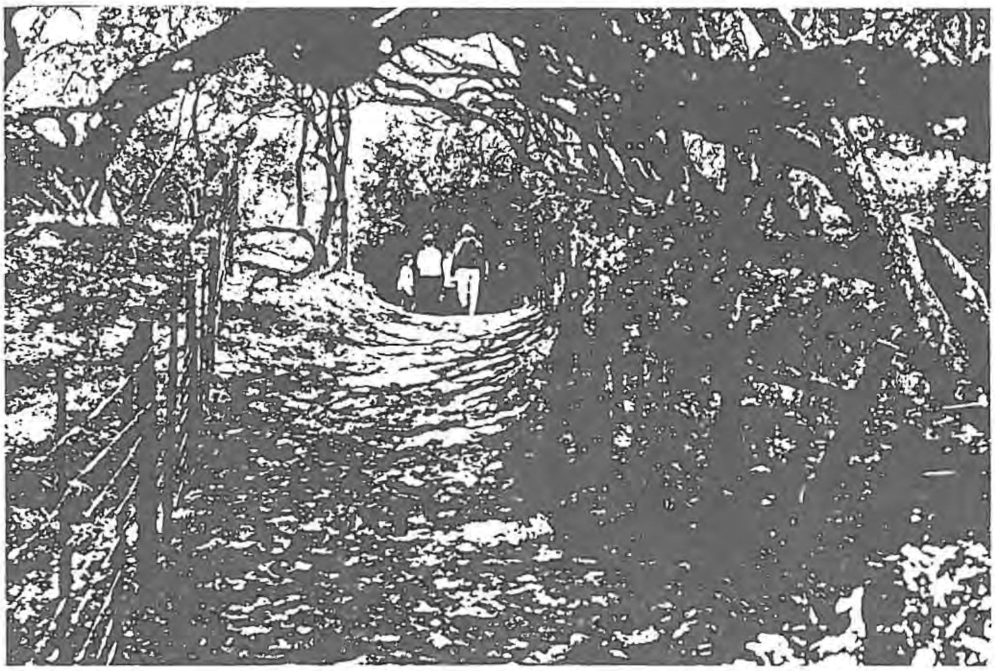


PLATE 19. Fenced in footpath through dune forest.

systematic eradication programme of all problem species occurring in the dunes and in some cases this involves the removal of exotics which were established in previous driftsand stabilization operations. Table 76 lists all species known to occur in the area and the treatments which have been employed to eradicate some of them. Most species are aggressive invaders.

The greatest problem is Sesbanea punicea which at present is almost impossible to eradicate due to the lack of neighbourly cooperation. The extensive seed bank present in the soil also contributes significantly towards the problem. Another serious potential problem species is Pereskia aculeata which has been noted recently at Bonza Bay and Sunrise-on-Sea. It is extremely difficult to eradicate and spreads rapidly due to its ability to propagate itself vegetatively.

Acacia cyclops does not pose the same problem as it does further south and does not occur very frequently north of the Keiskamma River. It has been almost totally eradicated along the East London Coast. Of all the exotic species, only a single stand of Casuarina equisetifolia will be left unfelled at Gulu River mouth and the area utilized for siting a picnic area, which will hopefully reduce the pressure on the indigenous forest.

Fire Protection

The greatest number of fires along the coast occur during the dry winter months when the incidence of hot berg winds is most prevalent. During this period a standby team is always available to extinguish

| SPECIES | INVASIVE POTENTIAL | PRESENT EXTENT OF INFESTATION | TREATMENT | CLASSIFICATION OF SPECIES |
|---|---|---|---|---|
| *Casuarina equisetifolia* | None | Three planted areas | Thinning followed by clearfelling | - |
| *Eucalyptus* spp. | Very low | Few individuals | Clearfelling plus 2.4.5.T stump treatment | - |
| *Acacia saligna* | Low | Two planted areas. Few scattered individuals | Thinning followed by clearfelling. 2.4.5.T stump treatment | * |
| *Acacia cyclops* | Moderate | Scattered individuals | Slashing and hand-pulling of younger plants | * |
| *Cestrum laevigatum* | Moderate | Locally dense particularly near water-courses | Slashing plus 2.4.5.T stump treatment | @ |
| *Lantana camara* | High | Scattered dense infestations | Manual eradication | @ |
| *Sesbania punicea* | Very high | Scattered dense infestations | Manual eradication | @ |
| *Pereskia aculeata* | High | Few, but densely infested areas at present | None employed locally. Slashing, stacking and burning plus spraying of regrowth with Round Up or 2.4.5.T | + |
| *Cirsium vulgare* | Moderate | Scattered | Manual eradication | @ |
| *Psidium guajava* (Guava) | Moderate | Scattered | None employed | - |
| *Ricinus communis* (Caster oil plant) | Moderate | Scattered, on disturbed areas | None employed | - |

+ = Weeds which must be totally eradicated
@ = Weeds which must be controlled
* = Invader plants to be controlled if necessary.
(According to the Conservation of Agricultural Resources Act of 1983)

TABLE 76. EXOTIC PLANT SPECIES OCCURING ON THE DUNES.

any reported fires but delays in reaching them do occur due to the extensiveness of the State Forest.

A policy of leasing autumn grazing in the grassland areas on State Land adjacent to the forests has been implemented at Gulu, Kwelera, Cape Henderson and Kei Mouth. This significantly reduces the amount of combustible material in these open areas and in turn, the risk of fire. Only cattle are permitted to graze and the conditions imposed ensure that the forest areas are not disturbed and that over-utilization of the veld does not occur. It is uncertain what effects this practice has on the grassland communities but it does have many advantages for the forests and in particular for the communities forming the ecotone along their margins. During favourable years, when the grass remains green throughout winter, grazing is not permitted and this irregular cropping rotation is probably beneficial to the various grass species.

A firebreak is burnt annually in early winter between Blue Bend and Bonza Bay to protect this section of forest, which has been damaged by fire on a number of occasions in the past.

Provision and maintenance of recreation facilities

Although the provision of picnic sites along the coast is primarily the responsibility of the Divisional Council of Kaffraria, the Directorate has recently initiated a move to expand and improve the existing facilities. This involves the provision of suitably sited picnic places and rubbish bins, the erection of fencing to protect the surrounding forests and the closure and rehabilitation of degraded areas. Apart from the nine picnic sites situated on State Forest land, the Caravan Park at Double Mouth is also administered by the Directorate.

Driftsand stabilization

Since driftsand stabilization was first carried out along the East London coast the Departmental policy towards it has changed considerably (Stehle, 1980). The result is that certain reclamation which was carried out in the past would now be neither economically justifiable nor ecologically desirable. As recently as 1968, the continued use of exotic acacias was advocated by the then Department of Forestry (Walsh, 1968) and some of the earlier reclamation work shown in Fig. 60 was started during this era. It was only some eight years later that a policy to use only indigenous species was implemented. Stehle (1980) produced the first descriptive driftsand reclamation plan in the Eastern Cape and many of the principles contained therein were applied in the most recent work at East London. Besides the elimination of exotics, the present policy, which is discussed by Burns and Reyneke (1983) also adopts a very conservative attitude towards any unnecessary reclamation. It is very unlikely that any of the sites indicated on Fig. 60 would have been reclaimed today.

Most of the present work carried out on the dunes is concerned with the replacement or eradication of exotics and the restoration of small

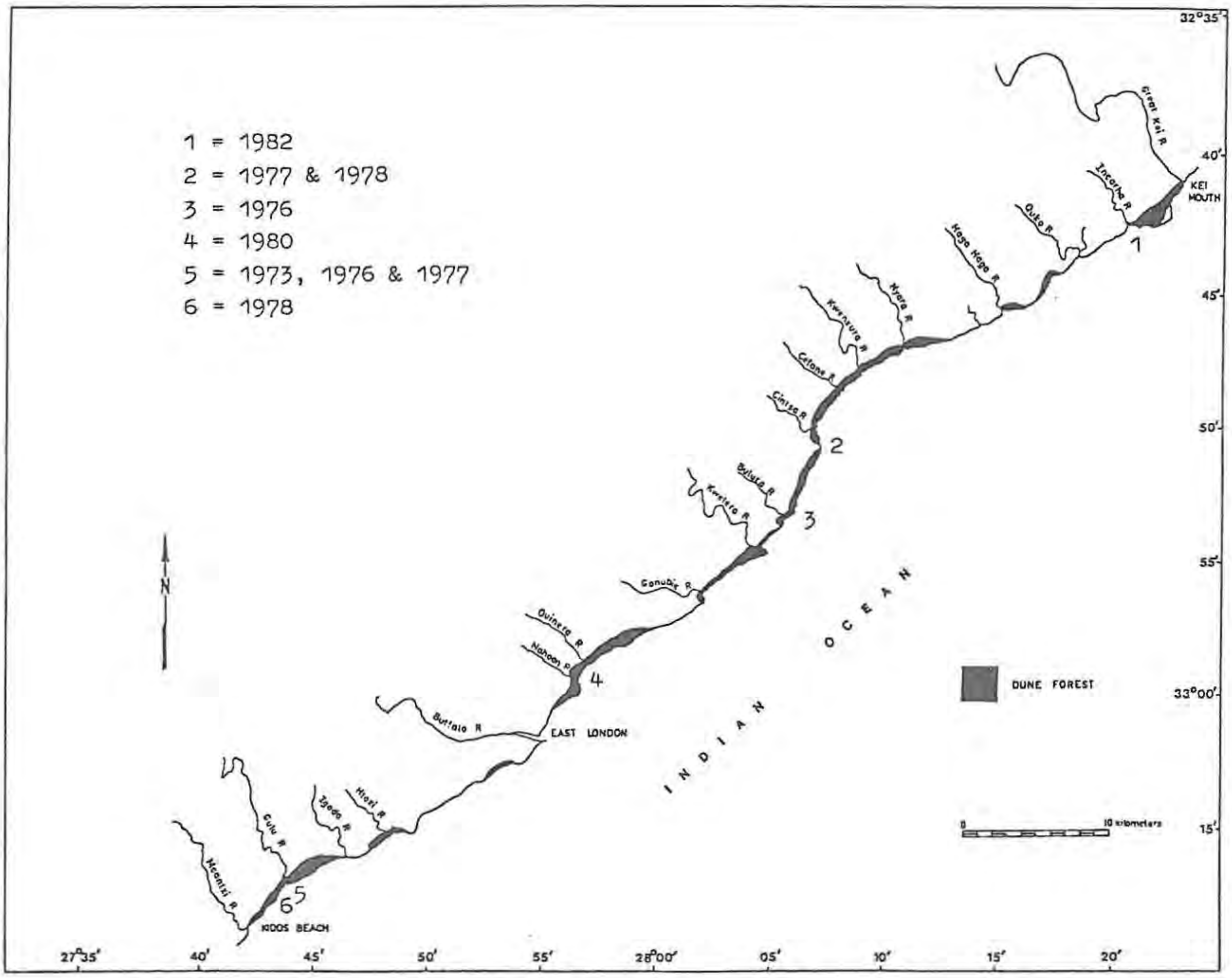



Fig 60. Driftsand areas reclaimed during the years indicated.

areas which have been disturbed by human activity - such as footpaths. The various stands of C. equisetifolia and A. saligna are first thinned out to reduce competition and increase light penetration and combined with this, a cocktail of indigenous seed is sown in situ. The results have been most promising, particularly in the areas formerly occupied by acacias and the shrub community which has developed closely resembles that of the natural early successional stages. The Casuarina stands have required much heavier thinnings and it would appear that the thick 'needle' layer does inhibit the establishment of secondary pioneers to a certain extent.

Additional functions of the Directorate

Apart from the activities described above, the Directorate performs several other important duties associated with the conservation and development of this coastline.

The demand by the building industry for beach sand for example has to be continually countered and motivated against and the control over the issue of permits for the removal of shellgrit, which has been delegated by the Department of Mineral and Energy Affairs, is also strictly enforced.

Where new coastal township plans are submitted for approval, the Directorate is often involved by contributing towards the ecological considerations of such development. Similarly, when applications for change in land-use are made to the Department of Constitutional Development and Planning, cases involving the coastal areas are also referred to the Directorate for comment.

An on-going effort is made to acquire unconserved stretches of coastline for incorporation into the State Forest. A lack of funds for the purchase of private land has resulted in the focus being shifted to those areas which were previously State Forest but which are now administered by Local Authorities. Various applications have also been made to transfer the control of unallocated State land along the coast to this Directorate.

### 6.3 Off-Road vehicles

Apart from urban development, the problem of off-road vehicles is perhaps the greatest factor which has caused deterioration to the many components of the beach and dune environment. The problem is relatively new and is coupled to the ability of an increasingly affluent population to afford such vehicles for sport and recreation. From the occasional 4x4 vehicle encountered the beaches ten years ago, the numbers have increased dramatically and with the opinion of an outspoken sector of the public in support of them, the problem is now quite formidable.

The past and current legislation over the control of vehicles on beaches in the East London area is somewhat confusing, and only since 1983, when the Divisional Council of Kaffraria considered imposing a ban on all vehicles, has the matter been clarified to a certain extent. In terms of articles 10 (3) (c) and 11 (2) of the Sea-Shore Act, 1935 (Act 21 of 1935) the then Minister of Agriculture could delegate the authority to the Provincial Executive Committees to promulgate regulations pertaining to the sea-shore. In 1977 this authority was delegated to the Cape Province but specifically excluded, was the jurisdiction over (inter alia) the sea-shore adjacent to the State Forest land - as described in the Forest Act, 1968 (Act No. 72 of 1968). The delegation also did not repeal any existing regulations which might have been promulgated previously by thevarious Local Authorities.

When the ban on vehicles was imposed, the legality of this action was disputed by prepresentatives of the local angling clubs who based their argument on the clause which excluded State Forest areas from Council jurisdiction. Legal opinion on the matter was, that since Council had applied to the Minister to approve its regulations in 1975 and that the approval which was subsequently obtained did not exclude areas adjacent to State forests, combined with the fact that this approval was not repealed by the conditional 1977 delegation, the regulations could in fact be applied. This is particularly significant since the latter delegation did not state which authorities would administer the excluded beaches. The authority which was granted in article 10 (3) (c) of the Act to local authorities was never granted to State officials and had the Kaffrarian regulations not been approved before 1977, no control could now be exercized over the East London Coast State Forest beaches.

At present vehicles are not permitted within any bathing area (defined as all beaches) north of East London without a permit. The regulation does not apply to the south and is only to be promulgated once finality has been reached over the Ciskei boundary. Although this has resulted in a slight reduction in vehicular traffic on the beaches, the inability of the Council to enforce the regulations with its single law enforcement officer is a problem. The ban is largely ignored and the damage caused by the vehicles continues.

Detailed studies on the deleterious effects of vehicles on the beach and dunes, such as those conducted in Western Australia by Vogt (1979) have not been carried out in South Africa. This is perhaps one of the great shortfalls locally, when motivation in support of a ban has to be based on observations, subjective speculation and scant quantitative data. A report has however recently been drafted by the working committee for the coastal zone for the Council for the Environment concerning the future policy towards off-road vehicles.

The plant communities of the embryonic dunes and early successional stages are initially, the components most susceptible to disturbance by vehicles through physical destruction. Their elimination from the successional sequence exposes the thicket and forest to increased loads of salt spray and mobile sand and with their deterioration, beaches can eventually occur in the more established fixed dunes. The organic drift line is easily broken up by passing vehicles and the process of releasing and recycling nutrients by fungal and bacterial activity is much reduced. These drift lines are often the initials of new dune ridges and contain seed stocks of species such as <u>Scaevola</u>

plumieri and Agropyron distichum which germinate and utilize the decayed organic material. By upsetting the dynamics of dune formation at the seaward end of the spectrum through the destruction of these elements, the entire development sequence is likely to be affected.

Vehicles also affect the birdlife which frequent the beaches. Nesting sites are threatened (eg. the black oystercatcher - Haematopus moquini) and feeding and resting periods are reduced when the birds are put to flight by passing vehicles. Such stress situations could eventually reduce the bird populations significantly.

## 6.4 Demands on the coastal resources

Although this aspect of the 'Human Influence' could be studied and assessed in great detail, only two of the most significant demands will be discussed briefly.

### Recreation and Tourism

Circumstances are often dictated by the principles of supply and demand and in the case of the recreational potential of the coastline, the demand is quite considerable. Due to the predetermined length of the coast it is not possible to increase the natural supply of desired facilities and judicious planning and development has to therefore be implemented to satisfy the demands. Past development, such as along the Natal South Coast, has failed to adequately safeguard the dune communities and it is therefore fortunate that the East London Coast dune cordon has been under the control of a conservation organization for many years.

The recommendations on coastal zone management made by the Council for the Environment (1983) and those contained in the report by the Cape Provincial Administration (1973) on the coastal areas of the Border Region are very sound and should be implemented. The latter report identifies the demand on the coastline to be somewhat artificial, in that the large coastal townships satisfy what is only a very seasonal demand. The large percentage of time during which these facilities are completely under-utilized should be weighed up against the associated environmental stresses which they create. Both reports advocate a policy of concentrating future development at existing towns or resorts and discourage the establishment of new nodes or growth points which lead to ribbon development. The establishment of a concentrated chalet-type of holiday accommodation is also encouraged, where the accommodation and not sub-divided township land is provided. Good examples of this type of development can be seen at some of the resorts between the Cintsa and Bulura Rivers where the facilities can seasonally accommodate hundreds of families in small concentrated areas (Plate 20). In contrast, the townships of Morgan Bay and Cintsa East for example, are quite extensive in area but are relatively underdeveloped (due partly to property speculation) and satisfy the recreational needs of only a small percentage of the population.

An acceptable procedure has been adopted recently for considering applications for new development projects. The project proposals are usually distributed by the Divisional Council of Kaffraria to various organizations such as the Provincial Department of Nature and Environmental Conservation, the Department of Environment Affairs and generally the National Research Institute for Oceanology (C.S.I.R.) for comment before the project is approved or rejected. In the absence of full environmental impact assessments, the above procedure is considered to be adequate until legislation governing coastal development, which incorporates the guidelines proposed by Heydorn and Tinley (1980) and Tinley (1985), is promulgated.

PLATE 20. Coastal chalet resort at Cintsa.

## Mining and the demand for building sand

Although the threat of dune mining for heavy minerals such as zircon, ilmenite and rutile is not as great as it is in Zululand, a mineral lease does exist for the dunes at Morgan Bay (Bruton, 1980 and Weisser, 1978). Mining operations began in 1969 when an extraction plant was erected in the area but were suspended some three years later when transport costs proved limiting. Attempts are now being made to have the lease cancelled.

More recently, demands have been made for access to deposits of beach sand to supply the building industry of the East London metropolitan area. The predominance of shale and sandstone deposits along the coast and within the catchments of the major rivers has resulted in a very poor quality of building sand which is however improved if blended with manufactured sands (Meissner, 1977). Limited quarrying operations were permitted at Igoda River Mouth and off the beach north of the Quinera River but these were halted under pressure of public protest. The report by Meissner (1977) identifies the inland fixed dunes between Gonubie and the Quinera River as being the most suitable source of natural sand in the vicinity and the area has been quarried now for a number of years, subject to various restoration clauses etc. (Plate 21). Mature dune forest has been destroyed in the process but this is perhaps preferable to having several such quarries along the coast and disturbance to the primary dunes with resulting deleterious effects on the adjacent system as well. All requests to make beach sand available from State Forest land are rejected on environmental grounds.

PLATE 21. Mined sandpit at Quinera.

## 6.5 The Conservation Status of the dune forests

Scheepers (1983), in his analysis of the conservation status of the Southern African vegetation types, has estimated that only 1,61 percent of the South-eastern Subtropical Coast Forest Biome is conserved. The statistics provided by Edwards (1974) for the areas of Coastal Forest and Thornveld differ somewhat from the latter due mainly to the inclusion of State Forest areas in the estimation. According to Table 77 8,8 per cent of this veld type is conserved in South Africa, with the Cape Province contributing 0,25 per cent towards the total. Approximately 1 per cent of the veld type represented in the Cape is conserved, all of which is on State Forest land (Edwards, 1974). The Eastern Cape dune forests make up only a small percentage of the above vegetation type, but it is fortunate that much of the dune areas are managed by the Forestry Branch and the protection thereof is thus reasonably well assured.

Traditionally, a function of this authority has been to control the spread of coastal driftsands, and although a limited amount of this work is done along the East London coast, the major recent efforts in this region has been to press for improved protection status of the forests themselves. In response to a motivated submisssion, three Nature Reserves were proclaimed during 1983 (Proclamation No. 2793 as gazetted during December 1983). These are the Cape Henderson, Kwelera and Gulu Nature Reserves which together measure some 790 hectares and include considerable areas of forest. The remaining State Forest land

| | CAPE PROVINCE | NATAL | SOUTH AFRICA |
|---|---|---|---|
| Provincial and National Reserves | - (0%) | 563,76 (3,76%) | 563,76 (2,81%) |
| State Forest Areas | 50,1 (0,98%) | 1162,00 (7,75%) | 1212,10 (6,03%) |
| Total Areas conserved | 50,1 (0,98%) | 1725,76 (11,5%) | 1775,86 (8,8%) |
| Total Area of veld type | 5104 | 14984 | 20088 |

| | |
|---|---|
| PROVINCIAL CONSERVATION CONTRIBUTION | |
| Cape province | 0,25% |
| Natal | 8,59% |

TABLE 77. CONSERVATION AREAS OF THE COASTAL FOREST AND THORNVELD VELD TYPE, BASED ON THE CLASSIFICATION OF ACOCKS (1975). AREAS ARE GIVEN IN $km^2$ AND THE FIGURES IN BRACKETS REPRESENT THE PERCENTAGE OF AREA CONSERVED PROVINCIALLY OR NATIONALLY. DIFFERENTIATION IS MADE BETWEEN THE VARIOUS CONSERVATION AUTHORITIES (after Edwards (1974) ).

| MANAGEMENT AGENCY | PROTECTION STATUS | APPROXIMATE AREA (hectares) |
| --- | --- | --- |
| DEPT. of ENVIRONMENT AFFAIRS | Proclaimed Nature Reserve with very high protection status | 325 |
| DEPT. of ENVIRONMENT AFFAIRS | Demarcated State Forest with high protection status | 521 |
| DEPT. of PUBLIC WORKS and LAND AFFAIRS | Unallocated State Land with moderate protection status | 30 |
| PUBLIC SERVANTS ASSOCIATION | No protection status. Area being exploited for building sand | 90 |
| MUNICIPAL OWNERSHIP | No protection status but reasonable conservation measures applied | 170 |
| PRIVATE OWNERSHIP | No protection status. Areas threatened with possible development | 70 |

TABLE 78. OWNERSHIP AND PROTECTION STATUS OF THE EAST LONDON COAST DUNE FORESTS.

is all demarcated, which in itself automatically ensures a high protection status.

The overall ownership situation of the dune forests between Transkei and Ciskei is shown in Table 78. Many of the municipal areas were previously State Forests prior to 1925 and 1950 and an attempt is now being made to reclaim any such areas which are not suitable for township development. A priority list has also been made for the purchase by negotiation of privately owned areas, following recognized NAKOR (National Committee for Nature Conservation) procedures.

REFERENCES


ACOCKS, J.P.H. 1975. Veld types of South Africa. 2nd ed. Mem. Bot. Surv. S. Afr. 40. Government Printer, Pretoria. 128 pp.

ANON. 1973. Cape Coastal Survey. Report No 2. Section f. Kei River to Great Fish River. Cape Provincial Administration.

ANON. 1983. Report and recommendations on coastal zone management. Council for the Environment.

AUSTIN, M.P. 1976. On non-linear species response models in ordination. Vegetatio 33 : 33-41.

BARBOUR, M.G., CRAIG, R.G., DRYSDALE, F.R. & CHISELIN, M .T. 1973. Coastal ecology at Bodega Head. University of California Press, Berkeley.

BARKMAN, J.J., DOING, H. & SEGAL, S. 1964. Chritische bemerkungen und vorschlage zur quantitativen vegetationanalyse. Acta Botanica Neederland 13 : 394-419.

BOARD, C. 1962. The Border region : Natural environment and land use in the Eastern Cape. Oxford University Press, London. 238 pp.

BOORMAN, L.A. 1977. Sand dunes. In : The Coastline, ed. Barnes, R.S.K. pp. 161-197, Wiley, London. pp 161-197.

BOSCH, O.J.H. 1977. Ordening van 'n aantal grondprofiele van die Sterkspruitvorm : 'n basis vir die verklaring van floristiese verskille tussen sommige weiveldtipes wat op gronde van die sterkspruitvorm voorkom. Agrochemophysica 9 : 21-52.

BOSCH, O.J.H. 1978. Vergelyking tussen die plantegroei en habitatte van die gronde van die Estcourt- en Sterkspruitvorms in die suidoostelike Oranje-Vrystaat. Bothalia 12 (3) : 499-511.

BOYCE, S.G. 1954. The salt-spray community. Ecol. Monogr. 24 : 29-67.

BREEN, C.M. 1971. An account of the plant ecology of the dune forest at Lake Sibayi. Trans. Roy. Soc. S. Afr. 39 : 223-234.

BREYTENBACH, J. 1976. A botanical survey of Eastern Shores St. Lucia Lake. Unpubl. Hon. Thesis, University of Pretoria.

BRUTON, M.N. 1980. Conservation and development in Maputaland. In : Studies on the ecology of Maputaland, eds Bruton, M.N. & Cooper, K.H. Rhodes University, Grahamstown.

BURNS, M.E.R. & REYNEKE, P. 1983. Some aspects of driftsand reclamation in the Republic of South Africa. In : Sandy Beaches as Ecosystems, eds McLachlan, A. & Erasmus, T. pp. 755. Junk, The Hague.

BUTZER, K.W. 1972. Geology of Nelson Bay Cave, Robberg, South Africa. S. Afr. Archeol. Bull. 27.

CHAPMAN, V.J. 1976. Coastal Vegetation. Pergamon Press, Oxford.
CLAYTON, J.L. 1972. Salt spray cycling in two Californian ecosystems. Ecology 53 : 74-81.
CLEMENTS, F.E. 1916. Plant Succession. Publication No. 242. Carnegie Institute, Washington.
CLEMENTS, F.E. 1936. Nature and structure of the climax. J. Ecol. 24 : 252-284.
COATES PALGRAVE, K. 1977.Trees of Southern Africa. Struik, Cape Town.
COMINS, D.M. 1962a. The vegetation of the Districts of East London and King William's Town, Cape Province. Mem. Bot. Surv. S. Afr. 33. Government Printer, Pretoria.
COMINS, D.M. 1962b. Vegetation. In : The Border Region natural environment and land use in the eastern Cape, ed. Board, C. Oxford University Press, London. 238 pp.
CONNELL, J.H. & SLATYER, R.O. 1977. Mechanisms of succession in natural communities and their role in community stability and organization. Am. Naturalist. III. 1119-1144.
COTTAM, G. & CURTIS, J.T. 1956. The use of distance measures in phytosociological sampling. Ecology 37 (3) : 451-460.
COTTAM, G., CURTIS, J.T. & HALE, B.W. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34 : 741-757.
COWLING, R.M. 1983. Phytochology and vegetation history in the south eastern Cape, South Africa. J. Biogeogr. 10 : 393-419.
CURTIS, J.T. 1959. The vegetation of Wisconsin : an ordination of plant communities. University of Wisconsin Press, Madison.
CURTIS, J.T. & COTTAM, G. 1964. Plant Ecology Workbook. 2nd ed. Burgess Publishing Company, Minnesota.
DONNELLY, F.A. & PAMMENTER, N.W. 1983. Vegetation zonation on a Natal coastal sand dune system in relation to salt spray and soil salinity. S. Afr. J. Bot. 2(1) : 46-51.
DRUMMOND, A.J. & VOWICNKEL, E. 1957. The distribution of solar energy throughout southern Africa. J. Meteor. 14 : 343-353.
DU TOIT, A.L. 1926. The geology of South Africa. Oliver & Boyd, Edinburgh.
EDWARDS, D. 1974. Survey to determine the adequacy of existing conserved areas in relation to vegetation types. A preliminary report. Koedoe 17 : 3-38.
EGLER, F.E. 1954. Vegetation science concepts. I. Initial floristic composition - a factor in old-field vegetation development. Vegetatio 4 : 412-417.
GAUCH, H.G. Jr. 1982. Multivariate analysis in community ecology. Cambridge University Press, Cambridge.
GAUCH, H.G. & WHITTAKER, R.H. 1981. Hierarchical classification of community data. J. Ecol. 69 : 135-152.

GIBBS-RUSSELL, G.E. and the staff of the National Herbarium. 1984. List of species of southern African plants. Mem. Bot. Surv. S. Afr. 48.

GOODALL, D.W. 1954. Objective methods for the classification of vegetation. III. An essay in the use of factor analysis. Aust. J. Bot. 2 : 304-324.

GREIG-SMITH, P. 1964. Quantitative plant ecology. 2nd ed. Butterworths, London.

GROVES, R.H. 1965. Growth of heath vegetation. II. The seasonal growth of a heath on a ground water podzol at Wilson's promontory, Victoria. Aust. J. Bot. 26 : 45-51. HARMSE, H.J. VON M. 1978. Schematic soil map of South Africa south of latitude 16 31'. In : Biogeography and ecology of southern Africa, ed. Werger, M. J. A. Junk, The Hague.

HEYDORN, A.E.F. & TINLEY, K.L. 1980. Estuaries of the Cape. Part I : Synopsis of the Cape coast : natural features, dynamics and utilization. C.S.I.R. Research Report 380. C.S.I.R., Pretoria.

HILL, M.O. 1979a. DECORANA - A fortran program for detrended correspondence analysis and reciprocal averaging. Section of ecology and systematics. Cornell University, New York.

HILL, M.O. 1979b. TWINSPAN - A fortran program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Section of ecology and systematics. Cornell University, New York.

HILL, M.O. & GAUCH, H.G. 1980. Detrended correspondence analysis, an improved ordination technique. Vegetatio 42 : 47-58.

HOBBS, R.J. & GRACE,J. 1981. A study of pattern and process in coastal vegetation using principal component analysis. Vegetatio 44 : 137-153.

HOPKINS, B. 1957. The concept of minimal area. J. Ecol. 45 : 441-449.

HUNTLEY, B. & BIRKS, H.J.B. 1979. The past and present vegetation of the Morrone Birkwoods National Nature Reserve, Scotland. I. A primary phytosociological survey. J. Ecol. 67 : 417-446.

JACKSON, S.P. 1954. Sea breezes in South Africa. S. Afr. Geog. J. 36 : 13-23.

JANZEN, D.H. 1969. Seed-eaters versus seed size, number, toxicity and dispersal. Evolution 23 : 1-27.

JANZEN, D.H. 1970. Herbivores and the number of tree species in tropical forests. Am. Naturalist 104 : 501-528

KENDALL, M.G. 1957. A course in multivariate analysis. Griffen, London.

KESSELL, S.R. 1979. Gradient modelling : Resource and fire management. Springer-Verlag, New York.

KLEIN, R.G. 1972. The late quaternary mammalian fauna of Nelson Bay Cave, (Cape Province, South Africa.) : Its implications for megafauna extinctions and environmental and cultural change. Quaternary Res. 2 : 135-142.

KUMLER, M.L. 1969. Plant succession on the sand dunes of the Oregon coast. Ecology 50 : 695-704.

KUMMEROW, J. 1983. Comparative phenology of mediterranean-type plant communities. In : Mediterranean-type ecosystems : the role of nutrients, eds Kruger, F.J., Mitchell, D.T. & Jarvis, J.U.M. Springer, New York.

LEVYNS, M.R. 1956. Notes on the biology and distribution of the rhenoster bush. S. Afr. J. Sci. 52 : 141-143.

LEVYNS, M.R. 1964. Migrations and origin of the Cape flora. Trans. Roy. Soc. S. Afr. 37 : 85-107.

LIETH, H. 1974. Introduction to phenology and the modelling of seasonality. In : Phenology and seasonality modelling. Ecological Studies 8. ed. Lieth, H. Chapman and Hall, London.

LIVERSIDGE , R.A. 1972. A preliminary study on fruit production in certain plants. Ann. Cape Prov. Mus. (Nat. Hist.) 9 : 1-63.

LOUW, A.J . 1970. 'n Ekologiese studie van Mopaniveld noord van Soutpansberg. Unpbl. D.Sc.thesis, University of Pretoria.

LUBKE, R.A. 1983. A survey of the coastal vegetation near Port Alfred, eastern Cape. Bothalia 14 (3 & 4) : 725-738.

LUBKE, R.A. & AVIS, A.M. 1982. Factors affecting the distribution of Scirpus nodosus plants in a dune slack community. S. Afr. J. Bot. 1 (4) : 97-103.

MACVICAR, C.N., LOXTON, R.F., DE VILLIERS, J.M., VERSTER, E., LAMBRECHTS, J.J.N., MERRYWEATHER, R.F., LE ROUX, J., VAN ROOYEN, T.H. & HARMSE, H.J. VON M. 1977. Soil classification. A binomial system for South Africa. Dept. Agric. Tech. Services, Pretoria.

MARAIS, J.A.H. & JOHNSON, M.R. 1965. Thicknesses of the Cape and Karroo systems in the eastern Cape. Ann. Geol. Surv. 4 : 49-55.

MAUD, R.R. 1982. Geomorphic genesis of the east and southeast coasts of Africa in the Quaternary. Unpbl. manuscript. In : Tinley, (1985), ( loc. cit.)

McATEE, J.W. & LYNNE DRAWE, D. 1981. Human impact on beach and foredune vegetation of North Parde Island, Texas. Environmental Management 4 (6) : 527-538.

McLACHLAN, A., ERASMUS, T., DYE, A.H., WOOLDRIDGE, T., VAN DER HORST, G., ROSSOUW, G., LASIAK, T.A. & McGWYNNE, L. 1981. Sandy beach energetics: An ecosystem approach towards a high energy interface. Estuarine Coastal and Shelf Science 13: 11-25.

MEISSNER, K.H. 1977. Building sand investigation in the East London area. Geol. Surv. Rep. No. 1977-0148.

MOLL, E.J. 1968. A quantitative ecological investigation of the Krantzkloof forest, Natal. J. S. Afr. Bot. 34 : 15-25.

MOLL, E.J. 1969. An investigation of the plant ecology of the Hawaan Forest, Natal, using an ordination technique. Bothalia 10 : 121-128.

MOLL, E.J. 1972. A preliminary account of the dune communities at Pennington Park, Mtuzini, Natal. Botalia 10 : 615-626.

MOLL, E.J. 1980a. Additional quantitative ecological studies in the Hawaan Forest, Natal. S. Afr. For. J. 113 : 16-25.

MOLL E.J. 1980b. A quantitative ecological study of the Hlogwene Forest, Natal. S. Afr. For. J. 144 : 19-24.

MOLL, E.J. & WHITE, F. 1978. The Indian Ocean coastal belt. In : Biogeography and Ecology of Southern Africa, ed. Werger, M.J.A. Junk, The Hague.

MOORE, J.J. 1962. The Braun-Blanquet system. A re-assessment. J. Ecol. 50 : 761-769.

MORRIS, J.W. 1969. An ordination of the vegetation of Ntshongweni, Natal. Bothalia 10 : 89-120.

MORROW, P.A. & MOONEY, H.A. 1974. Drought adaptations in two Californian evergreen sclerophylls. Oecologia 15 : 205-222.

MOUNTAIN, E.D. 1936. Tufa-lined basins in coastal platforms. S. Afr. J. Sci. 33 : 242-247.

MOUNTAIN, E.D. 1937. Anatectite veins at Gonubie River Mouth. S. Afr. J Sci. 33: 248-253.

MOUNTAIN, E.D. 1945. The geology of East London, Cape Province. Trans. Geol. Soc. S. Afr. 68 : 31-41.

MOUNTAIN, E.D. 1966. Footprints in calcareous sandstone at Nahoon Point. S. Afr. J. Sci. 62 : 103-111.

MOUNTAIN, E.D. 1974. The geology of the area around East London, Cape Province. Geological Survey. Government Printer, Pretoria.

NOBLE, I.R.& SLATYER, R.O. 1981. Concepts and models of succession in fascular plant communities subject to recurrent fire. In : Fire and the Australian biota, eds Gill, A.M., Groves, R.H. & Noble, I.R. pp. 311-335, Australian Academy of Science, Canberra.

OGDEN, J.G. 1982. Seasonal mass balance of major ions in three small watersheds in a maritime environment. Water, Air and Soil Pollution 17 : 119-130.

OOSTING, H.J. & BILLINGS, W.D. 1942. Factors affecting vegetational zonation on coastal dunes. Ecology 23 (2) : 131-142.
ORLoCI, L. 1978. Multivariate Analysis in Vegetation Research. Junk, The Hague.
PALMER, A.R. 1981. A study of the vegetation of the Andries Vosloo Kudu Reserve, Cape Province. Unpubl. M.Sc. thesis, Rhodes University.
PALMER, A.R. & LUBKE, R.A. 1982. The sorting of species-releve groups in phytosociology by means of an information processor. S. Afr. J. Bot. 1 : 7-9.
PIERCE, S.M. 1984. A synthesis of plant phenology in the Fynbos Biome. S. Afr. Nat. Sci. Prog. Rep. no. 88 : 1-57.
PIERCE, S.M. & COWLING, R.M. 1984a. Phenology of fynbos, renosterveld and subtropical thicket in the south-eastern Cape. S. Afr. J. Bot. 3 : 1-16.
PIERCE, S.M. & COWLING, R.M. 1984b. Seasonal growth of the overstorey and understorey in mediterranean-type shrublands and heathlands in the south-eatern Cape. S. Afr. J. Bot. 3 : 17-21.
POORE, M.E.D. 1955a. The use of phytosociological methods in ecological investigations. I. The Braun-Blaquet system. J. Ecol. 43 : 226-244.
POORE, M.E.D. 1955b. The use of phytosociological methods in ecological investigations. II. Practical issues involved in an attempt to apply the Braun-Blanquet system. J. Ecol. 43 : 245-269.
POORE, M.E.D. 1956. The use of phytosociological methods in ecological investigations. IV. General discussion of phytosociological problems. J. Ecol. 44 : 28-50.
POYNTON, R.J. 1971. A sylvicultural map of southern Africa with maps of thermal and moisture regions. S. Afr. J. Sci. 67(2) : 58-60.
ROGERS, D.J. & MOLL, E.J. 1975. A quantitative description of some coast forests of Natal. Bothalia. 11 : 523-537.
SALISBURY, E.J. 1925. Note on the edaphic succession in some dune soils with special reference to the time factor. J. Ecol. 13 : 322-328.
SALISBURY, E.J. 1952. Downs and Dunes. G. Bell and Sons, London.
SCHEEPERS, J.C. 1983. The present status of vegetation conservation in South Africa. Bothalia 14 : 991-995.
SCHULZE, B.R. 1947. The climate of South Africa according to the classification of Koppen and Thornthwaite. S. Afr. Geog. J. 29 : 32-42.
SCHULZE, B.R. 1965. Climate of South Africa. Part 8. General Survey. Weather Bureau Publ., Pretoria. 330 pp.
SCHULZE, B.R. 1975. Incoming radiation on sloping terrain : A general model for use in southern Africa. Agrochemophysica 7 : 55-61.

SCHULZE, R.E. & McGEE, O.S. 1978. Climatic indices and classification in relation to the biogeography of Southern Africa. In : The Biogeography and ecology of Southern Africa, ed. Werger, M.J.A. pp. 19-52, Junk, The Hague.

SCHWARZ, E.H.L. 1912. South African Geology. Blackie and Son, London.

SEAL, H. 1964. Multivariate Statistical Analysis for Biologists. Methuen, London.

SHIMWELL, D.W. 1971. Description and Classification of Vegetation. Sidgwick and Jackson, London.

SPECHT, R.L., ROGERS, R.W. & HOPKINS, A.J.M. 1981. Seasonal growth and flowering rhythms. In : Heathlands and related shrublands of the world. Volume B. Analytical studies, ed. Specht, R.L. Elsevier, Amsterdam.

SPECHT, R.L., MOLL, E.J., PRESSINGER, F. & SOMMERVILLE, J.E.M. 1983. Moisture regime and nutrient control of seasonal growth in mediterranean ecosystems. In : Mediterranean-type ecosystems. The role of nutrients, eds Kruger, F.J., Mitchell, D.T. & Jarvis, J.U.M. Springer, New York.

STEHLE, T.C. 1980. Waaisandbestuursplan vir die Alexandriakus staatsbos 1981/82 tot 1990/1. Internal Report, Directorate of Forestry.

STILES, F.G. 1977. Co-adapted competitors : the flowering seasons of hummingbird pollinated plants in a tropical forest. Science 198 : 1177-1178.

THOMPSON, C.H. 1981. Podzol chronosequences on coastal dunes of eastern Australia. Nature 291 : 59-61.

THOMPSON, C.H. & HUBBLE, G.D. 1979. Sub-tropical podzols (spodzols and related soils) of coastal eastern Australia: profile form, classification and use. Proc. Com. IV an V Intl. Soil Sci. Soc. CLAMATROPS Conf. Kuala Lumpur, August 1977.

TINLEY, K.L. 1985. Coastal dunes of South Africa. S. Afr. Nat. Sci. Prog.Rep. No. 109. 300 pp.

TRUSWELL, J.F. 1977. The geological evolution of South Africa. Purnell, Cape Town. 218 pp.

TYSON, P.D. 1964. Berg winds of South Africa. Weather 19 : 7-11.

VAN DER MERWE, C.R. 1962. Soil groups and subgroups of South Africa. Dept. Agric. Tech. Serv. Sci. Bull. No. 356.

VAN DER VALK, A.G. 1974. Environmental factors controlling the distribution of forbs on coastal foredunes in Cape Hatteras National Seashore. Can. J. Bot. 52 : 1057-1073.

VAN RIPER, J. 1971. Man's Physical World. McGraw-Hill, London.

VAN ZINDEREN BAKKER, E.M. Jr. 1971. Ecological investigations on ravine forests of the eastern Orange Free State, South Africa. Unpubl. M.Sc. thesis, University of the Orange Free State.

VENTER, H.J.T. 1972. Die plantekologie van Richardsbaai,Natal. Unpubl. D.Sc. thesis, University of Pretoria.

VENTER, H.J.T. 1974. 'n Plantekologiese studie van die duinwoud by Sibayimeer, noordoos-Zoeloeland. Unpubl. manuscript. 9pp.

VOGT, G. 1979. Adverse effects of recreation on sand dunes: A problem for coastal zone management. Coastal Zone Managment J. 6(1) : 37-68.

WALKER, J., THOMPSON, C.H., FERGUS, I.F. & TUNSTALL, B.R. 1983. Plant succession and soil development in coastal sand dunes of subtropical eastern Australia. In : Forest Succession: Concepts and Application, eds Shugard, H., Botkin, D. & West, D. Springer-Verlag, New York.

WALSH, B.N. 1968. Some notes on the incidence and control of drift sands along the Caledon, Bredasdorp and Riversdale coastline of South Africa. Dept. For. Bull. No. 44.

WALTER, H & LEITH, H. 1960. Klimadiagram-Weltatlas. Fischer, Jena.

WARD, C.J. 1980. The plant ecology of the Isipingo Beach area, Natal, South Africa. Mem. Bot. Surv. S. Afr. No. 45.

WEISSER, P.J. 1978. Conservation priorities in the dune area between Richards Bay and Mfolozi Mouth based on a vegetation survey. Natal Town and Regional Planning Report 38. Pietermaritzburg. 64 pp.

WEISSER, P.J. 1980. The dune forests of Maputaland. In : Studies on the ecology of Maputaland, eds Bruton, M.N. & Cooper, K.H. pp.78-90. Rhodes University, Grahamstown.

WEISSER, P.J. & BACKER, A.P. 1983. Monitoring beach and dune advancement and vegetation changes 1937-1977 at the farm Twinstreams, Mtunzini, Natal, South Africa. In : Sandy beaches as ecosystems, eds McLachlan, A. & Erasmus, T. Junk, The Hague.

WEISSER, P.J. & COOPER, K.H. In prep. The dry coastal ecosystems of the South African east coast.

WEISSER, P.J., GARLAND, I.F. & DREWS, B.K. 1982. Dune advancement 1937-1977 at the Mlalazi Nature Reserve, Natal, South Africa, and a preliminary vegetation-succession chronology. Bothalia 14 : 127-130.

WERGER, M.J.A. 1972. Species-area relationships and plot size : with some examples from South African vegetation. Bothalia 10 : 583-594.

WERGER, M.J.A. 1974. On concepts and techniques applied in the Zurich-Montpellier method of vegetation survey. Bothalia 11 (3) : 309-323.

WESTHOFF, V. & VAN DER MAAREL, E. 1978. The Braun-Blanquet approach. Ordination and classification of vegetation. In : Handbook of vegetation Science. Volume 5, ed. Whittaker, R.H. Junk, The Hague.

WHITE, F. 1983. The vegetation of Africa : A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. Natural Resources Research 20. UNESCO, Paris.

WHITTAKER, R.H. 1962. Classification of natural communities. Bot. Rev. 28 : 1-239. In : Gauch (1982), (loc. cit.).

WHITTAKER, R.H. 1967. Gradient analysis of vegetation. Biol. Rev. 42 : 207-264. In : Whittaker (1978), (loc. cit.).

WHITTAKER, R.H. 1973. Ordination and classification of communities. Handbook of Vegetation Science 5 : pp. 287-321. Junk, The Hague. In : Whittaker (1978), (loc. cit.).

WHITTAKER, R.H. 1978. Ordination of Plant Communities. Junk, The Hague.

WILLIS, A.J., FOLKES, B.F., HOPE-SIMPSON, J.F. & YEMM, E.W. 1959. Braunton Burrows : The dune system and its vegetation. I & II. J. Ecol. 47 : 1-24 & 249-288.

WOODS, D.B. & MOLL, E.J. 1967. Multivariate analysis of grasslands in the Three Rivers area, Natal. Proc. Grassld. Soc. S. Afr. 2 : 103-111.

## APPENDIX I - SPECIES LIST

A checklist of species occurring in the East London Coast dune forests is given below. This is by no means a complete floristic summary for the area but includes only those species actually recorded during sampling or included in the phenology study, as well as species occurring in the area, which are referred to in the text. Emphasis is placed on the woody shrub and tree species since these elements were studied in greater detail.

Brief notes have been made on the ecological significance of certain species within the dune communities and where possible, common names have been included. The latter were obtained from Coates-Palgrave (1977) or refer to those used by local Forestry staff.

Voucher specimens which were identified using material belonging to the Albany Museum herbarium are now lodged in the herbarium of the Eastern Cape Forest Region.

The nomenclature and sequence is after Gibbs Russell *et al*.(1984) and the following format has been used in listing the species :

Genus

specific name    author    *
common name
ecological significance

( * denotes naturalized species.)

### GYMNOSPERMAE

#### PODOCARPACEAE

*Podocarpus*

P. falcatus    (Thunb.) R. Br. ex Mirb.
"Outeniqua yellowwood"
Climax dune valley forest.

P. latifolius (Thunb.) R. Br. ex Mirb.
"Real yellowwood"
Climax dune valley forest.

## ANGIOSPERMAE-MONOCOTYLEDONAE

### POACEAE

Imperata
I. cylindrica (L.) Raeuschel
Primary and secondary colonizer. Common on dune crests.

Digitaria
D. eriantha Steud.
"Vingergras"
Recorded as secondary colonizer after fire.

Stenotaphrum
S. secundatum (Walt.) Kuntz
Common element of coastal grassland.

Panicum
P. deustum Thunb.
"Breeblaarbuffelsgras"
Recorded as secondary colonizer after fire.

Ehrharta
E. villosa Schult. F. var. villosa
"Pipe grass"
Primary colonizer of dunes.

Stipagrostis
S. zeyheri (Nees) De Winter subsp. zeyheri
Recorded as secondary colonizer after fire.

### CYPERACEAE

Mariscus
M. congesta (Vahl.) C. B. Cl.
"Giant sedge"
Early colonizer of open sand and dune slacks.

Ficinia
F. acuminata (Steud.) Nees.
Primary and secondary colonizer.

Scirpus
S. nodosus Rottb.
Common dune slack species.

Cynanchum
C. natalitium Schltr.
Vigorous secondary colonizer after fire.

ARECACEAE

Phoenix
P. reclinata — Jacq.
"Wild date palm"
Locally common on moist sites.

LILIACEAE

Dracaena
D. hookerana — K. Koch.
Relatively common understorey species on cooler sites.

Asparagus
A. suaveolens — Burch.
Vigorous secondary colonizer after fire.

STRELITZIACEAE

Stelitzia
S. nicolai — Regel and Koern.
"Natal strelitzia"
Common in moist seaward thicket.

ANGIOSPERMAE-DICOTYLEDONAE

CASUARINACEAE

Casuarina
C. eqisetifolia — G. Forst. *
"Coastal beefwood"
Non-invasive exotic used for sand stabilization.

MYRICACEAE

Myrica
M. cordifolia — L.
"Waxberry"
Vigorous colonizer of open sand.

MORACEAE

Ficus
F. burtt-davyi — Hutch.
"Veld fig"
Sub-canopy species, occasionally reaching canopy through scandent growth habit.

F. natalensis — Hochst.
"Common wild fig"
Isolated groups of large trees occur on relatively sheltered sites.

SANTALACEAE

Colpoon
C. compressum	Berg.
"Cape sumach"
Relatively common scrub-thicket species. Recorded as secondary colonizer after fire.

CHENOPODIACEAE

Chenopodium
C. botryodes	SM. *

MESEMBRYANTHEMACEAE

Carpobrotus
C. edulis	(L.) L. Bol.
"Hotnotsvy"
Common succulent fringe species of seaward scrub-thicket.

Delosperma
D. calycinum	L. Bol
Recorded as a secondary colonizer after fire.

Mesembryanthemum
M. aitonis	Jacq.
Succulent annual which is a vigorous secondary colonizer.

CAPPARACEAE

Capparis
C. sepiaria	L. var. citrifolia (Lam.) Toelken

Maerua
M. cafra	(DC.) Pax
"Bush cherry"
Uncommon thicket and sub-canopy species.

PITTOSPORACEAE

Pittosporum
P. viridiflorum	Sims
"Pittosporum"
Uncommon thicket and forest species.

FABACEAE

Acacia
A. cyclops	A. Cunn. ex. G. Don *
"Rooikrans"

| | |
|---|---|
| | Alien species which has been almost eradicated from dune areas. Occurs along landward forest margin. |
| A. karroo | Hayne<br>"Sweet thorn"<br>Uncommon in dune forest, but occurs along forest margin. |
| *Schotia* | |
| S. afra | (L.) Thunb. var. afra<br>"Karooboerboon"<br>Relatively common canopy species in developed, sheltered forest. |
| S. latifolia | Jacq.<br>"Bosboerboon"<br>Common canopy species in developed, sheltered forest. |
| *Sesbania* | |
| S. punicea | (Cav.) Benth. *<br>"Sesbania"<br>Serious problem invader species. Almost eradicated from forest areas but still occurs along landward margin. |
| *Rhynchosia* | |
| R. caribaea | (Jacq.) DC.<br>Recorded as a secondary colonizer after fire. |
| *Erythrina* | |
| E. caffra | Thunb.<br>"Coast erythrina"<br>Uncommon canopy species in developed, sheltered forest. |

ERYTHROXYLACEAE

| | |
|---|---|
| *Erythroxylum* | |
| E. emarginatum | Thonn.<br>"Common coca tree"<br>Uncommon forest and thicket species. |

ZYGOPHYLLACEAE

| | |
|---|---|
| *Zygophyllum* | |
| Z. uitenhagense | Sond.<br>Recorded as a herbaceous secondary colonizer after fire. |

RUTACEAE

| | |
|---|---|
| *Zanthoxylum* | |
| Z. capense | (Thunb.) Harv. |

"Small knobwood"
Not a very common thicket and forest species.

<u>Calodendrum</u>
C. capense — (L.f.) Thunb.
"Cape chestnut"
Coastal forest species not occurring on the dunes.

<u>Vepris</u>
V. lanceolata — (Lam.) G. Don
"White ironwood"
Not a very common species, occurring mainly in sub-canopy of climax valley forest.

<u>Teclea</u>
T. natalensis — (Sond.) Engl.
"Natal teclea"
Reasonably common, particularly in sub-canopy of forest on cooler sites.

<u>Clausena</u>
C. anisata — (Willd.) Hook. F. ex Benth.
"Horsewood"
Not a very common thicket and forest species.

MELIACEAE

<u>Turraea</u>
T. obtusifolia — Hochst.
"Small honeysuckle tree"
Relatively common sub-canopy species.

<u>Melia</u>
M. azedarach — L. *
"Syringa"
Alien species, uncommon in dune forest.

EUPHORBIACEAE

<u>Ricinus</u>
R. communis — L. *
"Caster Oil plant"
Alien species which colonizes disturbed areas.

ANACARDIACEAE

<u>Harpephyllum</u>
H. caffrum — Bernh.
"Wild plum"
Occurs in sheltered, well-developed forest.

<u>Rhus</u>
R. crenata — Thunb.
"Taaibos"
Common scrub-thicket and land- and seaward forest margin species

| | | |
|---|---|---|
| R. glauca | Thunb. | |
| | Relatively common scrub-thicket species. | |
| R. longispina | Eckl. and Zeyh. | |
| | "Thorny taaibos" | |
| | Uncommon sub-canopy species. | |
| R. natalensis | Bernh. | |
| | "Natal karee" | |
| | Uncommon sub-canopy thicket species. | |
| R. pyroides | Burch. | |
| | "Common taaibos" | |
| | Uncommon sub-canopy thicket species at southern extreme of its distribution limit. | |

CELASTRACEAE

<u>Maytenus</u>

M. heterophylla — (Eckl. and Zeyh.) N.B.K.-Robson
"Common spike-thorn"
Common member of most dune thicket and forest communities.

M. nemorosa — (Eckl. and Zeyh.) Marais
"White forest spike-thorn"
Uncommon sub-canopy member.

M. procumbens — (L.F.) Loes.
"Dune kokoboom"
Common stunted fringe species of seaward scrub thicket.

M. undata — (Thunb.) Blakelock
"Kokoboom"
Relatively common thicket species on drier slopes south of East London.

<u>Pterocelastrus</u>

P. tricuspidatus — (Lam.) Sond.
"Cherrywood"
Common canopy member of seaward thicket. Uncommon in climax valley forest.

<u>Cassine</u>

C. aethiopica — Thunb.
"Kooboo-berry"
Common canopy and sub-canopy member of most dune forest communities.

C. papillosa — (Hochst.) Kuntze
"Common saffronwood"
Uncommon sub-canopy species.

C. tetragona — (L.F.) Loes.
"Climbing saffronwood"
Relatively common in undeveloped primary and postfire communities; also an uncommon sub-canopy species.

ICACINACEAE

Apodytes

| | |
|---|---|
| A. dimidiata | E. Mey. ex Arn. subsp. dimidiata<br>"White pear"<br>Relatively common canopy species in seaward thicket. |

SAPINDACEAE

| | | |
|---|---|---|
| *Allophylus* | | |
| A. natalensis | (Sond.) De Winter<br>"Dune allophylus"<br>Common canopy and sub-canopy species in most forest communities. |
| *Deinbollia* | |
| D. oblongifolia | (E. Mey. ex Arn.) Radlk.<br>"Dune soap-berry"<br>Relatively common sub-canopy species in climax forest. |
| *Hippobromus* | |
| H. pauciflorus | (L.F.) Radlk.<br>"Basterperdepis"<br>Not a very common species, occurring in developed forest. |

RHAMNACEAE

| | |
|---|---|
| *Scutia* | |
| S. myrtina | (Burm. F.) Kurz<br>"Drogie"<br>An important scrub-thicket species. |

VITACEAE

| | |
|---|---|
| *Rhoicissus* | |
| R. digitata | (L.F.) Gilg and Brandt<br>"Baboon grape"<br>Relatively common creeper, particularly along seaward thicket margin. |

TILIACEAE

| | |
|---|---|
| *Grewia* | |
| G. occidentalis | L.<br>"Cross-berry"<br>Relatively common thicket and forest margin species. |

FLACOURTIACEAE

| | |
|---|---|
| *Scolopia* | |
| S. zeyheri | (Nees) Harv.<br>"Thorn pear"<br>Relatively common thicket species. |
| *Dovyalis* | |
| D. rhamnoides | (Burch. ex DC.)<br>"Common dovyalis"<br>Uncommon sub-canopy species. |

| | | |
|---|---|---|
| *D. rotundifolia* | (Thunb.) Thunb. and Harv.<br>"Dune dovyalis"<br>Very common in canopy and sub-canopy in most forest communities. |

OLINIACEAE

| | |
|---|---|
| *Olinia* | |
| *O. ventosa* | (L.) Cufod.<br>"Hard pear"<br>Uncommon thicket and forest species. |

THYMELAEACEAE

| | |
|---|---|
| *Passerina* | |
| *P. rigida* | Wikstr.<br>"Gonna"<br>Relatively early primary colonizer.<br>Also common in dune scrub. |

MYRTACEAE

| | |
|---|---|
| *Psidium* | |
| *P. guajava* | L. *<br>"Guava"<br>Potentially serious alien species. |
| *Eugenia* | |
| *E. capensis* | (Eckl. and Zeyh.) Harv. ex Sond.<br>"Dune myrtle"<br>Uncommon scrub-thicket species. |
| *Syzygium* | |
| *S. cordatum* | Hochst.<br>"Umdoni"<br>Uncommon species at southern distribution limit. Isolated individuals occur on sheltered landward sites. |

ARALIACEAE

| | |
|---|---|
| *Cussonia* | |
| *C. spicata* | Thunb.<br>"Cabbage tree"<br>Relatively uncommon canopy species in developed thicket and forest. |
| *C. thyrsiflora* | Thunb.<br>"Coast cabbage tree"<br>Relatively common scancent sub-canopy species. |

SAPOTACEAE

Sideroxylon

| | |
|---|---|
| S. inerme | L.<br>"White milkwood"<br>Common canopy member, particularly in developed forest. |

Mimusops

| | |
|---|---|
| M. caffra | E. Mey. ex A. DC.<br>"Red milkwood"<br>Coastal endemic. Very common canopy member, particularly in seaward thicket and forest. |

EBENACEAE

Euclea

| | |
|---|---|
| E. natalensis | A. DC. subsp. natalensis<br>"Large-leaved guarri"<br>Relatively common, particularly in sub-canopy in most forest and thicket communities. |
| E. racemosa | Murray<br>"Sea guarri"<br>Relatively common in most communities. |
| E. schimperi | (A. DC.) Dandy var. schimperi<br>"Bush guarri" |

Diospyros

| | |
|---|---|
| D. natalensis | (Harv.) Brenan subsp. natalensis<br>"Small-leaved jackal berry"<br>Occurs mainly in developed forest on sheltered sites. |
| D. scabrida | (Harv<br>ex Hiern) De Winter var. cordata<br>"Hard-leaved monkey plum"<br>Common sub-canopy species south of East London |

OLEACEAE

Chionanthus

| | |
|---|---|
| C. foveolata | (E. Mey.) Stearn subsp. foveolata<br>"Large-leaved ironwood"<br>Relatively common in most communities. |

Olea

| | |
|---|---|
| O. capensis | L. subsp. capensis<br>"Ironwood"<br>Occurs in canopy and sub-canopy in most communities. Coppices vigorously after fire. |
| O. exasperata | Jacq.<br>"Coast olive"<br>Common in scrub-thicket on drier sites. |

GENTIANACEAE

Chironia
C. baccifera — L.
Relatively common dune slack and scrub species.

APOCYNACEAE

Acokanthera
A. oblongifolia — (Hochst.) Codd
"Dune poison bush"
Very common sub-canopy species.

Carissa
C. bispinosa — (L.) Desf. ex Brenan var. bispinosa
"Num-num"
Common sub-canopy species.

C. macrocarpa — (Eckl.) A. DC.
"Large num-num"
Uncommon.

CONVOLVULACEAE

Ipomoea
I. brasiliensis — (L.) Sweet
"Seepatat"
Very common early pioneer of open sand.
Creates hummock dunes.

BORAGINACEAE

Cordia
C. caffra — Sond.
"Septee"
Very common canopy species in forest and thicket communities.

VERBENACEAE

Lantana
L. camara — L. *
"Lantana"
Potentially serious alien species presently under control in dune forest.

SOLANACEAE

Cestrum
C. laevigatum — Schlechtd. *
"Inkberry"
A less serious alien species.

ACANTHACEAE

<u>Isoglossa</u>

| | | |
|---|---|---|
| I. woodii | C.B. Cl. | |
| | Very common forest floor species, particularly on cooler sites. | |

RUBIACEAE

<u>Canthium</u>

C. obovatum — Klotzsch
"Quar"
Relatively common canopy species in most forest communities.

C. spinosum — (Klotzsch) Kuntze
"Coastal canthium"
Uncommon sub-canopy species.

<u>Pavetta</u>

P. revoluta — Hochst.
"Dune bride's bush"
Relatively common sub-canopy and canopy species.

<u>Psychotria</u>

P. capensis — (Eckl.) Vatke
"Cream psychotria"
Relatively common sub-canopy species on sheltered sites.

CUCURBITACEAE

<u>Coccinia</u>

C. quinqueloba — (Thunb.) Cogn.

GOODENIACEAE

<u>Scaevola</u>

S. plumieri — (L.) Vahl.
"Seeplakkie"
Very common early pioneer of open sand. Creates hummock dunes.

ASTERACEAE

<u>Brachylaena</u>

B. discolor — DC. subsp. discolor var. discolor
"Coastal silverleaf"
Common in seaward thicket, often forming a fringe adjacent to the open beach.

Tarchonanthus

T. camphoratus — L.
"Camphor bush"
Not a very common thicket species. Often occurs along thicket margin.

Helichrysum

H. cymosum — (L.) D. Don subsp. cymosum
Occurs in dune slacks and primary and secondary scrub.

Stoebe

S. plumosa — (L.) Thunb.
"Slangbos"
Relatively early primary colonizer.

Metalasia

M. muricata — (L.) D. Don.
"Blombos"
Early colonizer. Common dune crest and secondary thicket species.

Senecio

S. litorosus — Fourc.
Primary colonizer of open sand.

Chrysanthemoides

C. monilifera — (L.) T. Norl. subsp. molilifera
"Bitou"
Early primary colonizer. Often occurs in dense clumps along forest and thicket margin.

Arctotheca

A. populifolia — (Berg.) T. Norl.
"Seepampoen"
Early primary colonizer of open sand and drift line.

Gazania

G. rigens — (L.) Gaertn. var rigens
"Gousblom"
Early colonizer of open sand and drift line.

Cirsium

C. vulgare — (Savi) Ten. *
"Scotch thistle"
Alien invader plant of little significance.

# APPENDIX II : PHENOPHASE RECORDINGS OF DUNE SPECIES

STRAND SPECIES

| | | FLOWERING | | | | | | | | | | | | FRUITING | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
| *Arctotheca populifolia* | 1982 | | | | | | | | | | X | X | X | | | | | | | | | | | | |
| | '83 | X | X | | | X | | | | | X | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Chrysanthemoides monilifera* | '82 | | | | | | | X | X | X | X | X | X | | | | | | | X | X | X | X | X | X |
| | '83 | | | X | X | X | X | X | X | X | | | | | | | | X | X | X | X | X | X | | |
| | '84 | | | | X | X | X | X | X | | | | | | | | | X | X | X | X | X | X | | |
| | '85 | | | | X | | | | | | | | | | | | X | | | | | | | | |
| *Carpobrotus edulis* | '82 | | | | | | | | | X | X | X | | | | | | | | | | | | X | X |
| | '83 | | | | X | | | | | | X | | | | | | | | | | | | | | |
| | '84 | | X | | | | | | X | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Erharta villosa* | '82 | | | | | | | | | X | | | | | | | | | | | | | X | X | X |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | X | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | X | X | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Eugenia capensis* | '82 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | X | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Gazania rigens* | '82 | | | | | | | | | X | X | X | X | | | | | | | | | | | X | X |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Helichrysum cymosum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | X | | | | | | | | | | | | X | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Ipomoea brasiliensis* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | X | X | | | | | | | | | | | | X | | | | | | | | | | |
| | '84 | | X | | | | | | | | | | | | | X | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | X | X | X | | | | | | | |
| *Metalasia muricata* | '82 | | | | | | | X | X | | | | | | | | | | | X | X | X | X | | |
| | '83 | | X | X | X | X | X | X | | | | | X | | | | X | X | X | X | X | | | | |
| | '84 | X | X | X | X | X | X | | X | | | | | | | | X | X | X | X | X | X | X | | |
| | '85 | | X | X | X | | | | | | | | | | | | X | | | | | | | | |

| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Myrica cordifolia* | 1982 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | X | X | X | | | | |
| | '84 | | | | | | | | | | | | | | | | | X | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | X | | | | | | | | |
| *Passerina rigida* | '82 | | | | | | | | | | X | X | | | | | | | | | | | | X | |
| | '83 | | X | X | | | | | | | X | | | | | | | | | | | | | | X |
| | '84 | | | | | | | | | | X | | | | | | | | | | | | | | X |
| | '85 | | X | | | | | | | | | | | | | | | | | | | | | | |
| *Rhoicissus digitata* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | X | X | X | X | X | X | | | |
| | '85 | | | | | | | | | | | | | | | | X | | | | | | | | |
| *Rhus crenata* | '82 | | | | | | | | | | | | | | | | | | | | X | X | X | X | |
| | '83 | | | | X | | | | | | | | | | | | X | X | X | X | | | | | |
| | '84 | | | | X | | | | | X | | | | | | | X | X | X | X | | | X | X | X |
| | '85 | | | | X | | | | | | | | | | | | X | | | | | | | | |
| *Rhus glauca* | '82 | | | | | | | | | | | | | | | | | | | | | | X | X | |
| | '83 | | | | | | | | | X | | | | | | | | | | | | | | | |
| | '84 | | | | | | | X | X | | | | | | | | | | | | | | X | X | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhynchosia caribaea* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | X | | | | | | | | | | | | X | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Scaevola plumieri* | '82 | | | | | | | | | | | X | X | | | | | | | | | | | | |
| | '83 | | | | | | | | | | X | X | X | | X | | | X | | | | | | | |
| | '84 | X | X | | | | | | | | | | | | X | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | X | X | | | | | | | | |
| *Senecio littoreus* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | X | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Stoebe plumosa* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | X | X | X | | | | | | | | | X | | X | X | X | | | | | | | | |
| | '84 | | X | | | | | | | | | | | | X | X | X | | | | | | | | |
| | '85 | X | X | | | | | | | | | | | | X | | X | | | | | | | | |

WOODY TREE SPECIES

| | | FLOWERING | | | | | | | | | | | | FRUITING | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
| *Acokanthera oblongifolia* | 1982 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | | | | | | | | | | | | | | X | X | | X | X | X | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | X | | | | | |
| | '85 | | | | | | | | | | | | | | | X | X | | | | | | | | |
| *Allophylus natalensis* | '82 | | | | | | | | | | | | | | | | | | X | | X | X | X | | |
| | '83 | | X | X | X | X | X | | | | | | X | | | | | X | X | X | X | X | | | |
| | '84 | X | X | X | X | | | | | | | | | | | | | X | X | X | X | X | | | |
| | '85 | | X | | X | | | | | | | | | | | | | | | | | | | | |
| *Apodytes dimidiata* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | X | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Brachylaena discolor* | '82 | | | | | | | X | X | X | | | | | | | | | | | | X | X | X | |
| | '83 | | | | | X | X | X | X | X | | | | | | | | | | | X | X | X | | |
| | '84 | | | | | X | X | X | X | | | | | | | | | | | X | X | X | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Canthium obovatum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | X | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | X | | | | | | | | | | |
| *Carissa bispinosa* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | X | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | X | X | | | | | | | | | |
| *Carissa macrocarpa* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | X | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | X | | | |
| | '85 | | | X | | | | | | | | | | | | X | | | | | | | | | |
| *Cassine aethiopica* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | X | | | | | | | | | |
| | '84 | X | X | X | X | | | | | | | | | | | | X | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | X | | | | | | | | | |
| *Cassine papillosa* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | X | | | | | X | | | |
| | '85 | | | | | | | | | | | | | | X | | | | | | | | | | |

| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chionanthus foveolata* | 1982 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Clausena anisata* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | X | | | | | | | | | | | | | | X | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | X | | | | | | | | |
| *Cordia caffra* | '82 | | | | | | | | X | X | | | | | | | | | | | | | X | X | |
| | '83 | | X | | | | | | | X | X | X | X | | | X | X | | | | | | X | X | X |
| | '84 | | | | | | | X | X | X | X | X | | X | X | | | | | | X | X | X | X | X |
| | '85 | | | | | | | | | | | | | X | | | | | | | | | | | |
| *Deinbollia oblongifolia* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | X | | | | |
| | '84 | | | | X | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Diospyros natalensis* | '82 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | X | | | | | | | | X | | | | X | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | X | | | | | | | | | |
| *Dovyalis rotundifolia* | '82 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | | | | | | | X | | | | | | | | | X | | | | | X | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Erythrina caffra* | '82 | | | | | | | | | X | | | | | | | | | | | | | X | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | X | | | |
| | '84 | | | | | | X | | | | | | | | | | | | | | | | X | X | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Euclea natalensis* | '82 | | | | | | | | | | X | | | | | | | | | | | | X | X | |
| | '83 | | | | | X | | | | | | | | | | | | X | X | X | | | | | |
| | '84 | X | | | X | | | X | X | X | | | | | X | | | | | | | | X | X | X |
| | '85 | X | | | | | | | | | | | | X | X | X | X | X | | | | | | | |
| *Euclea racemosa* | '82 | | | | | | | | | | | | | | | | | | | | | X | X | | |
| | '83 | | | | | | X | | | | | | | | X | X | X | X | X | X | | | | | X |
| | '84 | | | | | | | | X | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Harpephyllum caffrum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | X | | | X | X | | | X | X | X |
| | '84 | | | | | X | | | | | | | | | | | | | | | X | | | X | |
| | '85 | | | | | | | | | | | | | | X | | X | | | | | | | | |

| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Hippobromus pauciflorus* | 1982 | | | | | | | | | | X | | | | | | | | | | | | | X | |
| | '83 | | | | | | | | X | | | | X | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | X | X | | | | | | | | | X | X | | |
| | '85 | | | X | X | | | | | | | | | | | | | | | | | | | | |
| *Maerua cafra* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | X | | | | | | | | | | | | | X | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Maytenus heterophylla* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | X | X | X | | | | | X | | | | | | | | | |
| | '84 | | | | X | | | | | | X | | | | | | | | | | X | X | X | | |
| | '85 | | | X | | | | | | | | | | | | X | X | | | | | | | | |
| *Mimusops caffra* | '82 | | | | | | | | | | | | | | | | | | | | | X | X | X | X |
| | '83 | | X | X | X | | | | | | | | X | X | X | X | | | | | | | | | |
| | '84 | X | X | | X | | | | | | | | | | | | | X | X | X | X | X | X | X | X |
| | '85 | | X | X | | | | | | | | | | X | X | X | X | | | | | | | | |
| *Olea capensis* | '82 | | | | | | | | | | X | X | | | | | | | | | | | | | |
| | '83 | | X | | | | | | | | X | | | | X | | | | | | | | | | |
| | '84 | | | | | | X | X | X | X | X | X | X | | | | | | | | | | | | |
| | '85 | X | | | | | | | | | | | | | X | | X | | | | | | | | |
| *Olea exasperata* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | X | X | X | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | X | X | | | X | | | X | | | | | | | | X | | | X | | |
| | '85 | | | | | | | | | | | | | | X | | X | | | | | | | | |
| *Olinia ventosa* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | X | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | X | | | | | | | | |
| *Pavetta revoluta* | '82 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | | | | | | | | | X | | | | | | | | | | | | | | |
| | '84 | | X | | | | | | | | | | X | | X | X | X | | | | | | X | | |
| | '85 | | | | | | | | | | | | | | X | X | X | X | | | | | | | |
| *Pittosporum viridiflorum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | X | X | | | | | | | X | |
| | '84 | | | | | | | | | | | | | | | | | X | | | X | X | X | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Psychotria capensis* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | X | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |

| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pterocelastrus tricuspidatus* | 1982 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | X | X | X | X | X | | | | | | | | | | | | | |
| | '85 | | X | | | | | | | | | | | | | | | | | | | | | | |
| *Scolopia zeyheri* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | X | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | X | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Schotia afra* | '82 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '83 | | | X | | | | | | | | | | | | | | | X | X | X | X | | | |
| | '84 | | | | | | | | | | | X | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Schotia latifolia* | '82 | | | | | | | | | | X | | | | | | | | | | | | | | |
| | '83 | X | X | X | | | | | | | | | | | X | X | | | | | X | X | X | | |
| | '84 | | | | | | | | | | | | X | | | | | | X | | | X | | | |
| | '85 | X | | | | | | | | | | | | | X | | X | | | | | | | | |
| *Strelitzia nicolai* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | X | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Syzygium cordatum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | X | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Tarchonanthus camphoratus* | '82 | | | | | | | | X | | | | | | | | | | | | | | | | |
| | '83 | | X | X | X | X | X | X | | | | | X | | | | | X | | | | | | | |
| | '84 | | X | X | X | X | | | | | X | | | | | | | | | | | X | X | | |
| | '85 | | X | X | X | | | | | | | | | | | | | | | | | | | | |
| *Zanthoxylum capense* | '82 | | | | | | | | | | X | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | X | | | | | X | | | | | | | | X | X | X |
| | '84 | | | | | | | X | X | | | | | | | | | | | | | | X | X | X |
| | '85 | | | | | | | | | | | | | | | X | | | | | | | | | |

HERB AND SHRUB SPECIES

| | | FLOWERING | | | | | | | | | | | | FRUITING | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
| *Asparagus suaveolens* | 1982 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | X | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Colpoon compressum* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | X | | | | | | | | X | | | X | X | X | X | X | | | | | |
| | '84 | | | | | | X | X | X | X | X | X | X | | | | X | X | X | X | X | X | X | X | X |
| | '85 | | | | | | | | | | | | | | | | X | | | | | | | | |
| *Cassine tetragona* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | X | | | | | | | | | | | X | X | X | X | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | X | | | | |
| | '85 | | | | | | | | | | | | | | X | X | X | | | | | | | | |
| *Ficus burtt-davyi* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | X | | | | | | | | | | | | X | X | | | | | | | | | X |
| | '84 | | | | | | | | | | | | | X | X | | | | | | X | | | X | X |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Grewia occidentalis* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | X | | | | | X | | | | | | | X | X | X |
| | '84 | | | | | | | | | | X | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Maytenus procumbens* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | X | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Rhus natalensis* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | X | X | X | | | | | | X | | | | | | | | | | | | X | X | X |
| | '84 | | | | | | | | | | | | | | | | | | | | X | X | X | | |
| | '85 | | X | | | | | | | | | | | | X | | | | | | | | | | |
| *Rhus pyroides* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | X | X | | | | | | | | | | | | | X | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | X | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Scutia myrtina* | '82 | | | | | | | | | | | | | | | | | | | X | | | X | | |
| | '83 | | | | | | | | | | | | | | X | X | X | X | X | X | | | | | |
| | '84 | | | | | | | | | | | X | X | | | | | | | | | | | | X |
| | '85 | X | | | | | | | | | | | | X | X | | X | | | | | | | | |

| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Turraea obtusifolia* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | X | | | | | | | | | | | | | | | | | | | | | | | |
| | '84 | | | | | | | | | | | | X | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |
| *Zygophyllum uitenhagensis* | '82 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '83 | | X | | | | | | | | | | | | X | | | | | | | | | | |
| | '84 | | | | | | | | | | | | | | | | | | | | | | | | |
| | '85 | | | | | | | | | | | | | | | | | | | | | | | | |