

**AN INTEGRATED APPROACH TO ASPECTS OF COASTAL DUNE
PLANNING AND MANAGEMENT ALONG A PORTION OF THE
EASTERN CAPE COASTAL ZONE**

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ABSTRACT

Ecological evaluation techniques have been used to classify or evaluate the relative conservation worthiness of a portion of the Eastern Cape coastal zone from Cannon Rocks to Port Alfred. A system-based approach, using a basic GIS, was used to compare three aspects of the coastal zone. Two existing planning documents (EMATEK's Coastal Vegetation Importance Rating plan and CPA's Cape Coastal Conservation plan) were statistically compared - based primarily on the size and number of the landscape fragments (environmental criteria polygons). The resultant plan, an Intermediate Sensitivity Class map, was further integrated with the biophysical aspect of the coastal zone - coastal dunes. The final map is the product of these overlays to be used as a working overlay for coastal zone decision-making. This is an Environmental Sensitivity map, which has no particular direct reference to any particular biophysical criteria, which categorizes the coastal zone according to the environmental sensitivity or conservation worthiness of the site. The categories are listed according to a sliding-scale of sensitivity or worthiness. There is, however, a strong association between the final map and the vegetation status of the coastline, as a direct result of the vegetation rating map and indirectly from the perception based coastal conservation plan. The formation of most assessment or evaluation plans are based on the vegetation status of the area.

This map can be overlaid over the particular stretch of the coastline which it covers and the particular conservation status noted. There are numerous techniques available for assessment and evaluation each having their own specific merits and advantages. This plan, however, is a first attempt at integrating other specific plans into a single working document for the coastal zone manager.

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PREFACE.

The greatest threat to the natural environment today is the ever-increasing exploitation, utilization and encroachment of man's developments of land. Mankind is expanding at the expense of nature, natural processes and species. This land use results in environmental damage, loss and fragmentation of natural areas in all parts of the world and in all types of ecosystems. The coastal zone is no exception: in fact, in the search for self actualization the coastal zone is a sought after environment, above most others, for the ultimate of habitation and recreational needs.

The whole process of reduction, fragmentation and isolation (termed insularisation) promotes the steady process of gradual environmental degradation. This gradualism is noticed on both spatial and temporal scales, when comparisons between differing time sequences (for example, a sequential analysis of aerial photo's over time) are made. Environmental degradation is not normally noticed with continual environmental referencing, ie. existing in an environment on a day-to-day basis.

Highly fragmented and isolated areas become more vulnerable to disturbance, have less ecosystem resilience and very easily break down naturally. Ecologists are frequently asked by regional planners and developers to determine the critical point at which an ecosystem ceases to function naturally, when being impacted on by agriculture, developments, or other forms of land use. Two conflicting answers to this question is that, on the one hand, only a totally undisturbed (by man) ecosystem is natural and on the other hand what we are seeing around us is now natural and the so-called remaining patches of natural environment are isolated refuges of a past environment. The initial forms of development result in the system being unnatural, to its previous extent, and that the particular point to be determined is not whether a system changes from natural to unnatural but exceeds its critical threshold of survival and ceases to exist at all.

Accepting the need to maintain a balanced environment between a totally man-made modified environment and isolated "natural" patches from the past it is essential to determine the critical point or threshold as a basic necessity - developments can not carry on unabated within an *ad hoc* random framework without a sound planning strategy. Pro-active planning, integrating

disciplines into multidisciplinary teams which approach environmental planning from an holistic view point, is required. Only after we have determined what we have remaining, and what we intend to do with it and how we would like to see it in the future can we progress forward into an environment that future generations can be proud of.

CHAPTER SUMMARIES

CHAPTER 1

Chapter 1 highlights the relevant literature concerned with the study site, including the biophysical aspects and explains the structure of these planning documents. The major objective of this thesis is to determine coastal zone sensitivity in order to categorise the coastline according to a sliding-scale of conservation worthiness. Conservation worthiness which is based primarily on the status of the vegetation. The main aim, therefore, is to determine whether the combination and integration of two accepted planning documents - the Cape Coastal Conservation Plan and the Coastal Vegetation Importance Rating maps - can be effectively used as a single planning document. The physical component of the environment, the coastal dune system, is also used as part of the planning process. The aims and objectives are also presented in this chapter.

CHAPTER 2

Chapter 2 is based primarily on the methodology and *modus operandi* of this study. The original two planning documents were modified (for example, simply changing scale headings from colour codes to sensitivity categories) into a standardised format for inclusion into a GIS. Accepting that these planning documents are relevant to the physical aspect of the coastline, a third component - the Dune Types, were used as representing the physical component of the coastline. These three aspects were computer digitized and overlaid to form conservation worthy sensitivity maps for the purpose of providing empirical data for each conservation sensitivity category.

CHAPTER 3

The Cape Coastal Conservation Plan is a human perception account of the coastline according to its conservation relevance and worthiness. This plan is based primarily on the relative undegraded state of the coastline indicated by the naturalness of the vegetation. However,

doubt was expressed as to the relevance of the data due to there being perceptions from both non-Government organisations (NGO's) and Authorities alike. If there were significant differences two separate plans would therefore need to be compiled for digitising and overlaying with the biophysical maps. Chapter 3 successfully used multivariate analysis techniques to compare these two perceptions through a process of hierarchical classification (TWINSPAN) and ordination (DECORANA). The analysis showed no differences between the perceptions of the NGO's and the Authorities. All differences were those of individuals and no trends were indicated for one group or another. Therefore only one map needed to be produced as an overlay with the biophysical data.

CHAPTER 4

The overlay of the digitized maps provided empirical data concerning the size and number of the conservation worthy fragments. These fragments are map polygons, each with a specific environmental sensitivity class, indicating a specific level of conservation worthiness. A modified Cape Coastal Conservation Plan (having 4 classes) was overlaid with the modified Coastal Vegetation Importance Rating map (having 4 classes) to produce an Intermediate Sensitivity map with 7 classes. This intermediate map was further overlaid with a map indicating the Dune Types (having 10 different morphological types) to produce a final Environmental Sensitivity map with seventeen different classes. This final Sensitivity map can be used to indicate a sliding-scale of conservation worthiness within the study site portion of the coastal zone.

CHAPTER 5

Chapter 5 deals with the integration and discussion of the overlay and final maps. The final Environmental Sensitivity map has been shown indicate a sliding-scale of conservation worthiness of the study sites coastline, with the largest portions having a medium to high conservation value. The remainder smaller portions have on the one side of the scale very little conservation value - mainly the developed areas, and on the top end of the scale very high conservation values - the aeolianite headlands with halophytic plant communities, headland bypass dunes and bushpocket thicket.

The Cape Coastal Conservation Plan was shown to be unrealistic in its application, as over 80 percent of the coastline was indicated as having total conservation protection. The Coastal Vegetation Importance Rating map, although having coarse community data, indicated a realistic overview of the conservation worthiness of the site.

CHAPTER 1.

INTRODUCTION

1.1 INTRODUCTION

Many recent changes in all forms of environmental ethics, management procedures and policy decision making has taken place in South Africa. A new and dynamic environmental management thought-process is evolving, being long overdue for future environmental decision-making, based on majority aspirations and needs. It is for this reason that new and different environmental management systems are also evolving. There is little time for the commencement of research into widespread new management techniques, and as such, existing techniques need to be modified, adapted and consolidated into one general management package. Combined with this is a change in thought process, from one of reactive crisis problem solving (attempting to resolve a situation which has already happened, or is happening) to one of pro-active solution generation (predicting and highlighting potential areas of development/environmental conflict). Integrated Environmental Management (IEM) procedures (Council for the Environment, 1989), and specifically Environmental Impact Assessments (EIA's), are inherently reactive to development and are thus generally problem solving techniques and which incur high costs - such as time and money.

There are many situations, such as Marina Martinique (Cape St Francis - Eastern Cape) and the Dunes Timeshare (Wilderness - Southern Cape) developments, which have become situations of developers aspirations which have failed. Development has been approved and permission granted by the authorities because there have been no restricting regulations concerning controlled development. Construction begins but soon after ceases altogether or becomes uneconomical to carry on. In such cases the environment has had to undergo marked changes and alterations from, usually, a conservation worthy environment to one that is conservation-undesirable. Many of these developments now stand empty and incomplete with little prospect of completion in the present economic climate.

It is because of this reason that an overall comprehensive site specific working Guide Plan is essential. Various organisations, such as The Division of Earth, Marine and Atmospheric Science and Technology (EMATEK), CSIR, have begun compiling conservation sensitivity maps for the coasts (EMATEK, 1989), but this mapping exercise has only used vegetation criteria. The dune systems of the cape coast have been classified by Tinley (1985) and Daines (1991) but no conservation status has been attached to these dune systems.

The IEM procedure, as proposed by the Council For The Environment (1989) and Department of Environmental Affairs (1992), is attempting to address the situation of uncontrolled coastal development and optimal environmental decision-making. Application and implementation of these procedures have in the past not followed the necessary procedures and thought process and therefore have not been totally successful. Either way the IEM procedure is a reactive process to development and not pro-active in its application - which is required.

The potential threat of sea level rise can result in the loss of beaches, recreational features and private property which in turn decreases the environmental and recreational value of the coast. Pro-active coastal zone planning and management, without economics and politics being the driving forces, is the only solution. Understandably the utilitarian approach to the coastline is based on economics and specifically the actual inherent value that can be obtained for personal gain.

Although National Parks, proclaimed Nature Conservation areas, Natural Heritage Sites and Private Nature Reserves are only one aspect in the protection of areas, they have been the flagship for the promotion of protected areas. As such the protection of other areas has not normally been a priority and it is only quite recently that the biospheric and biodiversity concepts are being taken seriously. Other categories of the conservation aspects of land use are being sought and managers therefore have to now take into account management strategies that cater for all levels and forms of conservation.

Coastal Zone Managers make decisions and solve problems by integrating various types of quantitative and qualitative information at hand. As such most coastal problems do not have exact solutions, and final actions taken are often judgmental based on fragmented information. Holistic pro-active coastal zone management requires detailed information of the entire area under management. At this stage of our knowledge and understanding of coastal and ecological processes the collation and synthesis of information and data is all that is required for managers and authorities to make decisions.

One possible solution to the pro-active thought process of holistic environmental planning, at a regional scale, is an overlay system using a Geographical Information System (GIS). Existing land use capability classes, coastal vegetation and sediment sensitivity maps and

geomorphological data can be determined for environmental condition assessments and GIS, whereby land use maps for specific land units can be produced.

The approach taken in this study is a systems-based approach, as compared to indicator-species assessments, where coastal vegetation, human perceptions and coastal dune systems are used as the basis for a decision-making process.

These land-use maps could be incorporated into Sub-Regional and Local Structure Plans and Local Guide Plans, as an aid for proposed development decision-making by authorities and consultants.

1.2 THE STUDY AREA

The study site from Cannon Rocks to Port Alfred lies between Port Elizabeth, in the south, and East London, in the north, along the Eastern Cape coast of the Eastern Region of South Africa. The study site, consisting of approximately 42.8 km of coastline, is predominantly sandy beaches interspersed with rocky promontories, five estuaries and five established coastal towns (Figure 1.1). The relative proportions of the main coastal features occurring along the study site is represented in Table 1.1.

Table 1.1. The approximate length of coastline, and relative percentage, of the main coastal features occurring in the study site from Cannon Rocks to Port Alfred.

COASTAL FEATURES	Approximate Length of coastline (km)	% of total length
Rocky shores	12.1	28.3
Sandy beaches and dunes	22.3	52.1
Development	8.4	19.9

1.2.1 Climate

The climate is variable and mild in both winter and summer with wind reducing the temperature and humidity in summer (Kopke, 1988), but peaking in summer. The temperature regime is between 10 to 22,2°C for most months (Schulze, 1980) resulting in a subtropical to temperate climatic regime. The modified Koppen system reports all months having at least 60 mm of rain (Daines, 1991). According to Schultz and McGee (1978) the study area falls within the Cfb climatic zone according to Koppen's classification.

Extremes in weather conditions are caused by the occurrence of low pressure systems together with their associated cold fronts. These move in a north-easterly direction along the coast and are more frequent in the winter months and result in warm "berg winds" followed by a drop in temperature, strong winds and rain (Kopke, 1988).

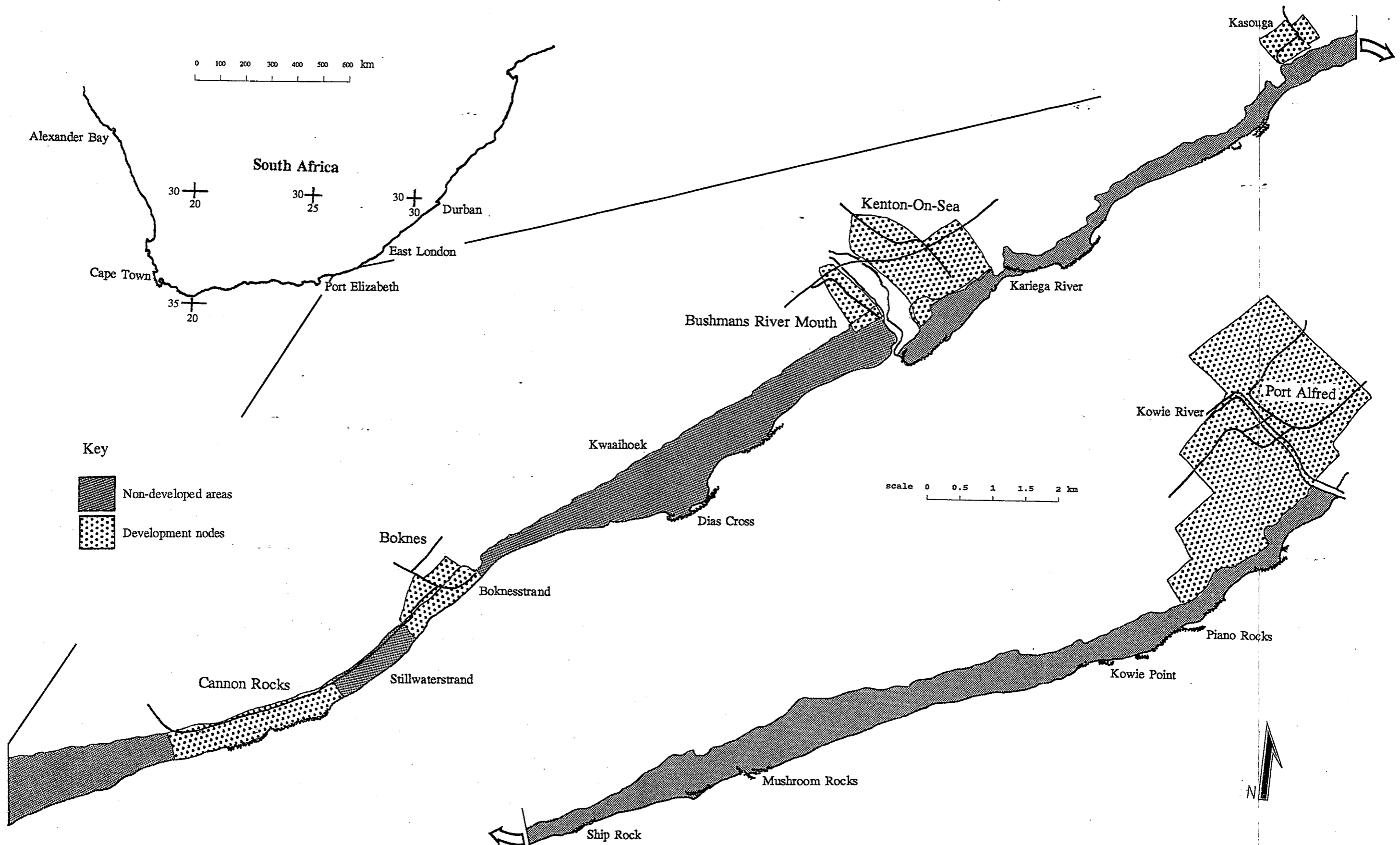


Figure 1.1 The study site in relation to the Eastern Region's coastline from Cannon Rocks to Port Alfred.

Rainfall

Rainfall distribution within the study area is generally bimodal with spring and autumn peaks (Cowling, 1983) and a rain maximum during equinox periods with dry periods in mid-summer and mid-winter (Kopke, 1988). The Eastern Cape coast does not experience a typical dry season (Schultz and McGee, 1978).

Rainfall varies between 500 and 700 mm per annum with maximum falls occurring during the equinox periods and with spring (September) the wettest period which falls in the transition zone between all-year rainfall and summer rainfall, but there is no definite summer rainfall season. The rainfall is mainly cyclonic or orographic with occasional heavy showers (Schulze, 1980; Daines, 1991).

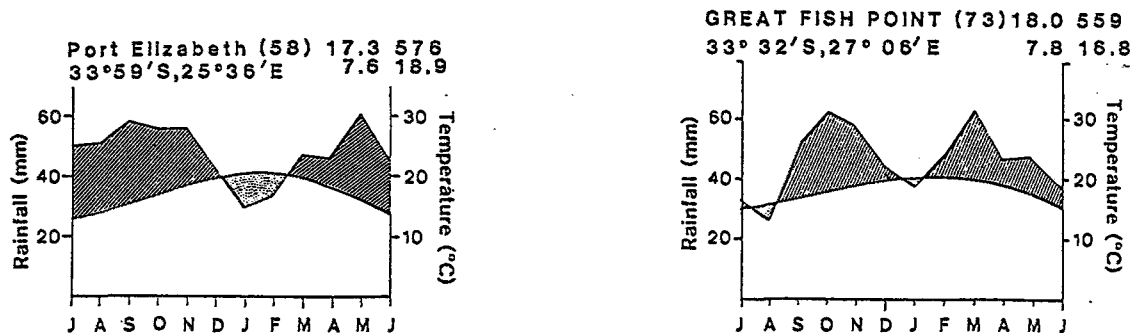


Figure 1.2 Walter-Leith diagrams for Port Elizabeth and East London (from Avis, 1992).

Heavy rainfalls (3-day-rains) are either caused by outbreaks of polar air, cut-off lows or by a high pressure system to the south which feeds in moist cool air (Daines, 1991). This rain normally occurs on an annual basis during the last week of August and the first week of March (Schultz and McGee, 1978; Kopke, 1988):

Wind

The Eastern Cape coast is considered to be one of the windiest zones of the South African coastline (Figure 1.3) and as such calm weather occurs infrequently (Kopke, 1988). Along the south east coast, summer winds predominate from the east-north-east (Heydorn and Tinley, 1980) as a result from the interaction with two subtropical high pressure anticyclones which fluctuate over the South Atlantic and South Indian Oceans (Tinley, 1985). Daines (1991), however, has recorded the dominant winds from the Cannon Rocks area to Port Alfred to be west-south-westerly winds.

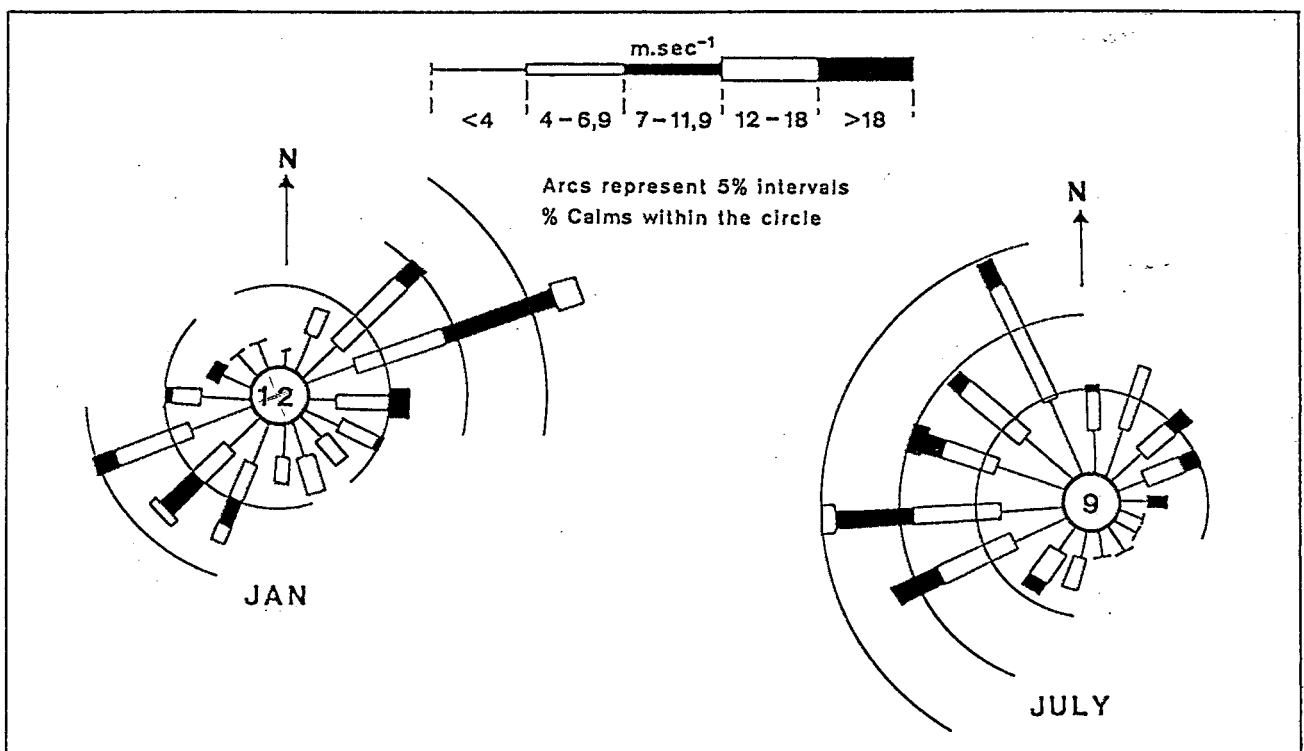


Figure 1.3 Wind rose diagrams for the Great Fish Point Lighthouse showing the wind regime for this area (from Avis, 1992).

1.2.2 Geology and Geomorphology

The geology of this portion of the Eastern Cape is described by Marker (1988) and Wallace (1990). The outline of this portion of the coastline was formed during tectonic activity in the Jurassic era as a result of faulting, uplifting and the intrusion of dolerite dykes and sills. Sandy coastal limestones were deposited as overlying deposits during an erosive Jurassic period.

Quartzite headlands, which are vertically orientated, occur west of Kasouga River and at Kowie Point. Limited intrusions of Dwyka tillite, of the Karoo Supergroup, occur in the Cape Padrone area. Similarly with limestones in the Alexandria formation (Marker, 1988; Wallace, 1990).

Surface sands, within the vegetated portion of the coastal zone, consist predominantly of regic sands overlain with a well formed humic layer and, within some mature stands of dune thicket, an A-horizon. Aeolianite, or dune rock, consisting of semi-consolidated marine derived sediments are calcareous sandstones and surface limestones. This dune material has been consolidated by the crystallization of calcite from shells and organic matter (Wallace, 1990). Examples of these rocky promontories occurring in the study site are Kwaihoek, Kenton rocks, ship rock and Glendower rock. The remainder of the coastline consists of unconsolidated wind blown marine derived sediments, as beach deposits, with differing morphological characteristics.

1.2.3 Coastal Sand Dunes

Although there have been other attempts at classifying coastal dunes (Mabbutt, 1977, McKee, 1979 and Davies, 1980; as cited by Tinley, 1985), coastal sand dunes can initially be classified into **active** and **non-active** dunes with a further sub-division of active coastal dunes into **retentive** and **transgressive** dune systems (Rust and Illenberger, 1994), where retentive dunes retain sand and grow temporally and transgressive dunes are highly mobile spatially. The differences and methodology of classification are explained in Chapter 2.

The dunes of the study area are mainly transversely orientated with respect to the wind direction (Lubke, 1988) and may either be transverse or crescentic (barchanoid), (Daines, 1991). The dominant wind direction being either from the west or from the east, at different periods or seasons of the year, usually results in these dune types reversing in orientation (Lubke, 1988).

Small littoral foredunes (or embryo dunes) are formed by sand deposition on the shore and within the dune system, lateral or transverse dunes move at right angles to the shore due to the predominant westerly or easterly winds. Parabolic blowouts extend into the vegetation, in the direction of the prevailing winds (Lubke, 1987; Daines, 1991).

Vegetated dunes found along the Eastern Cape coastline include hummock dunes, embryo dunes, parabolic or hairpin parabolic dunes (Lubke, 1987). These are partly stabilized by vegetation and advance into the coastal vegetation indicating the direction of the prevailing winds (Tinley, 1985; Lubke, 1988; Daines, 1991). Associated with these dune types are blowouts which may be formed as a result of a mechanical disturbance e.g. trampling, fire or changes in topography in parabolic dunes (Lubke, 1988) or a major increase in wind velocity (Tinley, 1985).

Headland bypass dunes occur across rocky headlands and rocky promontories (Tinley, 1985; Lubke, 1988) and are aligned in the direction of the dominant winds (Marker, 1988; Daines, 1991). These dune systems, for the most part, are heavily infested and vegetated with exotic alien vegetation, thus, negating the natural functioning of these systems.

Dune Sensitivity

At the time of this study, a few authors (Hesp, 1981; Heydom and Tinley, 1980; Tinley, 1985) suggested the possibility of dune sensitivity, but none classified dune morphology according to any form of sensitivity gradient. Rust and Illenberger (1994), however, have attempted to classify dunes according to sensitivity based on resilience to impacts. This classification has, at a first level of hierarchy, split dunes into Active and Non-active, and transgressive and retentive dunes.

Dune sensitivity is the extent to which a dune is readily affected by an external action or force and the degree to which it responds to this external action. Dune sensitivity, with regards to its conservation worthiness, is the deleterious response of a dune to an impact or action and the resilience of a dune to change. An impact can cause a change in a dunes morphological character (Rust and Illenberger, 1994). Impacts and actions, both natural and unnatural, vary greatly in magnitude and effect from minor localised microscale impacts (footpaths) to major regional macroscale impacts (dune mining).

Most sensitive dunes are those which have large changes to their morphological character with a relatively small impact or action (have little resilience to change), maintain their changed form indefinitely and which do not have the potential for rehabilitation. Retentive dunes tend to exhibit a high degree of sensitivity (Rust and Illenberger, 1994).

Least sensitive dunes are those which have small changes to their morphological character as a result of relatively large impacts or actions (having a large resilience to change), can quickly revert back to their original form (do not maintain their form indefinitely) and which do have the potential for rehabilitation. Rust and Illenberger (1994) have suggested that dunes reacting to changes lasting from hours and months to the most a season or two are resilient dunes. Transgressive dunes tend to be more resilient and therefore less sensitive.

These are the two extremes with a host of variations between the two scales. Sensitive dunes with a low resilience to change can be rehabilitated as a result of a very small impact. Similarly, non-sensitive dunes with high resilience can be adversely affected by a major impact resulting in irreparable damage with no prospect of rehabilitation (as in the case of large-scale residential developments). Rust and Illenberger (1994) suggest that sensitive or fragile dunes are those which retain the effects for years, decades and centuries.

As a result of this dune sensitivity cannot be viewed on its own as a justification for development. Other factors such as vegetation sensitivity are of vital importance for management decision-making. Other complicating factors are the major or significant impacts on individual dunes within a "dune field system" as compared to minor or insignificant impacts on limited or restricted "dune complexes" (individual dunes which occur as isolated "patches or units" which do not occur in dune fields). Variations between significance of

impacts, magnitude and rate of events and dune response or resilience are countless and directly relevant to the level of dune classification or splitting of dune characteristics.

Human Impact on Dunes

Human impact on dunes include (low level impacts), footpaths, roads, recreational development, residential development, agricultural practices and industrial development (high levels of impacts), (Tinley, 1985).

Management (development) decisions in the coastal dune zone are made on a particular set of information - at that particular time. The non-static nature of a dune field within a set of cadastral boundaries is not normally taken into account, only the limits of the cadastral boundaries and the nature of the environment - from an engineering and architectural perspective. Human limitations in the perception of natural time tend to confer permanency on the present dune state (Rust and Illenberger, 1994). Natural changes slowly alter the morphological character which is seldom perceived and difficult to manage.

1.2.4 Coastal Dune Vegetation

Coastal vegetation is important in the initiation, development, formation and sustainability of sand dunes by creating rough surfaces which traps sand (Hesp, 1981; Lubke, 1983; Pethic, 1984; Lubke, 1987; Lubke and Avis, 1986; Lubke and Avis, 1987; Lubke, 1988) which initiates, and later regulates, dune growth. Pioneer dune plants are physiologically adapted to mobile sand conditions and have a marked effect on dune formation by stabilizing the sand and reducing wind velocity and sand movement (Pethic, 1984; Lubke, 1985). This vegetation is therefore an important factor in dune stabilization and beach protection.

Rainfall is the most important variable in the demarcation of vegetation regions within the coastal zone (Lubke, 1991). From the south-west to the Bushmans River the rainfall occurs predominantly in the winter months, where more easterly the rainfall pattern changes to a bimodal distribution with rainfall peaks in both spring and autumn. Associated with the rainfall patterns is the form and dynamics of vegetated coastal dunes being controlled, mainly by three factors - the coincident occurrence of effective dune-building winds with availability

of moist sand conditions, the various strategies of plant stabilizers and the occurrence of high water-table conditions (Tinley, 1985; Daines, 1991).

Plant communities form a discontinuous or patchy zonation parallel to the shoreline (Tinley, 1985; Lubke and Avis, 1987). Four of these communities - the strand plant (pioneer) community (Zone 1); the shrub community (Zone II); the shrub thicket community (Zone III) and the thicket/forest community (Zone IV) - were found to form a seral suite of four zones parallel to the shore (Daines, 1991).

The Dune Pioneer Community

This community is situated nearest the sea and is composed of low creeping, stoloniferous, rhizomatous, ephemeral plants which are colonizers of bare shifting sand on the backbeach and on berms at the highest reach of wave swash. These plants are highly adapted to the harsh conditions of the foredune environment (Daines, 1991), e.g. high aerial and sediment salinity, rapid drainage, high day temperature extremes (Tinley, 1985), unstable substrate and high insolation (Ward, 1980). These are dune building plants, growing ahead of accumulating sand (Lubke, Tinley and Cowling, 1988). Indicator species include *Arctotheca populifolia*, *Scaevola plumieri*, *Agropyron distichum* and *Ehrharta villosa*.

These communities tend to be monospecific (Daines, 1991) but generally having low diversity and species richness. However, as these dunes develop additional species occur resulting in the community developing into the following dune community thus forming a mixed herbaceous community.

This dune pioneer community has been referred as littoral strand vegetation, pioneer plants, pioneer zone, sand dune vegetation, dune margin scrub and dune pioneer communities (Burns and Lubke, 1986; Lubke, 1987; Lubke and Avis, 1987; Lubke, Tinley and Cowling, 1988; Daines, 1991; McGwynne and McLachlan, 1992).

The Scrub Community

This community is found between the pioneer plant community and the dune scrub-thicket is composed of short open plant cover with a herb and climber understorey. Remnants of pioneer plants persist until out-competed by dune scrub. The main indicator species for the study area are *Chrysanthemoides monilifera*, *Olea exasperata*, *Maytenus proëumbens* and *Passerina rigida* (Tinley, 1985; Burns and Lubke, 1986; Lubke, 1988; Lubke, Tinley and Cowling, 1988).

This community is also referred to as the dune pioneer zone, dune heath, dune fynbos, littoral strand vegetation, pioneer communities, dune margin scrub and sand dune vegetation (Burns and Lubke, 1986; Lubke and van Wijk, 1988; Lubke and Avis, 1987; Lubke, Tinley and Cowling, 1988; EMATEK, 1989; McGwynne and McLachlan, 1992).

The Dune Scrub-Thicket Community

Dense, unistratal, multiple stemmed dwarf trees and shrubs with a compact canopy (Daines, 1991) is the life form of this community. The understorey is mostly devoid of plants (Tinley, 1985) although some geophytes and grass types do persist. Where steep foredunes rise immediately above the backshore, the canopy is hedged by salt-spray pruning (Tinley, 1985). This community is the regional climax cover on these frontal dune systems (Daines, 1991) and include shrub component species such as *Diospyros*, *Euclea*, *Mimusops*, *Sideroxylon*, *Rhus*, *Eugenia*, *Cassine*, *Scutia*, *Dovyalis*, *Lycium*, *Olea*, *Maytenus* and *Putterlickia* (Tinley, 1985; Burns and Lubke, 1986; Lubke, 1987; Lubke and Avis, 1987; Lubke, 1988; Daines, 1991).

Another characteristic of this community is the creepers and climbers which are particularly common where openings occur. Some of these species include *Asparagus*, *Cassytha*, *Cissampelos*, *Commelina*, *Cynanchum*, *Rhoicissus*, *Secamone*, *Senecio*, and *Smilax* (Tinley, 1985, as cited by Daines, 1991).

The dune scrub-thicket community has since been referred to as open dune scrub, open dune thicket, dune scrub, coastal thicket, dune thicket, dune scrub/thicket, scrub, coastal scrub and littoral scrub or coastal scrub (Cowling, 1983; Lubke, 1985; Tinley, 1985; Burns and Lubke,

1986; La Cock, 1986; Lubke, 1987; Lubke and Avis, 1987; Lubke and van Wijk, 1988; Lubke, Tinley and Cowling, 1988; EMATEK, 1989; McGwynne and McLachlan, 1992).

The Scrub-Forest Community

This community represents the most mature of coastal dune communities (Tinley, 1985) which are generally found on base-saturated, sometimes clayey, older, oxidized soils having a greater fresh water balance than the previously discussed dune systems (Tinley, 1985; Daines, 1991).

Indicator species include intrusions from Tongoland-Pondoland which are of subtropical origin as well as species from Afromontain, Cape and Karoo floras (Lubke and van Wijk, 1988) and are represented by *Sideroxylon inerme*, *Euclea spp.*, *Capparis sp.*, *Carissa bispinosa*, *Rhoicissus spp.*, *Pterocelastrus tricuspidatus* and *Olea spp.* This community has been referred to as littoral thicket, coastal forest, thicket-forest community, scrub forest and dune forest (Burns and Lubke, 1986; Lubke, 1987; Lubke and Van Wijk, 1988; EMATEK, 1989; Daines, 1991; McGwynne and McLachlan, 1992).

Within the coastal dune system a number of vegetated sub-environments occur which exhibit transitional developmental stages between the above communities e.g. dune slacks and bush pockets (Lubke, 1987; Daines, 1991; McGwynne and McLachlan, 1992).

Dune Fynbos

Dune fynbos occurs as localised communities within the study area and is the climax vegetation on calcareous dune sands (Lubke and van Wijk, 1988). Dune fynbos is often associated with variations of dune thicket and forest within blowout areas and rear dunes. The thicket elements include components of subtropical thicket (Cowling and Pierce, 1985; Lubke and van Wijk, 1988).

This community is only referred to as dune fynbos (Tinley, 1985; Lubke, 1987; EMATEK, 1989; Daines, 1991; McGwynne and McLachlan, 1992) and includes species such as *Olea exasperate*, *Rapanea gilliana*, *Restio eliocharis*, *Phylica litoralis* and a number of herbs.

Rocky halophytic communities

Rocky outcrops, within the study area, occur at Kwaihoek (Dias Cross), Kenton on Sea, Ship rock (Kasouga) and Mushroom rocks. On these rocky promontories halophytic communities dominate consisting of coastal grasses, predominantly *Stenotaphrum secundatum* and *Sporobolus virginicus*, and herbaceous plant communities consisting of *Chenolea diffusa*, *Limonium scabrum*, *Plantago carnosus* and *Disphyma crassifolia* (EMATEK, 1989; Lubke, 1991).

Halophytic communities occurring on the Kwaihoek promontory consists of a rocky ledge community, grassy cliff community and a herbaceous community.

Coastal Grasslands

Coastal grasslands are common on exposed ancient dunes which form a mosaic with bushclumps and dune thicket (Lubke and van Wijk, 1988). Little work has been carried out on these grasslands, except that which has been done in conjunction with associated vegetation studies (Tinley, 1985; Lubke and van Wijk, 1988; EMATEK, 1989).

These are complex communities of grasses and herbs including, grass species such as *Themeda triandra*, *Stenotaphrum secundatum*, *Sporobolus virginicus*, *Tristachya leucothrix*, *Aristida junciformis*, *Eragrostis spp.* and *Cymbopogon validus*. Herb species incorporate many legumes and composites above the coastal rocks, in damp vleis and along small streams (Lubke and van Wijk, 1988).

Human impact on dune vegetation

Coastal dune vegetation is adapted to severe physical stresses of mobile sand inundation, high wind velocities, salt spray and desiccation. This vegetation cannot, however, withstand continuous human pedestrian trampling and vehicular pressure (Vogt, 1979; Avis, 1986). The degradation of the vegetation cover is directly related to the type and the intensity of the traffic, with the least disturbed areas being the most productive, having the highest successional stages of vegetation for different zones and supporting the most diverse plant communities (Daines, 1991). These plant communities are therefore the most stable and most capable of withstanding the rigorous environmental conditions of the area, while still providing dune protection (Tinley, 1985; Lubke and Avis, 1986; Lubke, 1987; Daines, 1991).

Trampling studies indicate a curvi-linear relationship existing between the amount of trampling and the amount of vegetation loss (Daines, 1991). Trampling results in a reduced species diversity (Vogt, 1979). The destruction of dune vegetation also causes great changes. The removal of vegetation allows wind erosion to become a strong degrading force which may result in the formation of blowouts (Avis, 1986). Clearing areas for buildings and road construction can also cause blowouts and initiate dune slumping (Heydorn and Tinley, 1980; Tinley, 1985; Council for the Environment, 1989).

Close spacing of houses can channelise wind, increasing its velocity and reducing the likelihood of vegetation survival. Therefore, the manner in which buildings are constructed and the way the property is managed causes changes in the dunes (Nordström and McCluskey, 1984).

Structures built within coastal dune systems, e.g. car parks and recreational facilities, can modify the sand supply to the dune system resulting in a changed dune profile (Daines, 1991). The construction of roads and parking lots within the coastal dune area and the stabilization of driftsands are some such objects which have met with disaster, e.g. erosion at Port Elizabeth and St Francis bay beaches, and wind blown sand on beach roads (Lubke, 1985; Sudgen, 1985). These problems indicate the lack of appreciation of the time scales involved in dunefield processes (Brown and McLachlan, 1990, as cited by Daines, 1991).

Alien Vegetation

There are varying degrees of *Acacia cyclops* infestation within the woody component of dune thickets which constitutes a threat to the native flora. This vegetation successfully invades and replaces sensitive dune vegetation in areas which have been disturbed. Alien *Acacia* species have been used deliberately as a means of dune stabilisation and a sediment trap. An area where this act has been carried out is west of the Bushmans River mouth in an attempt to prevent sediments from being blown into the estuary. The artificial stabilisation of coastal dunes with exotic alien vegetation should not be permitted without a prior study of patterns of sediment movement in the areas concerned (Heydorn and Tinley, 1980; Avis, 1989).

1.3 LAND USE AND OWNERSHIP

It is the land use and land ownership which determines the ultimate development state of the coastline and more often than not economics, politics (Spellenberg, 1992) and crisis management dictates what areas are selected, and when, as well as the ultimate form and functioning of the coastal zone. Development, economic and political perceptions determines the management and development strategies for state owned property and function as the *ad hoc* decision-makers for development by the private land owner - private land owners perceive and propose the development for decision-making (Theunessen, 1992).

The ownership of the land within the study site is dominated by state owned land consisting of forestry, nature conservation and state owned areas such as regional, municipal and local authority areas as well as privately owned property (Theunessen, 1992).

1.4 DEVELOPMENT AND CONSERVATION PERSPECTIVES

There are at present many coastal zone management (CZM) initiatives attempting to improve management strategies and awareness amongst the public and authorities. Despite these initiatives poorly planned developments and inappropriate developments are still occurring (Sowman, 1991). Besides socio-economic factors affecting coastal degradation extensive inadequacies within the planning, legal and administrative framework governing resource

allocation decisions in the coastal zone occur. "A major issue in small coastal towns is the conflict between economic growth and environmental conservation" (Sowman, 1991). This, however, is not limited to small towns only, this conflict occurs in all coastal towns - whether tourist orientated or otherwise. Conservation and specifically ecological carrying-capacities are undetermined and a subsequent threshold limit of the rate of development is unknown. The situation is such that a potential situation arises where "the head of the goose that lays the golden egg is chopped off". The controversial marina development proposed for the Plettenberg Bay area (Jackson, 1989) is such a case in point, where great concern is viewed over the continual proposed rate of development. Plettenberg Bay has many environmental features and ecological processes which attracted tourism and development in the first place and it is these features and processes which are now under threat of over-exploitation.

Developments can have positive aspects to the conservation of areas along the coastal zone. Conditions of development approval can contain rehabilitation requirements, an account taken of any natural environment on the development site and prerequisites as to the style and density of the development set.

The management of land can be viewed both from an environmental and from an institutional perspective (Dale and McLaughlan, 1989), where the environment is seen mainly from a biological and physical perspective and institutionally from an authoritative or developmental perspective. The institutional aspect is concerned with social actions which influences, controls and steers people's use of the land (Dale and McLaughlan, 1989).

"If we plan remedial action with our eyes on political rather than ecological reality, then, very reasonably, very practically and very surely we will muddle our way to extinction", (paragraph 162 of the Blueprint for Survival, In: O'Riordan and Turner, 1983)).

Ecological issues are usually placed to one side when development is the priority. Liberal capitalism and classical economics (Burger, 1983) are generally seen as a problem and obstruction to social and economic progress. Shortages of prime land for development have resulted in the remaining sites, which in the past were seen as not being ideal for development, are now sought after. The present sought after coastal sites are now those sites which have biophysically sensitive features such as mobile sands, steep slopes and heavy vegetation coverage - all these features having high environmental sensitivities and are of

conservation worthiness.

1.4.1 The Ecosystem Approach

There is an increased pressure of uses on ecosystems in general and the coastal zone is no exception. In particular the coastal dunes are being increasingly sought for "hard" development, in the form of holiday accommodation. Therefore for the compilation of an integrated management plan for these areas, priorities encompassing proposed developments and their siting in relation to the ability of the ecosystem to adjust to new conditions, should be established. The ecosystem approach attempts to ensure that the survival of determinants and processes which maintain ecosystem structure and function are retained (Siegfried, undated).

Decisions concerning the planning of coastal areas need to take the ecosystem concept into account to ensure successful realization of the development objective. The emphasis will be from an ecologist-conservationist approach whereby the biophysical aspects are the priority factors in determining optimum development possibilities.

1.5 COASTAL ZONE MANAGEMENT PERSPECTIVES

Coastal zone management is largely perceived through a sectorial approach to the management of coastal resources. Growing environmental degradation and resource use conflicts in the coastal zone, the pursuit of sustainable coastal development and narrowly focused conservation and protection strategies dictate the need for a more integrated and well coordinated approach (Hildebrand and Norrena, 1992).

An aspect of CZM is still being seen in the light of active dune stabilization programmes at a national level. Localised events of crisis management occurred on an *ad hoc* basis where the areas of disturbance actually arose.

CZM today is seen according to both spatial and temporal scales where quantitative methods that link spatial patterns and ecological processes of the dune environment at broad spatial

and temporal scales. Ecological processes such as plant succession, biodiversity and the spread of disturbance have important spacial components (Turner and Gardner, 1991). Recent developments in landscape ecology (coastal dune ecology) have reemphasised the important relationships between spacial patterns and many ecological processes (Turner, 1989. In: Turner and Gardner, 1991). Land-use patterns and spatial dynamics can be analyzed with the use of quantitative methods to determine reliable landscape models (Turner and Gardner, 1991). Quantitative models determining landscapes can be determined with the aid of a GIS.

The nature of landscape problems has created new demands in understanding the effects of spacial heterogeneity and to make broad-scale predictions by extrapolating from fine-scale measurements (Turner and Gardner, 1991). However, CZM as it is practiced today makes small-scale predictions by extrapolating from broad-scale measurements (Heydorn, 1986; EMATEK, 1989; Council for the Environment, 1989; Daines, 1991). Coastal Zone managers must be able to predict responses that may not be manifested in the time frame of typical experimental studies (Turner and Gardner, 1991) and therefore management or development decisions must be made with existing information that is in a format to be readily used.

A critical threshold of the dune environment is the point at which there is an abrupt change in quality (Turner and Gardner, 1991) and potential conservation status of the environment. The ecological carrying-capacity has normally been exceeded at this stage by a site specific development disturbance. This critical ecological threshold of the dune carrying-capacity is normally undetermined and unpredictable.

Planning procedures must take into consideration the effects of projects and changes in land use on human health and welfare (Spellerberg, 1992). Coupled with this is the essential welfare of the environment and "sense-of-place" which is also of vital importance to the well-being of humans.

1.6 COASTAL ZONE MANAGEMENT IN SOUTH AFRICA

The management of the coastal zone in South Africa, and particularly in the Eastern Cape Province, occurs at different scales, both the temporal and spatial scales. National plans and strategies have been designed and set up at first tier level of Government, by the Department

of Environment Affairs (1992), The Integrated Environmental Management Procedure. Guideline Documents 1 - 6 and Council for the Environment (1989), A policy for Coastal Zone Management in the Republic of South Africa, Principles and Objectives, Guidelines for Coastal Land-Use, Integrated Environmental Management in South Africa.

At a Provincial Authority level and Provincial spatial scale, ie. second tier Governmental level, policy documents (CPA, 1992, Cape Coastal Conservation Plan) were designed specifically for the coastal zone. At a Provincial Authority level but at regional spatial scales Structure and Guide Plans (CPA, Sub-Regional Structure Plans and Sub-Regional Guide Plans) were drawn up for coastal requirements at a regional level. Coastal Zone Management planning is carried out by Cape Nature Conservation, Ecological Investigations Unit.

Third tier Government, Local Authorities (Regional Services Councils, Municipalities and other area specific Local Authorities), have in-house amendments and local by-laws pertaining to specific coastal management issues. In almost all cases the above three Government levels have legislated regulations and management proposals as part of crisis management based on ad hoc decision making.

Other organisations which have contributed towards the availability of information regarding CZM are University and Non Government Organisations and Institutions. Some of these include procedures for assessing recreational carrying capacity of coastal resort areas (Sowman, 1987), coastal action strategies for Southern Africa (Retief, et al., 1991), coastal dune dynamics and human impacts (McLachlan, et al., 1990), site specific beach area studies (Avis, 1986a; Avis, 1986b; La Cock, 1986; Lubke and Avis, 1987; Lubke and La Cock, 1988; Masson and McLachlan, 1990), principles, guidelines and objectives for coastal zone management in South Africa (Heydorn, 1986; Avis, 1986; Lubke and Avis, 1986; Swart and Geldenhuys, 1987; EMATEK, 1989), estuaries (Heydorn and Tinley, 1980; CSIR reports) and recreational planning (Möller and Theunissen, 1988; Brink, 1988; Sowman, 1991).

1.7 LAND-USE CATEGORIZATION AND EVALUATION - A COASTAL ZONE MANAGEMENT TECHNIQUE.

Almost all landscapes are affected by natural or anthropogenic disturbances (Turner and Dale, 1991), or both, specifically the sensitive coastal sand dunes. The spacial distribution of disturbance on dunes is an important ecological process that determines the landscape pattern. A disturbance disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment (White and Pickett 1985, In: Turner and Dale, 1991). Dune vegetation and morphology effect the rate and magnitude of the disturbance, thereby establishing a gradient of disturbance frequency. These disturbances normally spread from a nodal center forming landscape heterogeneity (Turner and Dale, 1991) or a mosaic of land-use categories.

Evaluating and ranking natural areas in a standardised fashion is as essential as standardised survey procedures and computer synthesis of survey data. Conservation organisation typically require a list of the most significant areas (Gehlbach, 1975). Normally these significant areas are those which have high conservation value and have been identified for expropriation and designated formal conservation status.

Land evaluation and assessment is a process whereby the potential use or suitability of the land for various purposes or alternative uses are assessed on the basis of certain criteria (Spellerberg, 1992). Evaluations are critical for planning the best use of the land, for evaluating the optimum management options and for providing the framework for authority decision-making. The basis of evaluations is for the need to identify conservation needs and to prioritise those needs for optimum conservation of an area. The intrinsic value (or the inherent conservation value of the coastal zone or community can be described and calculated with the use of ecological (Spellenberg, 1992) or biophysical criteria. System-based approaches and indicator-species assessments both classify and evaluate resources (Wathern, et. al. 1986). This study evaluates then prioritises the coastal zone, using the system-based approach, on the basis of biophysical features. Ecological evaluation in planning is based primarily on, and makes use of, land use mapping. It is the first approximation of any site which is a basic, simple and quick technique to determine what is to actually be managed. Attached to this is the use of the environmental impact assessment process which has provided new, quick and cost-effective ways of evaluating areas. The different ecological

categories and their associated categories should be identified and demarcated (Theunissen and Heinecken, 1989) in the form of sensitivity maps.

According to Spellenberg (1992) there are four scales of measurement which are used in evaluations: Nominal (qualitative), ordinal (low, medium and high categories), interval (numeric distance between category) and ratio (the assignment of scores or score classes). Nominal and a form of ordinal scale of measurement have been used in this study.

Land use classification in the form of overlays have been accepted widely as a universal technique for the analysis and planning of areas (Spellenberg, 1992). Inventory maps and environmental atlases provide an easy to use and understood format for the manager to obtain information at a first glance.

1.8 THE USE OF A GEOGRAPHICAL INFORMATION SYSTEM (GIS) - INDICATING LAND-USE CATEGORIZATIONS

GIS have combined the efforts of many separate but closely related fields, such as geography, botany and sociology, by linking spacial data associated with these fields into a general purpose geographical information system, in order to conceptualise and overcome specific environmental problems (Burrough, 1986) and, specifically, natural resource management (Coulson et al., 1991). Resource management of the coastal zone concerns the deliberate planned modification of the landscape components, function and the rate of change in the function of the ecological mosaic over time (Coulson, et al., 1991). GIS is a powerful tool for collecting, storing, transforming, retrieving and displaying spatial data from the real world for a particular set of purposes, where possible scenarios are examined and consequences of actions obtained. In addition to representing landscape features, using spatial data, a GIS can predict the consequences of a development action, evaluate the results of these actions and compare alternative actions (Coulson, et al., 1991).

With increased expertise and a larger knowledge base available for CZM improved and refined computer aided technology for problem solving and decision making, has been necessitated. The tasks performed by the GIS increase in complexity from file management systems, data base management systems, management information systems to knowledge-

based systems (Coulson, et al., 1991). Therefore the basic elements of a GIS incorporate a data input subsystem to collect and process spatial and descriptive data from maps, aerial photographs and other sources; a database management subsystem to store and retrieve data; an analysis subsystem to interpret the data; and a reporting subsystem to display maps and reports as hard copies (Coulson, et al., 1991).

1.9 HUMAN PERCEPTIONS

Coastal zone management is based broadly on a utilitarian approach and on a utilitarian ethic as a social response. This utilitarian ethic is based on the credo that "conservation is for man", as it produces the greatest amount of good for mankind (Avis, 1992). Development along the Eastern Cape coast reflects this utilitarian approach with the present perception that development, particularly "recreational" development, is of primary importance for the economic survival of the region. Avis (1992) is of the opinion that the importance of coastal land-use and therefore developmental trends are based on a hierarchy decreasing in importance from recreational use followed by social and economic values and lastly ecological values (Figure 1.4a). He carries on to say that the maintenance of ecological processes is of greater importance than the utility functions offered by the coastline (Figure 1.4b).

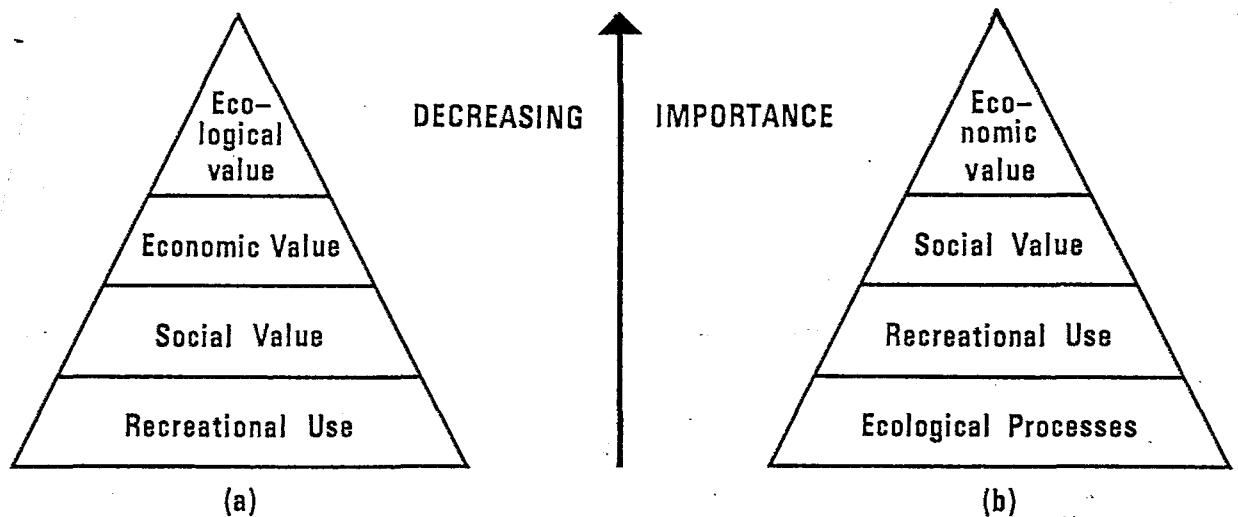


Figure 1.4 Human/use perceptions of the coastline (a) reflects a utilitarian ethic towards the value and importance of ecological processes, but maintenance of these processes is required for the correct management of the coastal zone, which will ensure sustainability (b) (from Avis, 1992).

Coastal zone perceptions vary from one extreme to another; from the hands-off preservation approach, by the radical conservationists, to the speculative developer who gauges the natural environment in terms of development difficulty and cost which is required to overcome these difficulties.

A conservation ethic which manifests itself in environmental policy is now being carried out by a few environmental organisations. This ethic is a result of perceptions which believe in "conservation with development" and "development with conservation" (Gaigher, 1992). This premise presumes the natural environment to be of vital importance to the extent of maintaining basic life support systems.

Practical implications of sound environmental management and development are being increasingly perceived by developers and managers alike purely as a response to the financial implications of pre-construction preparation and post-construction rehabilitation. This perception is leading to a greater awareness amongst developers, authorities and environmentalists alike.

1.10 FRAGMENTATION

Fragmentation is described by Hobbs et. al. (1993) as a human induced situation resulting in landscapes and ecosystems being subdivided through human activities, such agriculture, urbanisation and forestry. These segments are usually managed in isolation which can lead to degrading vegetation and diminishing species - similarly, the conservation value of these fragments are also degrading. Hobbs et. al. (1993) argues that successful management of both the productive segments of the landscape and the conservation segments required an integrated approach to the management of the landscape as a whole.

1.11 AIMS AND OBJECTIVES

The major objective of this thesis is to **determine coastal sand dune sensitivity in order to categorise the coast line according to a "sliding-scale" of conservation worthiness**, and illustrate if accepted coastal planning policy, and their techniques, can be assimilated into an applied decision making tool, thereby eliminating *ad hoc* coastal zone management decision-making, in the Eastern Cape coastal region. Each of the two existing planning and management techniques presently used have their own specific aims and objectives which are relevant to the purpose of that particular technique. The combination of these documents in conjunction with the physical environment, as a single plan, is the objective of this study.

The main aim, therefore, is to determine **whether the combination and integration of these two coastal planning and management documents can be effectively used as a single planning and decision-making document.**

With respect to the above major objective the following key questions are relevant.

- The relationship between authority and non-government organisations perceptions on the conservation value and status of the coastal zone?
- Is there is any association between human conservation values and perceptions and the vegetation sensitivity of coastal dunes?
- The association between coastal dune morphology and the planning documents?
- The association between the perceived Cape Coastal Conservation Plan and the conservation worthiness of the coastal zone?
- Can sensitive and conservation valuable plant communities be used to determine coastal zone sensitivity?
- The dependability and relatedness of these coastal planning documents?

CHAPTER 2.

METHODOLOGY

2.1 INTRODUCTION

Generally, coastal zone management and coastal decision-making is almost entirely *ad hoc*, based on site specific personal interpretation and a "gut feel" of the environment by the planner or manager. In order to remove this personal bias an overall holistic decision-support system should be established to ensure that each management case or planning situation is equally approached.

The coastal zone is fundamentally made up of (amongst others) three basic components; the physical component (rocky promontories, estuaries and dune fields), the biological components (flora and fauna) and human influences (the built environment according to human perceptions). Planning and management strategies must take all three components into account.

For the purpose of this study two planning documents were selected as representing the main approaches to coastal zone planning and management - as carried out by the environmental authorities and those whose task it is to plan, manage and make decisions with regards the coastal environment. There are numerous existing documents used by these authorities in their day-to-day activities, ranging from formal legislation through to "in-house" policy and planning documents. The two chosen for this study are;

- 1 **The Cape Provincial Administration's (1992), "Cape Coastal Conservation Plan".**

- 2 **EMATEK's (1989) "The mapping and conservation importance rating of the coastal vegetation as an aid to development planning".**

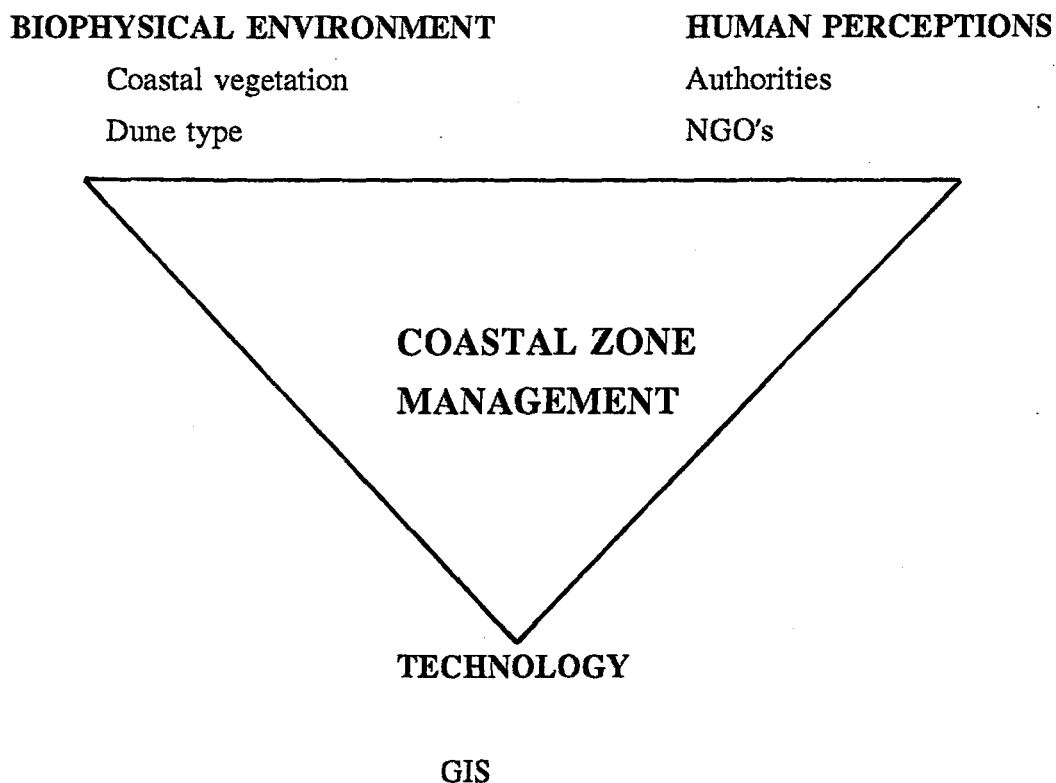
Further published work, although not formal decision-making policy, is considered as illustrating the physical environment of the coastal zone.

- 3 **Tinley's (1985) "Coastal Dunes of South Africa", and Rust & Illenberger's (1994) "Sensitive Dunes".**

These three documents, which are in constant use (Theunessen, 1992), were chosen as being the most reliable planning approaches representing specific aspects of the coastal zone. They are working documents acting as guidelines in coastal zone management decision-making. The main problem with the use of these documents are that they are usually used in isolation (Gaigher, 1992) and routinely selected for use only if they support the requirements of the planners, managers or decision-makers.

It is therefore the purpose of this study to integrate the three above documents into a single working plan highlighting, as close as possible, the actual environmental sensitivity as determined from the conservation worthiness of the study site. Conservation worthiness is generally accepted as being the worthiness of a site according to nature conservation objectives (Gaigher, 1992). These objectives are high biological diversity, relative uniqueness to other areas and level of human impact (CNC, 1992).

The three main aspects of Coastal Zone Management (CZM), as determined in this research, are seen as follows;



These three differing factors were in need of being integrated into one planning document. In order that the three divergent systems be compatible, at a similar temporal and spatial scale, a Geographical Information System (GIS) was used. GIS also enables additional future systems and data to be attached and updated as well as being an integral and powerful tool for a first environmental approximation for planning procedures.

2.2 SELECTED METHODS AND TECHNIQUES

The human consideration of the coastal zone is the aspect of **perceptions** (1), which ultimately results in the type and extent of development and therefore its true conservation value. Two main aspects of the biophysical environment are analyzed, these being the conservation importance rating of the **plant communities** (2) occurring on the dune types and the **dune type** (3) according to their morphology. An integration of these three aspects of the coastal zone, using computer technology, begins to achieve the aim of holistic and integrated coastal zone management.

The two planning documents incorporating human perceptions (Cape Coastal Conservation Plan), plant communities (Coastal Vegetation Importance Rating) and the dune types were digitized and overlaid as individual coverage maps - as depicted in Figure 2.1. The surface area coverage, in hectares (ha), and the number of individual fragments (polygons) of the series of polygons of each map was calculated.

The *modus operandi* for the integration of the existing planning documents used in this study is according to flow diagram of Figure 2.1.

This flow diagram is a systematic chain of events illustrating the method undertaken in this study, from the methodology to the results. Chapter 2 undertakes an explanation of the three schemes which are used in the study, and how they are modified.

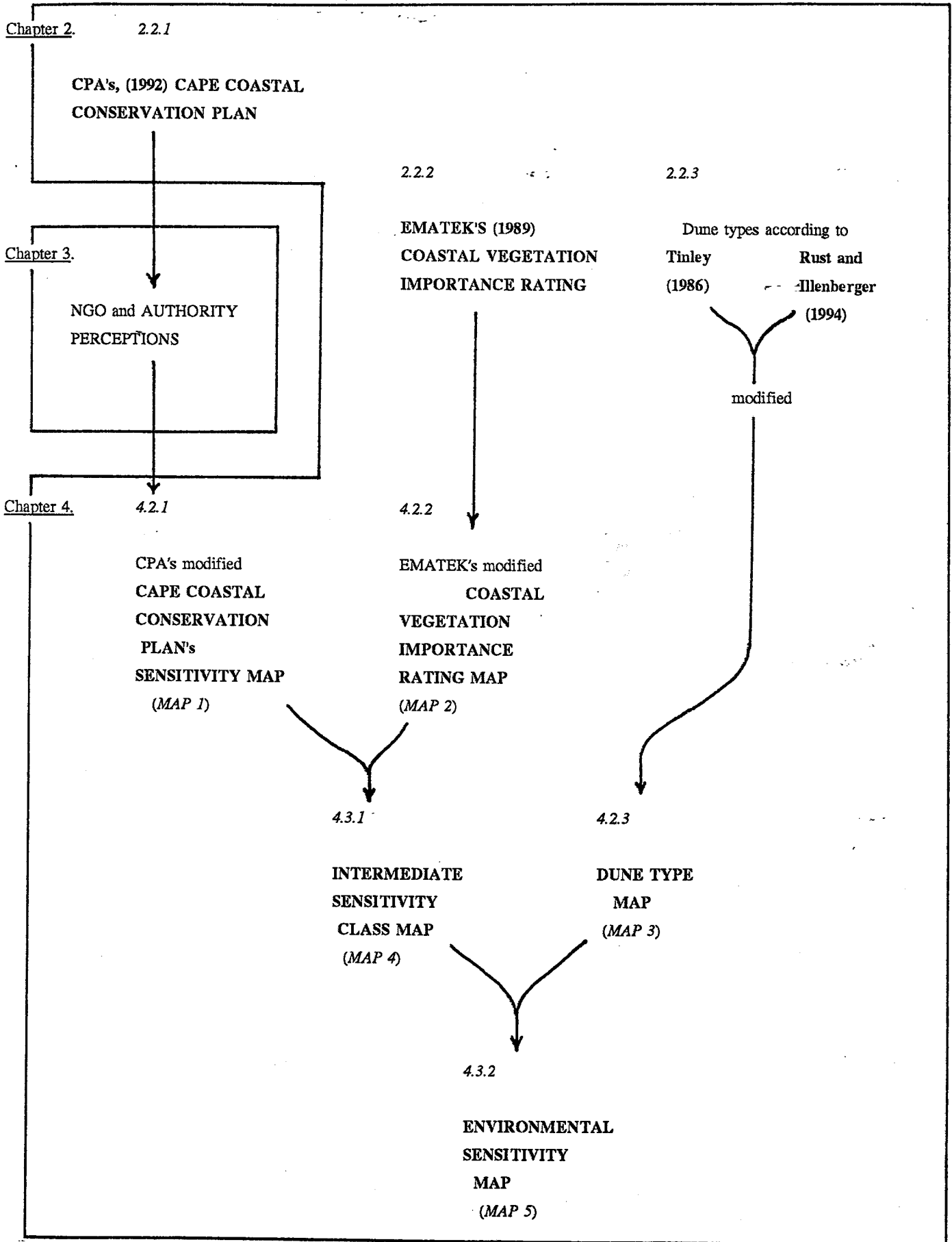


Figure 2.1 Flow diagram showing the *modus operandi* and line of action for this study. Chapter figures refer to the sections of this study in which they are dealt.

2.2.1 Human Perceptions - CPA, Cape Coastal Conservation Plan

It was mentioned by Rowntree (1992) that there could be a significant difference between the Non-Government and Authority Organisations in their perception of the ecological status of the coastal zone. A test of the relationship, therefore, between the NGO and authority perceptions was imperative to the overlay methodology. The level of difference between these two potential perceptions will depend on whether three or four overlays will be used. Any differences, and their extent, will be identified. This was undertaken in Chapter 3. The following diagram highlights the methodology used in the comparison.

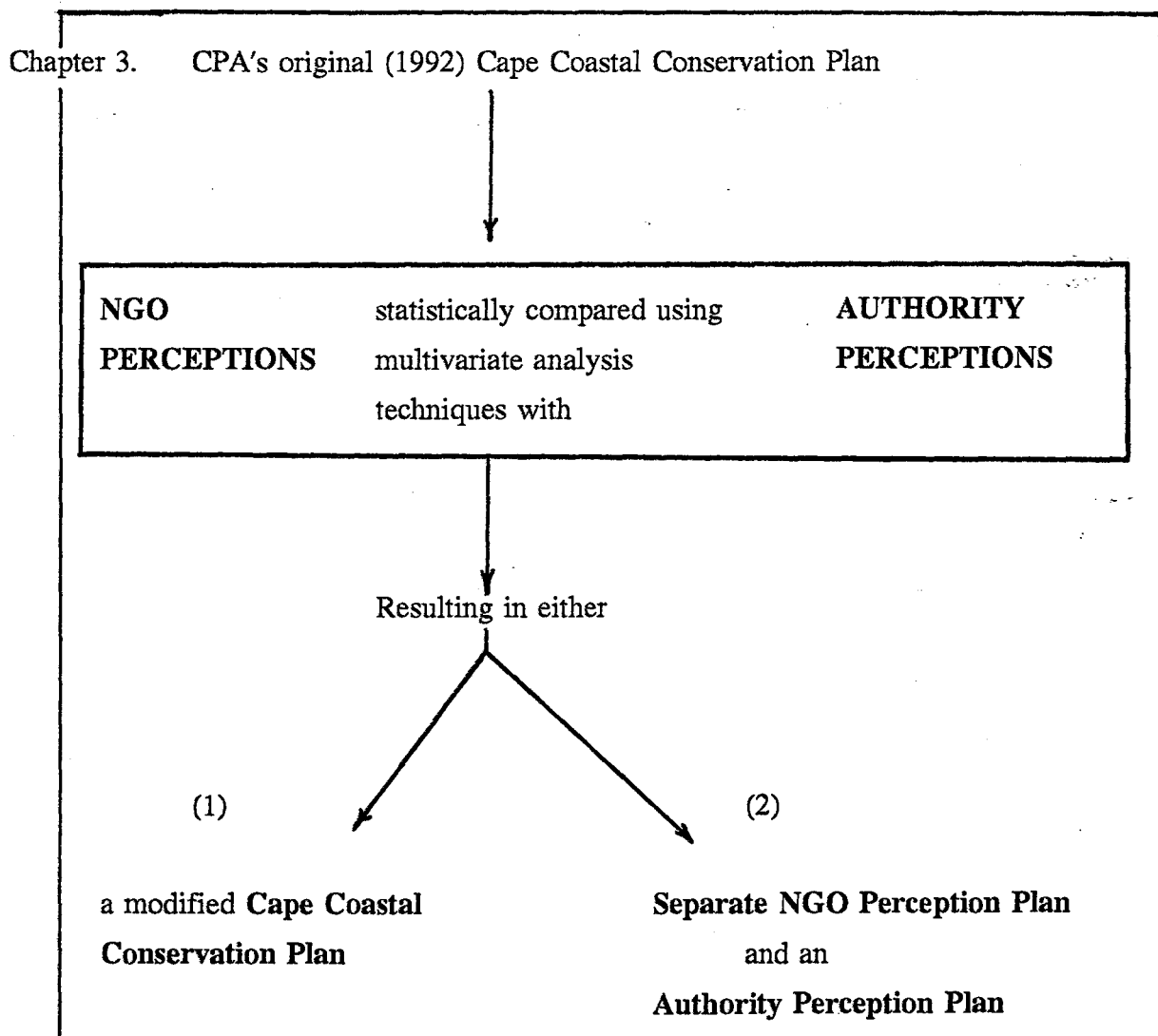


Figure 2.2 A sub-section of Figure 2.1 (methodology carried out in Chapter 3) showing the *modus operandi* and line of action for the comparison of NGO and Authority perceptions.

If there is a significant difference between these two perceptions then each of the perceptions will be overlaid and compared with the coastal vegetation map and dune types. If not only a single plan will be used for the overlay.

It is accepted that human perceptions per se are not quantitative, but in this case these perceptions have initially been converted into graphic indications on conventional maps and then expanded to incorporate two-dimensional spacial boundaries. These areas have been assigned values and with the use of a Geographical Information System (GIS) these perceptions, as an overlay, can be compared to biophysical data.

This plan was initiated to alleviate ad hoc decisions being made on proposed coastal developments. The results obtained from this plan were obtained from questionnaires sent to all possible Interested and Affected Parties (I & AP's); (see Appendix 2.1). The maps (Appendix 2a and 2b), and filled-in questionnaires were then returned, collated and groups according to the extent of coastline on which they were able to comment.

Category 1 - Protected areas (Colour code purple). These are land areas in State ownership with existing formal conservation status. They are indicated on the maps, and do not include private nature reserves (whose conservation status is voluntary).

Category 2 - Conserved Areas (Colour code red). These are areas in private or public ownership whose natural characteristics and sensitivities are such that they should be protected and where it is recommended that any form of resort or residential development should be excluded (Limited, controlled access may in some cases be compatible). This category should only be assigned with discretion as it identifies conservation-priority areas which should in time acquire formal conservation status or some other form of guaranteed protection.

Category 3 - Conservation with Development Areas (Colour code green). These are coastal areas where small-scale, environmentally sensitive new development could, from an environmental perspective, be acceptable. It is proposed that there should be a development "quota" on each similar property in this category and that this should not normally exceed 2 to 10 units per kilometer of coast (the greater number being recommended) where there are definite advantages for conservation of the coastal area. These units should be limited in size

and clustered in not more than two clusters per property to reduce impact. They should also be established in stable areas and should not visually or physically intrude on the coast.

Category 4 - Development with Conservation (Colour code yellow). These are existing resort/residential development nodes. Expansion to immediately adjacent areas should be indicated where this is recommended. Development in this category should be placed in environmentally-acceptable locations and should be clustered to preserve the character of the coastal environment. Final expansion should take into account the carrying capacities of coastal amenities (which may be augmented, by appropriate facilities e.g. "tidal pools", where necessary).

Category 5 - Development Areas (Colour code brown). These are existing nodes of standard urban/industrial/residential development where expansion is laid down in structure plans and development rights. Development should, however, take coastal processes into account and should (as in other categories) be subject to the Guidelines of Coastal Land-use of the Council for the Environment. Recommended expansion (or conservation categories within the "development area") should be eradicated.

Lastly, the CPA Coastal Conservation Plan is an authority insight into human perceptions as the conservation status of the coastal zone.

2.2.2 Vegetation Sensitivity Mapping

It is the status of the vegetation which gives the first and main approximation of a site when determining the suitability of the site for development. This vegetation status was established by Earth, Marine and Atmospheric Science and Technology, EMATEK (1989) to determine a "vegetation importance hierarchy" which identified areas of high biotic significance or high conservation value. It is normally the conservation value or worthiness of a site which determines the level of permissible development.

The Mapping and Conservation Importance Rating of the Cape Coastal Vegetation as an aid to Development Planning, as proposed by EMATEK (1989), serves to "identify, map and rate the vegetation along the Cape coast" for the Cape Provincial Administration, which required "this information as an aid to prevent development taking place within biotically sensitive areas along the coast and to direct the effective planning of all developments in accordance with conservation goals". Examples of their mapping is seen in Appendix 2.3.

The vegetation community types were classified by EMATEK (1989) according to;

- a. species composition
- b. vegetation structure
- c. floristic diversity
- d. abundance
- e. degree of impact

Vegetation types were identified by EMATEK (1989) on the basis of colour, structural variation and similarity to other components of the same structural class as previously identified vegetation units. The vegetation classes produced by EMATEK (1989) do not equate identically with those of other authors coastal vegetation classification (Burns and Lubke, 1986; Lubke, 1987; Lubke and Avis, 1987; Lubke, Tinley and Cowling, 1988; Daines, 1991; McGwynne and McLachlan, 1992). For example, EMATEK's (1989) fynbos and dune thicket mosaic community incorporates scrub, dune scrub-thicket, scrub forest and dune fynbos communities of the other authors.

Ground truthing by EMATEK (1989) included the compilation of species composition, diversity, degree of infestation by alien plants and general condition of the vegetation types. The refined boundaries of the vegetation types were adjusted on the overlays and corrected to a common scale of 1:10 000. Broad vegetation types were mapped, at a 1 : 10 000 scale, from colour aerial photographs taken in 1987. Inland boundaries of the vegetation types included the revised coastal zone boundary where vegetation types occurring seaward of the line were mapped.

The Coastal Vegetation Importance Rating map was re-digitized at a scale of 1 : 10 000 as digital data at the time of this study was unavailable for map reproduction using the IDRISI GIS system. The digitising of this map was standardised for comparisons to be made with the other overlays. This report provides planners with a guideline to floristically sensitive areas along the Cape coast so that any proposed new developments can be planned effectively.

The arithmetic formula for the CONSERVATION STATUS (CS) is; $CS =$

vegetation type rarity factor	habitat diversity	+	species richness	+	threatened species	+	size 2	+	shape 2	+	invasion 2	+	abuse 2	+	special attributes
diverse biogeographic region or large heterogenous areas					local geographic regions or small homogenous areas										

This formulae was designed and tested by the fynbos biome working group (Jarman, 1986) in order to determine the lowland fynbos conservation status. EMATEK has used this formula to determine the vegetation sensitivity of the coastal area at this scale of 1 : 10 000. The determination of community structure is determined at this scale. This formula was designed specifically for botanical purposes at the species level, which includes habitat diversity, species richness and threatened and rare species (Jarman, 1986).

The formula can therefore be used for both local homogenous areas (at the plant community level) and regional heterogenous areas (at the landscape level), as can be seen in the spatial

scale below the formula. This report aimed, a) "to delimit and map the different vegetation types recognised along the Cape Coast; b) to describe each recognised vegetation type and to provide an indication of its relative importance; c) to provide information on all known threatened plant species along the Cape coast; and d) to provide a comprehensive reference source to documented information relating to the coastal vegetation" and e) to direct most development decisions towards botanically low priority areas.

The vegetation classes were used because of the vegetation's sensitivity to disturbance. It is therefore used, as a first approximation, to determine site specific environmental conditions when analysing a potential development site for conservation worthiness.

From a vegetation perspective Tinley (1985), has identified a number of factors which conserve and maintain ecosystems;

- a. high biotic diversity
- b. high ecological variability
- c. high concentrations and numbers of endemic species
- d. concentration of biogeographic outliers
- e. examples of important natural processes
- f. aesthetic landforms and ecosystem diversity
- g. ecological quality (state of intactness/disturbance)
- and h. the degree of threat from human activities.

Within the study area coastal dunes are the dominant geomorphological phenomena and is best represented as the physical aspect of the environment. The overlay maps, indicating percentage alien infestation and percentage impact, have spot values recording sites and time of survey.

2.2.3 Coastal Dune Types

According to Tinley (1985) there are relatively few simple or basic dune forms, many dune type combinations and endless numbers of varieties. It is for this reason that dune sensitivity, or conservation value, *per se*, is not well defined. There have been several attempts at classifying coastal dune types (Mabbutt, 1977, McKee, 1979 and Davies, 1980; as cited by Tinley, 1985; Tinley, 1985; Daines, 1991).

Rust and Illenberger's (1994) broad categorisation of the coastal dunes have been included as the first split in an attempt at classifying the dunes according to a hierarchy. The further classification of specific dune types have been attempted by the author - this study - in section 2.3.3 of this chapter.

2.3 MODIFICATION AND IMPLEMENTATION OF THE ABOVE TECHNIQUES AND PLANS

The three above techniques were slightly modified to allow each to be compared using the GIS. Both the Cape Coastal Conservation Plan and the Coastal Vegetation Importance Rating map categories were modified to an identical series of classes, ie. V-High, High, Medium and Low classes. Modification was in the form of colour code changes (both the Cape Coastal Conservation Plan and the Coastal Vegetation Importance Rating maps used colour codes - but were not similar) to a standard used in this study - V-high to Low. The extent to which modification took place was according to the ease at which the technique could be used within the GIS, and is explained below.

2.3.1 Cape Coastal Conservation Plan

The only modification of this plan was to lump the original Category 1, Protected Areas (purple) with Category 2, Conserved Areas (red). The reasoning behind this was that both categories indicate total protection, due to their inherent conservation status, and have identical inherent conservation values on the ground. Category 1 has formal status because of its conservation value and Category 2, although not having formal protection status, should have this status because the natural characteristics and sensitivities are such that they should be protected. This category identifies conservation-priority areas which should in time acquire formal conservation status identical to Category 1.

The only differences are their existing protection status and potential land use. The formally proclaimed areas restrict or limit development and the unproclaimed areas allow development according to existing title deeds and allow proposed development in terms of the Land Use Planning Ordinance (No 15 of 1985). Table 2.1 highlights this conversion process.

Table 2.1. The modification process of the original Cape Coastal Conservation Plan's categories to Sensitivity Classes.

Cape Coastal Conservation Plan Categories	Sensitivity Classes
- Category 1 (purple) + Category 2 (red)	V - High
Category 3 (green)	High
Category 4 (yellow)	Medium
Category 5 (brown)	Low

Similarly with the conversion of the vegetation classes to general environmental sensitivity classes the Cape Coastal Conservation Plan's categories were also standardised to enable a consistent overlay of these two plan's. These sensitivity classes (V-High to Low) of the Cape Coastal Conservation plan further allow for the overlay and comparison with the sensitivity classes of the Coastal Vegetation Importance Rating map (see 2.3.2)

2.3.2 Coastal Vegetation Importance Rating

The final mapping procedure was carried out by digitising the data using a Geographical Information System and the compilation of these maps as transparent overlays on 1 : 10 000 orthophoto's.

The following community types (Table 2.2) are found within the study site and are broadly categorised into four categories. These categories, which are to be used in the vegetation overlay, are in order of decreasing importance.

On a scale of 1 - 100, codes; purple = 75 - 100
 green = 50 - 74
 yellow = 25 - 49
 red = 1 - 24

Table 2.2. The conversion of EMATEK's Vegetation Sensitivity categories to standardised Sensitivity Classes.

EMATEK's VEGETATION SENSITIVITY CATEGORIES		SENSITIVITY CLASSES
CODES	HABITAT DESCRIPTION	
Purple	a. Vleis	V - High
	b. Halophytic rocky coast communities	
Green	c. Forest and thicket on ancient dunes	High
	d. Saltmarsh (undifferentiated)	
	e. Fynbos and dune thicket mosaic	
Yellow	f. Secondary grasslands	Medium
	g. Dune slack and strand vegetation	
	h. Acacia savanna	
	i. Mosaic of natural vegetation and agriculture	
Red	j. Artificially established dune shrublands	Low
	k. Open sandy areas	
	l. Cultivated lands/plantations	
	m. Dense alien communities	

2.3.3 Coastal Dune Types

A major determinant in the classification of dune types in this study was the scale at which the dunes could be accurately noted and mapped. An initial desk-top mapping exercise highlighted eight main dune categories occurring along the study site portion of the Eastern Cape. There are many variations and sub-environments within the major dune types but determining boundaries around these sub-classifications would, for mapping purposes, be beyond the scale applied in this study.

One means of assigning a conservation value to dunes is by determining the extent and level of association of vegetation types, and specifically plant communities and sub-communities, with the specific dune morphology. This study makes use of this association and coastal dunes are broadly divided into active dunes and non-active dunes. Generally non-active dunes are those which have been stabilised by vegetation. Active dunes are further divided into transgressive and retentive dunes (Rust and Illenberger, 1994). There has been, up to and including this section, no attempt at classifying the dune system beyond that which Rust and Illenberger (1994) proposed.

The conservation value of dunes can, however, be determined by the association of vegetation types, specifically plant communities, with the dune morphology. Coastal dunes within the study site are broadly divided into active and non-active dunes - this study (Table 2:3), according to their association with coastal vegetation.

Table 2.3. Coastal Dune Types as determined by this study.

2.2.3 COASTAL DUNES		
2.2.3.1 ACTIVE DUNES		2.3.3.2 NON-ACTIVE DUNES
a. TRANSGRESSIVE	b. RETENTIVE	
Littoral beach zone	Littoral beach zone	Raised vegetated fossil dune
Reversing barchanoid dunes	Hummock dunes	Vegetated back dune
Headland bypass dunes	Butress barchanoid dunes	Aeolianite headlands
		Bidirectional parabolic ridges
		Unidirectional parabolic ridges

2.3.3.1 Active Dunes

Active dunes are characterised by sand movement and morphological change occurring over a relatively short period of time. Examples of these dunes are the barchanoid, hummock and headland bypass dune fields as well as the littoral beach zone.

2.3.3.1(a) Transgressive Dunes

These dunes are a result of sand transport being dominant over other processes. Down-wind migration is the characteristic process which results in this type of dune. Migration rates of the dunes are in the order of several m.yr^{-1} , which change shape and position depending on the wind regime (Rust and Illenberger, 1994). The ability for these dunes to move is a result of a lack of vegetation, which is the diagnostic feature. Sand is subsequently stored for longer periods of time resulting in them being sediment sinks. Dune fields lacking in vegetation, a diagnostic feature, and acting as sediment sinks were classified as transgressive dunes. These dunes are further subdivided according to the following criteria:

Littoral Beach Zone

The beach zone, that area between high water level and the first indication of hummock dune formation, was included as a means of demarcating the extreme seaward boundary of the sandy coastline for mapping purposes. Therefore, the extent of this beach zone was calculated along with the other dune types. It is also this beach zone which gives rise to the primary dunes - being the zone of sand deposition and accretion.

Reversing Barchanoid Dunes

Barchanoid dunes are generally parallel rows of linked crescent-shaped dunes having their axis at right angles to the prevailing winds. When winds alternate seasonally and periodically from opposing directions a second slipface develops opposite to that of the previous slipface (Tinley, 1985). These dunes frequently exhibit interdune troughs or moist dune slacks which facilitates the growth of typically dune slack vegetation.

Reversing transverse dunes, having straighter ridges than the true barchanoid dune, also fall into this category. These dunes within the study site generally exhibit a combination and merging of both these types of dunes and therefore, for simplicity, the term reversing barchanoid is preferred.

Headland Bypass Dunes

Tongues of migrating sand which cross the plateau of a normally rocky headland and supplying the shoreline of the opposite embayment are termed headland bypass dunes (Tinley, 1985). These dunes constitute parallel-sided deflation hairpin parabolic types being blown by the west and west-south-west dominated winds.

2.3.3.1(b) Retentive Dunes

Retentive dunes are a result of sand accumulation being dominant over other dune formation or bio-physical processes. Accretion is the dominant process resulting in the formation of a static dune. Retentive dunes are also characterised by a migration rate of 1m.yr^{-1} and act as sand sinks and store sediments in the littoral active zone for storm beach-erosion. These dunes may or may not exhibit vegetation, but it is the presence of vegetation which determines the character and morphology of the hummock and butress barchanoid dunes. These dunes are further subdivided according to the following criteria:

Littoral Beach zone

The littoral beach zone has also been included under the category of retentive dunes due to sediments, besides accumulating within this zone.

Hummock Dunes

Hummock dunes form the broad category of dunes resulting from wave and wind action accumulating sand around isolated plants. Hummock dunes incorporate an array of sub-classes; driftline embryo dunes, hillock dunes, vegetated swash bars or beach berms, primary dunes, strand plant hummock dunes, impeded dune and parallel beach ridge hummocks (Davies, 1980; Hesp, 1984, Tinley, 1985; Lubke, 1988).

Butress Barchanoid Dunes

Occurring inland of the free mobile dunes, these dunes are inclined landwards at right angles from the beach onto the slopes of forested high parabolic dune cordons (Tinley, 1985). These dunes may also exhibit "interdune troughs" and "dune slacks", which can be vegetated.

Reversing forms of this dune type result in "star-dune" forms with tongues of sand breaching through the vegetation as "blow-outs" and are also included in this category.

2.3.3.2 Non-active Dunes

Dunes in which past sand movement is now fixed, through the process of pedogenesis, climatic conditions, temporal scales, vegetation or man and which is morphologically stable, are included in this category. Examples of these dunes are fossil dunes or raised dune platforms. These dunes are further subdivided according to the following criteria:

Raised Vegetated Fossil Dunes

Dunes formed during pre-historic climates with stronger winds and larger sand supplies, being formed before the existing dune cordons, now supporting mature stands of coastal thicket and forest on soils which exhibit an Orthic A-horizon over regic sands - tending towards a B-horizon. Thus giving rise to a more "terrestrial" form of vegetation.

These old, stable dunes are generally large and high, and relatively flat. Present day mobile dunes back up against these dunes often overtopping and inundating portions with mobile sands.

Vegetated Back Dunes

These dunes, occurring at the most landward extent of the coastal dune cordon, are large, high and plant-arrested dunes with vegetation exhibiting mature dune scrub thicket and forest types. The dunes are relatively stable and mature displaying the initial stages of soil formation. These dunes also exhibit a characteristic "precipitation ridge" as a result of stronger wind conditions.

The term "precipitation dune" or "retention ridge" (Tinley, 1985) also falls within this general category. The main differences between these dunes and the "Raised vegetated fossil dunes" are their narrow but high morphology, unconsolidated and younger sands and precipitation slopes.

Aeolianite Headlands

Lithified dunes, aeolianites, and weathered aeolianite headlands which become lithified by downward percolation of soil water containing dissolved calcium carbonates. This lithification results in dune rock, also known as aeolianites, dune sandstone, coast sandstone or aeolian calcarenites (Tinley, 1985). The weathering of dune rock headlands forms masses of pitted pinnacles and ridges fronted by wave-cut platforms with pools. Although not true coastal dunes these structures often act as topographic barriers and an aid in the formation of other dune types and forms, such as headland bypass dunes.

Unidirectional Parabolic Ridges

Dunes in this category have tongues of advancing sand in the shape of a U migrating downwind - they are generally classified as parabolic dunes. This dune is concave to the wind. The crescent nose is opposite to that of the barchan dune which is convex to the wind (Tinley, 1985). Sets of similarly-aged parabolic dunes originating simultaneously override stabilised older dunes, becoming superimposed on one another.

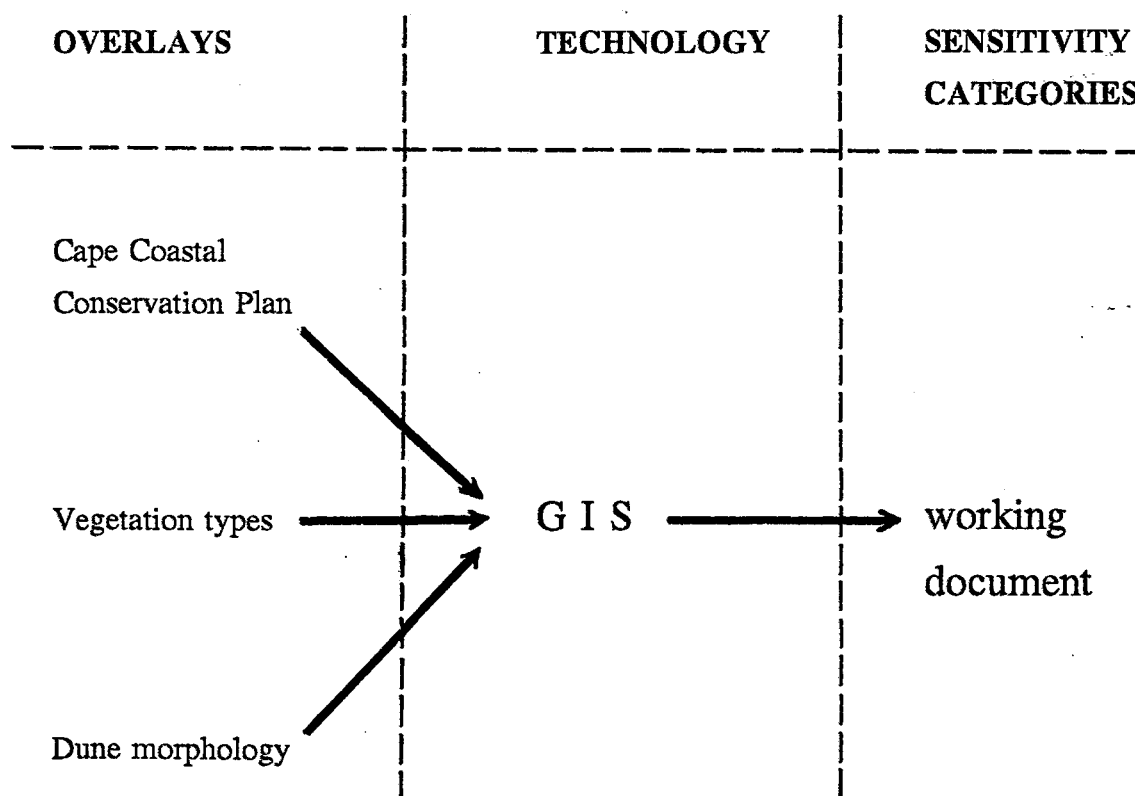
Bidirectional Parabolic Ridges

These dunes are similar to the previous parabolic dunes but where wind direction alternates from west-south-westerly to east-north-east during summer, and the configuration of the coastline favours their development, another set of parabolic dunes form at an opposing angle to one another (Daines, 1991).

2.2.4 Geographic Information Systems

The GIS programme which is used in this study is IDRISI. IDRISI is a grid-based geographic information and image processing system designed to provide raster-based image processing (Eastman, 1992). The make-up of this system consists of a series of programme modules consisting of core, analytical ring and peripheral modules which allow data entry, storage, management, display, analysis and conversion.

In this case the three main environmental components (techniques) are treated as separate overlays, where biophysical sensitivity scenarios are examined, in order to determine the sensitivity of the coastline.



The surface area coverage, in hectares, was calculated for each resulting overlay as well as their relevant statistics. The number of fragments were also determined.

2.2.5 The use of Fragmentation, Surface Area Coverage and Range of fragments.

Fragmentation is used in this study as a means of distinguishing the differences between one landscape character and another. A fragment is a portion of the landscape that is homogenous in structure exhibiting similar characteristics. Each of these different landscape components or fragments are assigned a class value according to its conservation worthiness. This is required for the two-dimensional spacial modelling of the coastline by the GIS programme IDRISI - the term polygon being the computer equivalent of a fragment. Therefore the segments which the GIS produces have been extrapolated to the concept of landscape fragmentation. Surface area coverage (in hectares) are the computer calculated two-dimensional area of a polygon. These polygons have been prioritised in order of decreasing surface area (ha), fragment size and number. The range of fragments have also been determined as a means of distinguishing many small and a few large fragments as well as a few small and many large fragments - all of which has conservation worthy implications.

CHAPTER 3.

HUMAN PERCEPTIONS

3.1 INTRODUCTION

Conflict occurs between the two goals of Coastal Zone Management: preservation and increased development or use for recreational purposes. This conflict is evident between the proponents and opponents of development, ie. usually the non-Government Organisations (NGO's - the opponents) and the Authorities (proponents). Legal decision-making carried out by the authorities or management agencies is supposed to be based on comments and recommendations of the NGO's, as well as the authorities. Unilateral decisions by authorities are a result of one set of perceptions and the formation of the IEM philosophy, to counter unilateral decision-making, is a result of another.

Human perceptions of the environment are those factors which determine the actual product of the coastal landscape. It is these perceptions which result in decisions being made as to the type of developments, development densities and styles of development, all resulting in a unique and characteristic land use coastal zone. The Cape Coastal Conservation Plan, which was determined from perceptions as to how the coastline should be classified, according to its conservation worthiness, has resulted in the formation of a subjective plan. This plan is then to be overlaid with the vegetation sensitivity classification of EMATEK and the coastal dune morphology.

The possibility of two main but important "camps" of perceptions (those of the opponents and proponents) was suggested as possibly being significant as to actually consist of two separate maps (Gaigher, 1992, pers. comm. & Lubke, 1992 pers. comm.). The test of the significance of their differences or similarities, using multivariate analysis techniques, is the basis of this chapter. The result will determine whether two separate maps should be digitized as overlays, or one.

The use of ecological multivariate techniques for elucidating social and philosophical aspects is not a new concept. Blackith and Reyment (1971) believes the desire to abstract from the great variety of living organisms forms which are essentially harmonious and capable of abstraction as the archetypal of some wider category of shapes and sizes, is very deep seated in human behaviour. The beginnings of the thought process of "multivariate morphometrics" (Blackith and Reyment, 1971) began with a combination of sociological and biological studies during the times of Plato and Aristotle. In recent history multivariate techniques have

manifested predominantly in biological studies. There have been however recent sociological studies which have used multivariate analysis for data interpretation.

Some sociological studies which have used multivariate analysis techniques include a study of the sociological differences between 157 towns in Britain, (Moser and Scott, 1961; In Blackith and Reyment, 1971), assessed 57 different characters of the towns, some including population size, structure, population change (demography), voting behaviour and health statistics. The 57 characteristics were submitted to a principle components analysis based on the correlation matrix.

Another study carried out by Casetti (1964, In: Blackith and Reyment, 1971), using principle components analysis to score various regions of Italy on a sociological basis. Twenty five attributes of the region were interpreted as reflecting standards of living, tourist attractions and agricultural differences between the regions. Lohns and McIntire (1967, In; Cooley and Lohns, 1971), set out to explore the validity of state and local norms which might be employed in local school guidance work, and to produce a comparison of the predictive validity of state and local school norms. Tests included reading vocabulary, reading levels and reading speed.

Other disciplines which have used multivariate techniques have been medical applications, immunology, taxonomy and biogeography, chromatographical and other chemically related botanical fields, pedology, meteorolgy and evolutionary studies. The multivariate approach to morphometrics is therefore common to each group which shares common morphometrical problems (Blackith and Reyment, 1971) and specifically when it comes to the interpretation of measurements.

The testing of peoples perceptions therefore involves the use of three sets of data, which fulfills the requirements of data input for the classification and ordination multivariate techniques.

3.2 METHODS

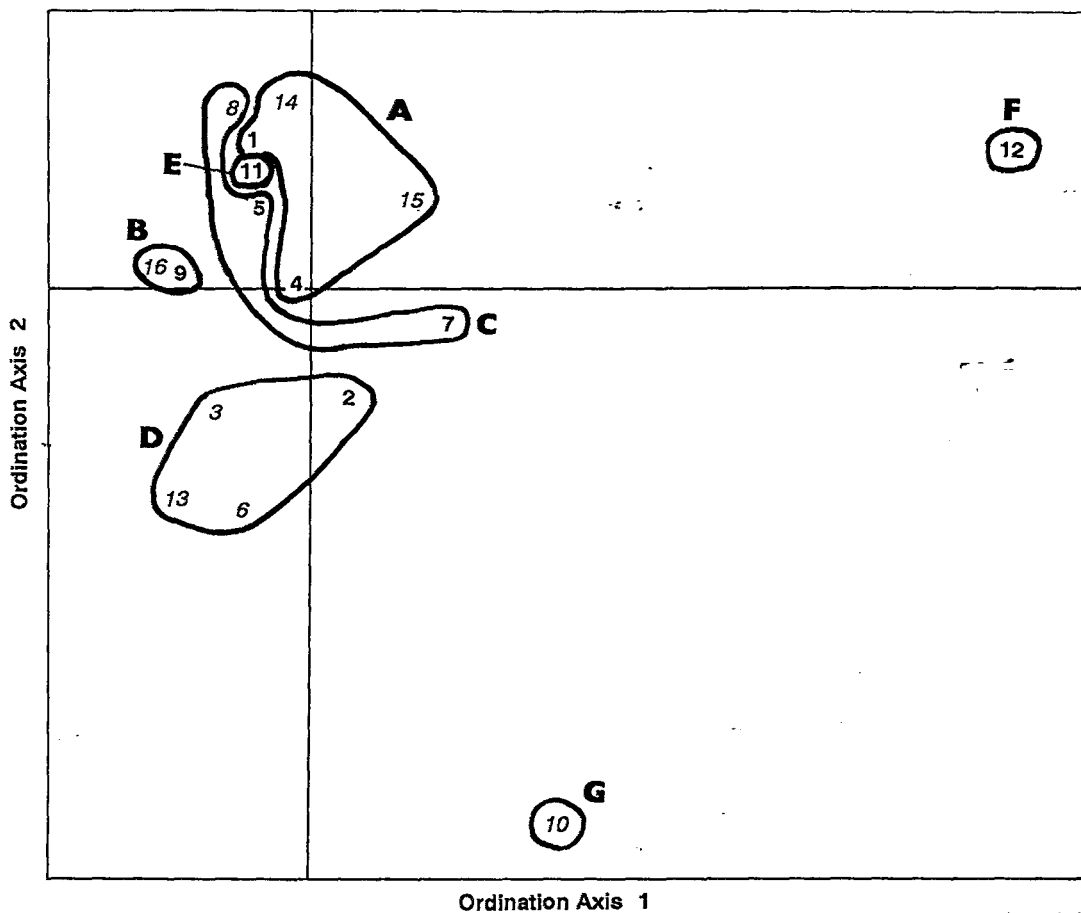
The original perceptions maps, which developed the Coastal Conservation plan, were categorised into 96 segments or 15 second delineations according to the geographical lines of latitude (Appendix 2a and 2b). Sixteen perceptions (analogous to "species") from a survey of 96 fifteen-second coastal segments (analogous to "relevés"), were determined. The data was modified into a Braun-Blanquet data set and then running a FORTRAN programme on this data set. With the use of ecological multivariate analysis the differences between the Authority and NGO perceptions were determined.

The categorisation of the coastline enabled 16 individual test subjects (separated into 8 authority and 8 non-governmental perceptions) to be compared according to the 96 subdivisions, each having a specific conservation category (according to the Cape Coastal Conservation plan). Appendix 3.2 is the list of organisations to which the Cape Coastal Conservation Plan was sent for comment. This enabled the readjusted data to be ordinated with the use of DECORANA (DEtrended CORespondance ANalysis), (Hill, 1979) and classified with TWINSpan (Two Way INDicator SPecies ANalysis), (Hill, 1979).

3.3 RESULTS

A dendrogram produced by TWINSpan (Figure 3.1), showing the classification of perceptions, indicated seven groupings (A to G) at the fifth level of division. Four of the seven groups had both authority and NGO perceptions with three outliers (groups E, F and G - perceptions 11, 12 and 10 respectively) having no affinity to a particular perception. Appendix 3.3 is the classification of the 16 organisations perceptions.

Similarly the detrended correspondence analysis (DCA) ordination graph (Figure 3.2) of the perception data was produced, superimposing the classification by TWINSpan upon this diagram, showed a clustering of like perceptions together but not separating out the authorities and NGO perceptions as separate entities.



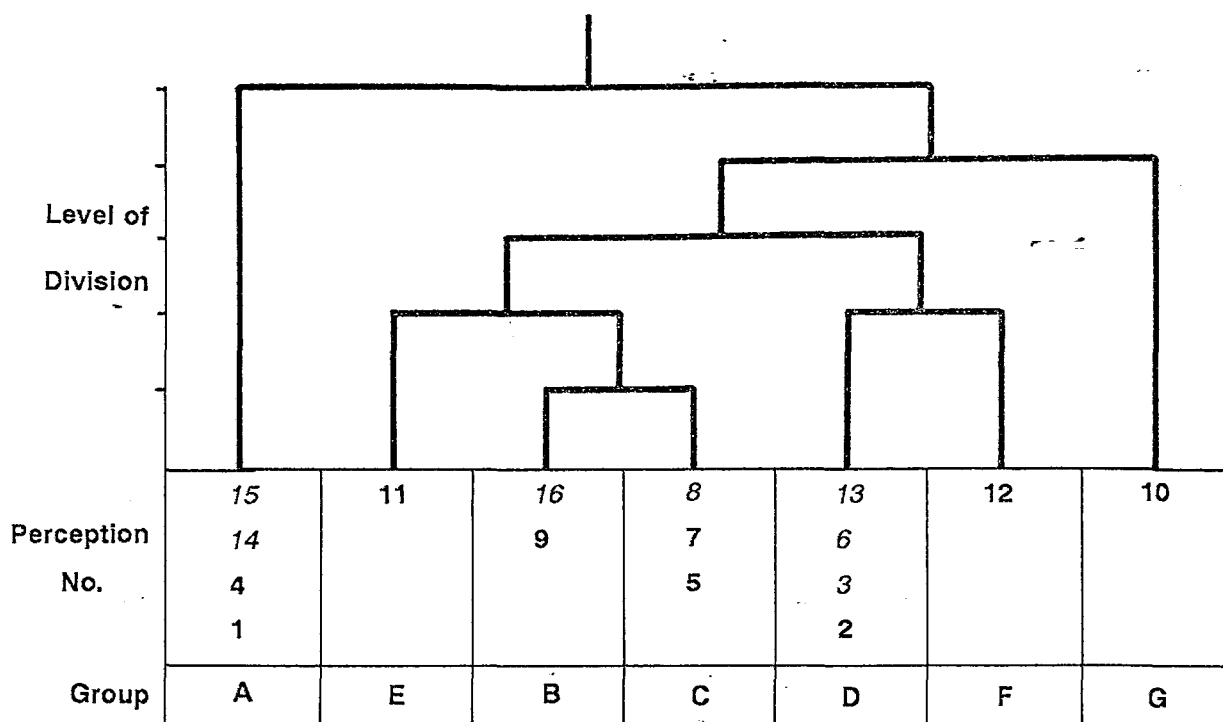
Organisations and their respective codes

1	CNC, Bok	9	NPB, Geldenhuis
2	RSC	10	<i>CES</i>
3	<i>Cape Coastwatch</i>	11	CNC, Hamnan
4	CNC, La Cock	12	PE Museum
5	Dept Water Affairs	13	<i>Rhodes University Botany</i>
6	<i>Diaz Bird Club</i>	14	<i>UPE Geology</i>
7	EMATEK, CSIR	15	<i>ICR</i>
8	<i>EP Wildlife Society</i>	16	<i>UPE Zoology</i>

Italics denote Non-Government Organisations

Bold denote Authority Organisations

Figure 3.2 Ordination of the Perception data set by DECORANA showing the distribution of the Organisations as isolated by TWINSpan.



Organisations and their respective codes

1	CNC, Bok	9	NPB, Geldenhuis
2	RSC	10	<i>CES</i>
3	<i>Cape Coastwatch</i>	11	CNC, Hannan
4	CNC, La Cock	12	PE Museum
5	Dept Water Affairs	13	<i>Rhodes University Botany</i>
6	<i>Diaz Bird Club</i>	14	<i>UPE Geology</i>
7	EMATEK, CSIR	15	<i>ICR</i>
8	<i>EP Wildlife Society</i>	16	<i>UPE Zoology</i>

Italics denote Non-Government Organisations

Bold denote Authority Organisations

Figure 3.1 A Dendrogram produced by TWINSpan showing the classification of Perceptions along the study site.

As the classification and ordination technique does not indicate the distribution of the Organisations Perceptions, according to the Conservation Categories, a histogram was produced of the TWINSPAN dendrogram by visually displaying the percentage frequency of the perceptions within the test subjects. This elucidated the differences between the perceptions test subjects of the first subject - NGO's and authorities (Figure 3.3).

Visually, the general tendency is for the purple category (conservation areas with formal status) to have a greater percentage weighting for most of the test subjects. Test subjects 2, 7, 8 and 15 perceive the red category (conservation areas without formal status) to be the most important, 12 the yellow category (development with conservation) and 10 the brown category (development). Test subject 11, which was classified separately, is visually similar in weighting to Perceptions 9 and 16. Although TWINSPAN and DECORANA separated test subject 11 out from 9 and 16 the histogram visually displays their similarity. There has to be, therefore, another factor over and above the weighting of the Conservation Categories which is determining a difference. Perception 10 is markedly different from the other organisations by having a general increased weighting from purple to brown (conservation to development).

In order to understand the lack of correlation between these perceptions the extent of fragmentation and number of categories were determined for each perception (Figure 3.4). The extent of coastline fragmentation was determined by obtaining the number of segments each organisation perceived along the study site. Similarly the number of Coastal Conservation plan categories were determined for each perception. No trends are evident in the comparison between the Authority and NGO Perceptions.

When analysing the differences in the mean values between the Authorities and NGO's, according to the number of fragments and conservation categories respectively (Figure 3.5), the NGO's perceived slightly more fragments (7.8) than the Authorities (7.1) but not significantly. However, the NGO's used less Conservation Categories (3.4) than the Authorities (3.8) but had a greater deviation (0.8) with the use of the categories than the Authorities who's deviation was less (0.7). The differences between authority and NGO perceptions were not found to be meaningful. By far the largest conservation category to be perceived along the coastline from Cannon Rocks to Kowie River Mouth was the category for Preserved Areas. Fifty percent of the coastline has legal status according to authority

perceptions and 41 % by the NGO's. The relative amount of land use according to the NGO perceptions systematically decreased from the CC plan P category having the highest conservation status to the B category having the least conservation status. The authority perceptions, however, determined the Y conservation category to have greater land use significance than either the G or B categories.

CNC -	Cape Nature Conservation
RSC -	Regional Services Council
EMATEK -	Division of Earth, Marine and Atmospheric Sciences
EP -	Eastern Province
NPB -	National Parks Board
CES -	Coastal & Environmental Services
UPE -	University of Port Elizabeth
ICR -	Institute for Coastal Research

Organisations and their respective codes

1	CNC, Bok
2	RSC
3	Cape Coastwatch
4	CNC, la Cock
5	Dept Water Affairs
6	Diaz Bird Club
7	EMATEK, CSIR
8	EP Wildlife Society
9	NPB, Geldenhuis
10	CES
11	CNC, Hannan
12	PE Museum
13	Rhodes Botany
14	UPE Geology
15	ICR
16	UPE Zoology

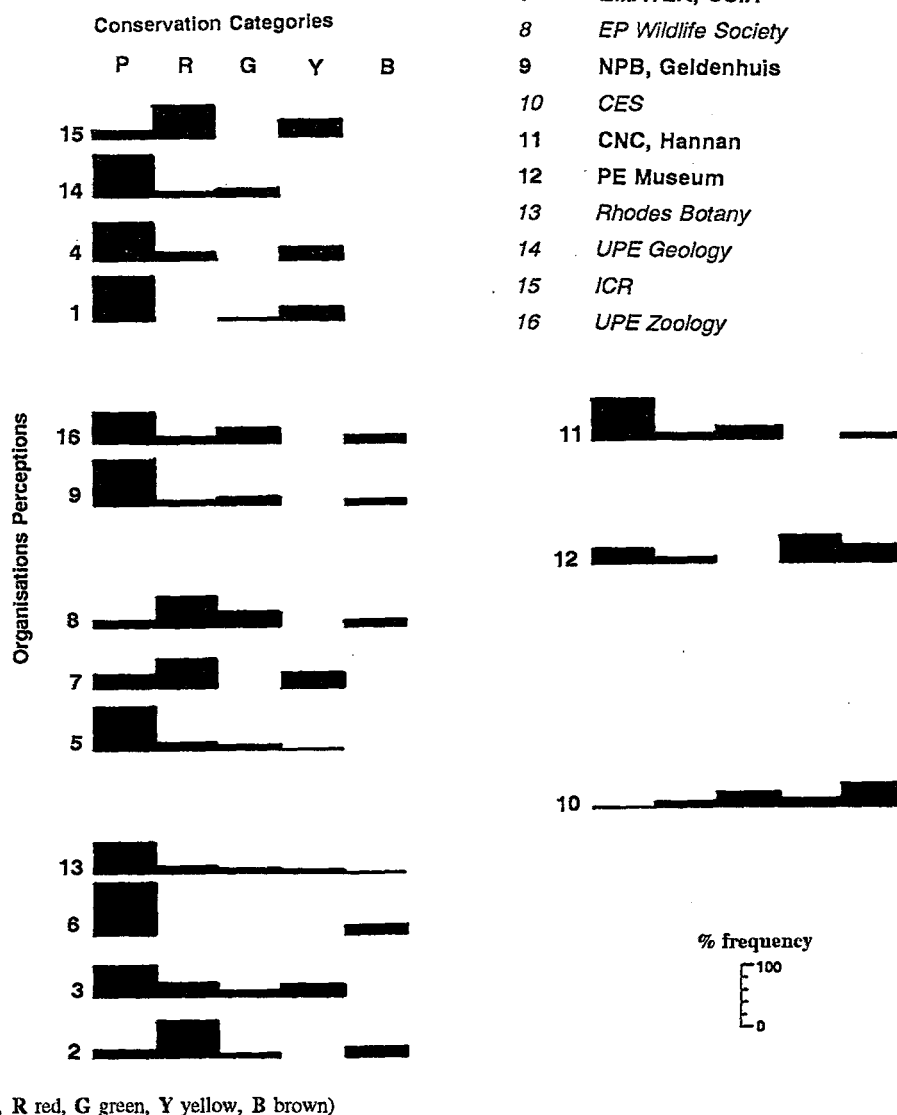


Figure 3.3 Histogram showing the frequency of the Conservation Categories according to the 16 test subjects.

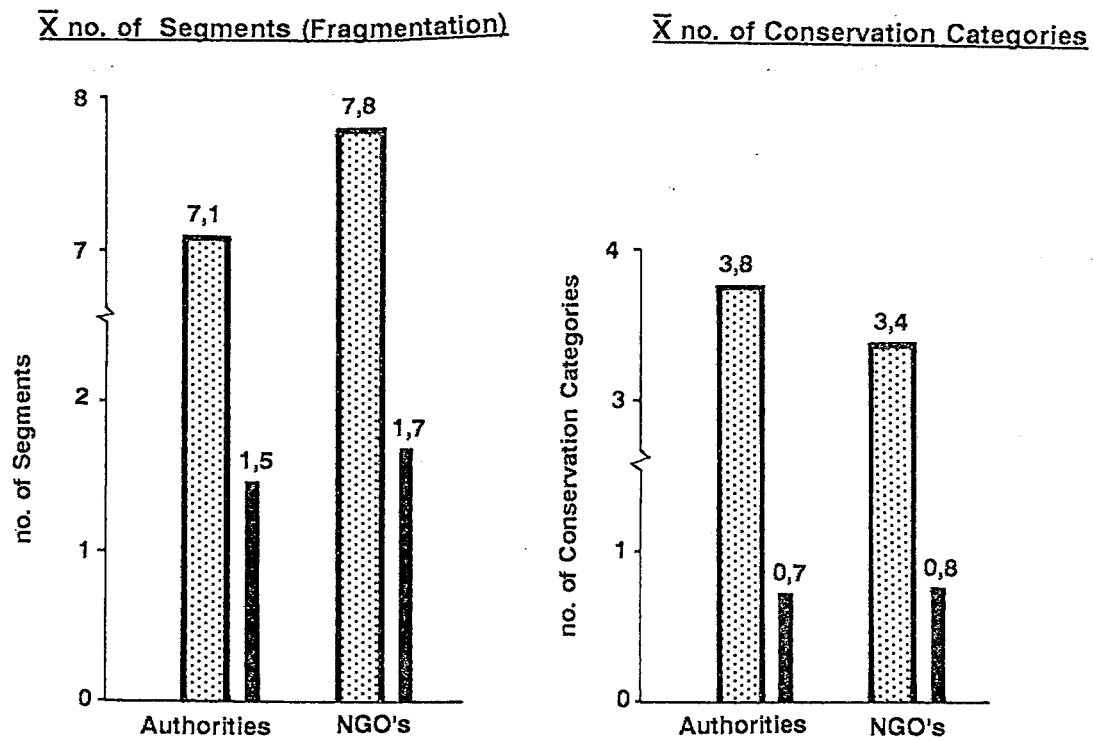


Figure 3.4 The number of segments according to the extent of Fragmentation and number of Conservation Categories as determined by the individual organisation. Mean (shaded bars) and standard deviation Solid bars).

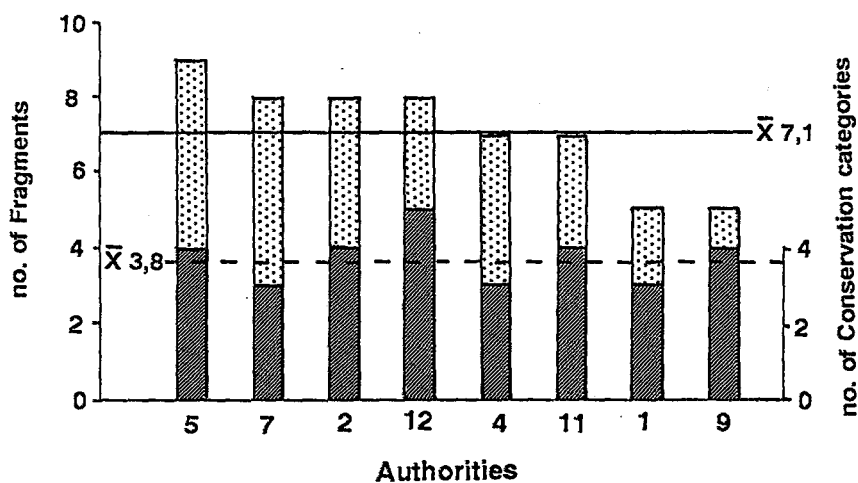
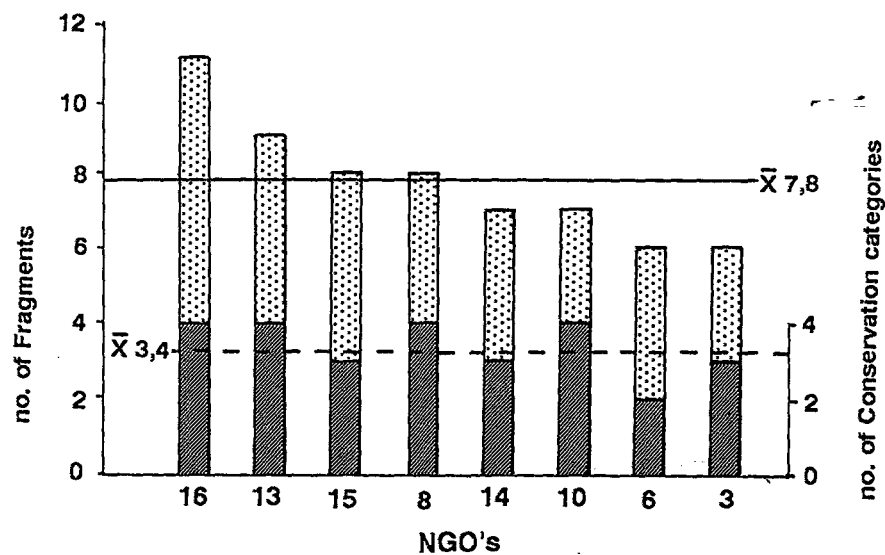


Figure 3.5 Extent of Fragmentation (light shading) and number of Conservation Categories (dark shading) as determined by the individual test subjects.

3.4 DISCUSSION

This analysis of 16 perceptions from a survey of 96 fifteen-second coastal segments revealed little differences existed between NGO's and authority perceptions, recognised by TWINSPAN and ordinated using DECORANA. There were however noticeable differences between the NGO's and to a lesser extent between the authorities. A general assumption can be made that authorities perceive sandy beaches from a management and legal perspective and NGO's perceive sandy shores from a recreational and developmental perspective. Different perceptions indicate different management aims and objectives and therefore different management strategies. Actual environmental quality is the product of these two main utilitarian perceptions. This study, revealing little difference between interested and affected organisations, has made it possible to justify the effect perceptions have on the biological (vegetation) and physical (dune morphology) coastal dune environment.

Differences between the perceptions of the Authorities and NGO's were not found to be significant in that the difference would effect the interpretation of the overlays with the vegetation and dune morphology maps. The insignificant differences observed for each of the previous analyses are interpreted as individual perception differences which cannot be extrapolated to an organisational level, ie. Authority or NGO level. The results then indicate that the perceptions are individualistic, as to the conservation status of sections of the coastline. No significant trends were observed to the contrary.

CHAPTER 4.

BIOPHYSICAL OVERLAYS

4.1 INTRODUCTION

For all of the digitized maps produced the surface area, or coverage, in hectares (ha) and the total number of fragments have been calculated and presented in tables for comparison purposes. The actual computed data, with statistics, is shown in Appendix 4. The surface area of each of the fragments (polygons) for the respective maps, related to a sensitivity class or category, indicates, as a measure, the extent and level of conservation worthiness inherent in each map. The final Environmental Sensitivity map is that map indicating the final combined conservation status, value and worthiness for the section of coastline from Cannon Rocks to Port Alfred.

First the Cape Coastal Conservation plan's modified perception map was digitized, then the Coastal Vegetation Importance Rating map and these two overlaid to create the Intermediate Sensitivity map. This Intermediate Sensitivity map was further overlaid with a digitized coastal Dune Type map which ultimately resulted in the final Environmental Sensitivity map. The results of these overlays are described in this chapter.

Any reference to the coastline infers only that portion of the coastline which is covered by the study site, ie. from Cannon Rocks to Port Alfred.

4.2 THE THREE INDIVIDUAL COVERAGE MAPS

4.2.1 Cape Coastal Conservation Plan's modified categories

Figure 4.1 is the digitized map of the modified Cape Coastal Conservation Plan showing the sensitivity categories for the area between Cannon Rocks and Port Alfred.

Table 4.1 depicts the surface area (ha) of the Cape Coastal Conservation Plan's modified sensitivity categories from the V-High sensitivity category to the Low sensitivity category. These categories indicate the coastal sensitivities or conservation worthiness as depicted by the modified Cape Coastal Conservation Plan. The hierarchy of the perception categories in decreasing order of surface area is as follows;

Table 4.1. The surface area (ha) and range of the Cape Coastal Conservation Plan's sensitivity categories - surface area in decreasing order.

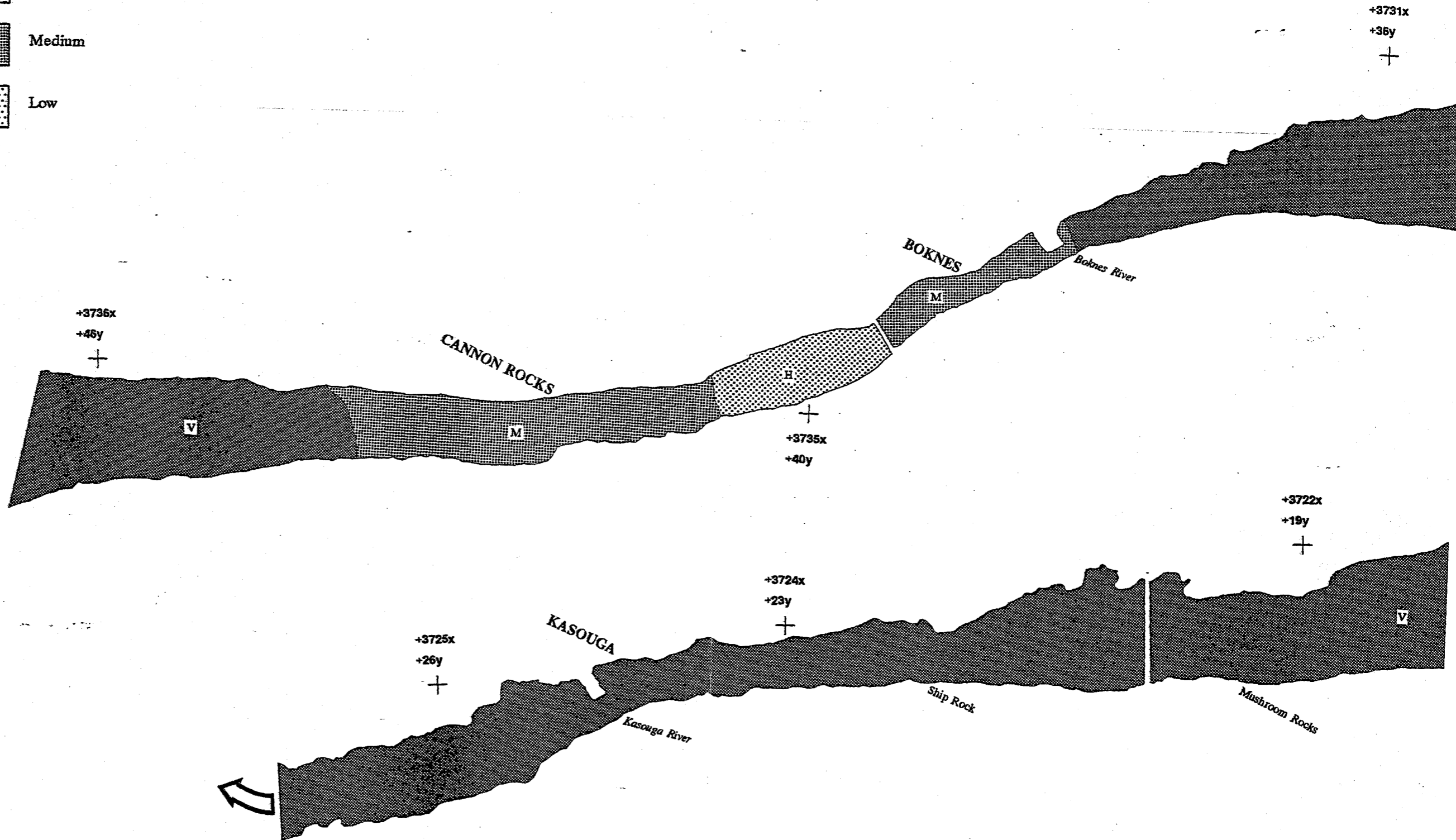
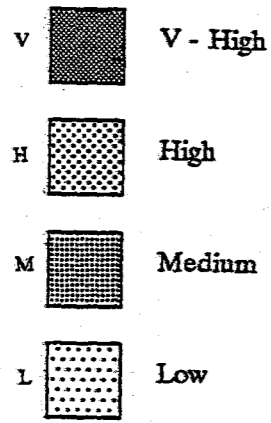
Sensitivity Categories	Surface Area Coverage (ha)	Range
V-High (purple + red)	2279.4	235.3 - 2044.1
Medium (yellow)	237.0	35.5 - 150.8
Low (brown)	64.6	64.6
High (green)	34.8	34.8
Total 2615.8		

The **V-High** sensitivity category, that with the greatest perceived conservation value, has by far the largest surface area (87.1 % of the coastline), ie. 2279.4 ha. This translates to almost ten times more surface area than the second largest category, that being the **Medium** sensitivity category. This **V-High** sensitive category now includes those areas which have existing formal conservation status and which should require formal conservation status. Only 9 percent of the coastline is perceived for full development. The **Low** sensitivity category, which has three fragments occurring at Cannon Rocks, Boknes and west of Port Alfred, covers 64.6 ha or 2.5 percent of the total surface area of the coastline, and the smallest category, the **High** sensitivity category, occurring between Cannon Rocks and Bokness, covers only 34,8 has or 1.3 percent of the total surface area.

Table 4.2 indicates the extent of fragmentation of the Cape Coastal Conservation Plan's modified perception categories in decreasing order of perceived conservation worthiness or coastal sensitivity. The hierarchy is as follows;

Figure 4.1. CPA's MODIFIED CAPE COASTAL CONSERVATION PLAN's SENSITIVITY CATEGORIES FOR THE AREA BETWEEN CANNON ROCKS AND PORT ALFRED.

ENVIRONMENTAL SENSITIVITY



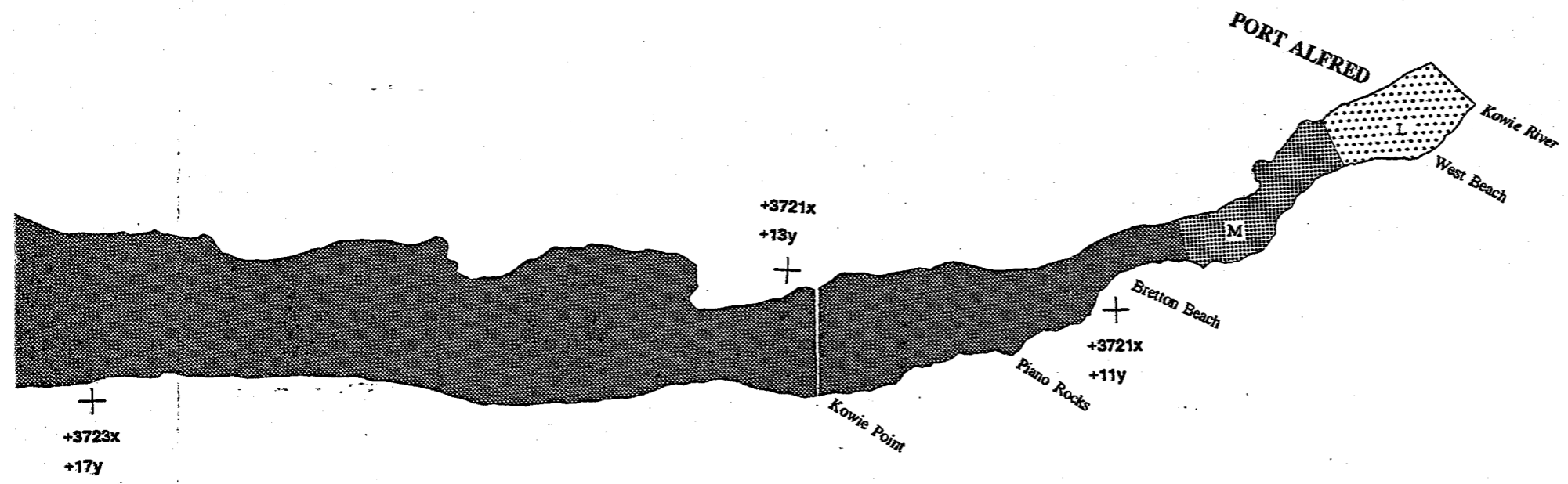
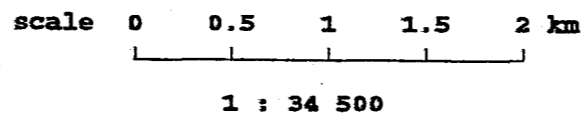
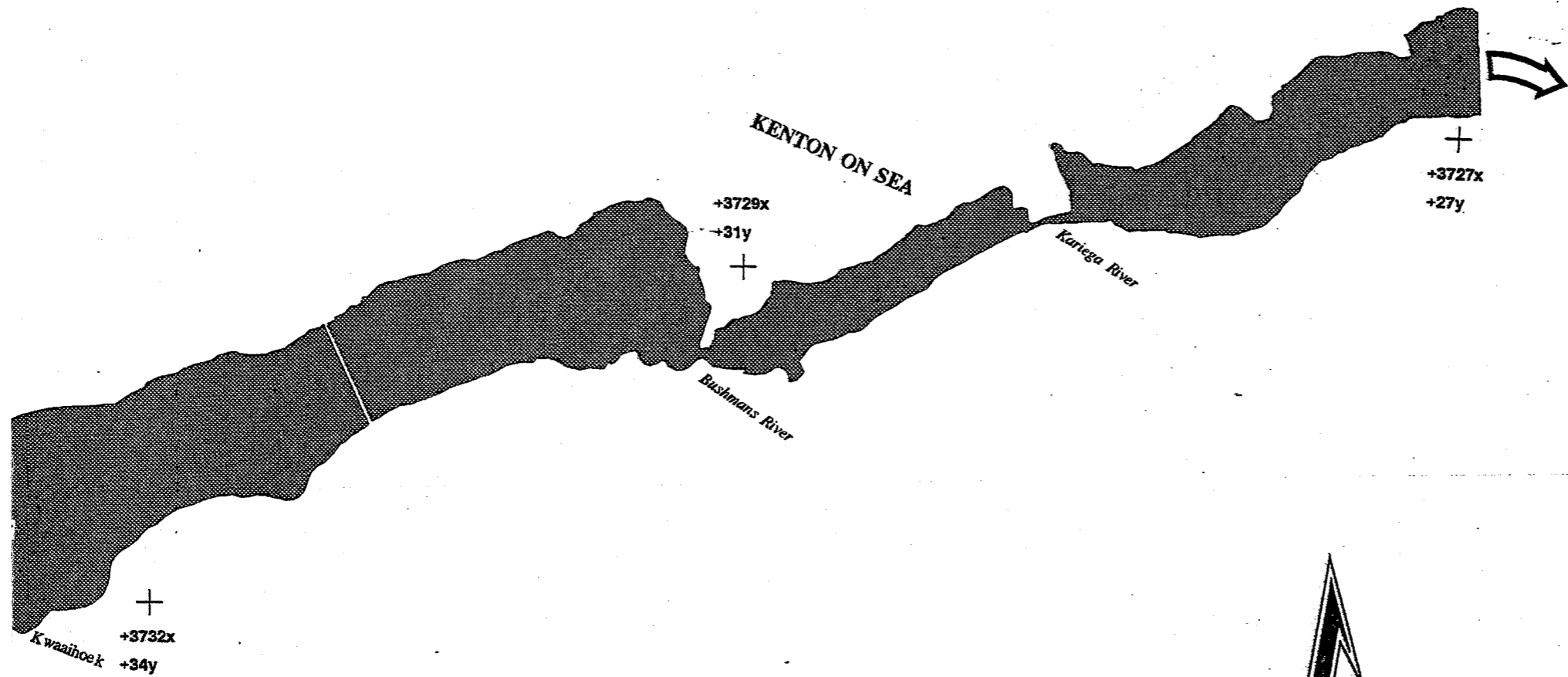


Table 4.2. The number of fragments in the Cape Coastal Conservation Plan's sensitivity categories - number of fragments in decreasing order.

Sensitivity Categories	Number of Fragments
Medium (yellow)	3
V-High (purple + red)	2
Low (brown)	1
High (green)	1

The **Medium** sensitivity category, covering 237 ha of surface area coverage, has the greatest number of fragments (three), consisting of a range of 35.5 ha to 150.8 ha, indicating three relatively smaller fragments. The **V-High** sensitivity category however, having by far the largest surface coverage within the study site, has two very large fragments (235.3 ha and 2044.1 ha respectively), indicating fewer but larger fragments.

4.2.2 Coastal Vegetation Importance Rating

Figure 4.2 shows the modified Coastal Vegetation Importance Rating map for the area between Cannon Rocks and Port Alfred.

Table 4.3 shows the distribution of the vegetation according to the sensitivity categories. The largest surface area (1705.3 ha) is the **High** Importance Rating Category, exhibiting 65 percent of the total area of the coastline. The smallest category is the **V-High** Importance Rating category having only 0.9 ha (2.5%) of the total coastline. The distribution of the vegetation sensitivities according to increasing surface area coverage is as follows;

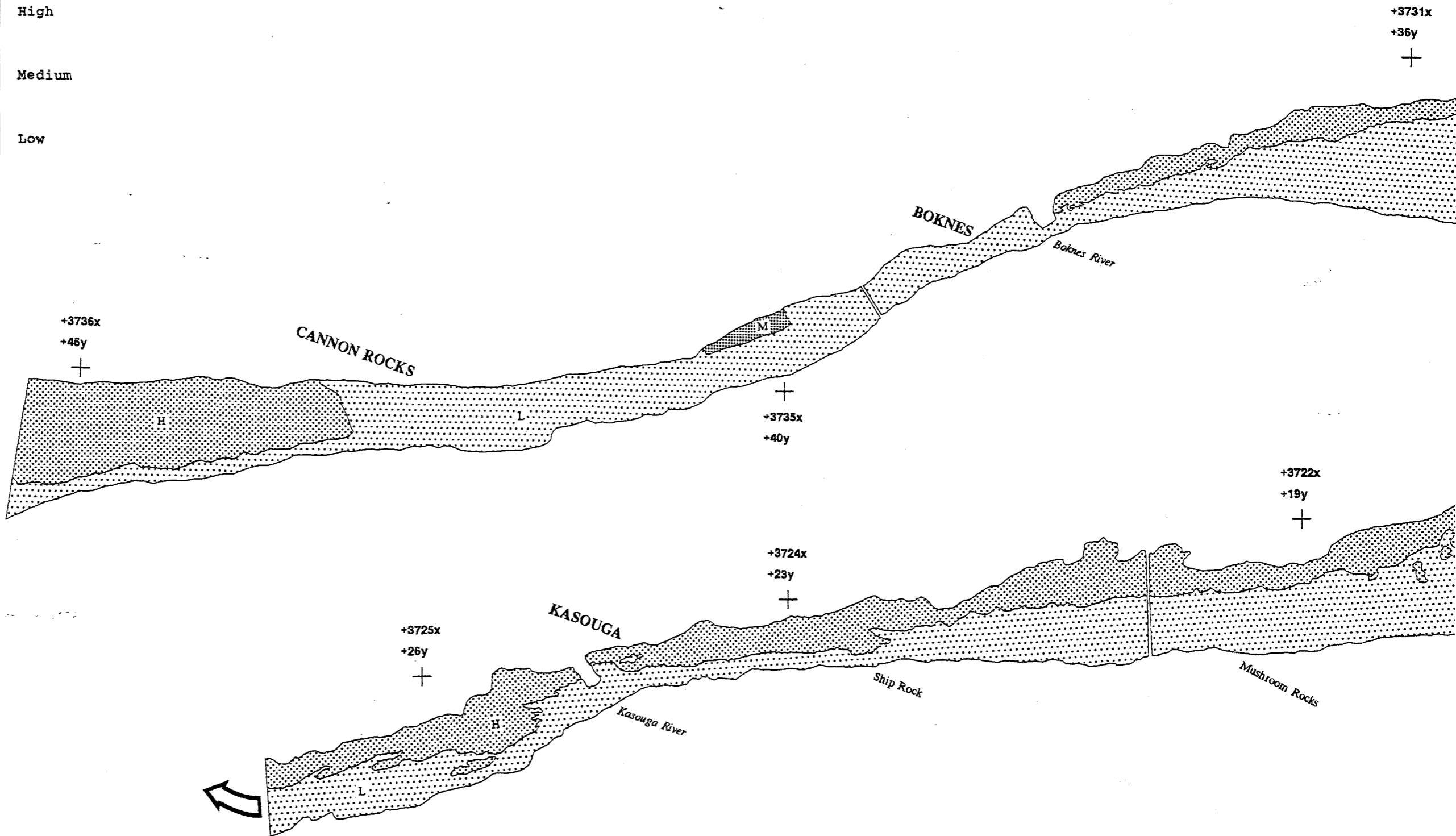
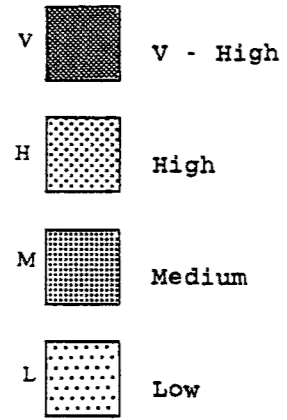
Table 4.3. The surface area (ha) and range of the Coastal Vegetation Importance Rating categories - surface area in decreasing order.

Importance Rating Categories	Surface Area Coverage (ha)	Range
Low	1705.3	0.8 - 1696.2
High	896.8	1 - 406.0
Medium	12.8	3 - 9.8
V-High	0.9	0.9

The vegetation having the most sensitivity (**V-High**), and therefore the highest conservation worthiness, has the lowest surface area (0.9ha) of the categories. This category constitutes only 0.03 percent of the total area. Of secondary importance, as far as surface area coverage is concerned, is the **High** Importance Rating category (896.8 ha) followed by the **Medium** Importance Rating Category (12.8 ha). The two categories (Low and High) constituting the largest portion of the coastline (2602.1 ha) with a total of 99.5 percent of the coastline. The Coastal Vegetation Importance Rating map indicates the large majority of the coastline (1705.3 ha or 65%) as having the lowest conservation value.

Figure 4.2. EMATEK's MODIFIED COASTAL VEGETATION IMPORTANCE RATING MAP FOR THE AREA BETWEEN CANNON ROCKS AND PORT ALFRED.

VEGETATION IMPORTANCE RATING



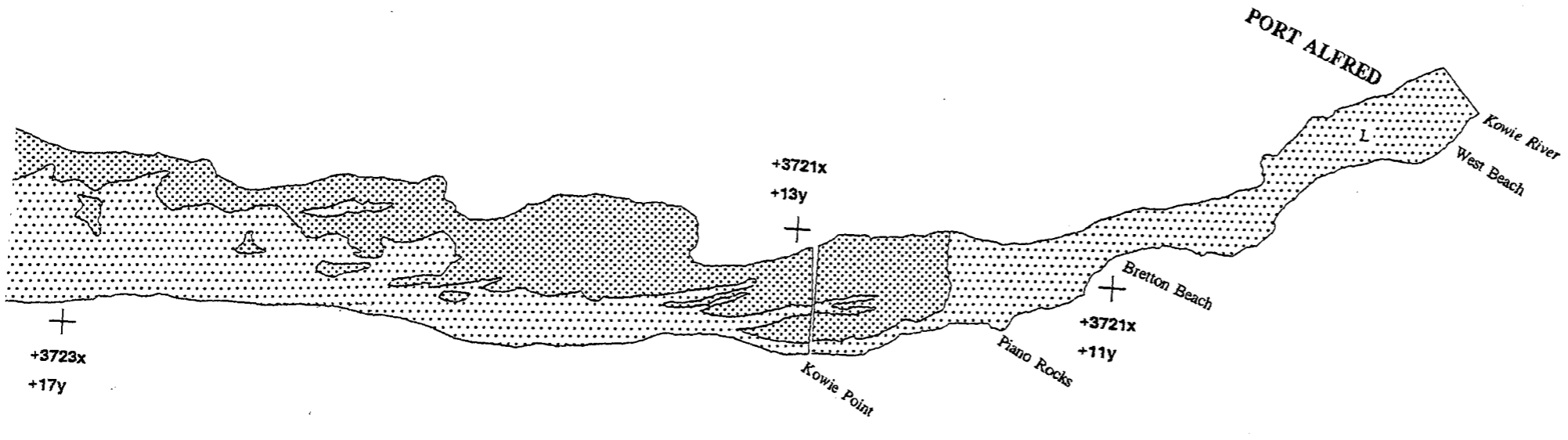
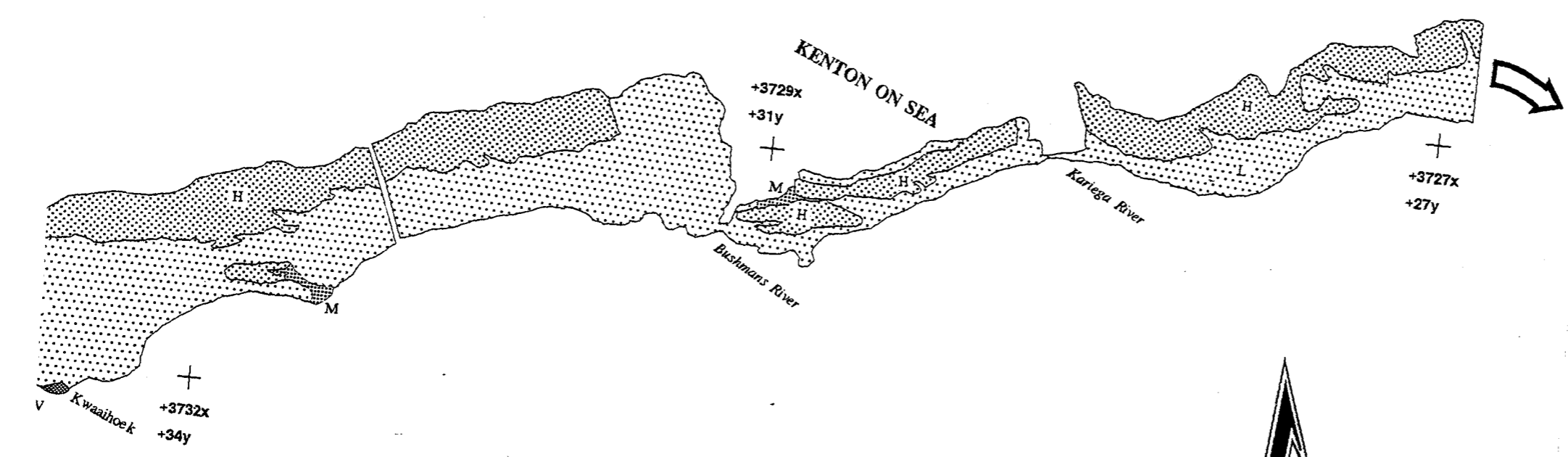


Table 4.4 depicts the extent of fragmentation of the modified Coastal Vegetation Importance Rating categories where the **V-High** category has only one fragment and the **High** Importance Rating category has the most (14) or 66.7 percent of the total number of fragments of the coastline. The very high rating category having only one fragment implies even greater conservation importance. This fragment is situated at the Kwaihoek aeolianite headland. The fragmentation in decreasing order of importance, ie. those having the most to the least fragments, are as follows;

Table 4.4. The number of fragments of the Coastal Vegetation Importance Rating categories - number of fragments in decreasing order.











Importance Rating categories	Number of fragments
V-High	1
Low	2
Medium	4
High	14

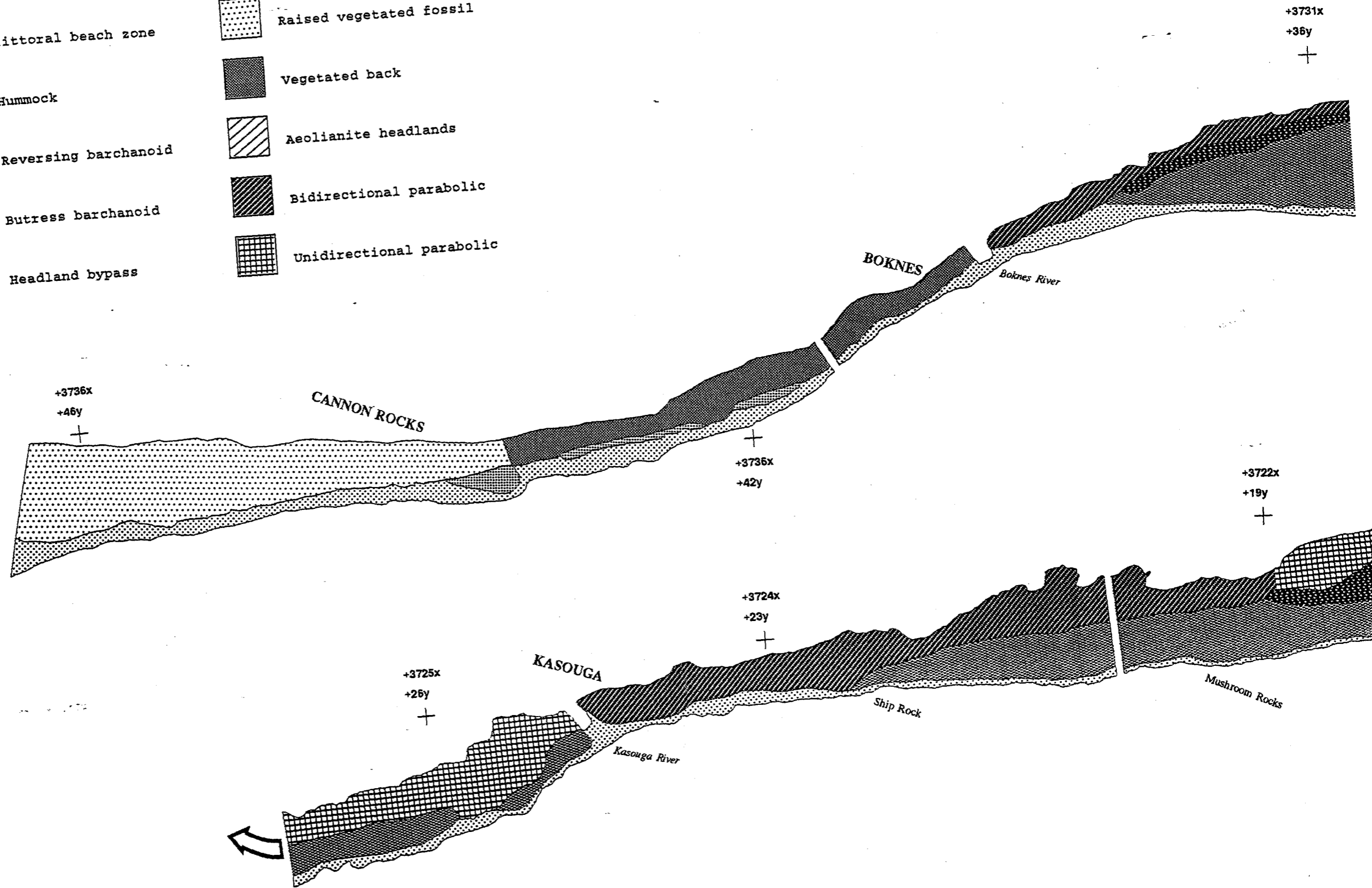
4.2.3 Coastal Dune Types

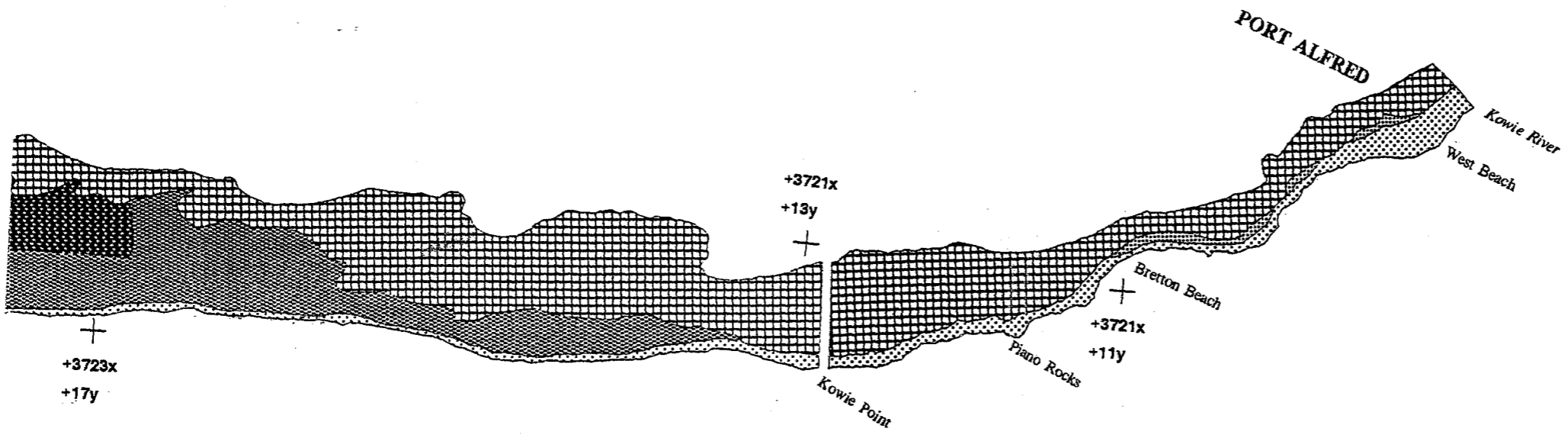
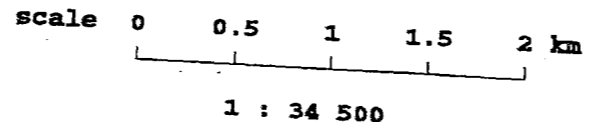
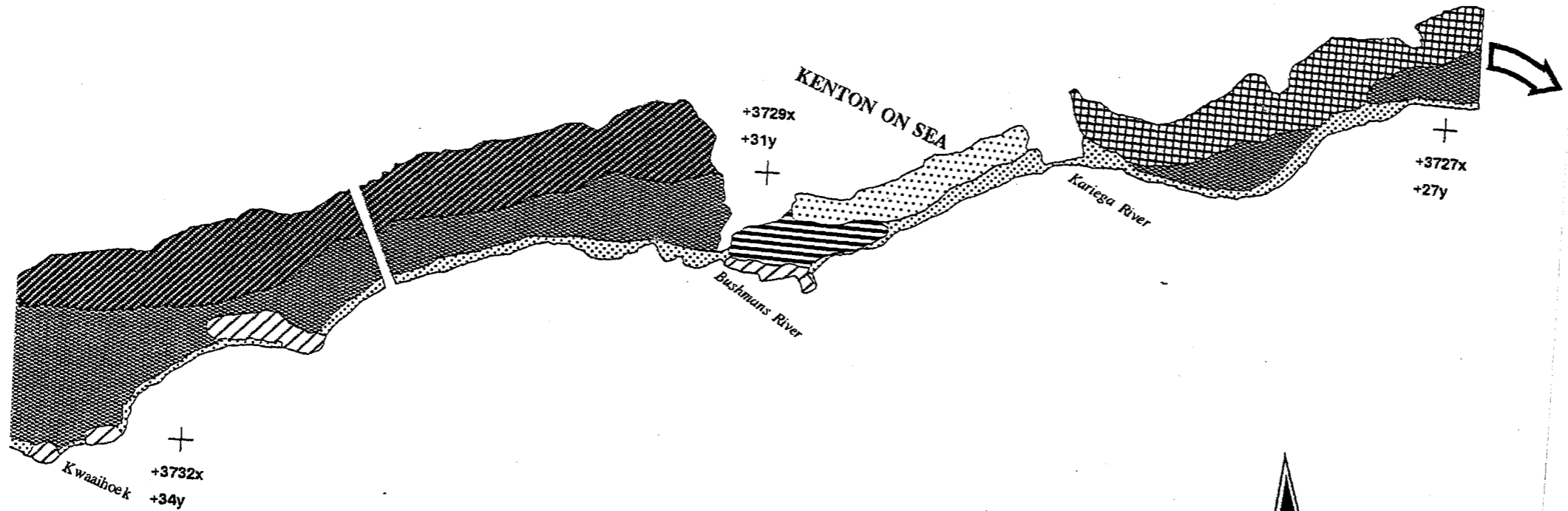
Each individual dune type has not been classified according to sensitivities, see Section 2, and therefore has been used as the basis on which to test the viability of the sensitivity classes. The dunes, therefore, were simply mapped and their two-dimensional surface area coverage determined, as with the original vegetation and perception maps. No modification into sensitivity categories, therefore, took place of the dune morphology. Figure 4.3 is the digitized map of the dune types occurring along the study site from Cannon Rocks to Port Alfred.

Figure 4.3. COASTAL DUNE TYPES FOR THE AREA BETWEEN CANNON ROCKS AND PORT ALFRED.

DUNE TYPES

- | | | | |
|---|----------------------|--|--------------------------|
|  | littoral beach zone |  | Raised vegetated fossil |
|  | Hummock |  | Vegetated back |
|  | Reversing barchanoid |  | Aeolianite headlands |
|  | Butress barchanoid |  | Bidirectional parabolic |
|  | Headland bypass |  | Unidirectional parabolic |





The total size range of coastal dune fragments, according to their surface area coverage, is from 0.9 ha to 374.9 ha. The reversing barchanoid dunes having the greatest size range (14.9 to 329.0 ha) and bidirectional parabolic dunes having a small range but very large surface area per fragment (203.6 to 231.8 ha), (Table 4.5). The aeolianite headlands have a small size range (4.6 to 9.9 ha) and also small individual fragment sizes. The hummock dunes constitute the smallest mean surface area (4.3 ha) and the unidirectional parabolic dunes the largest (286.1 ha). The dune types in increasing order of surface area coverage is as follows;

Table 4.5. Surface area coverage (ha) and range for the Dune Types - surface area in decreasing order.

Dune Type	Surface Area Coverage (ha)	Range
Aeolianite headlands	20.1	4.6 - 9.9
Headland bypass	20.3	20.3
Hummock	26.0	0.9 - 10.0
Butress barchanoid	75.0	21.8 - 53.2
Vegetated back	115.1	115.1
Raised vegetated fossil	297.3	32.3 - 260.2
Littoral beach zone	299.7	3.5 - 154.4
Bidirectional parabolic	443.4	203.6 - 231.8
Unidirectional parabolic	572.2	191.3 - 374.9
Reversing barchanoid	746.7	14.9 - 329.0

By far the most dominant dune types within the study area are the parabolic and reversing dune types with a total surface area coverage of 1762.3 ha, or 67.4 percent of the total coastal area. The smallest of the dunes are the aeolianite headlands, the headland bypass dune and the hummock dunes. These three dune types constitute a total of 66.4 ha, or 2.5 percent of the total area. The parabolic and reversing dunes are approximately ten times larger in surface area than the three smallest dune types.

Table 4.6 indicates the extent of fragmentation of the various dune types, and their fragmentation in decreasing order are as follows;

Table 4.6. The number of fragments of Dune Types - number of fragments in decreasing order.

Dune Type	Number of Fragments
Hummock	6
Reversing barchanoid	5
Littoral beach zone	4
Aeolianite headlands	3
Butress barchanoid	2
Unidirectional parabolic	2
Bidirectional parabolic	2
Raised vegetated fossil	2
Vegetated back	1
Headland bypass	1

The hummock dunes, which have the smallest surface area coverage of the dune types have the greatest number of fragments, inferring numerous small dunes, but the dune types with the least number of fragments (the vegetated back dune and the headland bypass dune) are also those dune types with the least surface area coverage. The parabolic dunes, however, have the largest surface area coverage but only have two fragments for each parabolic dune type. The dune systems of the study site have a combination of few - large, few - small, many - large and many - small dunes.

4.3 OVERLAYS

4.3.1 Overlay of Cape Coastal Conservation Plan and Coastal Vegetation Importance Rating map.

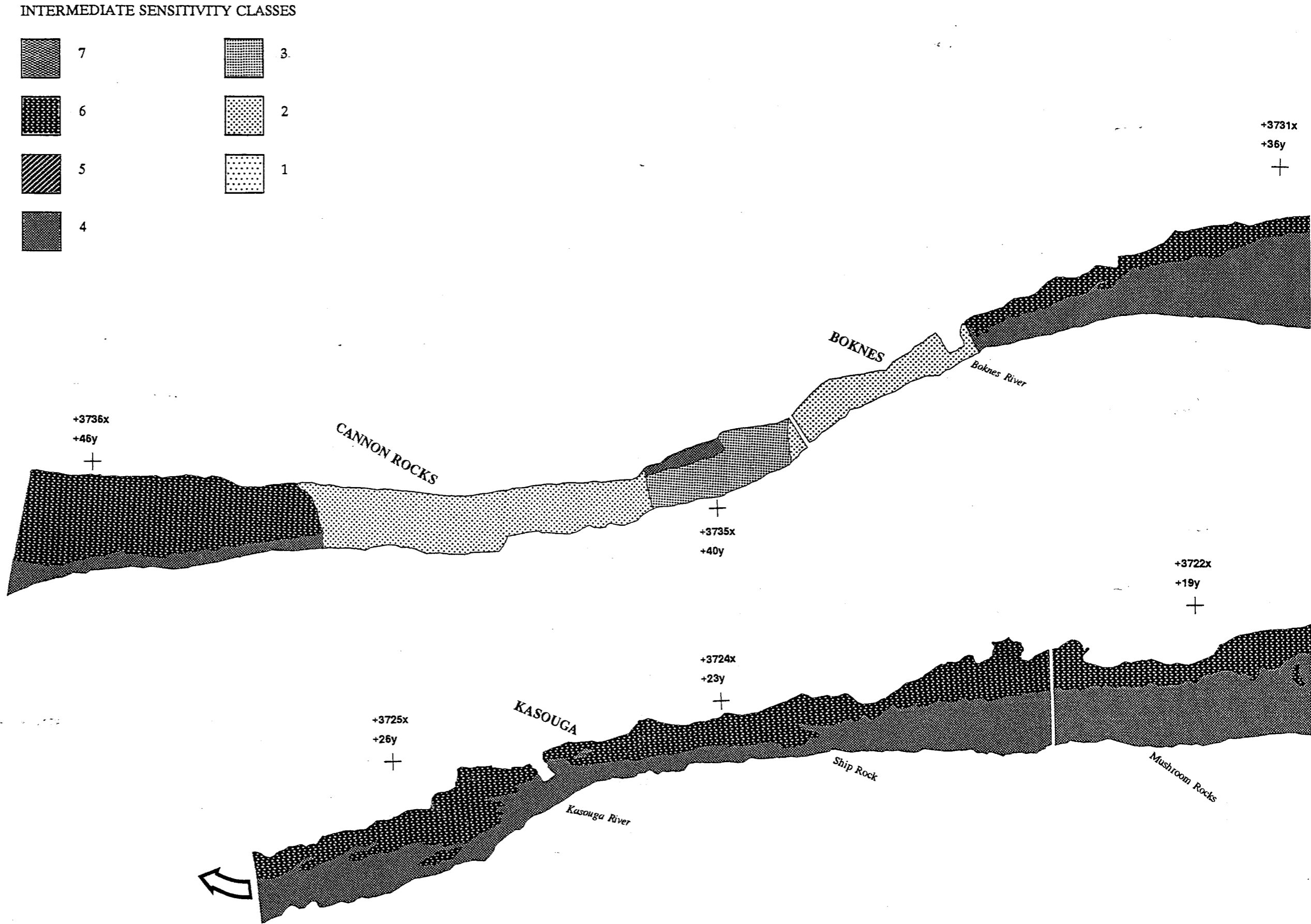
The result of the overlay of the planning policies, the Cape Coastal Conservation Plan and the Coastal Vegetation Importance Rating map is an **Intermediate Sensitivity Map** (Figure 4.4). The four categories from each of the conservation plan and vegetation rating map, after being overlaid, resulted in seven sensitivity categories being determined. These seven categories simply resulted from the distribution of the polygons and their configuration of the overlay process.

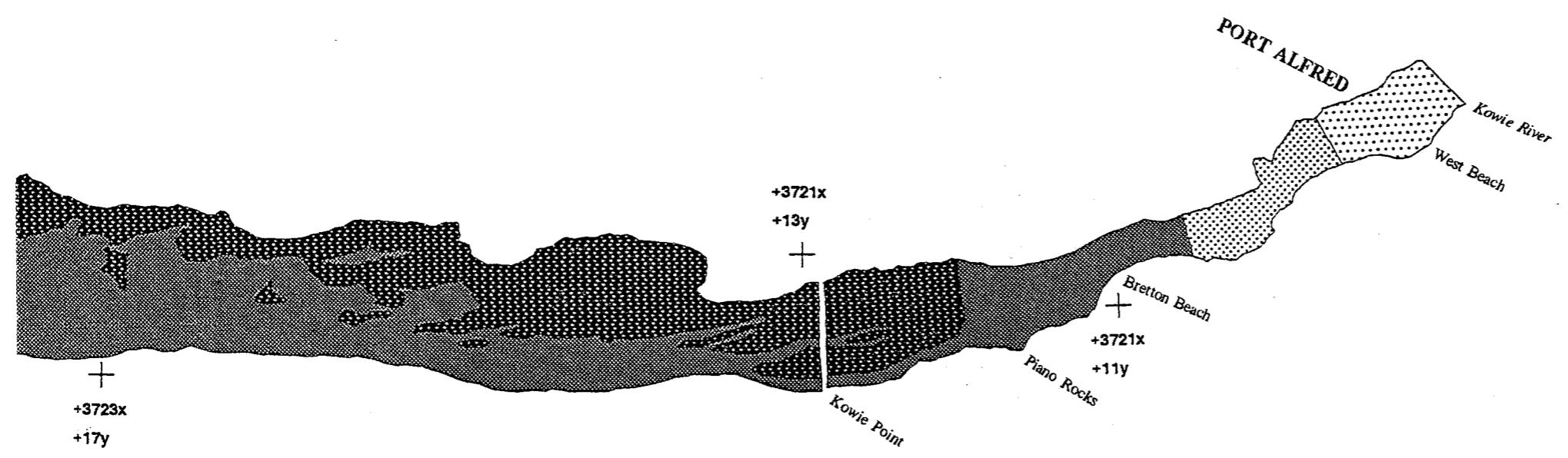
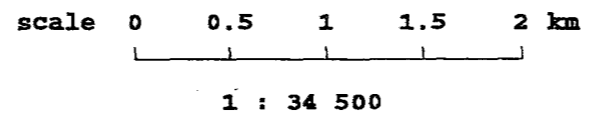
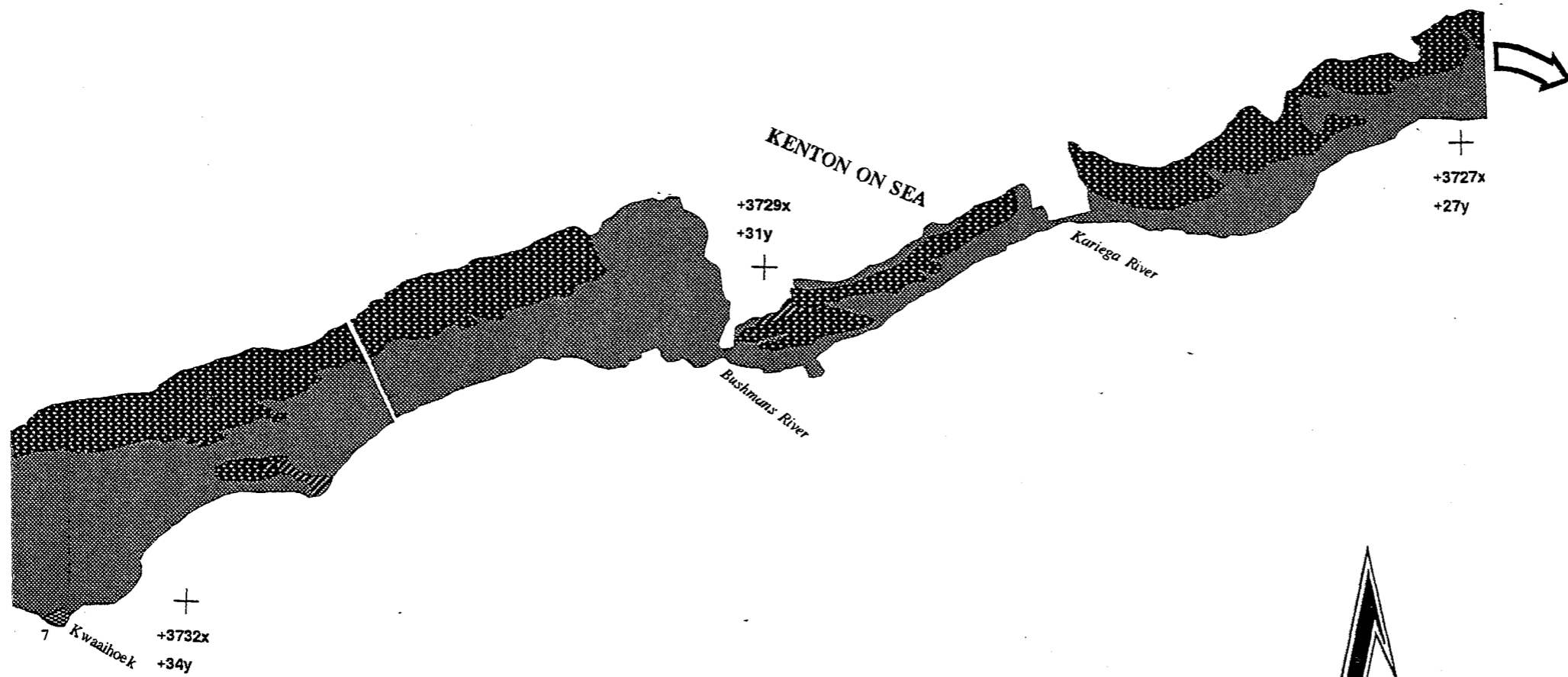
Category 7 has the highest conservation value and category 1 the least. Category 7 has the smallest surface area (0.9 ha) exhibiting 0.3 percent of the total area, and category 6 having 1030.1ha (39.4 %). Category 4, an intermediate sensitivity (conservation worthiness) category, had the largest surface area coverage of the coastline (1282.3 ha). The categories in increasing order of surface area coverage are depicted in Table 4.7 below;

Table 4.7. Surface area coverage (ha) and range of the Intermediate Sensitivity Classes - surface area in decreasing order.

Intermediate Sensitivity Classes	Surface area Coverage (ha)	Range
4	1264.3	0.8 - 1224.5
6	1015.1	1 - 307.0
2	243.4	32.6 - 161.1
3	54.8	45.8
1	33.3	33.3
5	3.2	1.2 - 2.0
7	0.9	0.9

Figure 4.4. INTERMEDIATE SENSITIVITY CLASS MAP FOR THE AREA BETWEEN CANNON ROCKS AND PORT ALFRED -
 (7) having the highest sensitivity and (1) the least.





The most sensitive category (7), has the smallest surface area coverage (0.9 ha) and the least sensitive category (1), having the lowest conservation status, has the third smallest surface area (33.3), or 1.3 percent of the total area. Categories 4 and 6 have the greatest surface area (2279.4 ha), or 87 percent of the study site.

Table 4.8 indicates the extent of fragmentation of the intermediate sensitivity classes - 6 having the largest number of fragments and 1, 7 and 3 the least. Sensitivity class 6 has both the most number of fragments and also the largest surface area, therefore exhibiting 14 areas of high sensitivity. The classes are ordered according to the decreasing number of fragments are as follows;

Table 4.8. Number of fragments of the Intermediate Sensitivity Classes - number of fragments are in decreasing order.

Intermediate Sensitivity Classes	Number of Fragments
6	14
4	6
2	3
5	2
3	1
7	1
1	1

Both the most sensitive and least sensitive classes have one fragment only, and both also have the smallest surface area coverage within the study site - 0.9 ha and 33.3 ha respectively. The class with the greatest surface area coverage (1264.3 ha) has 6 fragments, an average fragment size of 213.7 ha. Classes 1 and 2, having a combined mean total surface area coverage of 114.4 ha, constitutes 4.4 percent of the total area within the study site, they also have the lowest sensitivities or conservation worthiness.

4.3.2 Overlay of Dune Types and Intermediate Sensitivity Classes

The overlay of the dune types and the Intermediate Sensitivity Class map resulted in 33 separate fragments (Appendix 4.5), 7 from the Intermediate Sensitivity classes and 10 Dune Type classes. Once again these 33 categories simply resulted from the distribution of the polygons and their configuration of the overlay process. Thirty three separate environmental sensitivity classes was believed to be unrealistic and therefore an ordering and lumping of these classes was necessary.

One method of determining the sensitivity of dunes and their conservation value was to order or rank the dune types according to their specific sensitivity classes and more specifically the range of sensitivity classes in which each dune type occurred (Table 4.9). This table shows the result of ordering the surface area data from the two overlay maps. Firstly, the ranking of the Sensitivity classes from left to right enabled a further horizontal ranking and ordering of the dune types into broad groups (Table 4.9). This ordering lumped the dune types into similar categories in an attempt to classify the dune types according to a sensitivity scale.

On the highest conservation scale (occurring in high sensitivity classes) aeolianite headlands occurred in the 7 to 4 class scale with the littoral beach zone and hummock dunes occurring in the lowest sensitivity classes - those between 1 and 4. In between these two extremes, from high to low conservation value occur headland bypass, butress barchanoid and reversing barchanoid dunes (4 to 6 on the sensitivity scale), raised vegetated fossil and bidirectional parabolic (2 to 6 on the sensitivity scale), uniparabolic (1 to 6 on the sensitivity scale) and vegetated back dune (2 to 4 on the sensitivity scale).

Dune types having fragments larger than 100 ha are reversing barchanoid (sensitivity class 4 with 740.6 ha - having 5 fragments), raised vegetated fossil (sensitivity class 6 with 216.6 ha - having 2 fragments), bidirectional parabolic dunes (sensitivity class 6 with 349.5 ha - having 2 fragments), unidirectional parabolic (sensitivity classes 4 and 6 with 115.4 ha and 432.3 ha respectively - a total of 10 fragments) and the littoral beach zone (sensitivity class 4 with 248.4 ha - having 5 fragments).

Table 4.9 Dune types ordered according to Environmental Sensitivity Class clustering. Values indicate size of fragments in hectares (10 000 m²). Shadowed values are fragments larger than 100 hectares, and values in brackets are the number fragments for that category.

DUNE TYPE	INTERMEDIATE SENSITIVITY CLASSES						
	High						Low
	7	6	5	4	3	2	1
Aeolianite headlands	0.9 (1)	6.9 (1)	3.0 (1)	9.3 (2)			
Headland bypass		11.6 (1)	2.0 (1)	6.7 (1)			
Reversing barchanoid		1.1 (1)		740.6 (5)			
Raised vegetated fossil		216.6 (2)		11.3 (3)		63.8 (1)	
Bidirectional parabolic		349.5 (2)		84.9 (5)		1 (1)	
Butress barchanoid		17.2 (4)		9.1 (1)		3.4 (1)	1.5 (1)
Unidirectional parabolic		432.3 (5)		115.4 (5)		22.2 (1)	17.7 (1)
Vegetated back				9.8 (1)	33.6 (1)	71.7 (2)	
Hummock				2.5 (1)	4.8 (2)	14.7 (3)	
Littoral beach zone				248.4 (5)	16.4 (1)	73.7 (3)	15.6 (1)

Table 4.9 was further defined, from a to q, according to a manual ordering process whereby column 7 has the highest conservation value, column 6 the next highest conservation value, and so on.

The dune types were then ordered horizontally in rows according to the similarity of their range of fragments within the sensitivity classes (Table 4.10). For example, Raised vegetated fossil dunes and bidirectional parabolic dunes have fragments in sensitivity classes 6, 4 and 2. The dune type with the larger total area size per category is presumed to be slightly less sensitive dune to there being more of this dune type.

Table 4.10 The defining (a to q) of the Dune Types according to the Sensitivity Classes and a manual ordering procedure.

DUNE TYPE	INTERMEDIATE SENSITIVITY CLASSES						
	High						Low
	7	6	5	4	3	2	1
Aeolianite headlands	a	b	f	g			
Headland bypass							
Reversing barchanoid		c		h			
Raised vegetated fossil		d		i		m	
Bidirectional parabolic							
Butress barchanoid		e		j		n	p
Unidirectional parabolic							
Vegetated back				k	l	o	
Hummock							
Littoral beach zone							q

The summation of all the surface areas within the categories (eg., the aeolianite headland and headland bypass fragments occurring in the 6th sensitivity class, 6.9 ha and 11.6 ha, became 18.5 ha within the 2nd Environmental Sensitivity map) resulted in the compilation of the Environmental Sensitivity Class map.

The final overlay of the Dune types with the Intermediate Sensitivity class map has resulted in a final **Environmental Sensitivity Map** (Figure 4.5).

The range of seventeen classes generally has many small fragments and a few large fragments. Class 17 (Figure 4.5), having the greatest environmental sensitivity, only includes the Dias Cross aeolianite headland. Class 16 includes two slightly larger fragments, one at the headland bypass dune of Kenton-On-Sea and the other on a rocky aeolianite headland east of Kwaihoek. Class 15 incorporates a small bushclump pocket within the reversing barchanoid dune field between Mushroom Rocks and Kowie Point.

Classes at the least sensitive portion of the scale includes scales 1 to 5, having slightly different levels of development, which includes Cannon Rocks, Boknes and Port Alfred. The Kenton-On-Sea and Kasouga areas have a middle to upper range of sensitivity. Classes 6 and 7 occur between the settlements of Cannon Rocks and Boknes, and classes 8 to 14 constitute the various dune types within the coastal zone.

Figure 4.5. ENVIRONMENTAL SENSITIVITY CLASS MAP FOR THE AREA BETWEEN CANNON ROCKS AND PORT ALFRED -
 (17) having the highest sensitivity and (1) the lowest.

ENVIRONMENTAL SENSITIVITY CLASSES

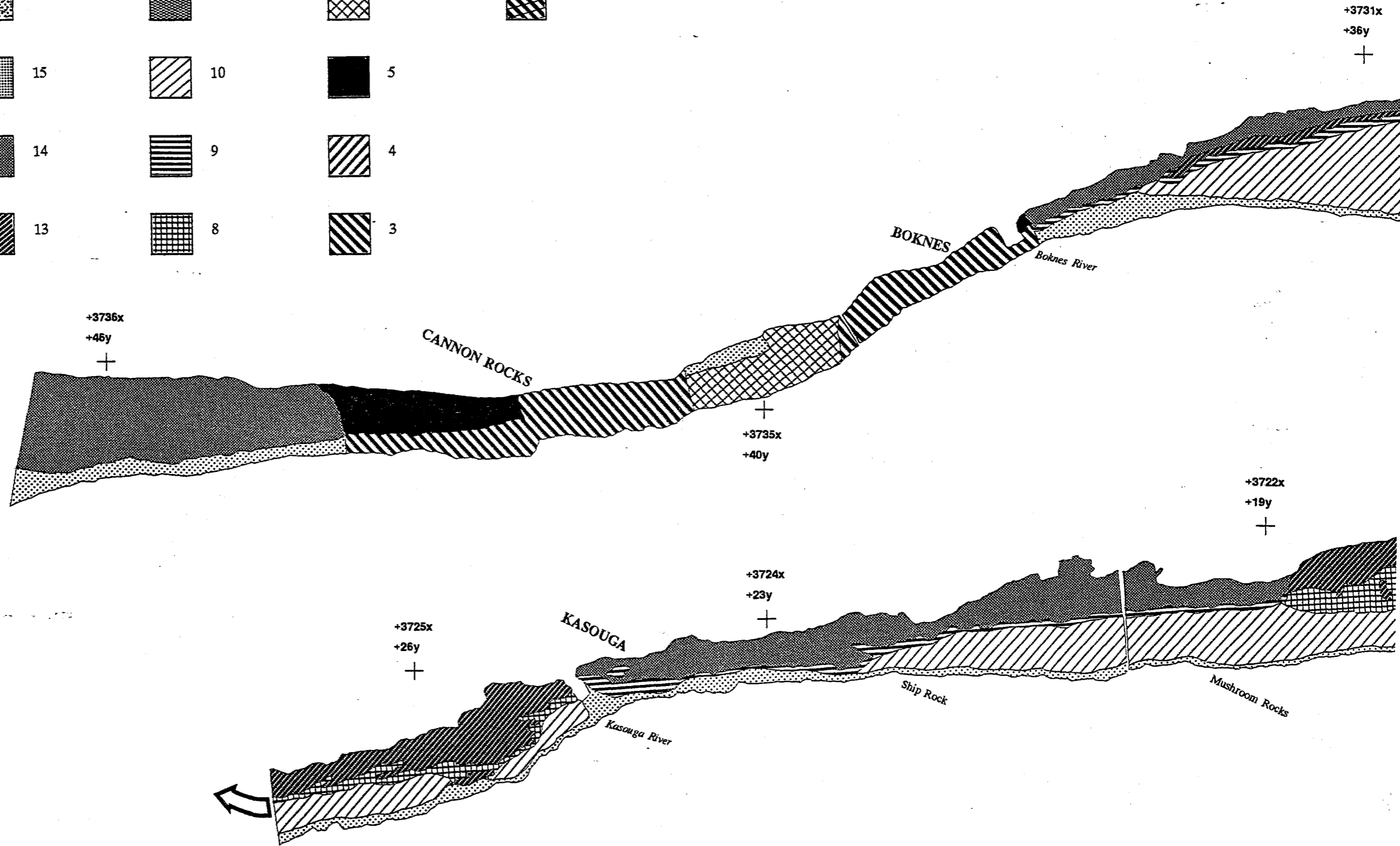
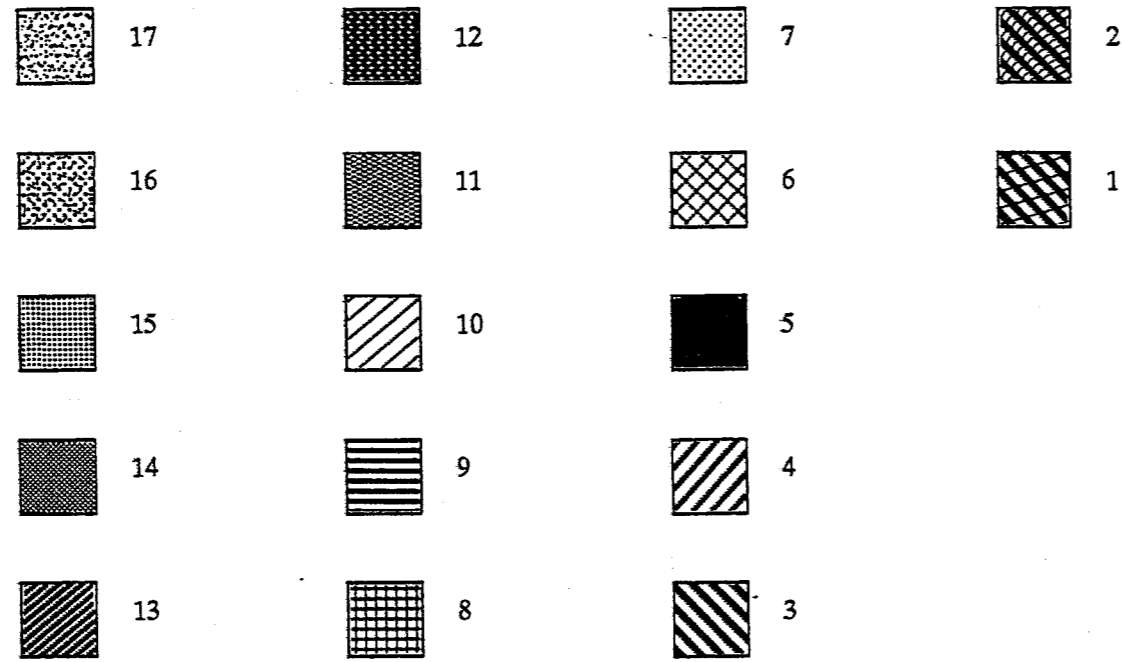
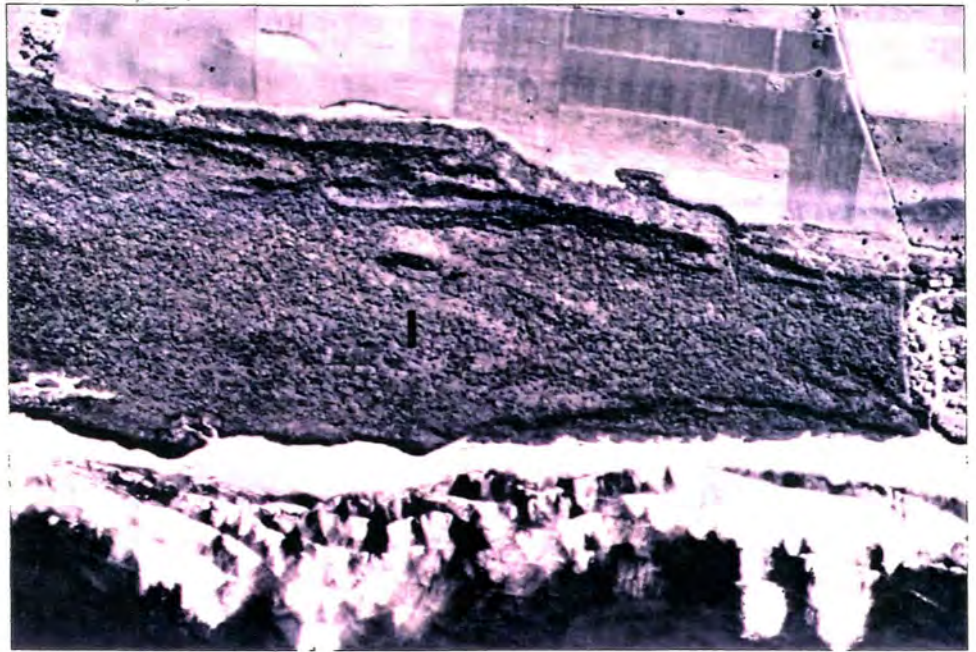


Plate 4.1

Well vegetated **Raised Vegetated Fossil** dune field west of Cannon rocks.

**Plate 4.2**

(a) Cannon Rocks residential area on **Raised Vegetated Fossil** dunes.

(b) The development of **Hummock** dunes south of Cannon Rocks.

**Plate 4.3**

(a) Badly invaded **Vegetated Back** dune field, by *Acacia cyclops*, east of Cannon Rocks.

(b) A wide **Littoral Beach** zone east of Cannon Rocks



Plate 4.4

An extension of Boknes River forming a natural boundary between the **Bidirectional Parabolic** dune ridge and the "terrestrial" component of the coastal zone.

**Plate 4.5**

(a) **Reversing Barchanoid** dune field, with well formed dune slacks, between Kwaaiohoek and Boknes.

(b) **Butress Barchanoid** dunes ridging in between the reversing Barchnoid and unidirectional parabolic dunes.

**Plate 4.6**

The Kwaaiohoek (Dias Cross) **Aeolianite Headlands**, or rocky promontories with good examples of halophytic plant communities.



Plate 4.7

Bushpocket thicket within
the Kwaihoek Reversing
Barchanoid dune fields.

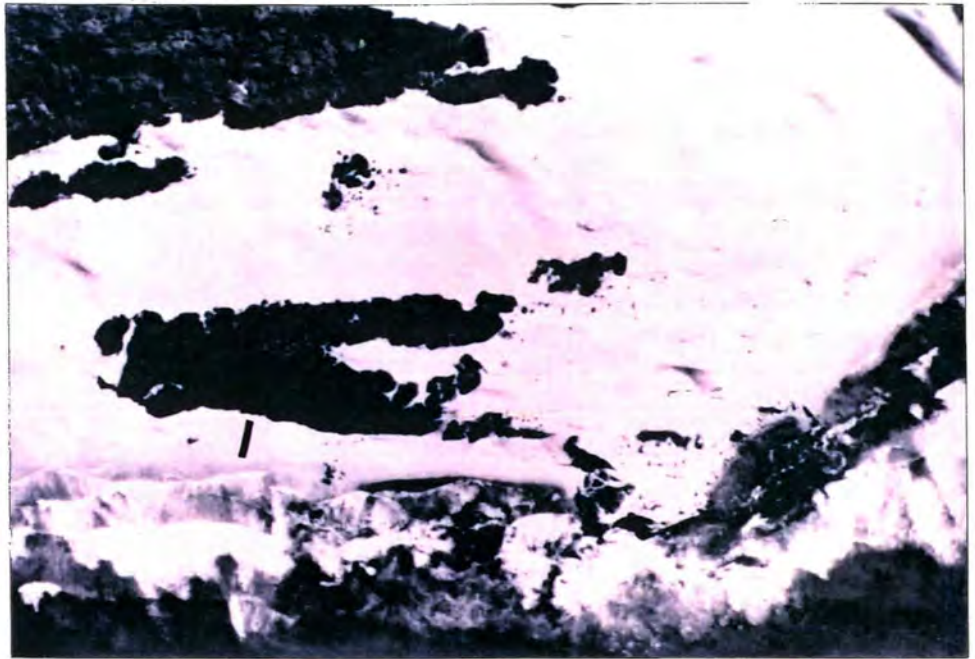


Plate 4.8

Reversing Barchanoid
dune field west of
Bushmans river mouth
reclaimed and stabilized
with *Acacia cyclops*.

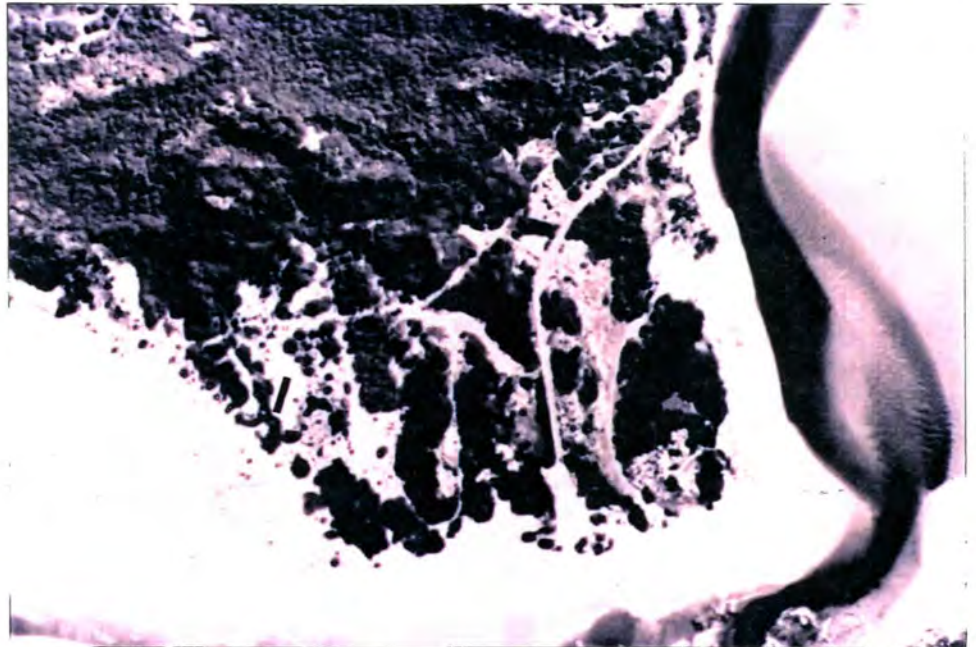


Plate 4.9

Headland bypass dune
field east of Bushmans
River mouth now
stabilized with *Acacia
cyclops*.



Plate 4.10

Kenton-On-Sea residential development on Raised Vegetated Fossil dunes. Mobile beach sediments have backed up against these ridges through onshore winds.



Plate 4.11

Bidirectional parabolic dunes east of Kariega River mouth.

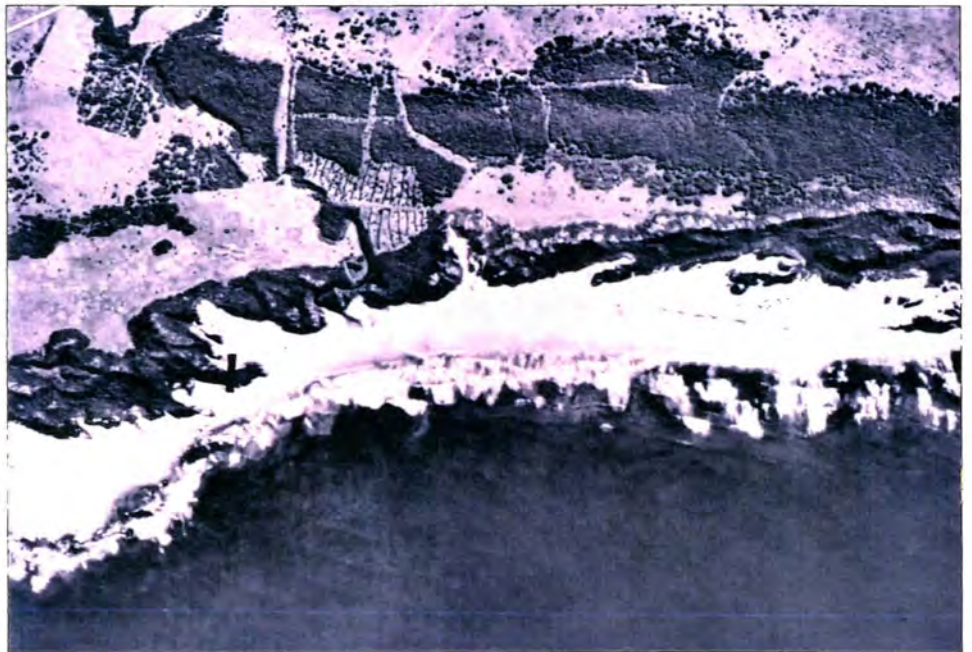


Plate 4.12

Bushpocket thickets within the Reversing Barchanoid dunes west of Port Alfred (note the blind river north of the dune fields).

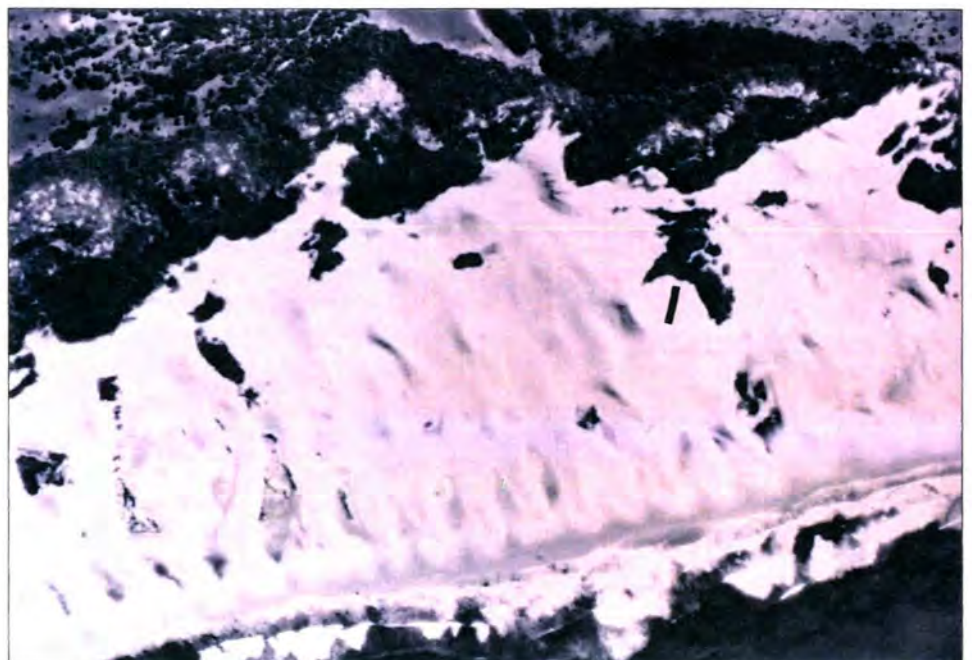
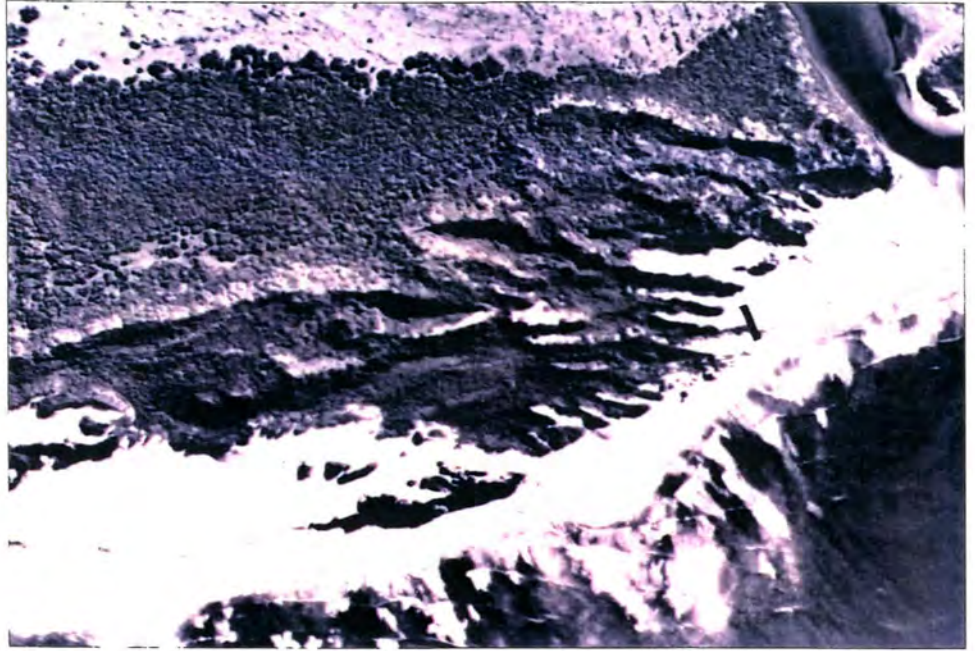


Plate 4.13

Bidirectional Parabolic
blowouts within the
Reversing Barchanoid
dunes west of Kasouga
river.

**Plate 4.14**

Well developed parabolic
blowouts within the
Unidirectional Parabolic
dune field west of Port
Alfred.

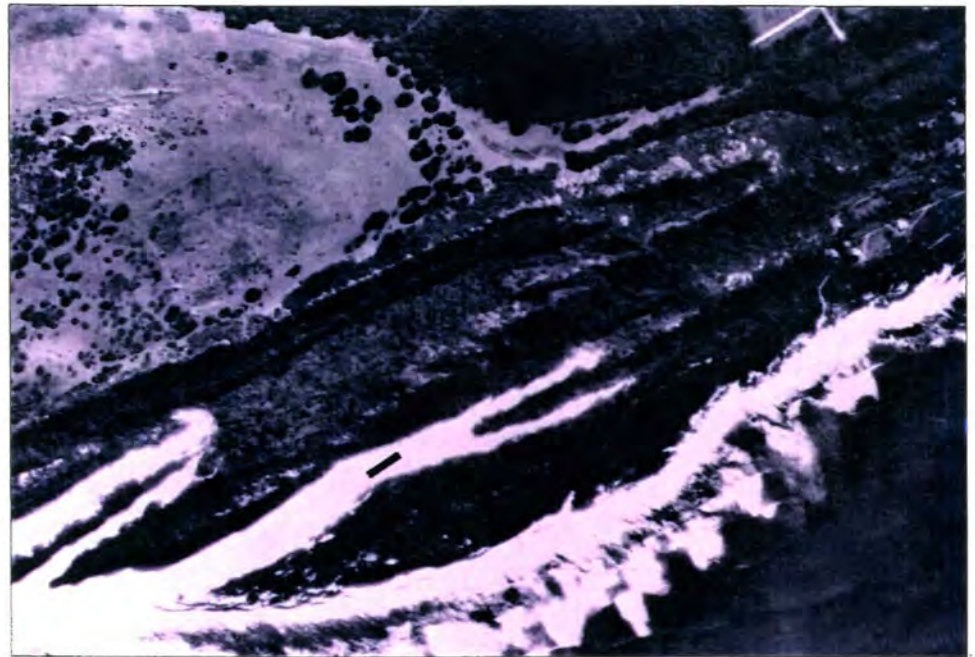


Table 4.11 indicates the final result of the overlay of the coastal sensitivity categories and the dune types. The relative surface area coverage, the number of fragments and the range of the dune types have been calculated for each of the sensitivity classes. The order of dune sensitivity is from **17**, having the highest sensitivity and **1** having the lowest.

Table 4.11. Surface area coverage (ha), number of fragments and range of the Environmental Sensitivity Classes.

	Environmental Sensitivity Classes	Surface area coverage (ha)	Number of fragments	Range
HIGH	17	0.9	1	0.9
	16	15.9	2	4.3-11.6
	15	1.1	1	1.1
	14	574.7	4	20.2-230.8
	13	379.9	8	1-252.2
	12	3.2	1	3.2
	11	16.8	4	1-12.3
	10	748.7	5	14.9-330.5
	9	111.8	6	0.8-65.6
	8	167.1	6	2.6-53.2
	7	246.7	7	1.5-125.4
	6	54.8	1	54.8
	5	64.8	2	1-63.8
	4	22.2	1	22.2
	3	147.1	3	11.4-107.0
	2	19.2	1	19.2
	LOW	1	15.6	1

The sensitivity class with the highest conservation value (17), a rocky promontory at Kwaihoek, has the smallest fragment (0.9 ha), only 0.03 percent of the total surface area of the study site. The largest series of fragments, consisting mainly of the reversing barchanoid dune fields in the Kwaihoek vicinity, along the coast from the Kariega River to the Kasouga River and the seaward dunes from Ship Rock to Kowie Point, have an intermediate conservation value, class 10, and a total 748.7 ha (28.6% of the area). These consists of 5 large fragments. Seven classes (classes 17, 15, 12, 6, 4, 2 and 1) have only one fragment with a combined surface area of 117.0 ha (4.5% of the total area). These classes only have an average surface area of 16.7 ha.

The Sensitivity classes from 7 to 14 (with the exception of classes 11 and 12) generally have fragments larger than a 100 ha in extent. These all have a medium to high conservation value and make up approximately 2229.0 ha or 85.2 percent of the total study site. These classes comprise mainly of the Littoral beach zone, Reversing barchanoid dunes and Raised vegetated fossil dune fields. Aeolianite headlands not having halophytic plant communities are also included.

Those classes having relatively lower conservation values have surface areas generally smaller than 70 ha in extent. These five classes (classes 1, 2, 4, 5 and six) comprise a total of 176.6 ha or 6.7 percent of the total area. The areas which have lower conservation values include the developed areas (Port Alfred and its immediate surrounds, Cannon Rocks and its surrounds and the town of Boknes. Class 3, which occurs on the Vegetated back dunes and beaches between Cannon Rocks and Boknes also has a lower conservation value. This site however is 147.1 ha in extent and comprises of approximately 5.6 percent of the total area.

4.4 CRITIQUE

In order to justify the use, and the relevance of, the original planning documents a critique was undertaken.

4.4.1 Cape Coastal Conservation Plan

This plan was initiated to alleviate *ad hoc* decisions being made on proposed coastal developments. The results obtained from this plan were obtained from questionnaires being sent to all possible Interested and Affected Parties (I & AP's). These were then returned, collated and sorted into two sets, the authorities perceptions and the NGO's perceptions.

This plan as a human perception plan and was not backed by or designed according to scientific methodology and interpretation. The response to the questionnaire was approximately 40 % of all returns (Southwood, 1992). However, this "data" was not subject to systematic, statistical or any form of unbiased synthesis or interpretation but based many on reputable or recognised individual perceptions. Those returns which "seemed" dubious or incomplete were discarded as being irrelevant.

It is reactionary in its purpose. This plan is a result of the problem of *ad hoc* decision-making by attempting to, primarily, address the dilemma of decision conflict between authorities and, secondly, to provide a standardised system of coastal classification according to "the conservation worthiness" of a linear section of the coastline.

Although not directly a criticism, there were originally many more NGO perceptions than authority perceptions thereby causing some initial doubt with regards the credibility of the final plan. The final plan being determined solely by the authorities.

Uncertainty arose by the contributors whether the coastline should be categorized according to what is actually been conserved at present or what should be conserved in the future.

On synthesising the data, as received back from the participants, it became evident that the response to the Cape Coastal Conservation Plan could be approached in two different ways. Either the respondents could have perceived the conservation status of the coastline as it is presently or perceived as it should be. The questionnaire, therefore, was based specifically on the latter: as the coastline should be, regardless of historical classification. However, state land in almost all cases was classified as purple as well as other land which was perceived as potentially having formal conservation status, therefore resulting in 81.5 % of the coastline being designated with formal conservation status. This plan also has no formalised policy thereby rendering it legally useless as an enforced planning policy document.

It is unfortunate that ambiguity was present in the questionnaire. This raises doubts as to the clarity and accuracy of data received back from the respondents which makes scientific synthesis and interpretation for the establishment of policy inconsequential. There can, however, be reasonable interpretation of the returned questionnaires on individual merit. Returns from the respondents could possibly be sorted out into those who were definitely commenting on what the future should be and those who gave an account of what is existing. Interpretation could be made of each group separately.

4.4.2 Coastal Vegetation Importance Rating

The advantage of this technique, besides being nationally acceptable, is that isolated patches of natural vegetation are taken into account and the long term conservation of species are considered (Jarman, 1986). Individual observer or researcher bias is minimized by the ranked grouping of habitats and communities. In order to test the validity of this mapping technique two sites were tested from each of the thirteen categories found within the eastern Cape, making it a total of 26 samples. The following points are a result of this test.

The vegetation of the Cape coastline was mapped to a scale of 1 : 10 000, ie. the end product is at a scale of 1 : 10 000, which is ideal for correlating and as overlays with orthophotos and colour aerial photographs. Aerial photographic interpretations pose limitations such as image warping, resolution differences and scale variation. However, the resolution of the vegetation categories (the coarseness or fineness of the vegetation categories) is not a level which

justifies using a 1 : 10 000 scale. The categories are too coarse and too broad thereby encompassing vegetation types which could otherwise be singled out.

Vegetation areas which looked similar were lumped and classified together as similar vegetation types. From maps and aerial photographs only broad categories can be made and not vegetation or community types. No distinction has been made between actual vegetation types, i.e. the distinctions between temperate Forest and Subtropical Thicket. All of the scrub, thicket, forest and dune types have been lumped into the category of fynbos and dune thicket mosaic. These distinctions have large implications for the conservation effort of plant communities from very localised developments.

The initial stages of mapping were using desk-top studies with the use of aerial photographs and orthophotos, which in itself is the correct method. It is at this stage and scale of the exercise that the mapping is used as the overlays without refinement of the vegetation categories and boundary locations. The ground-truthing exercise was not uniform to each of the predetermined vegetation categories, therefore, not all similar categories were ground-truthed to check the validity of their presumptions.

Percentage infestations of alien invasive plant species are given for each of the vegetation types after only one sample was carried out. In some cases the percentage infestation is higher and in others lower. In general though the broad categories were indicative of the vegetation as indicated.

Within each of the categories other community types, with varying sensitivities, were noticed but were not reflected as a component of the category.

The vegetation mapping was carried out at the "vegetation type" level whereas at a scale of 1 : 10 000 the "vegetation community type" could have been mapped. Admittedly, this would have increased the time and financial constraints which were the limiting factors in this case. However, one of the main aims of the sensitivity mapping was to facilitate decision making by authorities on proposed developments and it is these developments which occur within the intensive survey scale, i.e. scales between 1 : 2 500 and 1 : 5 000 (Tivy and O'Hare, 1981, as cited by Wallace, 1990). Precise quantitative data, from the ground-truthing exercise, is attached to only a few sample points, thereby extrapolating and relating precise

data to the entire set of coastal maps cannot be fully justified. For example, a vegetation category, which was ground-truthed by EMATEK, was extrapolated to other similar looking vegetation types. The data set was not thoroughly tested.

However, regardless of the negative aspects of this system it provides a basis for which holistic community data can be incorporated into a computer (GIS or data-base) thus enabling continual upgrading of the existing data and including yet unlisted sites. Spatial scales are easily modified thereby providing increased accuracy within the data set at a finer level of resolution.

CHAPTER 5.

DISCUSSION and CONCLUSIONS

5.1 INTRODUCTION

With the changes from a typically preservation approach to conservation to a biospheric approach land evaluation, assessment and ranking will become a more widely used system for conservation prioritisation. The increasing development pressure on the coastal zone will accentuate the need for an in-depth look into the land use patterns of the coast and the remaining conservation worthy areas. The level and extent of future development must be according to the conservation and sensitivity status of the existing coastal zone.

The realisation of the aims and objectives has, I believe, been achieved. Each of these will be discussed separately.

5.2 THE CONSERVATION WORTHINESS OF THE COASTAL ZONE

The ultimate conservation value or worthiness of the coastal zone will not depend solely on the individual planning documents but on the integration of these documents and the physical environment. This was achieved with the compilation of the Environmental Sensitivity Class map. Although a total of seventeen classes were created they give a range of sensitivities that can be associated to a range of conservation or development options. Classes 6 and 7 correspond to the vegetation rating map of agricultural and disturbed lands.

The middle range of Environmental Sensitivity Class map corresponds well with the dune types found in the study site, the top range of classes are associated with the aeolianite headlands and the bottom range of classes correlates well with the Coastal Vegetation Importance Rating map. There is little correlation between the final Environmental Sensitivity class map and the Cape Coastal Conservation Plan's perceptions.

This map can be overlaid over the particular stretch of the coastline which it covers and the particular conservation status noted. There are numerous techniques available for assessment and evaluation each having their own specific merits and advantages. This plan, however, is a first attempt at integrating other specific plans into a single working document for the coastal zone manager.

5.3 THE COMBINATION AND INTEGRATION OF THE COASTAL PLANNING AND MANAGEMENT DOCUMENTS AS A MEANS OF CREATING AN EFFECTIVE SINGLE PLANNING DOCUMENT.

This, the main aim of the study, can be briefly highlighted as the following - but taking into account the Key questions as further, more detailed explanations of this main aim.

Ecological evaluation techniques have been successfully used to classify or evaluate the relative conservation worthiness of the portion of coastline from Cannon Rocks to Port Alfred. The system-based approach, using IDRISI, enabled the comparison of the two formal planning documents and the dune types of the coastal zone. Even though the Cape Coastal Conservation Plan and the Coastal Vegetation Importance Rating map planning documents are in contradiction, they can be standardised and overlaid to form an intermediate map. Other biophysical data (in the form of maps) can be overlaid with the Intermediate Sensitivity map to create a final environmental sensitivity map.

In isolation these individual planning documents can result in confusion when determining coastal management strategies or in decision-making. By integrating a variety of biophysical data a decision-making or management tool can be produced. This map is then used by both the Authorities and NGO's as a basis from which to make decisions. There should then be very little discrepancy between the Authorities and NGO recommendations.

5.3.1 The relationship between authority and non-government organisations perceptions on the conservation value and status of the coastal zone.

In answer to the first of the Key questions, the assumption, from the results of this study, is that there will always be conflict between preservation (generally the NGO's) and development (Authorities), and yet the results of Chapter 3 show no significant similarity or difference between these opponents and proponents. It can be argued that there is a difference in management strategies or in the decision-making process, but little difference in what the perceived conservation status should be of the coastal zone. There now appears to be conflict within the authority organisations whereby they also perceive, along with the NGO's, much of the coastline to be conserved - but these decisions do not reflect their

perceptions of what the coastline should be like. Development proposals are still being supported and approved.

A conclusion to this contradiction could be the legislation under which the Authorities function, such as the Land Use Planning Ordinance or Physical Planning Act. It therefore appears that it is the legislation which ultimately determines the rate and extent of development and not authority perceptions.

The use of multivariate analysis techniques for the analysis of social data, in this case the perceptions of organisations towards the conservation categorisation of the coastline, is not a new approach. The classification, using TWINSPAN, and ordination, using DECORANA, techniques have elucidated no differences occurring between authority and non-governmental organisations perceptions of the coastline. Differences which were noticed were between the individual organisations as a whole, which is attributed to the fact that it was individuals which provided the perceptions. As such a single human perception plan could be used as a coverage overlay with the vegetation importance rating plan and the dune types. Multivariate techniques of peoples perceptions have highlighted the need to incorporate all interested and affected people when attempting to make decisions regarding the coastal zone. The use of the Integrated Environmental Management procedures takes general scoping into account which in effect takes all perceptions into account.

These findings highlight the necessity, when compiling coastal zone management policy documents, to take into account the variety of perceptions involved in decision-making. General consensus, according to pro-active democratic principles, should be attained before unilateral decisions are made by authorities and managers. The compilation of a series of biophysical overlays as a basis from which to create a single environmental sensitivity map must take into account perceptions from the Authorities and NGO's. This can be seen as the public scoping exercise of the IEM procedures.

This study has highlighted the importance allowing the environment to determine the level and scale of human interference - particularly that of coastal development. Architects, engineers and regional planners have the ability to site, design and construct any development in any type of landscape or environment. There is however very little evidence of development which has actually taken place with the environment as the key issue in

planning. The above planning and management are economically or politically based which normally manifests in developments which are now so familiar along the entire coastline. The general populace therefore perceives this as the norm which is comfortably accepted. The compilation of an Environmental Sensitivity map should create an equal basis from which both Authority and NGO's can make informed environmental decisions.

5.3.2 If there is any association between human conservation values and perceptions and the vegetation sensitivity of coastal dunes.

The four sensitivity categories/classes (V-High, High, Medium and Low), between these two maps, generally tended to be inconsistent with each other. The size of the fragments having the highest conservation value (V-High) were totally opposite for these maps. The Cape Coastal Conservation perception Plan's V-High sensitivity category included 2279.4 ha (87.1 % of the total area) as compared with only 0.9 ha (0.03 %) of the Coastal Vegetation Importance Rating map. The opposite also occurred with the High conservation values. The perception map has only 34.8 ha (1.3 % of the total area) designated to this category and the vegetation map 896.8 ha (34.3 % of the area). The Medium conservation category also follows the same trend as that of the V-High category for both maps. The Low category, of the perception plan has a low conservation value (64.6 ha or 2.5% of the total area). This low category for the Importance Rating map, however, has the largest surface area.

Overall these two map's conservation worthy categories show no similarities and depict contrasting conservation worthiness, for an identical site. For example, Beach areas of the south-westerly portion of the study site, west of Cannon Rocks, has been determined as having a low conservation status according to a vegetation importance rating plan and a very high conservation rating by the coastal conservation perception plan. This, obviously, for a coastal zone manager or decision-maker is a nightmare. Other sites with this identical problem includes the entire vegetated sections (the landward portion) of the coastal area from the Boknes River to slightly west of Port Alfred. On the other hand the only section of the vegetation map which has been designated as having a V-High conservation rating is the Dias Cross aeolianite headland, whereas with the perception map the entire portion of the coastline from Boknes River to Bretton Beach, west of Port Alfred, is been perceived as having V-High conservation value. This perception I believe to be unrealistic in both its goals and intent as

a planning document. It is perhaps an ideal conservation situation but realistically development will in the future be proposed from many sites within this area. A decision based on this plan will not justify the conservation cause or the planning profession.

The vegetation rating plan, however, goes to the opposite extreme. Due to the fact that only the presence of vegetation, and its sensitivity, was the criterion used for this plan, has led to the entire mobile dunes of this coastline being categorized as having a low conservation value. Those dunes having the occurrence of thicket, forest and fynbos have all been lumped into a single High conservation category giving these three coastal vegetation community types equal weighting. The medium conservation worthy category has those plant communities associated with invasion of natural vegetation or has become established through mans activities. This category does not include invasive alien plants. Within the study site only a small section occurs between the residential areas of Cannon Rocks and Boknes. The category having the lowest conservation value rating includes artificially established coastal vegetation, agricultural lands, alien invasive plant communities as well as open sandy areas. These open sandy areas are the mobile coastal dune fields. It is these same dune fields which are perceived to have the greatest conservation value. Even though the perception plan was based primarily on the "naturalness" of the area, including the state of the vegetation, it differs markedly from the vegetation rating map. It is therefore conclusive that a vegetation rating plan alone, on which to base a management decision, cannot be used in isolation.

5.3.3 The association between the Dune Types and the Planning Documents.

The coastal dune types were found to exhibit a form of sensitivity, by Rust and Illenberger (1994) at a broad level of classification, and at a more detailed level using the morphological types, this study. The ordering of the dune types and their fragments according to sensitivity classes resulted in this hierarchy of dune sensitivity from aeolianite headlands, headland bypass and reversing barchanoid dunes through to vegetated back dunes and hummock dunes to the least sensitive, the littoral beach zone.

Only by relating the Intermediate Sensitivity class map with the Dune Type map was it possible to prioritise the dunes in an order of sensitivity. By integrating the two planning documents into a combined intermediate map, and overlaying the dunes types with this

intermediate map, could a dune sensitivity hierarchy be determined. Typically the smaller more isolated dunes tended to have greater conservation values, such as headland bypass dunes, as well as those dunes associated with sensitive vegetation types such as aeolianite headlands and their associated halophytic plant communities.

Dunes which exhibited low sensitivities were those either associated with stable mature vegetation and those which experience the most frequent changes, such as hummock dunes and the littoral beach zone. Those dunes which fall between these two sensitivity extremes are those which display an interrelationship between wind velocity, the amount of available sediments and most importantly the dune vegetation. These are not normally stable dunes and are susceptible to disturbance or human impact.

The final map, the Environmental Sensitivity map, is the product of the Intermediate Sensitivity class map and the Dune Type map overlays to be used as a working overlay for coastal zone decision-making. This Intermediate Sensitivity map is a sensitivity map, which has no particular direct reference to any particular biophysical criteria, categorizes the coastal zone according to the environmental sensitivity or conservation worthiness of the site. The categories were according to a sliding-scale of sensitivity or worthiness. There is, however, a strong association between the final map and the vegetation status of the coastline - as a direct result of the vegetation rating map and indirectly from the perception based coastal conservation plan. The formation of most assessment or evaluation plans are based on the vegetation status of the area.

Tinley (1985) identified the butress dunes of the Eastern Cape as sensitive and they were regarded as priority areas for some form of protection. Daines (1991), however, has stated that in terms of sensitivity to development these butress barrier - in this study the butress barchanoid dunes - are not as immediately sensitive as some others. This was confirmed by this study. Others dunes in this study, which would be sensitive to disturbance, based on their conservation worthiness, includes aeolianite headlands, headland bypass dunes and reversing barchanoid dunes (transgressive dune fields).

There are few similarities between the Cape Coastal Conservation plan and the Dune Type map. The perception map categorises the coastal zone into "blocks", each having a sea and land boundary, whereas the dune type map has a series of category "layers" of dune types

from the sea landwards. The vegetation map shows more similarities with the dune type map. This is what would be expected as certain dunes are classified according to the presence or absence of vegetation.

5.3.4 The association between the perceived Cape Coastal Conservation Plan and the conservation worthiness of the coastal zone.

It was shown in this study that human perceptions of the conservation worthiness coastal zone is very much a personal judgment or opinion, according to their individual perception of what should be rated as conservation worthy. The lack of conclusive substantiation for a believed difference between non-Government organisations and authority or Government organisations negates bias, by one or another organisation, as to the management of the coastal zone. The Cape Coastal Conservation Plan's sensitivity map for the study area is unrealistic in its application due to the impractical weighting of 65 % of the area as having, or should having, a very high conservation status. This also implies that 65 % of this area should be formally classified as a Protected area - according to its original categories.

The Environmental Sensitivity Map, although having seventeen categories, is a more realistic reflection of the conservation value of the coastline. Only one perception, Rhodes Botany (Figure 3.3), reflects the spread of categories according to the Environmental Sensitivity Map. This could be interpreted as being the only realistic perception, given the present and future demand for development on the coastal zone. The results have shown the contradiction of these two maps, with respect to the surface area allocated for a particular conservation or sensitivity category. However, the integration of the Cape Coastal Conservation Plan with other planning documents, and the physical environment, has permitted the formation of the Environmental Sensitivity map.

5.3.5 The sensitivity and conservation valuable plant communities as a means of determining coastal zone sensitivity.

A few localised discrepancies did exist with the CSIR Coastal Vegetation Sensitivity Mapping, and the construction of 1 : 10 000 scale maps were not justified at the actual level

of vegetation sampling. An aspect of the vegetation survey which has not been thoroughly surveyed is the distribution of alien plant invaders. Although the surface area coverage of alien invader plants is calculated to be 77.3 ha the rate of invasion, densities and species distribution is not adequately known.

The difference between EMATEK's (1989) coastal vegetation categories - specifically the broad category of fynbos and dune thicket mosaic - and the categories determined by the other authors mentioned in section 2.2.2, can be equated with the same differences occurring between land cover classes and land use classes.

It has been shown in this study that the vegetation map shows the strongest similarities with the final Environmental Sensitivity map. This similarity leads to the conclusion that if seen in isolation the Coastal Vegetation Importance Rating map can be used in preference over the other planning document. The vegetation rating map can also be used as a first approximation for a site evaluation or management strategy. It has also been shown that even though EMATEK's vegetation rating map professes to take account of the vegetation at the plant community level, the level of mapping is too coarse. Updating of this map at the plant community level will increase the level of data resolution thereby increasing the map accuracy.

Vegetation occurring in the Environmental Sensitivity Class range 11 to 17 should be placed high on the conservation priority list for formal protection status. Plant communities occurring within these sensitivity classes include halophytic rocky communities and dune thicket and forest communities, both mature and immature types. All of these areas fall within EMATEK's high to very high importance rating categories.

5.3.6 The dependability and relatedness of these coastal planning documents.

The use of existing data and environmental policy as a test case for the compilation of a sensitivity map, as a determinant for conservation worthy areas, is feasible. Consensus should, however, once and for all be reached concerning a standardisation of environmental biophysical criteria. Scales of data collection and mapping should be determined, dune types standardised and rating systems designed to incorporate these environmental criteria.

The environmental overlay technique makes use of the ecosystem approach in determining the environmental status. Although not a micro-scale the ecosystem approach at a habitat level takes into account the major factors and forces which can be mapped, analysed and interpreted for management and development decision-making. The reconciliation between development aspirations and environmental and conservation ethics can be made possible by applying evaluation and synthesis techniques.

When developments are proposed the overall sensitivity map can be used to determine the desirability of the development, within a particular environment, as a result of the conservation categorisation of the sensitivity map. It becomes possible to pro-actively select alternative sites, on a regional scale, as potential development sites and to determine as a first approximation the conservation worthiness of a local site, in relation to the conservation status of a region.

Greater emphasis should be placed on quantitative data as an input, and modified into scores and score classes, into the mapping procedure. Added to this are rates of environmental change which, when monitored, can update the baseline data.

5.4 SCALE

The synthesis of environmental data relies heavily on existing data and the product and reliability of this synthesis is determined by the reliability of the data. The data used in this work varied in scale and resolution. Both temporal and spacial scales varied, but an attempt was made to standardise scales through a process of presumptive interpretation or subjective scale modification.

Map projections varied from 1 : 50 000, 1 : 10 000 and highly localised scales of 1 : 200 for site specific vegetation studies. These scales were modified to a common 1 : 10 000 scale which was suitable for GIS digitising and interpretation. Temporal scales varied from 1936 black and white aerial photographs to 1993 colour aerial photography. Research, in the form of vegetation and dune movement studies, was compared to research carried out in 1992. All modifications were made possible by taking a pragmatic and holistic approach to the concepts of environmental evaluation, synthesis and interpretation. The reality of coastal zone management makes use of all available data for an informed decision to be made.

Because the original conservation plan's purple and red categories were combined the modified purple category now has 87.1 % of the total surface area coverage of the study site.

This modification of the original Cape Coastal Conservation Plan has enabled the categories to be comparable with the other overlays. The combining of both conservation groups into one conservation group has not changed the interpretation from a perceived conservation view point. This studies understanding, therefore, presumes the perceptions to be according to what the conservation status of the coastline should be - which is in keeping with the aims and objectives of the study.

5.5 GEOGRAPHICAL INFORMATION SYSTEMS

The modification of data into a format for inclusion into a GIS process was relatively simple but the execution of the GIS package in order to obtain the desired synthesis of data for interpretation was extraordinarily difficult. The selection of a GIS package depends completely on the task at hand and the desired application and format.

The IDRISI GIS package was primarily designed for the manipulation of digital satellite imagery, for two-dimensional spacial analysis, and secondary as an overlay process. The IDRISI package was found to be unweildely and impractical for multiple overlays at one time and therefore comparisons were made between two overlays, producing a third overlay which was then compared with the next, and so forth. Vector data, such as linear utilities (roads, railway lines, power lines, etc.), complicates the overlay process which cannot easily be used within IDRISI. A vector GIS programme such as ARCINFO is better suited for this function.

A GIS system, however, can update environmental information which in turn could change the sensitivity classes and the ultimate sensitivity of the coastal zone. GIS therefore negates the recompilation of maps. A monitoring programme should be instated, for all non-static environmental parameters such as the changes taking place by the invasion of alien plant species, for the purpose of upgrading the overlay vegetation maps.

5.6 CONCLUSION

The planning of the coastal zone with the ultimate aim of being pro-active can be attained with the use of mapping techniques and an overlay system. Many environmental variables are taken into account regardless of the various temporal and spatial scales involved. The use of a geographical information system is becoming, in this age of computer technology, an essential tool for this purpose. However, care must be taken with the choice of GIS programme to be used for the digitizing, overlaying and synthesis.

The accurate mapping of the coastal vegetation, at the plant community level, is essential as a first approximation for any coastal zone management or planning document. Coupled with the vegetation are other biophysical overlays which add to the coastal inventory data base.

Conflicting perceptions, if standardised and combined, can be integrated into an overlay and synthesised with the biophysical data maps. This is the approach to integrated coastal zone management - perfection is not possible but can be approached asymptotically.

This practice of integrated coastal zone management removes the reactive sectorial approach and provides a pro-active holistic approach. Purely because of the huge array of role players in the coastal zone, integration of expertise, knowledge and disciplines are essential in providing realistic and pragmatic solutions to the present state of coastal management and decision-making practices. Land use sensitivity categorisation and mapping, coupled with the IEM philosophy is the only solution to an optimum coastal land use whereby the majority of coastal users perceptions are satisfied.

I believe the utilitarian ethic of Avis (1992) human/use perception pyramid of decreasing importance is valid for some areas of the coastline but the majority of development and management decisions are based on economic aspirations and market forces (Figure 5.1).

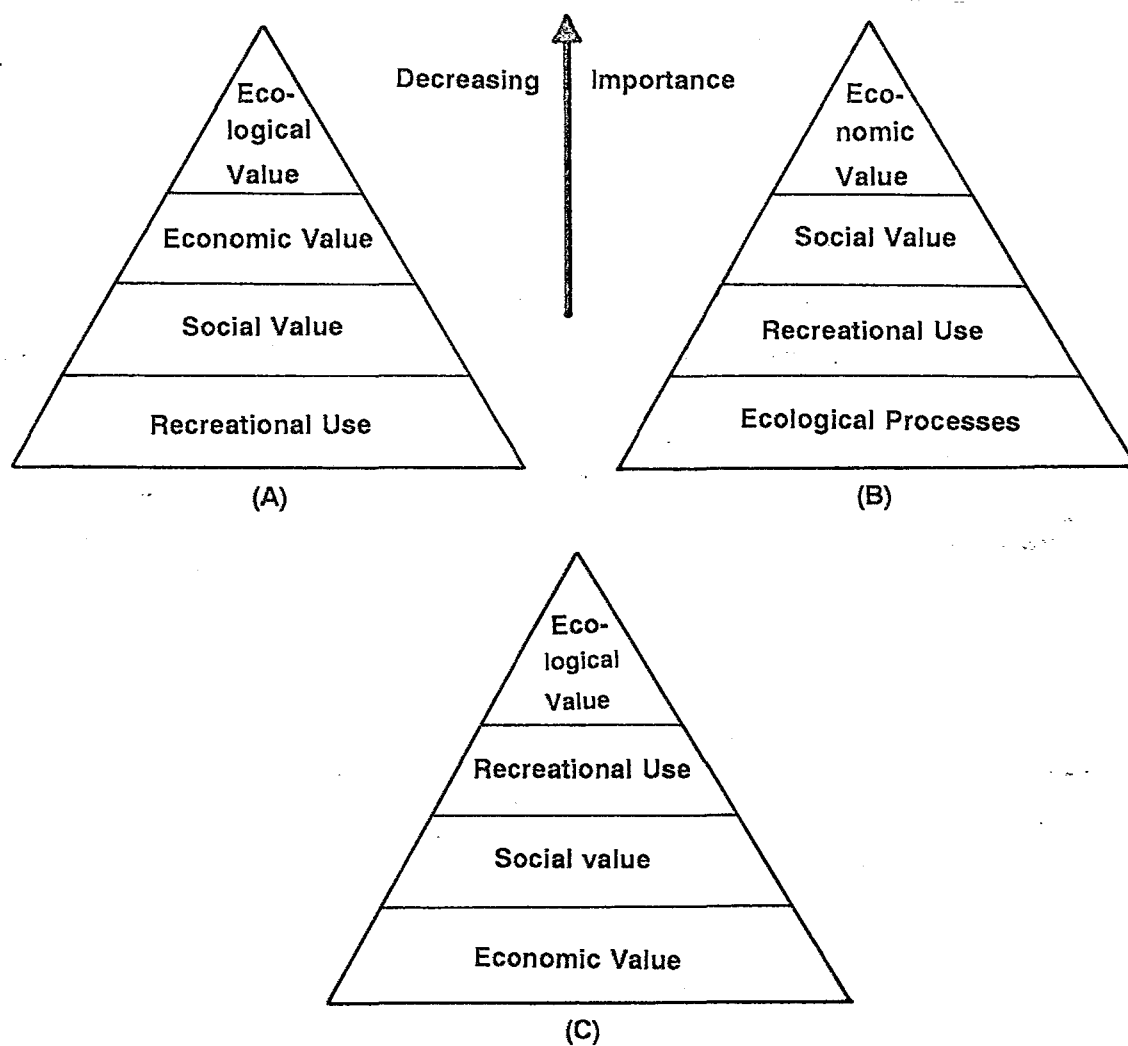


Figure 5.1 Human use/perceptions of the coastline (A) an utilitarian ethic and (B) a maintenance of ecological processes for sustained utilization (modified after Avis, 1992). (C) reflects a utilitarian reality as determined by the product of market forces, authority perceptions and decision-making (this study).

Individual perceptions vary widely from one individual to another but collectively a single perception can be determined. From the results presented the majority of organisations perceived the coastline within the study area to consist primarily of conserved dune systems - with status. This includes authority organisations which are involved in decision-making. However, the desired authority perceptions and their final decisions are normally in conflict. Two possible reasons can be attributed to this conflict, namely legislation which does not take into account environmental factors and/or political expediency.

It can therefore be concluded that a management decision based solely on the Cape Coastal Conservation plan or to a lesser extent only the vegetation of an area may not reflect the true conservation value of the area. One could argue that all remaining sites of undisturbed coastal environment are inherently valuable and that all should have formal conservation status - it is unrealistic and romantic to believe that all future development can be prevented from a site based on this plan.

Human perceptions are those social values which ultimately determine the aesthetics and resultant development on the coastal zone. The conflict which now arises is that the perceptions of the environmentalists and that of the developers are not in harmony.

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APPENDICES

CAPE COASTAL CONSERVATION PLAN : PHASE 2

There has been very good response to the first phase of this Project (which attempted to identify parties whose contributions would be vital in drawing-up of a conservation strategy for the Cape Coast). You have expressed your interest or have been nominated, as have other local authorities, governmental and semi-governmental agencies, private conservation bodies, coastal developers and development consultants as well as recreational user-groups and informed individuals.

In order to achieve consistency in responses it is, however, important that there should be agreement on the terms used and categories proposed :

DEFINITIONS :

Coastal area : The coastal area considered in this Plan is that part of the land/sea interface whose characteristics are or have been determined by the marine environment. It includes the close inshore area; that part of the coastline which is "sensitive" due to the physical processes occurring there (e.g. drift-sand areas); vegetated areas which are easily destabilised (e.g. vegetated dunes); adjacent coastal land where this forms an aesthetic unit with the coast; and the banks and flood-plain of tidal rivers. This area has been defined by a "coastal sensitivity line" on a set of 1:10 000 master plans by the C.S.I.R. and Cape Nature Conservation, and varies from less than a hundred meters wide to more than a kilometer.

Category 1 : ("Protected areas"). These are land areas in State ownership with existing formal conservation status. They are indicated on the maps, and do not include private nature reserves (whose conservation status is voluntary).

Colour code purple

Category 2 : ("Conserved" Areas). These are areas in private or public ownership whose natural characteristics and sensitivities are such that they should be protected and where it is recommended that any form of resort or residential development should be excluded. (Limited, controlled access may in some cases be compatible). This category should only be assigned with discretion as it identifies conservation-priority areas which should in time acquire formal conservation status or some other form of guaranteed protection.

Colour code red

Category 3 : ("Conservation with Development" Areas). These are coastal areas where small-scale, environmentally sensitive new development could, from an environmental perspective, be acceptable. It is proposed that there should be a development "quota" on each similar property in this category and that this should not normally exceed 2 to 10 units per kilometer of coast (the greater number being recommended where there are definite advantages for conservation of the coastal area. These units should be limited in size and clustered in not more than two clusters per property to reduce impact. They should also be established in stable areas and should not visually or physically intrude on the coast.

Colour code green

Category 4 : ("Development with Conservation"). These are existing resort/residential development nodes. Expansion to immediately adjacent areas should be indicated where this is recommended. Development in this category should be placed in environmentally-acceptable locations and should be clustered to preserve the character of the coastal environment. Final expansion should take into account the carrying capacities of coastal amenities (which may be augmented, by appropriate facilities e.g. "tidal pools", where necessary).

Colour code yellow

Category 5 : ("Development" Areas). These are existing nodes of standard urban/industrial/residential development where expansion is laid down in structure plans and development rights. Development should however take coastal processes into account and should (as in other categories) be subject to the Guidelines of Coastal Land-use of the Council for the Environment. Recommended expansion (or conservation categories within the "development area") should be indicated.

Colour code brown

INSTRUCTIONS :

Please indicate your recommendations for the categories you are interested in, using a clear line on the map in the appropriate colour code as per example. Although the scale used is coarse, landmarks as reference points should be easily recognised. (Maps have been reduced from 1: 50 000 to the scale which is indicated on the sheets).

No motivation is required: if you wish to bring particular aspects to our attention, please do so on a separate sheet referring by number to the map in question. We would also welcome any comment on the categories and specifications proposed.

PLEASE SUBMIT MAPS BEFORE 15 TH MAY 1992.

COMMENTS :

Obviously it will not be possible to achieve consensus amongst all participants, nor will it be possible to impose the Coastal Conservation Plan on development proposals which have already been approved in principle. This is also the first attempt at determining a specific environmental base-line for coastal development and it will be refined in the future.

Thank you for participating. You will be receiving feed-back in the future.

Chris Gaigher : Head : Ecological Investigations
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Colour code green

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Chris Gaigher : Head : Ecological Investigations
Alan Southwood : Senior Conservation Scientist



WETENSKAPLIKE DIENSTE
EKOLOGIESE ONDERSOEKE

SCIENTIFIC SERVICES
ECOLOGICAL INVESTIGATIONS

PRIVAATSAK Y6546, GEORGE 6530

PRIVATE BAG Y6546, GEORGE 6530

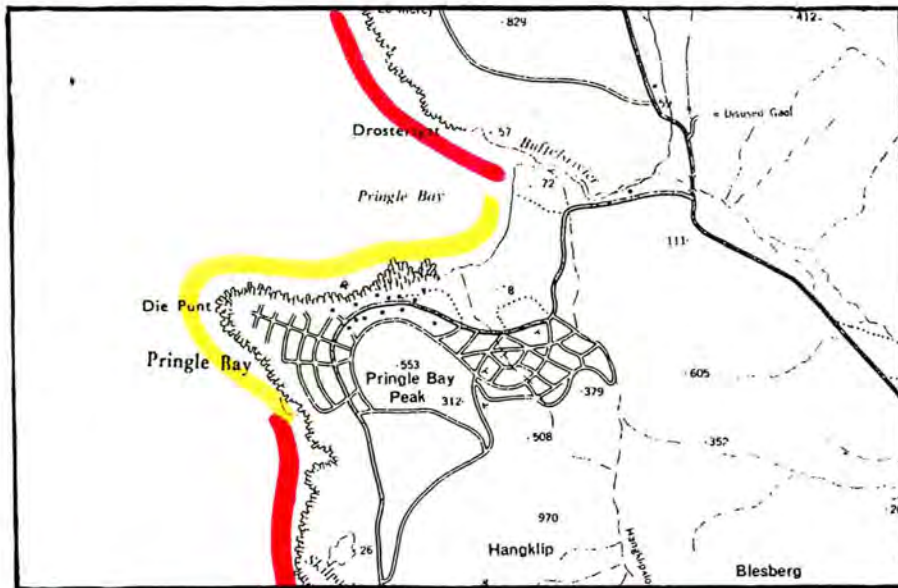
CAPE COASTAL CONSERVATION PLAN / KAAPSE KUS BEWARINGSPLAN

Please find enclosed the next phase of the Coastal Conservation Plan : your participation is very much appreciated.

Vind asseblief ingesluit die volgende fase van die Kusbeswaringsplan : u deelname word hoog op prys gestel.

EXAMPLE
(see instructions)

VOORBEELD
(sien aanwysings)



COMMENTS
(on categories/definitions)

KOMMENTAAR
(op kategoriee/definisies)

.....
.....
.....
.....
.....

.....
(Participant Deelnemer)

KEY

SCALE : 1 MM = 40 M
CONTOUR INTERVAL : 20 M

CONSERVATION CATEGORIES

- PURPLE : RESERVES
- RED : CONSERVATION
- GREEN : CONSERVATION WITH DEVELOPMENT
- YELLOW : DEVELOPMENT WITH CONSERVATION
- BROWN : DEVELOPMEN

APPENDIX 2.2a

COMPLETED MAPS AS RETURNED BY THE RESPECTIVE ORGANISATIONS - BUSHMANS RIVER MOUTH.

MAP NO : 65

3326 DA & DC : BOESMANSRIVIERMOND

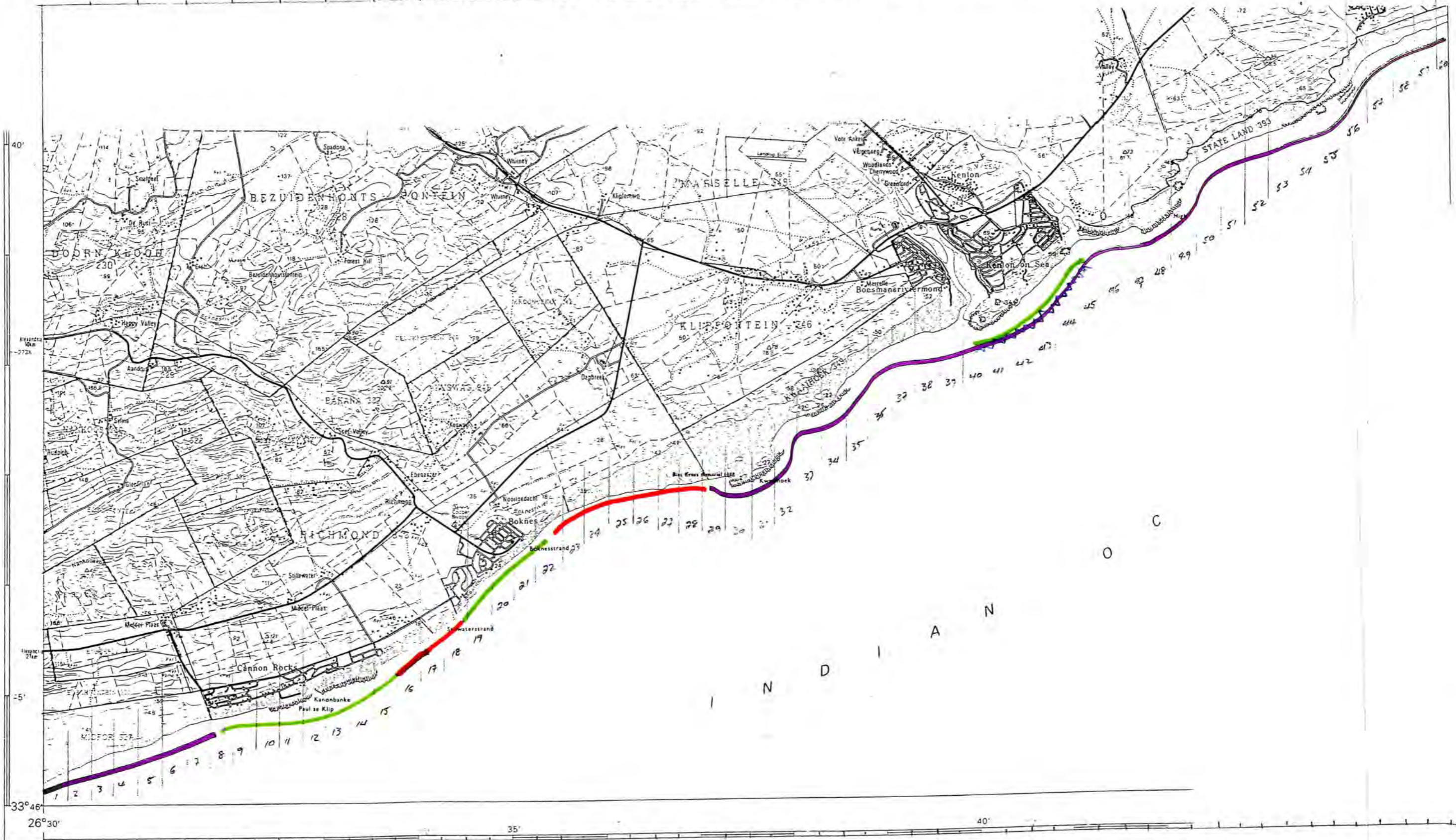
SUBMITTED BY :
INGEDIEN DEUR :

NAME :
NAAM :

INSTITUTION/CODE :
INSTELLING/KODE :

ONTSYDERSKAP EN TOEGANG
 STREEKAMPTOEGANG EN TOEGANG
 REGIONALE TOEGANG EN TOEGANG
 1992-09-21
 FERNATIEVE TOEGANG EN TOEGANG
 TOEGANG EN TOEGANG

5



KEY

SCALE : 1 MM = 40 M
 CONTOUR INTERVAL : 20 M

CONSERVATION CATEGORIES

- PURPLE : RESERVES
- RED : CONSERVATION
- GREEN : CONSERVATION WITH DEVELOPMENT
- YELLOW : DEVELOPMENT WITH CONSERVATION
- BROWN : DEVELOPMENT

MAP NO : 66

3326 DB : PORT ALFRED

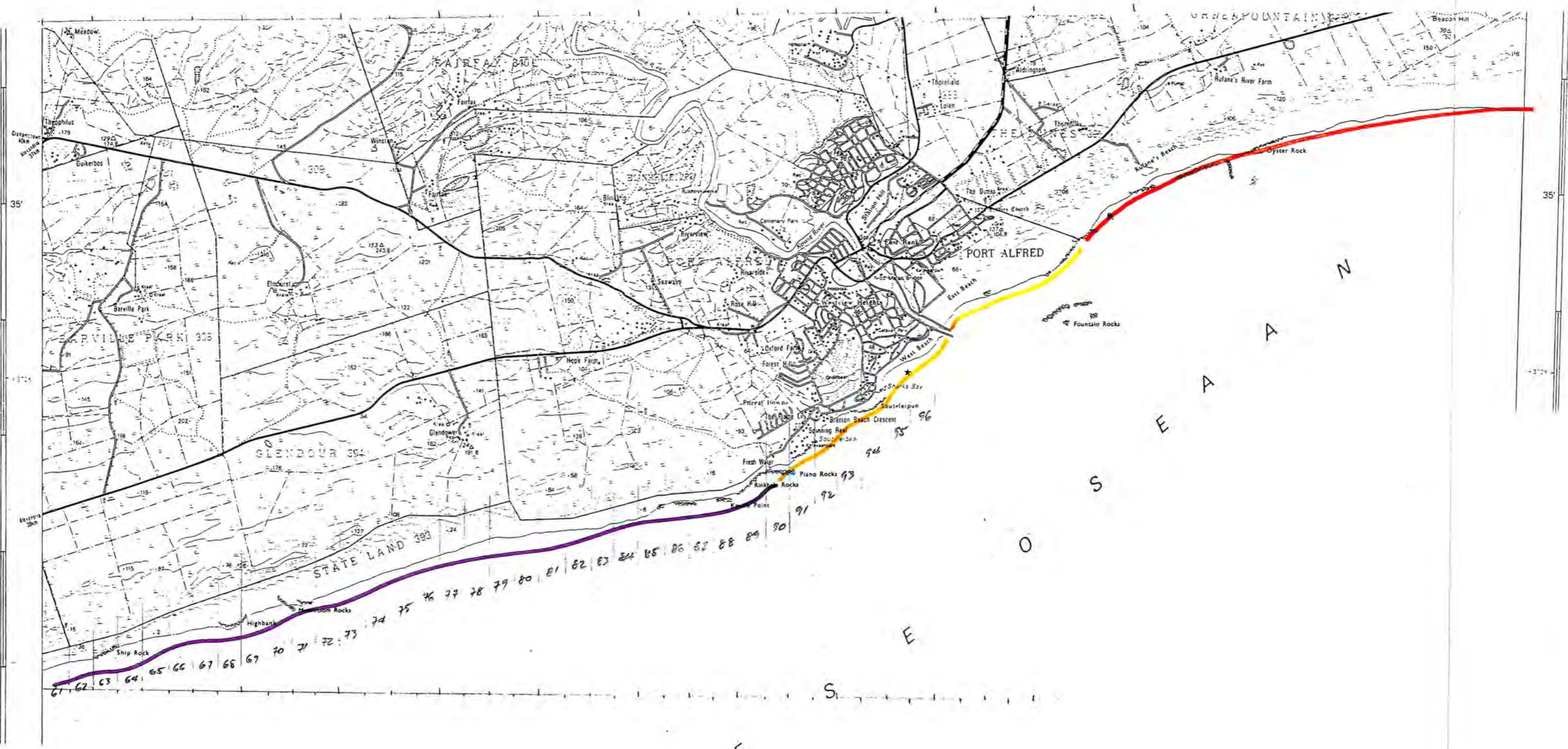
SUBMITTED BY :
 INGEDIEN DEUR :

NAME :
 NAAM :

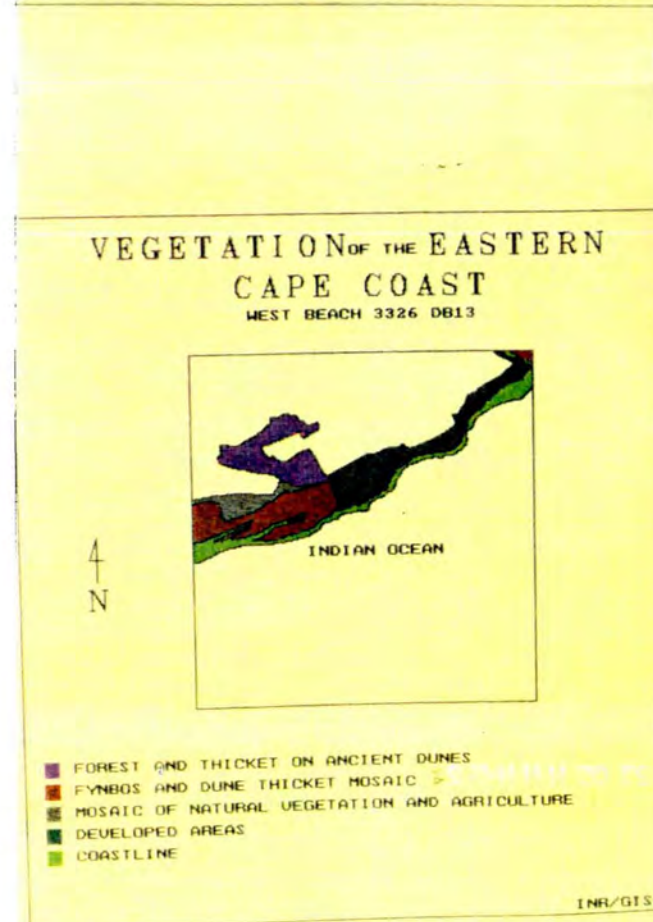
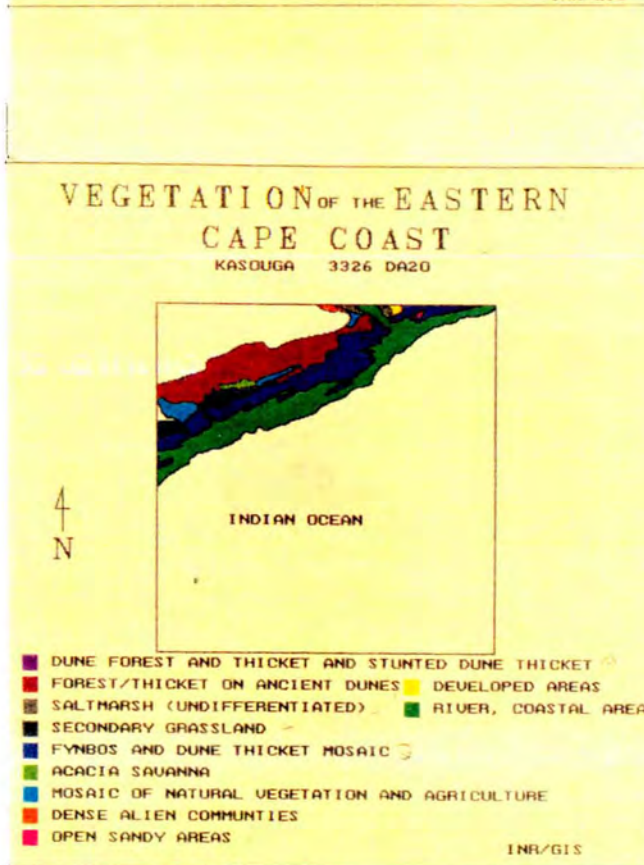
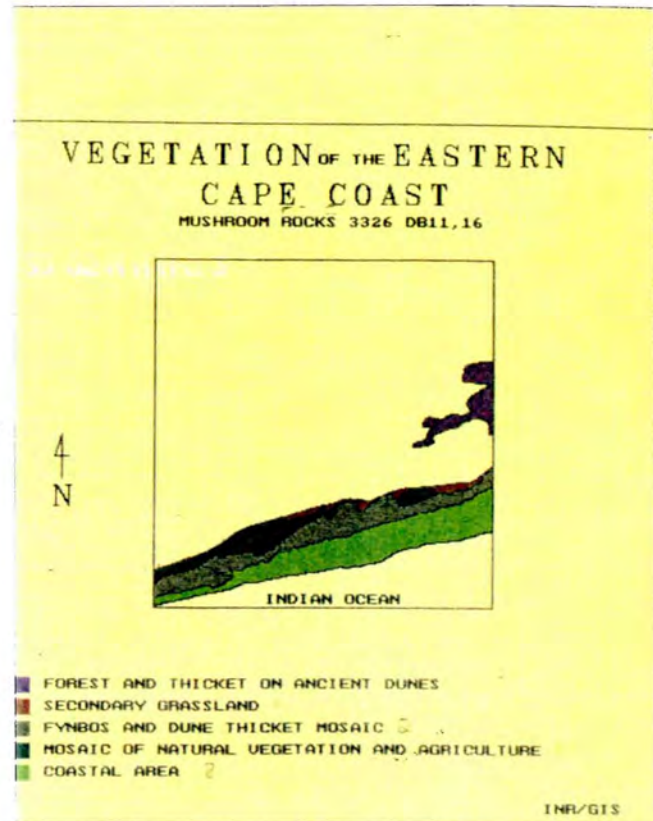
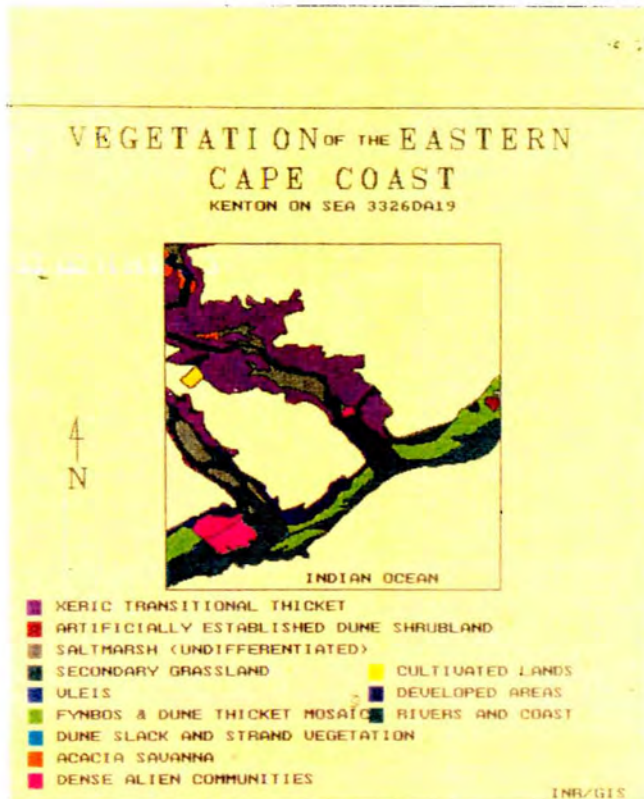
INSTITUTION/CODE :
 INSTELLING/KODE :

DEPT. VAN WATERSKAPPE EN BOSBOEI
 STELPLAAS: PORT-ALFRED
 REGIONAL DIREKTOR: BOSBOEI
 1992-09-21
 PRIVAATSAK/PRIVATE SAK 212
 KNYSHA 4570
 DEPT. OF WATER AFFAIRS AND FORESTRY

5



APPENDIX 2.3 EMATEK (CSIR) DIGITIZED COASTAL VEGETATION IMPORTANCE RATING MAPS.



APPENDIX 3.1. LIST OF ORGANIZATIONS TO WHICH THE CAPE COASTAL CONSERVATION PLAN WAS SENT (Organizations which are responsible for the study area only)

African National Congress.
 Albany Museum.
 Alexandria and District Angling Club
Algoa Regional Services Council.
 Bushmans Kariega Trust.
Cape Coastwatch.
Cape Nature Conservation, A. Bok.
Cape Nature Conservation, R. Hannan.
Cape Nature Conservation, G.A. la Cock.
Coastal and Environmental Services.
 Conchological Society of South Africa - Border Group.
 Democratic Party.
Dept. Water Affairs and Forestry.
Diaz Cross Bird Club.
 East London Museum.
 Eastern Province Rock and Surf Angling Association.
EMATEK - CSIR
 J.L.B. Smith Institute of Ichthyology.
Institute for Coastal Research.
 Kenton On Sea Municipality.
 Kowie Trust.
National Parks Board, N. Geldenhuis.
 National Party.
 Port Alfred Municipality
Port Elizabeth Museum.
 Prof. B. Allanson.
Rhodes University, Botany Dept.
 Rhodes University, Zoology Dept.
 SETPLAN.
 South African Archaeological Society.
 University of Port Elizabeth, Dept. Zoology
University of Port Elizabeth, Prof. A. McClachlan.
 University of Port Elizabeth, Dept. Botany.
University of Port Elizabeth, Geology.
Wildlife Society of South Africa, Eastern Province Branch.

(n = 35)

NB Boldface organizations are those which returned their conservation perceptions but were not used in the final analysis (n = 6).

NB Boldface and Italicized organisations are those which returned their conservation perceptions and used in the final analysis. (n = 16).

Total no. sent out	= 35
Total no. returned	= 22
% returned	= 62,9
No. used in analysis	= 16
% used	= 45,7
No. returned but not used	= 6
% returned but not used	=17,1

APPENDIX 4.1. TOTAL AREA COVERAGE (HA) AND EXTENT OF FRAGMENTATION OF THE MODIFIED CPA'S CAPE COASTAL CONSERVATION PLAN PERCEPTION CATEGORY.

Sensitivity Categories	Fragments and their respective areas (ha)	x	n-1	$\sum x$	%x	%x	N	%N	Range
V-High	235.3/2044.1	1139.7	1279.0	2279.4	86.5	87.1	2	28.6	235.3 - 2044.1
Low	64.6	64.6		64.6	4.9	2.5	1	14.3	64.6
Medium	150.8/50.7/35.5	79	51.2	237	5.0	9.1	3	42.9	35.5 - 150.8
High	34.8	34.8		34.8	2.6	1.3	1	14.3	34.8

APPENDIX 4.2. TOTAL AREA COVERAGE (HA) AND EXTENT OF FRAGMENTATION OF EMATEK'S COASTAL VEGETATION IMPORTANCE RATING MAP.

Vegetation Categories	Fragments and their respective areas (ha)	x	n-1	$\sum x$	%x	%x	N	%N	Range
V-High	0.9	0.9		0.9	0.2	0.03	1	4.8	0.9
High	196.4/92.3/4.6/1.6/21/154.5/2.3/406.1/1.1/1/2.2/1.1/1.6/1	64.1	117.4	896.8	12.9	34.3	14	66.7	1 - 406
Low	9.8/3	6.4	4.8	12.8	1.29	0.5	2	9.5	3 - 9.8
Medium	0.8/2.6/5.7/1696.2	426.3	846.6	1705.3	85.7	65.2	4	19.1	0.8 - 1696.2

**APPENDIX 4.3. TOTAL AREA COVERAGE (HA) AND EXTENT OF
FRAGMENTATION OF THE DUNE TYPES.**

Dune Types	Fragments and their respective areas (ha)	x	n-1	$\sum x$	%x	%x	N	%N	Range
Butress Barchanoid dunes	21.8/53.2	37.5	22.2	75.0	3.5	2.9	2	7.1	21.8-53.2
Reversing Barchanoid dunes	322.4/19.6/14.9/55.8/329.0	149.3	164.0	746.7	14.0	28.6	5	17.9	14.9-329.0
Hummock dunes	10.0/4.8/3.8/5.0/0.9/1.5	4.3	3.3	26.0	0.4	1.0	6	21.4	0.9-10.
Unidirectional Parabolic dunes	191.3/374.9	286.1	134.1	572.2	26.9	21.9	2	7.1	191.3-374.9
Bidirectional Parabolic dunes	231.8/203.6	221.7	19.9	443.4	20.8	17.0	2	7.1	203.6-231.8
Raised Vegetated Fossil dunes	260.2/32.3	148.7	164.5	297.3	14.0	11.4	2	7.1	32.3-260.2
Vegetated Back dunes	115.1	115.1		115.1	10.8	4.4	1	3.6	115.1
Headland Bypass dune	20.3	20.3		20.3	1.9	0.8	1	3.6	20.3
Littoral Beach Zone	154.4/3.5/16.9/124.9	74.9	75.9	299.7	7.0	11.5	4	14.3	3.5-154.4
Aeolianite Headlands	4.6/9.9/5.6	6.7	2.8	20.1	0.6	0.8	3	10.7	4.6-9.9

APPENDIX 4.4. TOTAL AREA COVERAGE (HA) AND EXTENT OF FRAGMENTATION OF THE INTERMEDIATE SENSITIVITY CLASS MAP. 7 HAVING THE GREATEST SENSITIVITY AND 1 THE LEAST.

Sensitivity classes	Fragments and their respective areas (ha)	x	N-1	$\sum x$	%x	% $\sum x$	N	%N	range
7	0.9	0.9		0.9	0.2	0.03	1	3.6	0.9
6	197.4/202.2/11.6/21/276/2.3/307/1.1/ 1/2.2/1.1/1.6/1/4.6	73.6	116.1	1015.1	16.0	39.0	14	53.9	1-307
5	1.2/2	1.6	0.6	3.2	0.4	0.02	2	7.2	1.2-2
4	38.9/9.8/1224.5/0.8/2.6/5.7	213.7	495.4	1264.3	46.6	48.5	6	21.4	0.8-1224.5
3	54.8	54.8		54.8	11.9	2.1	1	3.6	45.8
2	161.1/49.7/32.6	81.1	69.8	243.4	17.7	9.2	3	10.7	32.6-161.1
1	33.3	33.3		33.3	7.3	1.3	1	3.6	33.3

**APPENDIX 4.5. TOTAL AREA COVERAGE (HA) AND EXTENT OF
FRAGMENTATION OF THE SENSISTIVITY CLASSES AND
DUNE TYPES.**

Dune Types	SENSITIVITY CLASSES							Statistics						
	High			Low				x	n-1	Σx	%x	%Σx	N	%N
	7	6	5	4	3	2	1							
Butress Barchanoid dunes		12.9/1.1/1/ 2.2		9.1				5.3	5.4	26.3	1.5	1.0	5	7.6
Reversing Barchanoid dunes		1.1		55.8/14.9/ 322.4/ 19.6/ 327.9				123.6	157.2	741.7	34.7	28.4	6	9.1
Hummock dunes				2.5	3.8/1	0.9/1 0/3.8	1.5	3.4	3.2	23.5	1.0	0.9	7	10.6
Unidirectional Parabolic dunes		1.6/1/154.5/ 252.2/23		2.6/42.7/ 34.5/4/ 31.6		22.2	17.7	49.0	76.3	587.6	13.7	22.5	12	18.2
Bidirectional Parabolic dunes		177.2/172.3		30.5/0.8/ 3.6/18.7/ 31.3		1		54.4	75.3	435.4	15.0	16.7	8	12.1
Raised Vegetated Fossil dunes		196.4/20.2		4.5/5.7/ 1.1		63.8		48.6	76.1	291.7	13.5	11.2	6	9.1
Vegetated Back dunes				9.8	33.6	36/3 5.7		28.8	12.7	115.1	8.0	4.4	4	6.1
Headland Bypass dune		11.6	2.0	6.7				6.8	4.8	20.3	1.9	0.8	3	4.6
Littoral Beach Zone				16.9/ 138.3/ 38.9/50. 8/3.5	16.4	2.5/1 4/57. 2	15.6	35.4	40.8	354.1	9.9	13.5	10	15.2
Aeolianite Headlands	0.9	6.9	3.0	3.7/5.6				4.0	2.3	20.1	1.1	0.8	5	7.6

APPENDIX 4.6. TOTAL AREA COVERAGE (HA) AND EXTENT OF FRAGMENTATION OF THE SENSISTIVITY CLASSES.

Environmental Sensitivity Classes	Fragments and their respective areas (ha)	x	N-1	Σx	%x	$\% \Sigma x$	N	%N	range
1	15.6	15.6	-	15.6	2.4	0.6	1	1.9	15.6
2	19.2	19.2	-	19.2	3.0	0.7	1	1.9	19.2
3	107/55.7/11.4	58.0	47.8	174.1	9.0	6.7	3	5.6	11.4-107.0
4	22.2	22.2	-	22.2	3.5	0.9	1	1.9	22.2
5	63.8/1	32.4	44.4	64.8	5.1	2.5	2	3.7	1-63.8
6	54.8	54.8	-	54.8	8.5	2.1	1	1.9	54.8
7	38.9/9.8/50.8/3.5/1.5/16.8/125.4	35.2	43.8	246.7	5.5	9.4	7	13.0	1.5-125.4
8	16.2/18.353.2/2.6/31.6/45.2	27.9	19.1	167.1	4.3	6.4	6	11.1	2.6-53.2
9	3.6/65.6/5.7/5.6/0.8/3 0.5	18.6	25.4	111.8	2.9	4.3	6	11.1	0.8-65.6
10	330.5/19.6/55.8/14.9/327.9	149.7	164.6	748.7	23.3	28.6	5	9.2	14.9-330.5
11	2.3/1.2/1/12.3	4.2	5.4	16.8	0.7	0.6	4	7.4	1-12.3
12	3/2	3.2	-	3.2	0.5	0.1	1	1.9	3.2
13	154.5/217.2/1.6/1/1.1/1 /1.2/2.3	47.5	87.0	379.9	7.4	14.5	8	14.8	1-252.2
14	176.4/205.8/20.2/172.3	143.7	83.7	574.7	22.4	22.0	4	7.4	20.2-230.8
15	1.1	1.1	-	1.1	0.2	0.04	1	1.9	1.1
16	4.3/11.6	8.0	5.2	15.9	1.3	0.6	2	3.7	4.3-11.6
17	0.9	0.9	-	0.9	0.1	0.03	1	1.9	0.9