Dune Vegetation between Richards Bay and Mlalazi Lagoon and its Conservation Priorities in Relation to Dune Mining

P.J. Weisser

Dune Vegetation between Richards Bay and Mlalazi Lagoon and its Conservation Priorities in Relation to Dune Mining

Contents

Foreword

South Africa is caught between the compelling needs of a rapidly increasing population demanding a fast and effective development of natural resources and the necessity for preserving its natural heritage. With less than one per cent of the surface of South Africa covered with forest, the conservation of natural gems such as the pristine, species-rich Zululand dune forests becomes a vital priority.

It is imperative to have an ecological inventory for decision making in relation to development and conservation. For this reason, the Botanical Research Institute has been engaged in the study and survey of main plant communities present and their distribution. As an integral component of the mapping exercise, each mapping unit is evaluated in terms of conservation potential. The onus now rests on the decision makers and the managers to use this information for the benefit of the country.

This work is not only of value to planners requiring base-line data for planning purposes, but will also interest botanists and ecologists requiring information about the Zululand dune vegetation. Additional interest lies in the treatment of the rehabilitation of devastated areas by vegetating mined dunes. For these reasons, I trust that this report will be appreciated by a wide readership.

B. DE WINTER
Director: Botanical Research Institute

Acknowledgements

Acknowledgements and thanks are due to the following institutions and persons for their valuable contribution in the preparation of this report: to the Director of the Botanical Research Institute, Dr B. de Winter, for his continuous and effective interest and support of this work; Dr J.C. Scheepers, Mesdames E. van Hoepen, R. Müller adn J.N. Weisser and Misses A.P. Backer, E.C.A. Smith, S. van Eeden, and A. Stadler and Mr G.B. Deall for their valuable technical assistance, advice and proof reading of the manuscript; Mr K. Roxburgh for help in the mapping work; members of the Committee for the Controlled Utilization of Natural Resources (Zululand Coast) for their effective support and information given; Messrs W. de Waal, H. Bower, D. Freeman, P.D. Camp, P.B. Odendaal, I.F. Garland and C. Buthelezi for their help during field work; Mr P. Davies, pilot of the helicopter, for his good will and continuous support. Acknowledgements are due to the staff of the Herbarium of the Botanical Research Institute for plant identifications; Mr R.E. Crofts (Office of the Director-General of Surveys); Prof. Dr D.A. Scogings and Mr A. Bikaroo (Survey Department, University of Natal) for their help in obtaining aerial photographs; Richards Bay Minerals for aerial photos and information mainly about dune rehabilitation; General Mining for maps and data on their envisaged mining as well as the sponsoring of a flight to take photographs; Mesdames L. Louw and J. Schaap for the drawing of maps and diagrams; Mrs A. Romanowski for the photographic work; and Mesdames M.M. Loots, M. van der Merwe, S. Thiart and J. Mulvenna for Preservation Board and their personnel for their logistical support while on field work; Mr A. Jeffrey of Air Survey of Africa (Ltd) for special air-photography work and to Wild-Leitz RSA (Pty) Ltd for the loan of an Aviopret APT1 Stereoscope used for air-photo interpretation.

Abstract

Weisser, P.J., 1987. Dune vegetation between Richards Bay and the Mlalazi Lagoon and its conservation priorities in relation to dune mining. *Natal Town and Regional Planning Report* Vol. 19, Pietermaritzburg, South Africa.

Six 1:10 000 vegetation maps based on aerial photographs (1976) were drawn and used to assess conservation priorities with special reference to proposed dune mining. The information was summarized on three conservation-priority maps (1: 25 000). They revealed that most of the area is covered by third-priority vegetation and no major objection to mining exists if a few areas are excluded from mining. First-priority areas were found in the Richards Bay area, at the Mlalazi Estuary Peninsula, and some scattered patches mainly along the landward limit of the study area, and along the coast. Most of these areas are already excluded from the prospecting lease. The suggestion that a KwaZulu Botanical Garden be established and that the northern dune forest and adjacent patches of hygrophilous forest be incorporated into the Richards Bay Sanctuary area deserves urgent attention.

1. Introduction

Dune mining along the Zululand Coast began during 1977. Such mining entails the complete removal of dune vegetation followed by revegetation after mining activities have ceased (Figs. 1, 14, 15 and 16). Therefore, to preserve parts of the coast having the highest conservation value, conservation priorities must be established before mining begins. It is also important that vegetation studies be made before the area is exploited so that dune rehabilitation can be assessed by comparison with the original vegetation. These are the reasons why the Botanical Research Institute (Department of Agriculture and Water Supply) agreed, at the request of the Committee for the Controlled Utilisation of Natural Resources (Zululand Coast), to establish conservation priorities along the Zululand Coast.

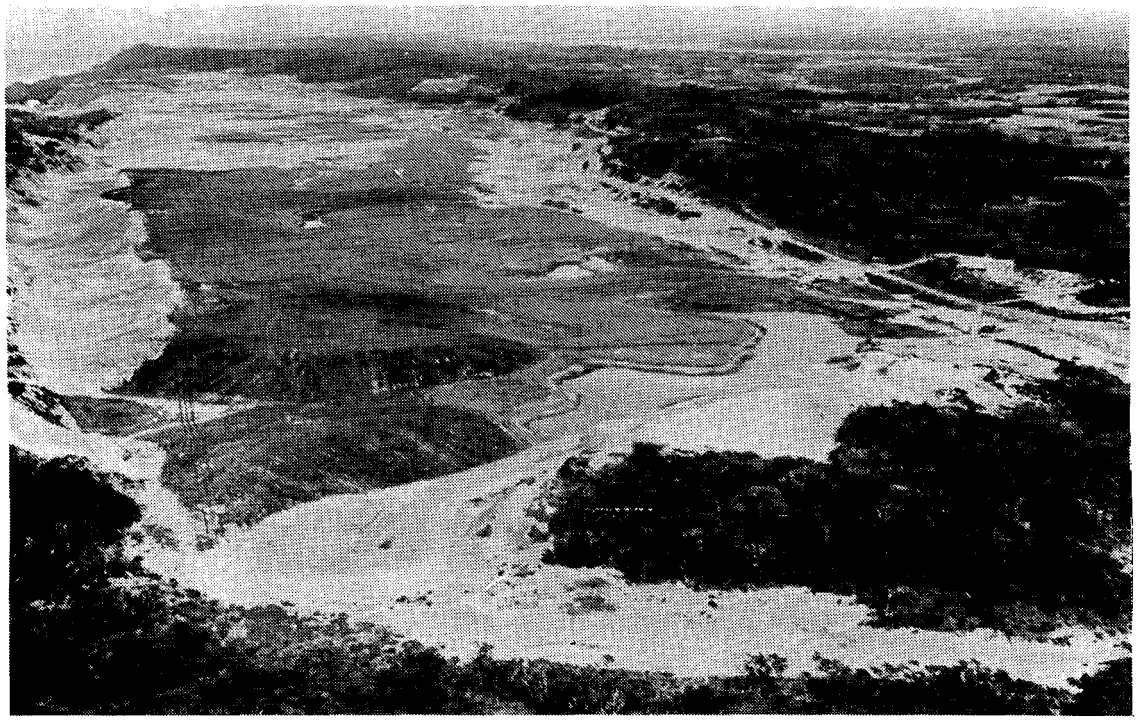

Figure 1: Dune mining north of Richards Bay and its effect on the dune barrier. Rehabilitation successes indicate that most of the mining scar will disappear in about ten years. Nevertheless the drastic changes caused by dune mining, such as destruction of the existing plant cover and associated animal communities, changes in topography and ecological conditions represent a reality that must be faced. Therefore advantages and disadvantages of dune mining must be carefully assessed before prospecting and mining leases are granted (1983.02.07).

2. Objectives

The main aims of this research were to gather information on the vegetation and other natural features of the dune area between Richards Bay and the Mlalazi Estuary to assess the desirability of dune mining; to recommend areas suitable and unsuitable for mining from the point of view of nature conservation; and to gather base-line data on plant cover for vegetation monitoring and as a guide line for dune rehabilitation.

This would be achieved by:

(1) making an inventory and description of the main plant communities in the study area;
(2) providing 1:10 000 vegetation maps that could serve for management and vegetation monitoring purposes;
(3) evaluating the vegetation, and establishing conservation priorities with special reference to the intended dune mining;
(4) mapping conservation priorities;
(5) gathering information for the re-establishment of vegetation after mining; and
(6) providing a list of plants recorded during the survey.

3. Methods and Materials

3.1 VEGETATION STUDY AND MAPPING

Both a reconnaissance and plant collections were undertaken prior to a more detailed study of specific areas.

For the collection of specimens, standard herbarium methods were employed. The facilities of the Herbarium of the Botanical Research Institute were available for the identification of specimens.

Aerial photos were chosen as the main source of information because of the high efficiency of this remote-sensing material. Mapping of the vegetation was done from aerial photos of Job 11737 (1937) from the Trigonometrical Survey (Pretoria) and Job 251 (University of Natal) through direct inspection, enlargement and transference onto a base map using a Bausch & Lomb ZT-4 Zoom Transfer Scope (ZTS). This instrument was also employed to draw the six 1:10 000 base maps from the orthophoto maps. No orthophoto map for the Mlalazi Peninsula was available at the time of the work. In this case, the base map was drawn directly from the aerial photo. Fig. 2 indicates the area covered by each map. Interpretation of the aerial photographs was aided by Topcon and Aviopret APT1 Stereoscopes. Areas were measured with a MOP - AMO2 Image Analyser. Ground truth and additional field data were gathered during 1979 to 1981.

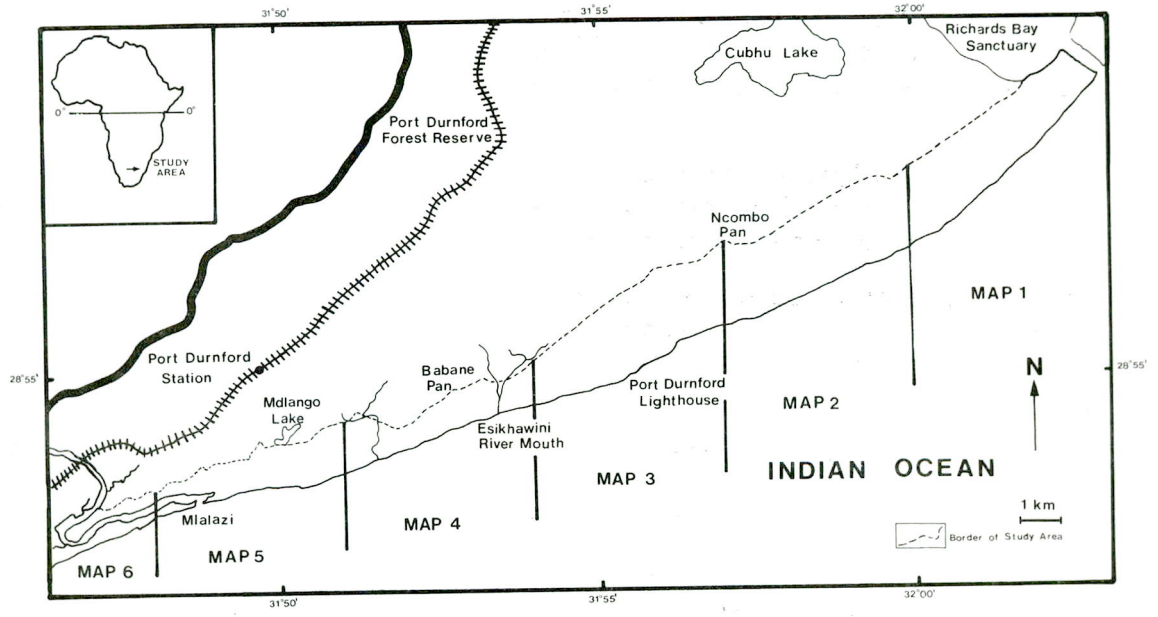

Figure 2: Study area (between stippled line and Indian Ocean) showing areas covered by the six vegetation maps.

The mapping units were chosen in accordance with what could be distinguished by air-photo interpretation and available field information. To obtain additional information and, especially, to discern the primary or secondary nature of a community, a historical approach was employed. First, the vegetation as shown in the 1937 photos was mapped and information from the 1976 photos was then superimposed onto these maps. In this way, the changes in the vegetation could be monitored and secondary situations readily discovered.

The potential and limitations of air photos for this type of vegetation study have been discussed in literature, e.g. Edwards (1972), Weisser (1979 a) and Jarman et al. (1983). Because of air-photo and topographic distortions, the positioning of vegetation patches is only approximate. While mapping, the air photos were realigned as soon as a deviation of corresponding points and areas could be observed. Inaccuracies owing to distortions and mapping difficulties are at a level that will not impair main conclusions.

A pragmatic approach to site selection was taken and samples were subjectively chosen on stratified aerial photographs in order to cover the broadest range of communities and optimize information on each mapping unit. Systematic sampling (e.g. plots along a profile) proved to be impracticable, as extensive communities would have been over-represented, whereas ecological situations covering small areas, but important for conservation could easily have been missed. Because of shortage of manpower and time it was impracticable to sample inaccessible areas representing a mapping unit which could be studied more efficiently in accessible areas.

Plot sizes were determined by the type of communities. The sample sizes were 5m x 5m in floristically simple communities, 10m x 10m in more complex ones and plots were unbounded (no specifically defined limits) in difficult situations such as dense dune scrub and climax dune forests.

To characterize each mapping unit after these were interpreted from air photos, a total of 130 sites or plots were studied. Simple, uniform and homogeneous mapping units were sampled by four sites and more complex ones by up to twelve.

The quantity of sites per mapping unit depended on the complexity of the community, its extent and ecological importance, its conservation status and the degree to which mining proposals pose a threat to it. Mapping units covering less than 5 ha and situated in inaccessible localities and not in proposed mining areas were omitted from the study.

The sites (also called plots or releves) were sampled recording the following data: (1) site number; (2) date; (3) locality; (4) site size; (5) mapping unit; (6) notes; (7) structure of vegetation; and (8) floristics.

The following structural parameters regarding the vegetation were recorded for each stratum: (1) cover (estimates in per cent): total cover, field layer, understorey, canopy cover; (2) height (estimates in metres): field layer, understorey, canopy, maximum height.

The floristics of a site were recorded by listing the main and permanently recognizable plant species. A cover-abundance value for most species recorded was estimated according to the Braun-Blanquet Scale (1964).

A synthesis was obtained by tabulating the data from the sites for each mapping unit, thereby obtaining an overall view of structural and floristic characteristics for each mapping unit.

3.2 CONSERVATION PRIORITY MAPPING

In establishing the conservation priorities and suggesting which areas should be preserved, the following principles described by Diamond (1975) were applied as far as possible.

(1) A large reserve is better than a small one because it will have lower extinction rates.

(2) The reserve should be divided into as few disjunctive pieces as possible.

(3) If the available area must be broken into several disjunctive reserves then these reserves should be as close to each other as possible if the habitat is homogeneous. Proximity will increase immigration rates between reserves, hence the probability that disseminules from one reserve will reach another reserve where the population of the immigrant species has become extinct. If there are several disjunctive reserves, these should ideally be grouped equidistant from each other rather than grouped in linear fashion. An equidistant grouping means that populations from each reserve can recolonize, or be colonized from another reserve, with more or less equal probability.

(4) If there are several disjunctive reserves, connecting them by strips of the protected habitat (Preston, 1962; Willis, 1974; as referred to in Diamond, 1975) may significantly improve their conservation function at little further cost in land withdrawn from development. This is because species of the protected habitat can then disperse between reserves without having to cross a stretch of unsuitable habitat. Especially in the case of sedentary species with restricted habitat preferences, corridors between reserves may dramatically increase dispersal rates over what would otherwise be negligible.

(5) Any given reserve should be as nearly circular in shape as other considerations permit, to minimize dispersal distances within the reserve. If the reserve is too elongated or has dead-end peninsulas, dispersal rates to outlying parts of the reserve from more central parts, may be sufficiently low to perpetuate local extinction by island-like effects.

3.3 CONSERVATION PRIORITY SCALE

3.3.1 First priority for conservation

Areas with a high conservation value, mainly from an ecological point of view, fall under this category. Mining should be avoided, interference and destruction minimized.

In this first conservation priority we have to deal with communities with some or all of the following characteristics:

(1) these communities are pristine, with little or no human influence;
(2) they often have a large number of plant species (high species diversity);
(3) they are unique or rare;
(4) they cover a small area;
(5) they are threatened and diminishing in other parts of South Africa;
(6) they are difficult or impossible to re-establish;
(7) they are vulnerable;
(8) they have scenic beauty; and
(9) there is danger of driftsands.

3.3.2 Second priority for conservation

This conservation category comprises communities with some scientific or general interest where mining should preferably not take place. There is no strong objection to mining. These communities are mostly secondary owing to human interference and tend to have a low species diversity. They sometimes occupy unstable environments but could be re-established.

3.3.3 Third priority for conservation

Under this rating, areas have been included that are badly degraded, which are relatively easily restored and that are common. These communities are generally simple in their structure, anthropogenic in origin and normally have low species diversity. In these areas there is no objection to mining. Although some of these units occupy unstable environments, the re-establishment of these communities presents no great difficulties.

These conservation ratings are relative and additional considerations are taken into account, and integrated for each specific place. The grading was made considering the total information available from each site. Because there are abundant interactions between adjacent communities, the conservation of an area often requires the presence of a buffer area. Therefore buffer zones were drawn where necessary.

4. Study Area and Environmental Factors

The coastal zone between the Richards Bay Sanctuary and the Mlalazi Estuary was studied. It is a 28km strip of vegetated dunes along the Natal Coast between 28°50′ and 28°57½′ South and 31°46½′ and 32°03′ East (Fig. 2). The maximum width of the dune field is 2 250m, averaging about 1 500m. The area is about 3 582ha. The highest dune reaches 79m above sea level. Two rivulets traverse the dune field and drain the hinterland. The water bodies Mdlangu, Babane and Ncombo are located on the western border of the study area.

The study area is situated on the southern end of the Mozambique Coastal Plain. This was formerly part of the sea bed (Cretaceous, early Miocene and Pliocene). Along the Quaternary shores, a great dune system was built up. Today, most of the beach is narrow, the erosion processes dominating over the accretion. Sand accretion and dune formation occur between the Mlalazi Mouth and the Esikwaweni Mouth, and south of the Richards Bay Sanctuary Mouth.

The coastal dune soils are predominantly sandy. Recent sands are whitish, whereas older sands are reddish to brown, having a higher clay content and are more fertile. In a few places along the coast, sandstones are exposed (e.g. near Port Durnford Lighthouse). Venter (1972) gives additional information on soils of Richards Bay.

The climate is humid and warm to hot with a high year-round rainfall (Schulze, 1965), the mean annual temperature at the Cape St Lucia Station being 21,5°C. The mean annual rainfall at the Umhlatuzi Valley Sugar Estates near Richards Bay being 1 106mm (Venter, 1972). In this climate plant growth is luxuriant and of a tropical nature (Aubert de la Rue et al., 1958, in Venter, 1972).

The original vegetation was mainly Dune Forest and Closed Dune Scrub. Most of this vegetation was destroyed and degraded owing to shifting cultivation by local inhabitants (Weisser & Müller, 1983).

The Forestry Department in 1952 moved the inhabitants from the dunes thereby stopping cultivation and grazing, and initiating a programme of rehabilitation of driftsands by afforestation.

This dune area is part of Reserve 10, that was re-allocated to the Forestry Department under the Bantu Trust and Land Act (1952), and handed over to KwaZulu on the 1/4/1972 (Bower, pers. comm.). Today the area falls under the KwaZulu Department of Agriculture and Forestry.

5. Literature Review

Papers and books on the dune vegetation in South Africa were reviewed by Venter (1972) and Weisser (1979). Therefore, only publications appearing after 1979 or not previously included are dealt with in this report.

Begg (1978) compiled, summarized and evaluated the information available on the estuaries of Natal. He deals extensively with the Richards Bay and Mlalazi Estuaries. His work was a valuable source of information.

Ward (1980) published his work on the vegetation of Isipingo, giving detailed information on the dune vegetation and their successional relationships.

Bruton and Cooper (1981) edited the "Ecology of Maputaland" wherein the knowledge on the ecology of Maputaland is compiled and presented in an integrated manner by specialists in the different fields. These contributions on diverse facets of ecology are in many cases also applicable to the study area and were often the only readily available source of information.

The book "Coastal Evolution and Coastal Erosion in New South Wales" (Australia) by Chapman *et al.* (1982) is a very useful source for general knowledge on coastal processes. Many of the problems dealt with have validity on the Zululand Coast and this book constitutes excellent background reading.

Tinley (1985) synthesizes the available knowledge on South African Dune Systems and provides a valuable source of information on dunes.

6. Results

6.1 THE VEGETATION MAPPING

Methodological aspects of mapping were discussed in Chapter 3. Only map six (Fig. 3) of the 1:10 000 vegetation maps is included in this publication because of the large size of vegetation maps 1-5. Copies of them can be acquired from the Botanical Research Institute, Private Bag X101, Pretoria, South Africa.

LEGEND FOR VEGETATION MAP 6


First Seaward Dune Slope


Climax Dune Forest


Mangrove Swamp


Hibiscus tiliaceus Thicket


Primary *Acacia karroo* Woodland


Secondary *Acacia karroo* or *Trema orientalis* Woodlands with Secondary Scrub


Secondary Dune Scrub and Forest


Reedswamp


Primary Grassland

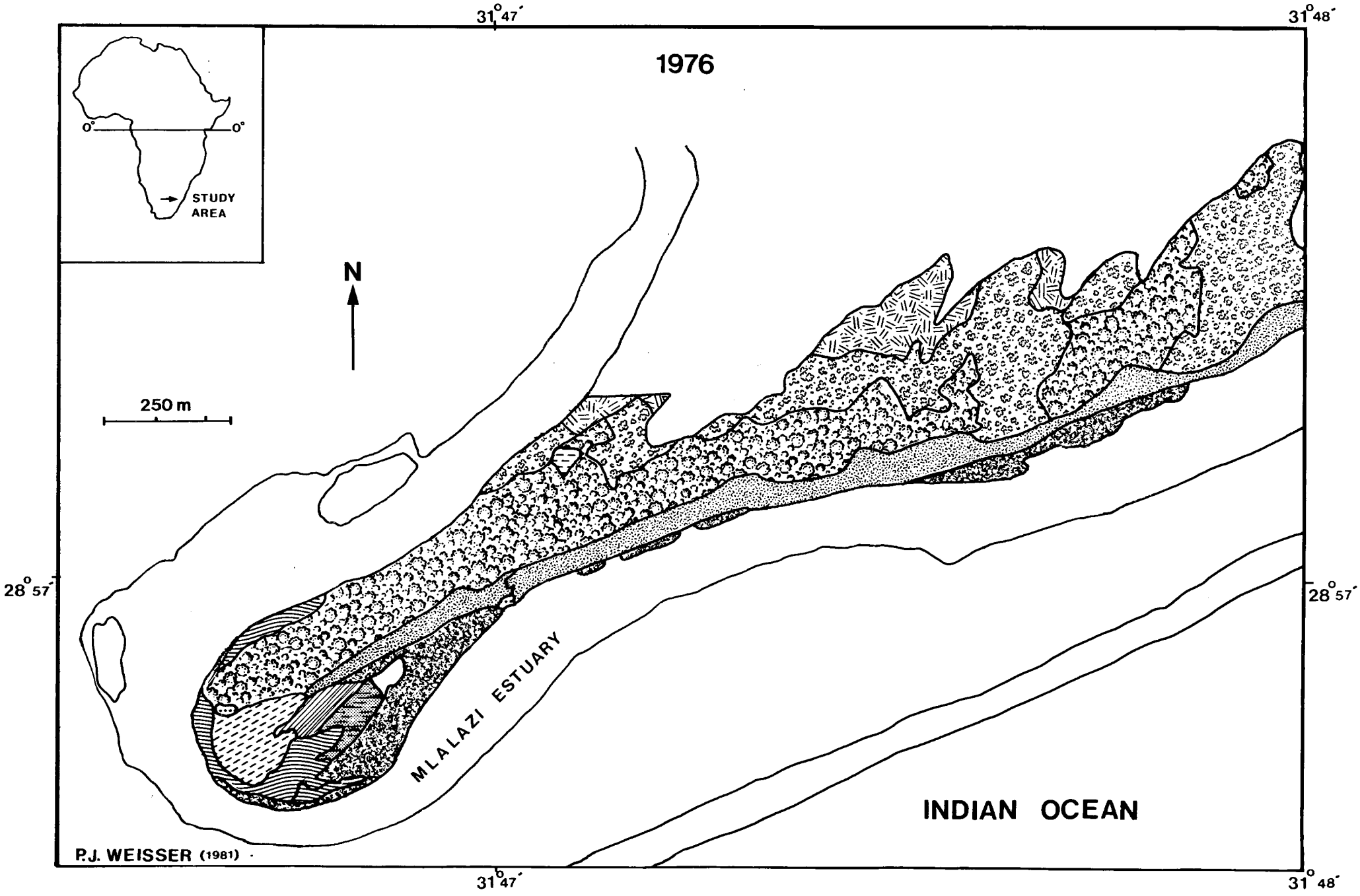

Figure 3: Vegetation Map 6 of Mlalazi Peninsula as an example of the 1:10 000 maps. The other vegetation maps are not included in the report because of their size. They can be acquired from the Botanical Research Institute, Pretoria.

6.1.1 The mapping units and their conservation value

The mapping units were chosen in accordance with what could reliably be distinguished and deduced by air-photo interpretation and field information. The description of the twenty-eight mapping units follows. The tables of mapping units were mainly compiled by Miss L. Smith, whose help is gratefully acknowledged.

(1) Water

This mapping unit comprises fresh water bodies, such as ponds and rivulets, and saline/brackish water bodies created during earthworks to open the mouth for the Richards Bay Sanctuary in 1974 (Begg 1978). The estimated area of this mapping unit is 19,3ha.

Evaluation

There is no overlapping of the intended mining area with this mapping unit. Nevertheless, dune mining requires a considerable amount of water and, if nearby underground water sources are to be tapped, an indirect damaging effect could arise through water table changes. Also, when infrastructures such as roads, pipelines etc. are constructed, ponds and rivulets can be damaged and this should be taken into acount in the planning.

Because of their ecological and hydrological importance, most of the waterbodies are considered to have first priority for conservation.

(2) Mud-flats

Tidal mud-banks in the Richards Bay New Mouth area (3,44 ha, Fig. 7) and at the Mlalazi Peninsula (0,27 ha). At the Richards Bay mud-flats, recent colonization by *Avicennia marina* seedlings was observed, an indication of an incipient mangrove community.

A similar trend was observed at the Mlalazi Peninsula, where mud-banks visible on the air photos of 1937 and 1957 are today mostly colonized by *Avicennia marina* and *Bruguiera gymnorrhiza.*

Evaluation

The areas of this mapping unit lie outside the influence zone of proposed mining activities. They are classified as first and second priority in conservation because they are potential mangrove habitat.

(3) Beach

The interface between sea and dunes is delineated within this mapping unit (109,1 ha). Interrupted only by two rocky outcrops, it forms an almost continuous band between the Sanctuary Mouth and Mlalazi Estuary. Dune pioneer communities may occasionally have been included in this unit because they may have been masked on the aerial photos by the reflection from the beach sand.

Air-photo interpretation and field inspection showed one coastal erosion zone with narrow beaches (Fig. 4), in between two sand accretion zones with 40—70 m wide beaches (Fig. 5). The one sand accretion zone extends from the Richards Bay Sanctuary Mouth to about 4km south and the other extends from the Mlalazi Estuary northwards for about 4,5km (Fig. 2). The retrograding coast lies between them.

The greatest accretion is found north of the Mlalazi Estuary where, in parts, the beach has advanced about 70m from 1937 to 1976. This sand accumulation can be related

Figure 4: On the eroding stretch of coast slumping of the dune front occurs, causing the destruction of Closed Dune Scrub and Climax Dune Forest. They are replaced by pioneer communities that establish themselves on the newly exposed surfaces (January, 1979).

Figure 5: *Dune Pioneer Community on the wide beach north of the Mlalazi Estuary Mouth, where sand accretion is occurring through interception of sand mainly by Scaevola plumieri.* In the left corner, *Gazania rigens* var. *uniflora* and in the lower centre *Arctotheca populifolia* are visible. *Casuarina equisetifolia* trees can be seen at the left upper corner (1980/11, are Map 5).

to agricultural malpractices in the catchment area that lead to an increase of sediments brought to the sea by the Tugela, Matigulu, Siyaya and Mlalazi Rivers. Coastal accretion and seaward advancement are also reported for the more southernly situated Mlalazi Nature Reserve (Weisser *et al.* 1982).

This mapping unit includes drift sands that originate on the beach and form tongues into the vegetated dunes. Keet (1936) and Stephens (1939), indicated that many drift sands start as cattle paths by exposing the sand to the wind after destroying the vegetation. Many drift sands were too small to be mapped because their size was less than the mapping resolution. The drift sands were quite constant through the years in their position along the coast, so they often proved to be adequate matching points during mapping.

Comparing 1937 and 1976 maps, a reduction in size and number of littoral drift sands was found. This is probably a consequence of the protective management (e.g. exclusion of cattle and fire) by the Department of Forestry since 1952.

In this mapping unit, two rocky outcrops of sandstone in the vicinity of Port Durnford Lighthouse were included because it was difficult to delimit these rocky areas by means of the aerial photographs. Depending on the shore conditions, these rocks can be exposed or covered by sand deposited on them by the sea. The water at the northern rocky outcrop shows a great quantity of foam, and the area frequently smells bad, both consequences of the waste disposal pipeline that discharges there (area Map 3).

Where the conspicuous lignite (Port Durnford Formation) appears along the coast (on Maps 2 and 3), e.g. the area of Port Durnford Lighthouse, stones and boulders coming from the cliff layer can be seen lying on the beach.

Noteworthy is the presence of kaolinitic ochre or "zulu clay", used as a cosmetic by local inhabitants and brought onto the beach by water from wells coming out of the dune cliffs.

Evaluation

Wind, salt water and wave action make the beach environment very unstable and unsuitable for plant growth. There is no overlapping of the area intended for mining with this unit. This area has high recreation value. The recovery of this unit after mining is good.

(4) Sand at the Richards Bay New Mouth Area

This unit covers the bare sand (15,46 ha) resulting from works related to the opening of the New Mouth for the Richards Bay Sanctuary (Fig. 7). Occasional dune pioneers are colonizing some of these places.

Evaluation

This area has low priority in conservation because of its secondary nature, low vegetation cover and high degree of disturbance. However, it has been rated as second priority in conservation because it is situated within the Richards Bay Sanctuary.

(5) Inland Sand

Bare inland sand areas (2 ha) were detected mainly on the 1937 photos. Most of the driftsands were reclaimed by the Department of Forestry's *Casuarina equisetifolia* plantings.

Evaluation

Because of its sparse to absent vegetation cover this mapping unit rates low in conservation priority.

Under present management, there is no danger of driftsands reappearing. However, their presence in 1937 is a warning of the potential dangers to which inappropriate use of the area such as deficient rehabilitation after mining can lead.

(6) Borrow Pit

This bare area (0,344 ha, Map 4) results from clay quarrying activities.

Evaluation

Third priority in conservation from a botanical point of view, because of the absence of vegetation.

(7) Dune Pioneers

In the study area this community is mainly present adjacent to the northern and southern beaches of the study area (Fig. 5) and occupies an area of 12,1 ha. The main plant species is *Scaevola plumieri* which plays an essential part in the dune build-up by causing sand deposition around its branches. Other common species are *Arctotheca populifolia* and *Gazania rigens* var. *uniflora.* Table 1 summarizes the structural and floristic findings of eight sample sites in the study area.

Table 1 Structure, species composition and cover-abundance values of Dune Pioneer Community. F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	399	400	335	336	342	343	359	358	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	8	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	11	11	5	6	6	6	6	6	–	–	–	–	–
Day	9	9	31	2	2	2	10	10	–	–	–	–	–
Cover:													
Total Cover	20	15	20	25	20	16	10	35	–	–	10-35	–	–
Field Layer	–	–	20	24	20	1	–	–	–	–	1-24	–	–
Emergent	–	–	–	1	10	15	–	–	–	–	1-15	–	–
Height:													
Field Layer	0-0,4	0-0,51	0-1 –	0-1 –	0-0,2	0-0,1	0-0,25	0-0,4	–	–	0-0,51	0-0,48	0,51 –
Gazania rigens var. uniflora	2	1	1	1	2	+	2	2	8	100	–	–	–
Scaevola plumieri	2	2	2	2	2	2	–	–	6	75	–	–	–
Arctotheca populifolia	2	1	–	–	–	–	–	–	2	25	–	–	–
Chrysanthemoides monilifera	–	–	–	–	–	–	–	+	1	12,5	–	–	–
Carpobrotus dimidiatus	–	–	–	–	–	–	–	2	1	12,5	–	–	–
Launaea sarmentosa	–	–	–	–	–	–	–	R	1	12,5	–	–	–

Since 1937 the area occupied by this community has increased. The main reason is new sand accumulation near the Richards Bay New Mouth area and north of the Mlalazi Estuary Mouth (Weisser & Müller, 1983).

Evaluation

This area fulfils an important function in that it protects the landward vegetation from the direct onslaught of waves and wind. It is of an unstable nature and vulnerable to disturbances, but would be relatively easy to re-establish.

There is no overlapping of this mapping unit with intended mining. Beach vehicles are a threat to dune pioneers, when the drivers drive over the plants.

(8) Open Dune Scrub

This mapping unit consisted of a 1,5 km band of vegetation (3,7 ha) situated north of the Mlalazi Estuary Mouth in 1976. The seaward displacement of this vegetation band for about 30 m since 1937 is remarkable. The landward side of the band has been invaded by Closed Dune Scrub and seawards this community has encroached onto the Dune Pioneer Community. This denotes the advancement of succession and is similar to that reported from south of the Mlalazi Mouth (Moll, 1972; Weisser *et al.*, 1982 and Weisser & Backer, 1983).

Only three sites were studied because of the unit's restricted distribution lying outside the proposed mining area. The community consists of two layers, a field layer about 0-0,5 m tall with 30% cover and a scrub layer from 0,5-1,5 m tall with 30% cover (Table 2). Dominant shrubs were *Passerina rigida* and *Chrysanthemoides monilifera.* The presence of *Eugenia capensis, Rhus nebulosa* and *Mimusops caffra* (outside study site) indicates the direction of the succession towards a coastal dune forest.

Table 2 Structure, species composition and cover-abundance values of Open Dune Scrub. F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	344	337	338	F	RF	R	AR	MH
Running No.	1	2	3	–	–	–	–	–
Date Year	80	80	80	–	–	–	–	–
Month	6	5	5	–	–	–	–	–
Day	2	23	23	–	–	–	–	–
Cover:								
Total Cover	–	50	55	–	–	50-55	–	–
Field Layer	–	35	30	–	–	30-35	–	–
Scrub Layer	–	20	30	–	–	20-30	–	–
Height:								
Field Layer	–	0-0,6	0-0,5	–	–	0-0,6	0-0,55	0,6
Scrub Layer	–	0,6-1,7	0,5-1,5	–	–	0,1-1,7	0,55-1,6	1,7
Passerina rigida	1	2	2	3	100	–	–	–
Chrysanthemoides monilifera	3	1	1	3	100	–	–	–
Carpobrotus dimidiatus	3	+	1	3	100	–	–	–
Rhoicissus digitata	1	+	–	2	66,7	–	–	–
Imperata cylindrica	–	2	2	2	66,7	–	–	–
Rhus nebulosa	–	1	+	2	66,7	–	–	–
Helichrysum kraussii	–	+	+	2	66,7	–	–	–
Eugenia capensis	–	+	+	2	66,7	–	–	–
Scaevola plumieri	–	+	1	2	66,7	–	–	–
Chironia baccifera	–	+	+	2	66,7	–	–	–
Anthospermum littoreum	1	–	–	1	33,4	–	–	–
Ipomoea wightii	R	–	–	1	33,4	–	–	–
Launaea sarmentosa	1	–	–	1	33,4	–	–	–
Tephrosia purpurea	–	+	–	1	33,4	–	–	–

Evaluation

This community rates as first priority in conservation because it lies in the 200 m coastal protection strip and it includes the proposed Botanical Garden area. It plays an essential rôle as intermediate stage in the succession of the dune vegetation. It is followed in time by Closed Dune Scrub and Climax Dune Forest. There is no cause for concern as no mapped areas of this community are in the proposed mining area.

(9) First Seaward Dune Slope

This is a heterogeneous mapping unit based on topography, encompassing the first main seaward slope of the dune barrier. Delineation was done on the aerial photographs using a stereoscope. Seawards it usually borders on the beach and the landward limit coincides with the first major dune crest of the dune barrier. This

mapping unit ranges from nearly perpendicular cliffs caused by undercutting by the sea in the central part of the study area (Fig. 4) to gently, moderately or steeply rising dunes in the northern and southern end of the study area. It covers an area of 260 ha.

Various habitats are found in this mapping unit, habitats that differ for example in their topography, exposure to the seawinds, type of substrate, degree of human interference, salt spray, age, and radiation, which also gives rise to a broad spectrum of plant growth. All these habitats have the common characteristic of being near the sea, and therefore, with the exception of some "arcuate scars" and a few dune valleys, they are directly exposed to the sea wind and salt spray.

These factors tend to produce a dense and stunted vegetation. The shoot tips are inhibited in their growth and tend to branch, giving rise to the wind-pruning effect.

This mapping unit includes the steep, often perpendicular cliffs caused by erosion, mainly due to wave action causing undercutting and slumping of the dune barrier.

The plant cover on the steep dune faces is usually low to absent. Sometimes, pioneers such as *Chrysanthemoides monilifera, Passerina rigida, Gazania rigens* var. *uniflora, Senecio* sp. and *Samolus valerandi* were observed colonizing slumped areas (Fig. 4).

(10) Arcuate Scars, Littoral Dune Valleys and Major Coastal Erosion (20,8 ha)

These include 25 valleys of arcuate form, located on the seaward flank of the dune barrier from the Port Durnford Lighthouse area to 8 km north, usually covered with dense, well-conserved vegetation. Arcuate scars were first reported from the coastal stretch between Mbonambi Beach to Richards Bay (Weisser, 1978) and are associated with the presence of an impermeable layer and the Port Durnford Lignite Formation in the Coastal Dune Barrier. The appearance of arcuate valleys is related to the presence of a strong spring over an impermeable layer in the dunes. Spring-sapping results in the removal of sand with consequent collapsing of adjacent higher-lying sand. This sand removal spreads laterally until a situation of equilibrium is reached. The swampy area where the water reaches the surface is often oval in shape. These swamps are often colonized by sedges and reeds.

The arcuate scars can be found at different stages of evolution. In the final stage of equilibrium, they are completely covered by vegetation. Because of the crater-like form, the sea wind and the salt-spray effect are greatly reduced and therefore the wind-pruning effect can be absent or reduced. The environment differs also in the presence of surface water or raised water table. Their identification on the air photos is difficult as they can be mistaken for normal dune valleys and errors in the mapping are then possible. Also, only the biggest and most easily identifiable arcuate scars were mapped. Because of inaccessibility, only one site was sampled. However, more botanical information will be available on an equivalent arcuate scar at Mbonambi Beach, north of Richards Bay (Weisser & Smith, MS).

The use of this mapping unit was unsatisfactory because of the difficulty in consistent interpretation, that occasionally may have led to littoral valleys and conspicuous erosion zones being interpreted as arcuate scars.

Depending on the age of the exposure, the vegetation will be successionally more advanced. The vegetation cover will tend to increase with the length of time after exposure. No special study was done of the cliff communities.

Undisturbed, less steep and old zones of the seaward-facing dune barrier tend to be colonized by a Closed Dune Scrub of varying height ranging in the sites studied from

1,5 m to 7 m with a total cover of 70 to 100%. Plot 375 is atypical because it was situated in a trough and had trees up to 8 m high.

This community is generally formed by a single layer of densely growing woody plants. Occasionally herbs occur but then usually with low cover values.

Woody species common in this community are *Eugenia capensis, Ficus burtt-davyi, Mimusops caffra, Strelitzia nicolai, Aloe thraskii, Brachylaena discolor, Tricalysia sonderiana, Euclea natalensis, Chrysanthemoides monilifera, Passerina rigida, Canthium obovatum, Apodytes dimidiata* and *Allophylus natalensis.* The field-layer species *Rubia cordifolia, Microsorium scolopendrium* and *Centella asiatica* were recorded. Climbers included *Rhus nebulosa, Rhoicissus digitata, Cynanchum* sp., cf. *C. obtusifolium* and *Ipomoea wightii.* Additional structural and floristic information is given in Table 3.

Evaluation

This mapping unit is of highest priority in conservation because these *arcuate scars* often contain samples of original, undisturbed vegetation. The habitat diversity caused by the differences in slope exposure and the gradient in water availability allow a great number of communities and plant species to be concentrated in a small area.

(11) Low Forest

This unit comprises a low forest at the Mlalazi Nature Reserve on even ground. No special study was done of the area because of difficult access, and because it lies outside the proposed mining area. In 1976 it covered an area of 2,2 ha on the Mlalazi Peninsula.

(12) Climax Dune Forest

This mapping unit represents the climax forest on dune slopes and ridges (Fig. 6). It denotes a pristine condition with little or no human interference. This unit covers a wide range of ecological situations and more detailed work will reveal that it is a complex formed of various floristically different communities. These dune forests are usually formed by relatively few, tall dominant trees with a poorly developed understorey and often a dense field layer with *Isoglossa woodii.* Additional information on this type of vegetation can be obtained from Venter (1972) and Weisser (1978b & 1980).

This vegetation covered most of the study area before colonization by man. In 1976, owing to clearing for shifting cultivation and grazing, it had dwindled to an area of about 27,7 ha at the Mlalazi Peninsula, some minor isolated pockets situated mainly near the coast and some areas near Richards Bay. The trend of diminishing Climax Dune Forest was halted by conservation measures after the Forestry Department took over management of the area during 1952 (Weisser *et al.* MS).

The boundaries of this mapping unit with the Secondary Dune Scrub and Forest are difficult to establish because of their similar appearance on the air photos. Therefore, the boundaries drawn must be regarded as tentative.

The total area covered by this mapping unit in the study area amounts to 305,2 ha. The species composition may vary considerably depending on the site. Table 4 gives structural and floristic information on the Climax Dune Forest.

Trees present in six or more sites were *Mimusops caffra, Sideroxylon inerme, Euclea natalensis, Tricalysia sonderiana, Deinbollia oblongifolia, Clausena anisata, Celtis africana, Allophylus natalensis* and *Canthium inerme.*

Table 3 Structure, species composition and cover-abundance values of Closed Dune Scrub and vegetation of "Arcuate Scars" on the Seaward Dune Slope.
F = Frequency.

Relevé No.	332	333	345	346	360	361	362	363	375	376	377	379	393	413	F
Running No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	–
Date Year	80	80	80	80	80	80	80	80	80	80	80	80	80	80	–
Month	5	5	6	6	6	6	6	6	10	10	10	10	11	11	–
Day	22	23	2	2	2	10	10	10	23	23	26	26	5	17	–
Cover:															
Total Cover	80	70	90	90	85	80	80	100	90	70	80	80	80	95	–
Field Layer	3	30	–	5	10	1	10	80	30	2	30	20	5	–	–
Understorey	–	2	–	–	–	–	5	10	10	–	10	15	–	95	–
Canopy	80	50	90	85	80	80	70	85	60	70	50	70	80	5	–
Height:															
Field Layer	0-0,5	0-0,7	–	0-0,5	0-0,5	0-0,3	0-0,5	0-1,5	0-1	0-0-2	0-0,8	0-0,5	0-0,1	0-0	–
Understorey	–	0,7-2	–	–	–	–	0,5-2	1,5-3	1-4	–	0,8-2	0,5-2	0,1-1,5	0-0,3	–
Canopy	0,5-6	2-6	0-1,5	0-2,0	0,5-5	0,3-3	2-6	3-7	4-8	0-4	2-6	2-6	–	–	–
Brachylaena discolor	5	2	2	2	4	5	+	1	–	2	1	1	–	1	12
Mimusops caffra	–	1	–	2	2	1	4	5	3	4	4	4	–	+	11
Microsorium scolopendrium	4	3	–	1	1	+	–	1	–	–	3	3	1	+	10
Pupalia atropurpurea	3	1	–	–	1	+	2	+	1	1	–	1	–	–	9
Psychotria capensis	–	+	–	1	1	–	1	1	1	R	1	1	–	–	9
Allophylus natalensis	3	4	–	1	–	–	–	2	1	+	2	–	–	–	7
Carissa macrocarpa	3	1	–	–	1	2	1	–	–	–	–	–	2	4	7
Tricalysia sonderiana	3	–	–	–	–	–	1	1	2	2	2	2	–	–	7
Apodytes dimidiata	–	2	–	–	–	–	1	2	–	2	2	2	2	–	7
Euclea natalensis	–	+	–	–	–	–	1	+	–	+	2	1	–	+	7
Cynanchum obtusifolium	–	–	1	+	+	+	–	–	–	+	–	R	–	+	7
Kraussia floribunda	3	1	–	–	–	–	+	–	1	–	+	1	–	–	6
Commelina spp.	3	+	–	–	+	–	–	–	1	+	R	–	–	–	6
Strelitzia nicolai	3	2	–	–	–	–	R	–	–	–	1	–	2	1	6
Secamone alpinii	3	+	–	–	–	+	–	+	–	–	–	R	+	–	6
Protasparagus falcatus	–	+	–	–	–	+	1	–	+	–	1	1	–	–	6
Dracaena hookeriana	3	–	–	–	–	–	1	+	1	–	–	+	–	–	5
Canthium inerme	3	–	–	–	2	–	–	–	1	–	2	1	–	–	5
Ipomoea wightii	3	–	–	–	+	+	+	R	–	–	–	–	–	–	5
Peddiea africana	3	1	–	–	–	–	–	–	1	–	2	–	–	–	4
Grewia occidentalis	3	2	–	–	1	–	–	–	–	–	1	–	–	–	4
Rhus nebulosa	3	–	–	–	–	–	–	–	–	–	1	+	1	–	4
Adenia gummifera	2	–	–	–	+	–	–	–	+	–	–	1	–	–	4
Carissa bispinosa	–	–	4	–	–	–	–	–	+	–	1	+	–	–	4
Eugenia capensis	–	–	1	–	–	–	–	–	–	2	–	–	2	1	4
Rhoicissus digitata	–	–	1	1	1	–	+	–	–	–	–	–	–	–	4
Chrysanthemoides monilifera	–	–	1	1	–	–	–	–	–	1	–	–	2	–	4
Rhoicissus rhomboidea	–	–	–	–	–	R	–	–	+	–	1	R	–	–	4
Clausena anisata	3	–	–	–	+	–	–	–	–	–	–	+	–	–	3
Rhoicissus tomentosa	–	–	–	–	+	–	–	–	+	–	–	R	–	–	3
Dovyalis longispina	–	–	–	–	–	1	–	–	–	–	1	2	–	–	3
Harpephyllum caffrum	–	–	–	–	–	–	–	–	3	–	1	1	–	–	3
Maytenus nemorosa	–	–	–	–	–	–	–	–	1	–	2	1	–	–	3
Rhoicissus revoilii	–	–	–	–	–	–	–	–	1	1	–	1	–	–	3
Embelia ruminata	2	–	–	–	–	–	–	–	+	–	–	–	–	–	2
Scadoxus membranaceus	2	–	–	–	–	–	–	–	+	–	–	–	–	–	2
Cissampelos torulosa	2	R	–	–	–	–	–	–	–	–	–	–	–	–	2
Maytenus heterophylla	–	1	–	–	–	–	–	–	–	1	–	–	–	–	2
Smilax kraussiana	–	–	–	–	R	–	–	–	–	–	–	–	+	–	2
Ficus burtt-davyi	–	–	–	2	–	1	–	–	–	–	–	–	–	–	2
Maytenus procumbens	–	–	–	1	–	–	1	–	–	–	–	–	–	–	2
Scadoxus puniceus	–	–	–	–	–	+	–	R	–	–	–	–	–	–	2
Canthium obovatum	–	–	–	–	–	–	–	–	–	–	–	1	–	1	2
Putterlickia verrucosa	–	–	–	–	–	–	–	–	1	–	2	–	–	–	2
Monanthotaxis caffra	–	–	–	–	–	–	–	–	+	–	R	–	–	–	2
Oplismenus hirtellus	–	–	–	–	–	–	–	–	+	–	–	+	–	–	2
Sideroxylon inerme	–	–	–	–	–	–	–	–	–	–	1	1	–	–	2
Deinbollia oblongifolia	–	–	–	–	–	–	–	–	–	–	1	+	–	–	2
Scutia myrtina	–	–	–	–	–	–	–	–	–	–	1	1	–	–	2
Imperata cylindrica	–	–	–	–	–	–	–	–	–	–	–	–	+	+	2
Stenotaphrum secundatum	–	–	–	–	–	–	–	–	–	–	–	–	+	2	2

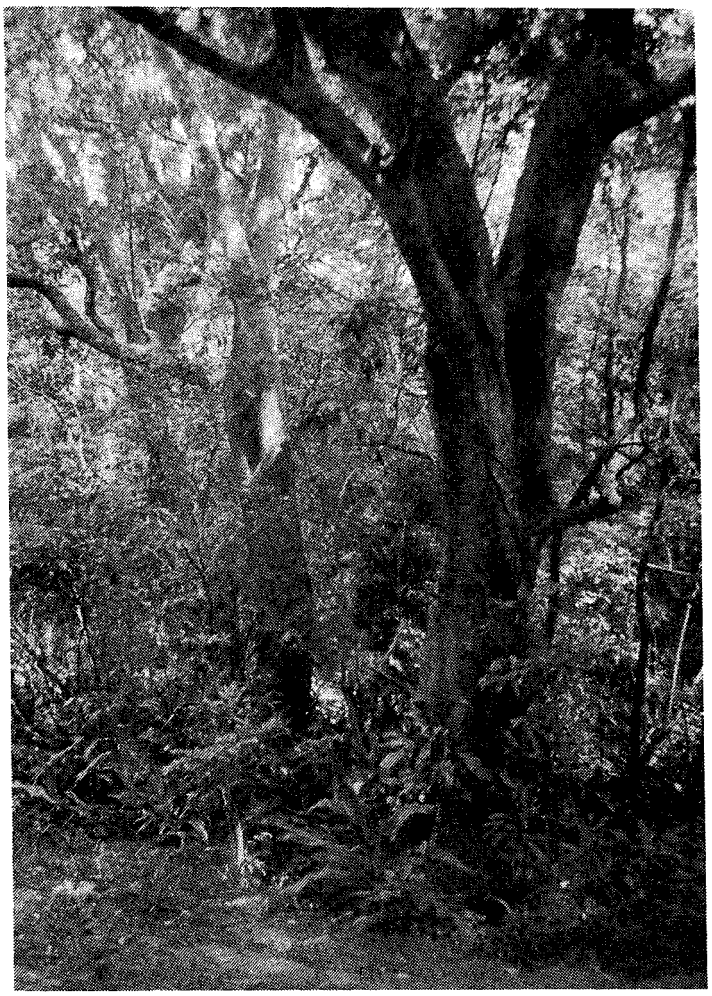

Figure 6: Climax Dune Forest on the road to the Richards Bay Sanctuary Mouth with tall *Celtis africana* trees and *Dracaena hookeriana* in the undergrowth.

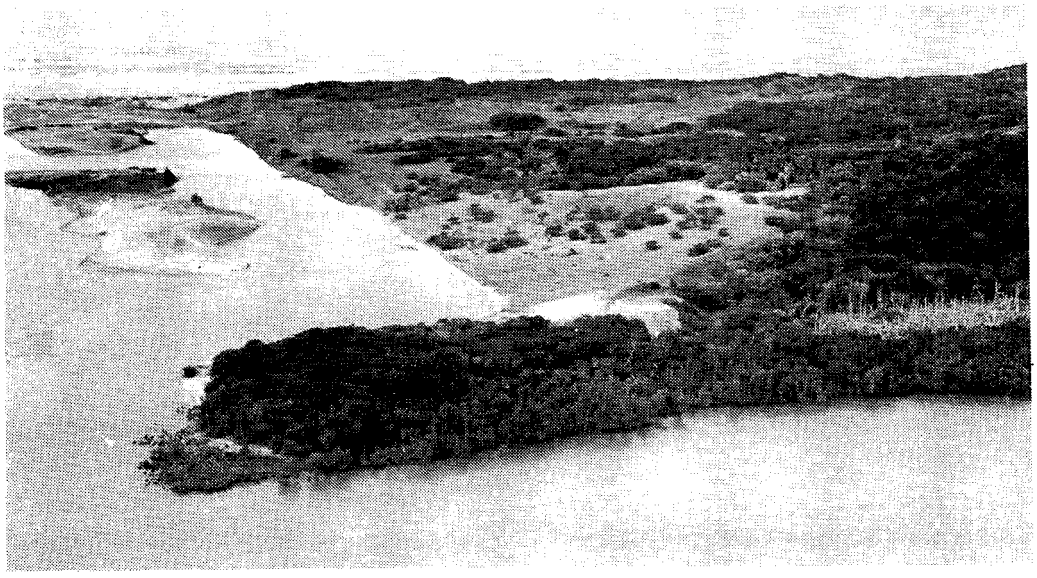

Figure 7: Northern limit of the study area showing dredged areas filled up with salt water; mud-flats where seedlings of *Avicennia marina* were found; secondary grassland invaded by *Acacia karroo;* Secondary Dune Scrub and Climax Dune Forest. The water at the lower part of the picture is fringed by a band of mangroves, mainly *Bruguiera gymnorrhiza.* The northern end of the destroyed Swamp Forest is visible (1982/03/29).

Table 4 Structure, species composition and cover-abundance values of Climax Dune Forest. Species where no cover-abundance value is available are indicated by X. Species occurring only once are ommitted.
F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	301	302	303	348	355	373	374	378	380	381	404	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	10	11	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	5	5	6	6	10	10	10	10	10	10	11	–	–	–	–	–
Day	18	18	2	3	6	23	23	26	28	28	13	–	–	–	–	–
Cover:																
Total Cover	90	80	100	95	80	80	90	100	90	80	90	–	–	80-100	–	–
Field Layer	35	20	85	90	10	25	35	5	10	10	2	–	–	2-90	–	–
Understorey	10	10	10	10	20	20	10	90	10	15	10	–	–	10-90	–	–
Canopy	50	60	60	60	70	50	70	50	80	60	80	–	–	50-80	–	–
Height:																
Field Layer	0-1,5	0-1	0-2	0-2	0-1	0-0,5	0-1	0-0,5	0-0,2	0-0.5	0-0,2	–	–	0-2	0-1,35	2
Understorey	1,5-6	1-6	2-6	2-5	1-2	0,5-4	1-6	0,5-2	0,2-4	0,5-4	0,2-3	–	–	0,2-6	1,35-4,36	6
Canopy	6-18	6-10	6-13	5-14	2-6	4-7	6-14	2-5	4-8	4-7	3-8	–	–	2-18	4,36-10	18
Emergent	18	15	15	16	8	8	8	12	9	–	12	–	–	–	–	18
Microsorium scolopendrium	x	x	x	+	1	2	2	1	2	2	–	10	90,9			
Dracaena hookeriana	x	x	–	+	1	+	2	1	+	–	2	9	81,8			
Psychotria capensis	x	x	–	1	1	1	1	1	1	1	–	9	81,8			
Canthium inerme	x	–	–	1	1	1	2	2	2	1	1	9	81,8			
Rhoicissus rhomboidea	x	–	x	1	+	+	–	1	+	–	+	8	72,7			
Allophylus natalensis	x	–	–	1	1	–	1	3	–	1	+	8	72,7			
Clausena anisata	x	x	x	–	1	2	1	1	–	–	1	8	72,7			
Celtis africana	x	x	x	2	2	–	–	–	–	–	3	6	54,5			
Deinbollia oblongifolia	x	x	–	+	1	–	1	–	–	–	2	6	54,5			
Pupalia atropurpurea	–	x	x	–	+	+	1	+	–	–	–	6	54,5			
Tricalysia sonderiana	–	–	x	–	1	2	–	1	+	1	–	6	54,5			
Rhoicissus tomentosa	–	–	–	–	R	–	2	1	1	1	+	6	54,5			
Euclea natalensis	–	x	–	1	–	1	–	2	2	4	–	6	54,5			
Sideroxylon inerme	–	x	x	1	+	–	2	–	–	–	2	6	54,5			
Mimusops caffra	–	–	–	2	–	3	4	4	3	2	–	6	54,5			
Commelina spp.	–	x	–	–	+	+	–	R	–	+	1	6	54,5			
Isoglossa wooddii	–	–	–	5	–	–	2	5	2	1	–	5	45,5			
Peddiea africana	–	–	–	–	–	1	+	1	1	1	–	5	45,5			
Carissa bispinosa	–	–	–	–	–	1	1	+	+	1	–	5	45,5			
Dovyalis longispina	–	–	–	–	1	2	2	–	2	1	–	5	45,5			
Cussonia sphaerocephala	x	–	–	–	1	–	3	–	+	1	–	5	45,5			
Cordia caffra	–	–	–	–	2	–	1	+	–	–	2	4	36,4			
Harpephyllum caffrum	–	–	–	–	–	R	–	2	1	2	–	4	36,4			
Monanthotaxis caffra	–	–	–	–	–	1	1	1	+	–	–	4	36,4			
Oplismenus hirtellus	–	–	–	–	+	+	–	+	+	–	–	4	36,4			
Bersama lucens	–	–	x	–	–	–	–	–	1	1	R	4	36,4			
Apodytes dimidiata	–	–	x	–	–	–	1	1	1	–	–	4	36,4			
Kraussia floribunda	–	–	–	–	–	+	–	1	+	1	–	4	36,4			
Ekebergia capensis	x	x	–	–	–	–	–	–	1	1	–	4	36,4			
Cyperus albostriatus	x	x	–	–	–	–	–	–	+	1	–	4	36,4			
Putterlickia verrucosa	–	–	–	–	–	–	1	–	1	2	–	3	27,3			
Scadoxus membranaceus	–	–	–	–	–	R	–	–	R	+	–	3	27,3			
Secamone filiformis	–	x	x	–	–	–	–	–	–	+	–	3	27,3			
Rhus nebulosa	–	–	x	–	–	+	–	–	–	1	–	3	27,3			
Rhoicissus sp. nov.	–	–	–	–	–	+	1	–	1	–	–	3	27,3			
Asplenium prionitis	–	–	x	+	–	–	+	–	–	–	–	3	27,3			
Pavetta revoluta	–	x	–	–	–	–	–	–	–	1	1	3	27,3			
Turraea floribunda	x	x	–	–	2	–	–	–	–	–	–	3	27,3			
Protasparagus setaceus	x	–	–	–	+	–	–	–	–	–	+	3	27,3			
Phoenix reclinata	x	x	–	–	–	–	–	–	–	–	–	2	18,2			
Acacia schweinfurthii	x	x	–	–	–	–	–	–	–	–	–	2	18,2			
Scutia myrtina	–	–	–	–	–	–	1	–	–	–	–	2	18,2			
Secamone alpinii	–	–	–	–	–	+	–	–	+	–	–	2	18,2			
Grewia occidentalis	–	–	–	–	–	–	2	1	–	–	–	2	18,2			
Vepris lanceolata (= V. undulata)	–	–	–	–	–	–	–	–	1	2	–	2	18,2			
Crocosmia aurea	–	–	–	–	–	–	–	–	+	+	–	2	18,2			
Ficus natalensis	–	–	–	–	–	–	–	–	1	–	1	2	18,2			
Maytenus nemorosa	–	–	–	1	–	1	–	–	–	–	–	2	18,2			
Maytenus procumbens	–	–	–	–	+	–	–	1	–	–	–	2	18,2			
Secamone filiformis	–	–	x	–	+	–	–	–	–	–	–	2	18,2			
Strelitzia nicolai	–	–	–	–	–	+	+	–	–	–	–	2	18,2			
Scadoxus puniceus	–	–	–	–	–	+	–	–	–	–	+	2	18,2			
Protasparagus falcatus	x	–	x	–	–	–	–	–	–	–	–	2	18,2			

Areas that could fall under the mapping unit "Coastal Dune High Forest" used for a high Dune Forest Type occurring in the dune valleys of Mapelana (Weisser, 1978b) were not found. This underlines the uniqueness of the Mapelana situation.

Evaluation

The mapping unit is of a high conservation priority and should be kept unspoiled. It is the product of centuries of community evolution, comprising a large number of species (high species diversity) and contains most of the largest individuals of different natural tree species and is therefore of the greatest scientific interest. The complex structure of communities of this mapping unit provides many specialized habitats, often occupied by plant species with special environmental requirements. This makes them vulnerable and irreplaceable.

This unit overlaps with intended mining operations in a few areas and it will be necessary to compromise in a few situations. These patches are important as seed reservoirs for rehabilitation of mined areas. In the planning of roads and other infrastructure for mining operations, the presence of this unit should be noted and disturbance avoided wherever possible.

(13) Mangrove Swamp (13,6 ha)

This type of vegetation is confined to estuarine situations and was detected in the Richards Bay area and at the Mlalazi Peninsula. Structural and floristic information is given in Table 5.

Table 5 Structure, species composition and cover-abundance values of Mangrove Swamp.
F = Frequency, RF = Relative frequency in %, CR = Cover Range, MH = Maximum Height in metres, AR = Average Range

Relevé No.	407	408	409	426	427	428	429	439	440	444	F	RF	CR	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	10	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	11	11	11	11	11	11	11	11	11	11	–	–	–	–	–
Day	14	14	14	20	20	20	20	24	24	24	–	–	–	–	–
Cover:															
Total Cover	50	60	30	50	60	50	80	3	1	90	–	–	1-90	–	–
Field Layer	–	–	–	–	–	–	–	–	–	–	–	–	0-3	–	–
Understorey	5	20	10	30	50	5	35	–	–	80	–	–	5-80	–	–
Canopy	45	50	20	30	10	50	40	3	1	60	–	–	1-60	–	–
Height:															
Field Layer	–	–	0-1,5	–	–	–	–	–	–	–	–	–	0-1,5	0-0,92	1,5
Understorey	0-2	1-5	–	0-0,8	0-1,5	0-0,5	0,5-1,7	–	–	0-1,2	–	–	0-1,7	0,92-1,81	1,7
Canopy	2-4	5	1,5-2,5	0,8-6	1,5-8	0,5-8	1,7-8	–	–	0-6	–	–	0-8	1,81-5,94	8
Emergent	5	6	8	–	–	–	–	0,8	0,3	–	–	–	–	–	8
Avicennia marina	3	4	3	1	+	–	–	1	+	4	7	70	–	–	–
Bruguiera gymnorrhiza	2	2	–	3	4	4	5	–	–	5	6	60	–	–	–

1. Mangroves at Richards Bay (Fig. 7)

Mangroves occupy an area of about 6,5 ha and consist of a band of tall *Bruguiera gymnorrhiza* with occasional *Avicennia marina* trees along the shores of the Richards Bay Sanctuary. Detailed information about the mangroves of Richards Bay can be found in Venter (1972). C.J. Ward (1976, pers. comm.) found plants of *Rhizophora mucronata* in the Richards Bay area.

A landward expansion of this community is occurring into what were the *Phoenix/Hibiscus* and *Barringtonia racemosa* communities (*sensu* Venter 1972) destroyed after the new mouth for the Richards Bay Sanctuary was opened (Weisser & Ward, 1982).

Through earth movements and dredging, new mud-flats were created near the new mouth, and the establishment of *Avicennia marina* seedlings on these mud-flats was observed.

2. Mangroves at the Mlalazi Estuary

These mangroves are recent and no mangroves were detected on the 1937 air photos. Ward (in Begg, 1978) reports that the mangroves first became established at the Mlalazi Estuary in the 1940's. Seedlings and young trees were observed during field work. This suggests that this community is tending to increase in extent. The mangroves mapped at the Mlalazi Estuary cover 7,0 ha. Ward and Steinke (1982) estimated the Mlalazi Lagoon mangrove area (including shores outside our study area) to be 30 ha.

Evaluation

There is no overlapping of areas proposed for mining with this unit. Because of its small extent, it is assessed as a first priority for conservation.

(14) Destroyed Phoenix/Hibiscus *and* Barringtonia racemosa *Swamp*

The vegetation of this mapping unit (7,2 ha) was destroyed after the opening of the new mouth at Richards Bay Sanctuary (1974) (Figs. 7 and 8) because of the increased tidal range and salinity (Weisser & Ward, 1982)

Figure 8: Remnants of *Phoenix/Hibiscus* and *Barringtonia racemosa* communities on the southern shore of Richards Bay destroyed by increased salinities and tidal range following the opening of new mouth at Richards Bay. *Bruguiera gymnorrhiza can be seen in the background.*

Venter (1972) described the *Phoenix/Hibiscus* community prior to its destruction as occupying a small zone immediately behind the *Bruguiera gymnorrhiza* community at

the south-eastern shore of Richards Bay (see Fig. 3 in Venter 1972). It was a dense thicket formed mainly by the palm *Phoenix reclinata, Hibiscus tiliaceus* and the fern *Acrostichum aureum.*

The *Barringtonia racemosa* community was also studied by Venter (1972). The habitat was muddy and covered with stagnant water. *Barringtonia racemosa* and *Syzygium cordatum* were predominant. Other common canopy species were *Voacanga thouarsii, Bridelia micrantha* and *Macaranga capensis.*

Colonization of the destroyed habitat by *Phragmites australis, Bruguiera gymnorrhiza* and *Avicennia marina* was observed (Weisser & Ward; see Table 6).

Table 6 Structure, species composition and cover-abundance values of destroyed *Phoenix/Hibiscus* and *Barringtonia* Swamp with *Phragmites australis* regrowth.

F = Frequency, RF = Relative Frequency in %, CR = Cover Range, AR = Average Range, MH = Maximum Height in metres

Relevé No.	441	442	443	446	445	F	RF	CR	AR	MH
Running No.	1	2	3	4	5	–	–	–	–	–
Date Year	80	80	80	80	80	–	–	–	–	–
Month	11	11	11	11	11	–	–	–	–	–
Day	24	24	24	24	24	–	–	–	–	–
Cover:										
Total Cover	10	6	15	70	7	–	–	7-70	–	–
Field Layer	2	–	–	10	2	–	–	2-10	–	–
Canopy	8	6	15	60	5	–	–	5-60	–	–
Height:										
Field Layer	0-0,2	0-0,3	–	0-1,5	0-0,3	–	–	–	–	1,5
Canopy	0,2-1,2	0,3-1,7	0-2	1,5-3,5	0,3-1,5	–	–	0-3,5	0,46-1,98	3,5
Phragmites australis	2	2	2	4	+	5	100	–	–	–
Bruguiera gymnorrhiza	1	–	–	–	1	2	40	–	–	–
Acrostichum aureum	–	–	–	2	1	2	40	–	–	–
Phoenix reclinata	–	–	–	1	1	2	40	–	–	–
Avicennia marina	–	r	–	–	–	1	20	–	–	–
Barringtonia racemosa	–	–	–	–	+	1	20	–	–	–

Evaluation

There is no overlapping with proposed mining. Because of the sensitivity of the estuarine habitat, it has been rated as first priority for conservation.

(15) Hibiscus tiliaceus *Thicket*

This woody community is formed by almost monospecific stands of *Hibiscus tiliaceus,* usually near water, forming a vegetation band around some ponds. It covers an area of only 0,5 ha.

The consistent detection of this mapping unit on the air photos is difficult and most of the mapped occurrences are based on field knowledge (Table 7).

Evaluation

No mining is intended in the area of this mapping unit and all the areas mapped fall into the Richards Bay Sanctuary or the proposed KwaZulu Botanical Garden and were therefore rated as first priority for conservation.

(16) Swamp Forest

This mapping unit consists of small areas of forest on the landward side of the dune field near ponds, usually on flat, muddy ground, often with standing water and mainly composed of *Ficus trichopoda.*

Only one sample was studied. It was a 9 m high forest with the following height/cover values: tree layer 6—9 m/50%; understorey 1—6 m/10% and field layer 0—1 m/50%.

Tree species recorded included *Syzygium cordatum, Trichilia emetica* and *Phoenix reclinata.* In the field layer the fern *Asplenium prionites* and the grass *Setaria megaphylla* were present.

Evaluation

Because of the small area occupied and the fragility of this ecosystem and associated aquatic sites, these areas were rated as first priority for conservation.

Table 7 Structure, species composition and cover-abundance values of *Hibiscus tiliaceus* Thicket.
F = Frequency, CR = Cover Range, MH = Maximum Height in metres, AR = Average Range

Relevé No.	367	368	369	372	405	406	F	CR	AR	MH
Running No.	1	2	3	4	5	6	–	–	–	–
Date Year	–	–	–	–	80	80	–	–	–	–
Month	–	–	–	–	11	11	–	–	–	–
Day	–	–	–	–	14	14	–	–	–	–
Cover:										
Total Cover	–	40	60	70	60	70	–	40-70	–	–
Field Layer	–	–	1	5	–	–	–	1-5	–	–
Understorey:	–	–	20	–	10	3	–	3-20	–	–
Canopy	–	40	50	65	55	70	–	40-70	–	–
Height:										
Field Layer	–	–	0-0,7	0-1	–	–	–	0-1	0-0,85	1
Understorey	–	–	0,7-2	–	0-2	0-1	–	0-2	0,85-1,67	2
Canopy	0-6	0-6	2-6	1-6	2-5	1-6	–	0-6	1,67-5,83	6
Hibiscus tiliaceus	3	3	4	4	4	4	6	–	–	–
Phragmites australis	1	1	1	–	–	–	3	–	–	–
Bruguiera gymnorrhiza	–	+	–	–	2	–	2	–	–	–
Barringtonia racemosa	+	–	–	–	–	–	1	–	–	–
Juncus kraussii	–	–	1	–	–	–	1	–	–	–
Microsorium scolopendrium	–	–	–	1	–	–	1	–	–	–
Ipomoea congesta	–	–	–	+	–	–	1	–	–	–
Allophylus natalensis	–	–	–	–	–	1	1	–	–	–
Grewia occidentalis	–	–	–	–	–	2	1	–	–	–
Rhoicissus rhomboidea	–	–	–	–	–	+	1	–	–	–

(17) Hygrophilous Forest

In two places, the dunes are crossed by streamlets, on the banks of which a hygrophilous woody vegetation, consisting mainly of *Barringtonia racemosa, Syzygium cordatum, Bridelia micrantha* and *Ficus sur* exists. The medium-tall size (6—10m) suggests a young forest. In 1937 the vegetation along the streamlets was probably formed by predominantly herbaceous elements (not mappable), that was later outgrown by woody elements after protection was enforced by the then Department of Forestry.

In 1976 the area occupied was estimated to be 5,6 ha. The real area is probably less, as the limit of this unit is difficult to establish on the air photos and being such a narrow band of vegetation, it becomes difficult to represent on a map. Structural and floristic information can be obtained from Table 8.

Evaluation

The two streamlets and a vegetation band of 50 m on either side have been rated as first priority for conservation.

Table 8 Structure, species composition and cover-abundance values of Hygrophilous Forest.
F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	410	411	412	447	448	449	450	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	–	–	–	–	–
Month	11	11	11	11	11	11	11	–	–	–	–	–
Day	17	17	17	25	25	25	25	–	–	–	–	–
Cover:												
Total Cover	80	90	85	80	90	90	95	–	–	80-90	–	–
Field Layer	10	15	10	0	20	30	10	–	–	10-30	–	–
Understorey	–	–	–	20	5	10	10	–	–	5-20	–	–
Canopy	75	80	80	75	70	80	90	–	–	70-90	–	–
Height:												
Field Layer	0-1	0-0,5	0-0,6	0-	0-0,1	0-0,5	0-0,3	–	–	0-0,5	0-4,8	0,5
Understorey	–	–	–	–	0,1-0,5	0,5-2	0,3-2	–	–	0-2	0-1,28	2
Canopy	1-7	8	0,6	–	0,5-8	2-6	2-10	–	–	0-10	1,38-6,6	10
Emergent	–	10	–	–	–	–	–	–	–	–	–	10
Barringtonia racemosa	4	4	4	3	4	3	3	7	100			
Syzygium cordatum	2	2	–	2	2	2	–	5	71,4			
Isoglossa woodii	1	1	2	–	2	–	–	4	57,1			
Psychotria capensis	–	–	+	1	1	–	1	4	57,1			
Bridelia micrantha	–	2	–	–	–	1	2	3	42,9			
Thelypteris dentata var. dentata	+	+	1	–	–	–	–	3	42,9			
Adiantum capillus-veneris	+	–	+	+	–	–	–	3	42,9			
Commelina sp.	+	R	–	+	–	–	–	3	42,9			
Rhoicissus rhomboidea	1	–	–	2	1	–	–	3	42,9			
Peddiea africana	1	1	1	–	–	–	–	3	42,9			
Phoenix reclinata	–	+	+	–	–	–	1	3	42,9			
Protasparagus falcatus	–	+	+	+	–	–	–	3	42,9			
Ficus sur	–	–	2	–	–	2	2	3	42,9			
Ficus lutea	–	–	–	5	+	–	4	3	42,9			
Trema orientalis	–	–	–	–	1	2	1	3	42,9			
Ipomoea spp	+	–	+	–	–	–	–	2	28,6			
Senecio tamoides	–	1	1	–	–	–	–	2	28,6			
Smilax kraussiana	–	–	+	–	+	–	–	2	28,6			
Drimiopsis maculata	–	–	–	+	1	–	–	2	28,6			
Canthium inerme	–	–	–	–	–	2	+	2	28,6			
Microsorium punctatum	+	–	–	–	–	–	–	1	14,3			
Setaria megaphylla (=S. chevalieri)	1	–	–	–	–	–	–	1	14,3			
Albizia adianthifolia	+	–	–	–	–	–	–	1	14,3			
Deinbollia oblongifolia	1	–	–	–	–	–	–	1	14,3			
Crocosmia aurea	+	–	–	–	–	–	–	1	14,3			
Kraussia floribunda	–	+	–	–	–	–	–	1	14,3			
Celtis africana	–	+	–	–	–	–	–	1	14,3			
Strelitzia nicolai	–	R	–	–	–	–	–	1	14,3			
Harpephyllum caffrum	–	1	–	–	–	–	–	1	14,3			
Dalbergia armata	–	–	1	–	–	–	–	1	14,3			
Dalbergia obovata	–	–	1	–	–	–	–	1	14,3			
Maesa lanceolata	–	–	–	2	–	–	–	1	14,3			
Dioscorea cirrita	–	–	–	1	–	–	–	1	14,3			
cf. Stenochloena tenuifolia	–	–	–	+	–	–	–	1	14,3			
Cissampelos torulosa	–	–	–	+	–	–	–	1	14,3			
Oplismenus hirtellus	–	–	–	–	2	–	–	1	14,3			
Cyperus textilis	–	–	–	–	1	–	–	1	14,3			
Hypoëstes aristata	–	–	–	–	2	–	–	1	14,3			
Aristida junciformis	–	–	–	–	2	–	–	1	14,3			
Aneilema schlechteri	–	–	–	–	+	–	–	1	14,3			
Asystasia gangetica	–	–	–	–	1	–	–	1	14,3			
Cestrum laevigatum	–	–	–	–	–	1	–	1	14,3			
Grewia occidentalis	–	–	–	–	–	–	+	1	14,3			
Halleria lucida	–	–	–	–	–	–	+	1	14,3			
Dracaena hookeriana	–	–	–	–	–	–	1	1	14,3			
Microsorium scolopendrium	–	–	+	–	–	–	–	1	14,3			
Centella asiatica	1	–	–	–	–	–	–	1	14,3			

(18) Primary Acacia karroo *Woodland*

Acacia karroo may be the dominant woody colonizer on accretion zones at the Mlalazi Peninsula when the land has risen sufficiently to be outside the tidal range. With time this community will be replaced by forest. An area of 2,7 ha was mapped.

No data were gathered about this mapping unit, because areas concerned lie outside the proposed mining zone and occupy a small area.

Evaluation

All areas mapped occur on the Mlalazi Peninsula and will form part of the KwaZulu Botanical Garden. They are therefore rated as first priority for conservation.

(19) Secondary Acacia karroo *or* Trema orientalis *Woodland with Secondary Scrub.*

As found in other areas (e.g. Edwards, 1967; Weisser, 1983) *Acacia karroo* is a frequent invader of abandoned fields, secondary grasslands and dwarf scrub communities.

During field checking it was discovered that some areas at Richards Bay interpreted as *Acacia karroo* Woodland were *Trema orientalis* stands. *Trema orientalis* Woodland is therefore included in this mapping unit. McDonald and Pammenter (MS) reported *T. orientalis* as being the main woody species in the regeneration of a coastal dune forest after fire. This suggests that the areas where *T. orientalis* was found, may have been affected by fire, but it is a pantropical pioneer colonizing bare and disturbed sites. This mapping unit occupies 652 ha.

Acacia karroo Woodland

This woodland represents a successional stage that has developed from dune grassland and that leads to the Secondary Dune Forest and later to the Climax Dune Forest. Some areas that were grassland in 1937 are today covered with *Acacia karroo* about 6 m tall with dense undergrowth formed either by *Isoglossa woodii* or by plants such as *Laportea peduncularis, Asystasia gangetica* and *Barleria repens.* Structure and species composition recorded on sampled sites are given in Table 9.

Acacia karroo is a rapidly growing tree that can colonize bare sand when conditions are favourable, e.g. protection from wind and sun with little or no salt spray and favourable rains. In the abandoned test mining site at Mapelana, the average cover of *Acacia karroo* was 50% and some seedlings had reached a height of 1,5 m after one and a half to two years. Dune rehabilitation work done by Richards Bay Minerals corroborates the speed with which this species can colonize dunes. Areas mined during 1979 are today covered with a dense *Acacia karroo* thicket.

Evaluation

Acacia karroo Woodland covers some areas intended for mining. In general, it rates as second and third priority for conservation because it is secondary, has low species diversity and is easy to re-establish.

Trema orientalis Woodland

Because of difficulties of consistently separating this vegetation on the air photos from the *Acacia karroo* Woodland both vegetation types were consolidated into one mapping unit. *Trema orientalis* and *Acacia karroo* are both dune forest pioneers and lead in the succession to a Climax Dune Forest.

Table 9 Structure, species composition and cover-abundance values of Secondary *Acacia karroo* Woodland and Secondary Scrub. F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres. Species occurring once were omitted. When a presence list was made, the present species are marked with x.

Relevé No.	304	341	351	352	389	390	434	435	436	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	5	6	6	6	11	11	11	11	11	–	–	–	–	–
Day	22	1	6	6	3	3	22	22	22	–	–	–	–	–
Cover:														
Total Cover	90	80	90	100	95	90	100	90	60	–	–	60-100	–	–
Field Layer	80	30	80	70	70	80	80	70	20	–	–	20-80	–	–
Understorey	30	20	20	25	10	10	10	15	5	–	–	10-30		
Canopy	20	40	40	40	30	30	60	50	50	–	–	20-60	–	–
Height:														
Field Layer	0-1,5	0-0,5	0-1	0-1,5	0-0,5	0-0,5	0-1	0-1	0-0,3	–	–	0-1,5	0-0,86	1,5
Understorey	1,5-6	0,5-4	1-6	1,5-7	0,5-4	0,5-5	1-4	1-5	0,3-1	–	–	0,3-7	0,86-4,6	7
Canopy	6-10	8	6-10	7-12	4-8	5-6	4-8	5-7	1-5	–	–	1-12	4,6-8,2	12
Emergent	–	–	12	–	–	–	–	–	–	–	–	–	–	12
Protasparagus falcatus	x	+	+	+	1	1	1	1	–	8	88,9			
Pupalia atropurpurea	x	+	1	1	1	1	+	–	+	8	88,9			
Acacia karroo	–	–	3	3	3	2	3	3	3	7	77,8			
Brachylaena discolor	x	–	1	1	2	2	–	R	+	7	77,8			
Rhus nebulosa	x	1	+	+	2	2	2	–	–	7	77,8			
Cestrum laevigatum	x	–	+	+	1	1	–	2	–	6	66,7			
Allophylus natalensis	x	–	2	2	2	2	2	–	–	6	66,7			
Laportea peduncularis	x	–	2	2	2	2	–	–	–	5	55,6			
Scutia myrtrina	x	–	–	–	1	1	1	–	+	5	55,6			
Asystasia gangetica	x	2	1	–	2	2	–	–	–	5	55,6			
Microsorium scolopendrium	–	–	1	2	2	–	1	2	–	5	55,6			
Tricalysia sonderiana	–	+	1	1	–	–	+	+	–	5	55,6			
Secamone filiformis	–	–	–	–	+	+	+	+	–	5	55,6			
Phoenix reclinata	x	+	–	–	1	1	–	–	–	4	44,5			
Canthium inerme	x	–	1	2	–	–	–	–	+	4	44,5			
Deinbollia oblongifolia	–	+	1	+	–	–	–	–	+	4	44,5			
Cynanchum ellipticum	–	–	–	–	+	+	+	–	+	4	44,5			
Rubia cordifolia	x	–	–	–	+	+	–	+	–	4	44,5			
Oplismenus hirtellus	x	–	1	–	2	–	–	–	–	3	33,4			
Smilax kraussiana	x	+	–	–	–	–	–	+	–	3	33,4			
Strelitzia nicolai	–	1	–	–	–	–	1	+	–	3	33,4			
Psychotria capensis	–	+	+	+	–	–	–	–	–	3	33,4			
Rivina humilis	–	–	–	–	–	5	4		–	3	33,4			
Trichilia emetica	x	–	–	–	–	–	1	–	–	2	22,3			
Trema orientalis	–	–	–	+	–	–	–	1	–	2	22,3			
Spec. indet.	–	–	–	–	1	1	–	–	–	2	22,3			
Secamone alpinii	–	–	–	–	+	–	R	–	–	2	22,3			
Cissampelos torrulosa	–	+	–	+	–	–	–	–	–	2	22,3			
Vernonia aurantiaca	–	+	–	–	–	–	–	+	–	2	22,3			
Aneilema schlechteri	–	–	–	+	+	–	–	–	–	2	22,3			
Apodytes dimidiata	–	–	1	–	–	–	–	1	–	2	22,3			
Spec. indet.	–	–	1	1	–	–	–	–	–	2	22,3			
Commelina spp.	–	–	+	+	–	–	–	–	–	2	22,3			
Dracaena hookeriana	–	–	+	1	–	–	–	–	–	2	22,3			
Protasparagus setaceus	–	–	+	+	–	–	–	–	–	2	22,3			
Clausena anisata	–	–	1	+	–	–	–	–	–	2	22,3			
Thelypters sp.	–	–	+	+	–	–	–	–	–	2	22,3			
Grewia occidentalis	–	–	–	–	–	–	1	–	1	2	22,3			
Solanum seaforthianum	–	–	–	–	–	–	R	+	–	2	22,3			
Cyphostemma cirrhosum	–	–	–	–	–	–	+	+	–	2	22,3			

Table 10 gives structural and floristic information obtained at four sites. It is a woodland of trees usually 5 - 7m high, with 20 - 30% cover, a well developed understorey of 0,5 - 1,5 m/5 - 10% cover and a field layer 0 - 0,5 m/and 40 - 70%

cover. The presence in the understorey of dune forest species, such as *Celtis africana, Teclea gerrardii* and *Sideroxylon inerme,* gives an indication of the species composition of the canopy when these trees should reach maturity.

Evaluation

The *Trema orientalis* Woodlands found were mostly outside the prospecting area and do not pose a conservation problem. They were usually graded as second or third priorities.

(20) Secondary Dune Scrub and Secondary Dune Forest

The inclusion of these two structurally and floristically different vegetation types into one mapping unit arises from the difficulty of separating them on the air photos and the many intermediate situations found while mapping. This mapping unit is mainly found at the northern and southern end of the study area and covers an area of 862,4 ha.

The physiognomy of this unit varies from scrub groups with scattered patches of grassland to dense forest vegetation. Tables 11 and 12 list species recorded and provide information on height and cover values obtained at the sites sampled.

Evaluation

Some areas of this unit fall within the prospecting lease area. Their replaceability, secondary nature and relatively low scientific value relegate most of the Secondary Dune Scrub to second and third priority for conservation.

(21) Casuarina equisetifolia *Afforestation*

Casuarina equisetifolia was extensively and successfully planted in rows as wind breaks to stabilize driftsands, and along eroding parts of the coast to aid stability.

In 1976 *C. equisetifolia* covered an area of about 360,0 ha. This mapping unit is mainly found on driftsands near the coast and inland. The first plantations were established after 1952. Table 13 gives structural and floristic information on this mapping unit.

Evaluation

This mapping unit has a low conservation priority, because it is easy to re-establish.

(22) Eucalypt and Pine Afforestation

Most of the Secondary Grasslands and Dwarf Scrub of 1937 are today covered with this mapping unit. The Department of Forestry planted extensive areas with eucalypts and pines and an area of 786,1 ha was measured. Information given by the Department of Forestry (KwaZulu) reveals that the following species were the most frequently planted: *Pinus elliottii, Eucalyptus grandis, E. saligna* and *E. maculata.* Table 14 gives structural and floristic information on this mapping unit.

The main plantations are located in areas covered by Maps 2-5, whereas the northern and southern extremes of the study are almost free of pines and eucalypts.

Evaluation

Over extensive areas an overlap exists between areas intended for mining and those afforested. The afforested areas have low priority for conservation because of their easy replaceability and low species diversity.

Table 10 Structure, species composition and cover-abundance values of *Trema orientalis* Woodlands with Secondary Scrub.
When presence lists were made, the present species is marked with x.
F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	305	323	414	415	F	RF	R	AR	MH
Running No.	1	2	3	4	–	–	–	–	–
Date Year	80	–	80	80	–	–	–	–	–
Month	5	–	11	11	–	–	–	–	–
Day	22	–	18	18	–	–	–	–	–
Cover:									
Total Cover	80	–	60	80	–	–	60-80	–	–
Field Layer	60	–	40	70	–	–	40-70	–	–
Understorey	10	–	5	10	–	–	20-35	–	–
Canopy	35	–	25	20	–	–	–	–	–
Height:									
Field Layer	0-0,5	–	0-0,5	0-0,5	–	–	0-0,5	0-0,5	0,5
Understorey	0,5-5	–	0,5-1,5	–	–	–	0,5-5	0,5-3,25	5
Canopy	3,5-7	–	1,5-6	0,5-5	–	–	1,5-7	1,84-6	7
Trema orientalis	x	x	3	2	4	100	–	–	–
Commelina sp.	x	–	+	R	3	75	–	–	–
Asystasia gangetica	x	x	–	2	3	75	–	–	–
Acacia karroo	x	–	1	–	2	50	–	–	–
Laportea peduncularis	x	–	1	–	2	50	–	–	–
Rubia cordifolia	x	x	–	–	2	50	–	–	–
Microsorium scolopendrium	x	x	–	–	2	50	–	–	–
Rhus nebulosa	–	–	1	1	2	50	–	–	–
Celtis africana	–	–	1	2	2	50	–	–	–
Scutia myrtina	–	–	1	+	2	50	–	–	–
Gloriosa superba	–	–	+	+	2	50	–	–	–
Pupalia atropurpurea	–	–	2	1	2	50	–	–	–
Cyperus albostriatus	–	–	2	1	2	50	–	–	–
Vernonia aurantiaca	–	–	+	+	2	50	–	–	–
Abutilon grantii	–	–	+	R	2	50	–	–	–
Secamone filiformis	–	–	+	+	2	50	–	–	–
Tragia durbanensis	–	–	1	1	2	50	–	–	–
Panicum maximum	–	–	+	+	2	50	–	–	–
Clerodendrum glabrum	–	x	+	–	2	50	–	–	–
Phoenix reclinata	x	x	–	–	2	50	–	–	–
Cestrum laevigatum	x	–	–	–	1	25	–	–	–
Poacea spp.	x	–	–	–	1	25	–	–	–
Smilax kraussiana	x	–	–	–	1	25	–	–	–
Protasparagus falcatus	x	–	–	–	1	25	–	–	–
Momordica sp.	x	–	–	–	1	25	–	–	–
Secamone alpinii	x	–	–	–	1	25	–	–	–
Solanum sp.	x	–	–	–	1	25	–	–	–
Allophylus natalensis	x	–	–	–	1	25	–	–	–
Rhus macowanii	–	x	–	–	1	25	–	–	–
Cordia caffra	–	–	+	–	1	25	–	–	–
Teclea gerrardi	–	–	+	–	1	25	–	–	–
Clausena anisata	–	–	R		1	25	–	–	–
Peddiea africana	–	–	+	–	1	25	–	–	–
Bidens pilosa	–	–	1	–	1	25	–	–	–
Phyllanthus sp. cf. nummulariifolius	–	–	+	–	1	25	–	–	–
Rauvolfia caffra	–	–	–	1	1	25	–	–	–
Sideroxylon inerme	–	–	–	+	1	25	–	–	–
Imperata cylindrica	–	–	–	+	1	25	–	–	–
Canthium inerme	–	–	–	+	1	25	–	–	–
Olea woodiana	–	–	+	–	1	25	–	–	–
Zanthoxylon capense	–	–	+	–	1	25	–	–	–
Dovyalis longispina	–	–	+	–	1	25	–	–	–
Panicum aequinerve	–	–	1	–	1	25	–	–	–
Achyranthes sicula	–	–	1	–	1	25	–	–	–
Cynanchum ellipticum	–	–	1	–	1	25	–	–	–
Senecio tamoides	–	–	+	–	1	25	–	–	–
Strelitzia nicolai	–	x	–	–	1	25	–	–	–
Rhoicissus revoilii	–	–	–	+	1	25	–	–	–
Brachylaena discolor	–	x	–	–	1	25	–	–	–
Hyphaene natalensis	–	x	–	–	1	25	–	–	–
Hydrocotyle bonariensis	–	x	–	–	1	25	–	–	–
Acacia kraussiana	–	–	–	+	1	25	–	–	–

Table 11 Structure, species composition and cover-abundance values of Secondary Dune Scrub.
F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.
Species occurring only once are omitted.

Relevé No.	307	308	384	385	386	387	396	397	398	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	–	–	–	–	–
Date Year	–	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	–	5	10	10	10	10	11	11	11	–	–	–	–	–
Day	–	19	31	31	31	31	9	9	9	–	–	–	–	–
Cover:														
Total Cover	–	95	70	70	70	70	60	70	40	–	–	40-90	–	–
Field Layer	–	10	5	5	15	5	20	30	30	–	–	5-30	–	–
Understorey														
Canopy	–	90	70	70	65	60	40	50	20	–	–	20-90	–	–
Height:														
Field Layer	–	0-0,5	0-0,2	0-0,3	0-0,5	0-0,3	0-0,4	0-0,5	0-0,5	–	–	0-0,5	0-0,4	0,5
Understorey														
Canopy	–	0-5	0,2-5	0,3-5	0,5-4	0,3-4	0,4-2	0,5-4	0,5-2,5	–	–	0-5	0,34-3,94	5
Emergent	–	6	6	6	–	8	3,5	–	–	–	–	–	–	8
Eugenia capensis	3	3	1	+	1	+	2	2	2	9	100	–	–	–
Microsorium scolopendrium	5	4	1	–	2	1	3	3	3	8	88,9	–	–	–
Kraussia floribunda	4	4	1	1	+	1	1	1	–	8	88,9	–	–	–
Brachylaena discolor	3	3	3	2	4	2	2	2	–	8	88,9	–	–	–
Rhus nebulosa	3	–	2	2	1	–	3	1	1	7	77,8	–	–	–
Smilax kraussiana	–	–	1	1	1	1	1	1	1	7	77,8	–	–	–
Dichrostachys cinerea	–	–	–	1	1	1	2	2	2	6	66,7			
Peddiea africana	–	3	+	1	1	+	–	+	–	6	66,7	–	–	–
Strelitzia nicolai	4	5	2	2	+	–	–	–	–	5	55,6	–	–	–
Hyphaene natalensis	3	–	2	–	1	1	–	1	–	5	55,6	–	–	–
Rubia cordifolia	3	–	+	–	+	R	–	1	–	5	55,6	–	–	–
Trichilia emetica	3	3	1	1	–	1	–	–	–	5	55,6	–	–	–
Putterlickia verrucosa	–	–	1	+	1	+	–	+	–	5	55,6	–	–	–
Allophylus natalensis	4	4	R	1	–	–	–	–	–	4	44,5	–	–	–
Mimusops caffra	–	2	–	R	–	+	+	–	–	4	44,5	–	–	–
Tricalysia sonderiana	–	2	1	1	+	–	–	–	–	4	44,5	–	–	–
Imperata cylindrica	4	–	–	–	–	–	1	+	1	4	44,5	–	–	–
Annona senegalensis	–	–	1	+	1	1	–	–	–	4	44,5	–	–	–
Canthium inerme	–	–	1	2	1	3	–	–	–	4	44,5	–	–	–
Apodytes dimidiata	–	–	–	1	2	1	–	+	–	4	44,5	–	–	–
Sclerocarya birrea (=S. caffra)	–	–	1	–	–	–	1	1	1	4	44,5	–	–	–
Chrysanthemoides monilifera	–	4	–	–	–	–	1	–	1	3	33,4	–	–	–
Euclea natalensis	2	2	–	1	–	–	–	–	–	3	33,4	–	–	–
Protasparagus falcatus	2	–	–	–	+	1	–	–	–	3	33,4	–	–	–
Gloriosa superba	2	–	+	–	+	–	–	–	–	3	33,4	–	–	–
Strychnos spinosa	–	–	2	–	1	1	–	–	–	3	33,4	–	–	–
Asystasia gangetica	–	–	+	+	+	–	–	–	–	3	33,4	–	–	–
Psychotria capensis	–	–	R	R	–	+	–	–	–	3	33,4	–	–	–
Erythrina caffra	2	–	2	2	–	–	–	–	–	3	33,4	–	–	–
Secamone alpinii	–	2	–	–	–	–	–	1	–	2	22,3	–	–	–
Carissa bispinosa	–	2	1	–	–	–	–	–	–	2	22,3	–	–	–
Salacia kraussii	–	–	1	–	–	+	–	–	–	2	22,3	–	–	–
Commelina sp.	–	–	+	+	–	–	–	–	–	2	22,3	–	–	–
Cyperus sp.	–	–	R	R	–	–	–	–	–	2	22,3	–	–	–
Scutia myrtina	–	–	–	+	–	1	–	–	–	2	22,3	–	–	–
Tragia durbanensis	–	–	–	R	–	R	–	–	–	2	22,3	–	–	–
Dovyalis longispina	3	3	–	–	–	–	–	–	–	2	22,3	–	–	–

Table 12 Structure, species composition and cover-abundance values of Secondary Dune Forest.
F = Frequency, RF = Relative Frequency in %, CR = Cover Range, MH = Maximum Height in metres, AR = Average Range.
Species occurring only once are omitted.

Relevé No.	349	350	354	390	391	394	395	401	402	F	RF	CR	AR	MH
Running No.	2	3	4	5	6	7	8	9	10	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	6	6	6	11	11	11	11	11	11	–	–	–	–	–
Day	4	4	6	4	4	9	9	10	10	–	–	–	–	–
Cover:														
Total Cover	70	60	85	80	80	80	80	70	80	–	–	60-80	–	–
Field Layer	10	10	40	15	15	10	30	20	20	–	–	10-40	–	–
Understorey	20	10	20	20	10	30	10	10	15	–	–	10-30	–	–
Canopy	50	40	50	70	75	60	75	60	50	–	–	40-75	–	–
Height:														
Field Layer	0-0,5	0-0,5	0-1	0-0,5	0-0,5	0-0,5	0-0,6	0-0,6	0-0,7	–	–	0-1	0-0,6	1
Understorey	0,5-4	0,5-3	1-3	0,5-3	1,5-3	0,5-2	0,6-4	0,6-2	–	–	–	0,5-4	0,6-3	4
Canopy	4-6	3-8	3-8	3-6	3-6	2-8	4	2-8	0,7-6	–	–	0,7-8	3-6,7	8
Emergent	–	10	10	7	–	–	–	–	–	–	–	–	–	10
Tricalysia sonderiana	1	1	1	1	1	1	1	+	+	9	100	–	–	–
Allophylus natalensis	1	2	3	1	–	3	1	2	2	8	88,9	–	–	–
Microsorium scolopendrium	+	–	1	2	2	1	3	2	2	8	88,9	–	–	–
Scutia myrtina	–	–	+	1	1	1	2	+	+	7	77,8	–	–	–
Euclea natalensis	+	+	–	2	3	1	–	1	–	6	66,7	–	–	–
Canthium inerme	–	+	1	1	–	2	+	2	–	6	66,7	–	–	–
Brachylaena discolor	–	–	+	1	2	2	–	1	2	6	66,7	–	–	–
Protasparagus falcatus	–	–	+	1	+	+	–	+	1	6	66,7	–	–	–
Peddiea africana	–	–	–	+	1	1	1	1	1	6	66,7	–	–	–
Kraussia floribunda	–	–	–	1	1	1	+	1	1	6	66,7	–	–	–
Apodytes dimidiata	–	–	–	1	1	2	2	1	1	6	66,7	–	–	–
Commelina sp.	+	1	1	+	–	+	–	–	–	5	55,6	–	–	–
Psychotria capensis	–	–	1	+	+	1	+	–	–	5	55,6	–	–	–
Secamone alpinii	–	–	–	–	+	+	+	+	+	5	55,6	–	–	–
Clausena anisata	1	1	3	1	–	–	–	–	–	4	44,5	–	–	–
Pupalia atropurpurea	1	1	1	1	–	–	–	–	–	4	44,5	–	–	–
Dovyalis longispina	–	–	–	2	2	1	–	–	1	4	44,5	–	–	–
Harpephyllum caffrum	–	–	–	1	+	+	+	–	–	4	44,5	–	–	–
Eugenia capensis	–	–	–	1	+	–	1	–	+	4	44,5	–	–	–
Smilax kraussiana	–	–	–	+	+	+	–	1	–	4	44,5	–	–	–
Protasparagus setaceus (=P.plumosus)	1	1	1	–	–	–	–	–	–	3	33,4	–	–	–
Vernonia aurantiaca	+	+	–	R	–	–	–	–	–	3	33,4	–	–	–
Dracaena hookeriana	1	+	1	–	–	–	–	–	–	3	33,4	–	–	–
Canthium obovatum	2	–	–	1	1	–	–	–	–	3	33,4	–	–	–
Celtis africana	2	2	1	–	–	–	–	–	–	3	33,4	–	–	–
Turraea floribunda	1	1	2	–	–	–	–	–	–	3	33,4	–	–	–
Strelitzia nicolai	–	+	–	1	–	1	–	–	–	3	33,4	–	–	–
Putterlickia verrucosa	–	1	–	2	1	–	–	–	–	3	33,4	–	–	–
Mimusops caffra	–	1	–	–	2	2	–	–	–	3	33,4	–	–	–
Deinbollia oblongifolia	–	1	1	+	–	–	–	–	–	3	33,4	–	–	–
Secamone filiformis	–	+	+	–	–	–	3	–	–	3	33,4	–	–	–
Strychnos spinosa	–	–	–	1	1	–	–	–	1	3	33,4	–	–	–
Scolopia mundii	–	–	–	2	+	–	–	R	–	3	33,4	–	–	–
Dichrostachys cinerea	–	–	–	–	+	–	+	–	+	3	33,4	–	–	–
Phoenix reclinata	–	–	–	–	–	+	–	+	+	3	33,4	–	–	–
Acacia schweinfurthii	1	1	–	–	–	–	–	–	–	2	22,3	–	–	–
Ochna holstii	+	+	–	–	–	–	–	–	–	2	22,3	–	–	–
Acacia karroo	2	3	–	–	–	–	–	–	–	2	22,3	–	–	–
Capparis sp.	+	1	–	–	–	–	–	–	–	2	22,3	–	–	–
Pavetta revoluta	+	–	–	+	–	–	–	–	–	2	22,3	–	–	–
Sideroxylon inerme	–	+	–	1	–	–	–	–	–	2	22,3	–	–	–
Laportea peduncularis	–	1	1	–	–	–	–	–	–	2	22,3	–	–	–
Maytenus procumbens	–	–	1	+	–	–	–	–	–	2	22,3	–	–	–
Ekebergia capensis	–	–	–	3	–	–	–	3	–	2	22,3	–	–	–
Carissa bispinosa	–	–	–	1	1	–	–	–	–	2	22,3	–	–	–
Annona senegalensis	–	–	–	1	–	–	–	+	–	2	22,3	–	–	–
Bersama lucens	–	–	–	+	R	–	–	–	–	2	22,3	–	–	–
Secamone filiformis	–	–	–	1	1	–	–	–	–	2	22,3	–	–	–
Spec. indet.	–	–	–	+	–	–	–	1	–	2	22,3	–	–	–
Rhoicissus digitata	–	–	–	+	+	–	–	–	–	2	22,3	–	–	–
Cyperus albostriatus	–	–	–	+	+	–	–	–	–	2	22,3	–	–	–
Crocosmia aurea	–	–	–	+	–	+	–	–	–	2	22,3	–	–	–
Rhus nebulosa	–	–	–	–	–	–	1	1	–	2	22,3	–	–	–
Scadoxus sp.	–	–	–	–	R	–	–	–	R	2	22,3	–	–	–
Rhoicissus rhomboidea	–	–	–	–	+	+	–	–	–	2	22,3	–	–	–
Rubia cordifolia	–	–	–	–	+	–	–	–	+	2	22,3	–	–	–
Carissa macrocarpa	–	–	–	–	–	1	2	–	–	2	22,3	–	–	–
Dalbergia armata	–	–	–	–	–	1	1	–	–	2	22,3	–	–	–
Rhoicissus revoilii	–	–	–	–	–	–	+	–	+	2	22,3	–	–	–
Strelitzia nicolai	–	–	–	–	–	–	2	2	–	2	22,3	–	–	–
Maytenus nemorosa	1	–	–	–	–	–	2	–	–	2	22,3	–	–	–
Grewia occidentalis	–	1	–	–	1	–	–	–	–	2	22,3	–	–	–

Table 13 Structure, species composition and cover-abundance values of *Casuarina equisetifolia* plantation.
F = Frequency, RF = Relative Frequency in %, CR = Cover Range, MH = Maximum Height in metres, AR = Average Range.
Species occurring only once are omitted.

Relevé No.	331	364	365	366	F	RF	CR	AR	MH
Running No.	1	2	3	4	–	–	–	–	–
Date Year	80	80	80	80	–	–	–	–	–
Month	5	10	10	10	–	–	–	–	–
Day	23	22	22	22	–	–	–	–	–
Cover:									
Total Cover	60	40	70	80	–	–	40-80	–	–
Field Layer	20	1	10	30	–	–	1-30	–	–
Understorey	15	–	1	10	–	–	1-15	–	–
Canopy	40	40	60	40	–	–	40-60	–	–
Height:									
Field Layer	0-0,5	0-0,15	0-0,2	0-0,3	–	–	–	0-0,28	0,05
Understorey	0,5-4	–	0,2-0,8	0,3-2	–	–	–	0,28-5,47	4
Canopy	8	10	10	12	–	–	–	10	12
Casuarina equisetifolia	5	3	4	3	4	100	–	–	–
Secamone alpinii	3	–	–	2	2	50	–	–	–
Kraussia floribunda	3	–	–	+	2	50	–	–	–
Vernonia aurantiaca	–	–	1	2	2	50	–	–	
Microsorium scolopendrium	4	–	–	–	1	25	–	–	–
Eugenia capensis	3	–	–	–	1	25	–	–	–
Sideroxylon inerme	3	–	–	–	1	25	–	–	–
Asystasia gangetica	3	–	–	–	1	25	–	–	–
Protasparagus falcatus	3	–	–	–	1	25	–	–	–
Peddiea africana	3	–	–	–	1	25	–	–	–
Dovyalis longispina	3	–	–	–	1	25	–	–	–
Embelia ruminata	2	–	–	–	1	25	–	–	–
Grewia sp.	2	–	–	–	1	25	–	–	–
Cordia caffra	2	–	–	–	1	25	–	–	–
Allophylus natalensis	3	–	–	–	1	25	–	–	–
Ficus burtt-davyi	3	–	–	–	1	25	–	–	–
Euclea natalensis	2	–	–	–	1	25	–	–	–
Capparis sp.	2	–	–	–	1	25	–	–	–
Carissa bispinosa	3	–	–	–	1	25	–	–	–
Scaevola plumieri	–	+	–	–	1	25	–	–	–
Sonchus oleraceus	–	R	–	–	1	25	–	–	–
Mimusops caffra	–	–	+	–	1	25	–	–	–
Pupalia atropurpurea	3	–	–	+	2	50	–	–	–
Brachylaena discolor	3	–	–	1	2	50	–	–	–
Cynanchum obtusifolium	3	–	1	–	2	50	–	–	–
Tricalysia sonderiana	3	–	–	1	2	50	–	–	–
Rhoicissus rhomboidea	–	–	–	+	1	25	–	–	–
Trichilia emetica	–	–	–	+	1	25	–	–	–
Adenia gummifera	–	–	–	1	1	25	–	–	–
Microglossa mespilifolia	–	–	–	+	1	25	–	–	–
Rhus nebulosa	–	–	–	+	1	25	–	–	–

(23) Reedswamp

This mapping unit is present in the form of isolated pockets of wetlands covered with reedbeds (Table 15). They are usually in low-lying places, where the water table is near the surface. Reedswamp is also present at Richards Bay, where it fringes on some open-water areas near the New Mouth. Reeds have also expanded in the destroyed *Phoenix/Hibiscus* and *Barringtonia racemosa* Swamp (Weisser & Ward, 1982). Main species are *Phragmites australis* and *Typha capensis.*

Table 14 Structure, species composition and cover-abundance values of Eucalypt and Pine Afforestation.
F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres.
Species occurring only once are omitted.

Relevé No.	329	330	334	339	340	353	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	–	–	–	–	–
Date Year	80	80	80	80	80	80	–	–	–	–	–
Month	5	5	5	6	6	6	–	–	–	–	–
Day	23	23	31	1	1	6	–	–	–	–	–
Cover:											
Total Cover	90	50	70	42	40	80	–	–	40-90	–	–
Field Layer	50	10	30	1	–	70	–	–	1-70	–	–
Understorey	5	5	5	1	–	–	–	–	1-20	–	–
Canopy	35	40	40	40	40	20	–	–	20-40	–	–
Height:											
Field Layer	0-0,8	0-0,6	0-0,8	0-0,3	–	0-0,8	–	–	0-0,8	0-0,83	1,5
Understorey	0,8-3	0,6-2	0,8-5	0,3-3	–	–	–	–	0,3-5	0,83-2,83	4
Canopy	8	2-8	5-14	3-9	9	0,8-6	–	–	0,8-14	2,83-9,25	14
Pinus sp.	5	5	5	3	3	–	5	100	–	–	–
Microsorium scolopendrium	5	5	3	–	–	1	3	60	–	–	–
Brachylaena discolor	4	3	+	–	–	–	3	60	–	–	–
Rhus nebulosa	3	2	+	–	–	–	3	60	–	–	–
Kraussia floribunda	3	3	1	–	–	–	3	60	–	–	–
Allophylus natalensis	2	3	1	–	–	–	3	60	–	–	–
Poaceae spp.	–	2	+	–	–	2	3	60	–	–	–
Asystasia gangetica	–	3	–	–	–	2	2	40			
Apodytes dimidiata	–	3	+	–	–	–	2	40	–	–	–
Peddiea africana	–	3	+	–	–	–	2	40	–	–	–
Smilax kraussiana	–	2	+	–	–	–	2	40	–	–	–
Commelina sp.	–	–	–	R	R	–	2	40	–	–	–

Table 15 Structure, species composition and cover-abundance values of Reedswamp.
F = Frequency, RF = Relative Frequency in %, CR = Cover Range, AR = Average Range, MH = Maximum Height in metres.

Relevé No.	326	328	370	371	385	386	425	437	438	F	RF	CR	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	5	5	10	10	11	11	11	11	11	–	–	–	–	–
Day	22	22	23	23	3	3	19	24	24	–	–	–	–	–
Cover:														
Total Cover	20	50	40	35	70	50	80	70	80	–	–	20-80	–	–
Field Layer	10	40	–	5%	30	40	78	–	–	–	–	3-78	–	–
Canopy	15	10	40	30	50	20	5	70	80	–	–	5-80	–	–
Height:														
Field Layer	0-1,6	0-1	0-1	0-1,5	0-0,3	0-1,5	0-0,5	–	–	–	–	–	–	–
Canopy	1,6-3,5	1-2	1-2	1,5-2,5	0,3-3	1,5-3	0,5-1,7	0-3	0-3	–	–	0-3,5	1,5-2,6	–
Emergent	2,5	2,5	–	–	3,5	3,5	–	–	–	–	–	–	–	3,5
Phragmites australis	–	–	3	3	–	–	1	4	5	5	55,6	–	–	–
Phragmites mauritianus	4	–	–	–	3	2	–	–	–	3	33,4	–	–	–
Typha capensis (=T. latifolia)	4	4	–	1	–	–	–	–	–	3	33,4	–	–	–
Polygonum pulchrum	3	–	–	–	+	1	–	–	–	3	33,4	–	–	–
cf. Cyperus spp.	–	4	–	–	+	1	–	–	–	3	33,4	–	–	–
Commelina sp.	–	4	–	–	+	+	–	–	–	3	33,4	–	–	–
Juncus kraussii	–	–	1	1	–	–	–	–	–	2	22,3	–	–	–
Urera cameroonensis	–	–	–	–	2	3	–	–	–	2	22,3	–	–	–
Senecio sp.	–	–	–	–	+	+	–	–	–	2	22,3	–	–	–
Hydrocotyle bonariensis	–	–	–	–	+	R	–	–	–	2	22,3	–	–	–
Thelypteris sp.	4	–	–	–	–	–	–	–	–	1	11,2	–	–	–
Cyperus papyrus	3	–	–	–	–	–	–	–	–	1	11,2	–	–	–
Cyperus prolifer var. isocladus (=C. isocladus)	–	–	–	1	–	–	–	–	–	1	11,2	–	–	–
Stenotaphrum secundatum	–	–	–	–	–	–	5	–	–	1	11,2	–	–	–

The trend of this mapping unit will depend mainly on the climatic conditions and water table situation. If wet years should predominate, an expansion of this mapping unit can be expected, whereas prolonged droughts will cause a decrease. The area occupied in 1976 was 1,9 ha.

Evaluation

Reedswamp areas were usually rated as first priority in conservation because of the small area they occupy and their connection with sensitive wetlands.

(24) Marsh

This mapping unit indicates wetland conditions usually with sedges, hygrophilous grasses and ferns, typically occupying low-lying depressions along the west side of the dune ridges. It covers a total of 12,8 ha. The soils tend to be heavy, with a higher clay content than the dune soils. This ecological situation is also found around pans and lakes, forming a zone around waterbodies. The field layer reaches a height of 1,5 m and its cover fluctuates between 95 and 100%.

Evaluation

There is no overlapping of proposed mining areas with this unit. In relation to other possible developments, the destruction of this unit should be avoided, as the surface area that these vlei plants are able to colonize is restricted because of their specific environmental requirements.

(25) Primary Grassland

Newly emerged areas arising through silt deposition may be covered with pioneer grasses. This mapping unit occupies a small area (0,31 ha) at the Mlalazi Peninsula. This community will later be invaded by woody plants and develop into an *Acacia karroo* Woodland and later into a forest community.

Evaluation

This mapping unit outside the proposed mining area is rated as first priority in conservation because of its rarity and the small area covered.

(26) Fields and Mixed Secondary Grasslands and Dwarf Shrubland

Depending on the time since a field has been abandoned and the subsequent influence of factors such as grazing and fire, this mapping unit presents a varied picture, from a grassland dominated by *Imperata cylindrica* to a dwarf scrub with species such as *Chrysanthemoides monilifera* and *Helichrysum* spp. (Table 16). Secondary succession of this community will in time lead to a Secondary *Acacia karroo* Woodland, or a Secondary Dune Scrub and a Secondary Dune Forest.

This was the most prevalent mapping unit in 1937. This situation resulted from the degradation of the original vegetation by humans, through fire and clearing of the forest for cultivation and grazing. The 1957 air photos show a reduced surface of this mapping unit that by 1976 was present only as isolated minor patches. This is similar to the situation reported of the dune are north of Richards Bay (Weisser, 1978 a).

After the then Department of Forestry took over control of the area, most of this mapping unit was afforested with *Pinus* and *Eucalyptus.* In 1976 this mapping unit covered an area of 121,1 ha.

Table 16 Structure, species composition and cover abundance values of Fields and Mixed Secondary Grassland and Secondary Dwarf Shrubland. F = Frequency, RF = Relative Frequency in %, R = Range, AR = Average Range, MH = Maximum Height in metres. Species occurring only once are omitted. When presence lists were made, the present plants are marked with x.

Relevé No.	308	309	356	357	382	383	387	388	392	393	430	431	432	433	F	RF	R	AR	MH
Running No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	–	–	–	–	–
Date Year	80	80	80	80	80	80	80	80	80	80	80	80	80	80	–	–	–	–	–
Month	5	5	10	10	10	10	11	11	11	11	11	11	11	11	–	–	–	–	–
Day	19	19	6	6	30	30	3	3	4	4	20	20	20	20	–	–	–	–	–
Cover:																			
Total Cover	70	10	10	15	90	80	100	100	90	80	50	80	80	50	–	–	10-100	–	–
Field Layer	30	10	5	10	80	70	90	90	80	70	10	10	30	5	–	–	5-90	–	–
Understorey	30	–	5	5	–	–	15	10	20	–	–	–	–	30	–	–	5-30	–	–
Canopy	20	–	–	5	40	30	–	5	10	20	45	75	70	33	–	–	5-75	–	–
Height:																			
Field Layer	0-0,5	–	0-0,4	0-0,4	0-1,2	0-1	0-0,6	0-0,7	0-0,5	0-0,5	0-0,1	0-0,1	0-0,5	0-0,4	–	–	0-1,2	0-0,53	1,2
Understorey																			
Canopy	0,5-1,7	–	0,4-1,5	0,4-1,5	1,2-2	1-2	0,6-1,2	0,7-1,2	0,5-1	0,5-1,5	0,1-0,5	0,1-0,4	0,5-1,5	0,4-1	–	–	0,1-2	0,53-1,23	2
Emergent	2	1,2	2	1,8	–	–	2	2,5	2,5	–	1,5	0,7	–	–	–	–	–	–	2,5
Imperata cylindrica	x	x	1	1	4	3	5	5	2	1	2	–	2	2	13	92,9	–	–	–
Chrysanthemoides monilifera	x	x	+	+	2	2	–	–	–	1	1	–	4	2	10	71,4	–	–	–
Helichrysum cymosum	x	–	–	–	+	1	1	2	+	1	–	+	–	–	8	57,1	–	–	–
Eugenia capensis	x	x	–	–	1	2	–	–	1	1	–	–	–	2	7	50	–	–	–
Digitaria natalensis	x	x	–	–	–	–	–	–	–	–	2	1	1	1	6	42,9	–	–	–
Passerina rigida	x	–	–	1	+	1	–	–	–	1	–	–	–	–	5	35,7	–	–	–
Salacia kraussii	x	–	–	–	+	1	–	–	1	1	–	–	–	–	5	35,7	–	–	–
Aristida junciformis	x	–	–	–	–	3	3	–	4	4	–	–	–	–	5	35,7	–	–	–
Rhus nebulosa	–	–	–	–	2	1	2	2	–	–	–	–	–	2	5	35,7	–	–	–
Spec. indet. (P.W. 7666)	x	–	–	–	+	+	–	–	+	–	–	–	+	–	5	35,7	–	–	–
Helichrysum asperum var. comosum	x	–	+	–	–	–	–	–	–	–	+	1	–	–	4	28,6	–	–	–
Carpobrotus dimidiatus	x	–	+	+	–	–	–	–	–	–	–	–	–	1	4	28,6	–	–	–
Gloriosa superba	–	–	–	–	+	+	–	–	+	+	–	–	–	–	4	28,6	–	–	–
Dactyloctenium geminatum	x	–	–	–	–	–	–	–	–	–	1	4	1	–	4	28,6	–	–	–
Eulophia speciosa	x	–	+	R	–	–	–	–	–	–	–	–	–	–	3	21,4	–	–	–
Rhynchosia caribaea	–	x	–	–	+	+	–	–	–	–	–	–	–	–	3	21,4	–	–	–
Nidorella auriculata	–	x	–	+	–	–	–	–	–	–	+	–	–	–	3	21,4	–	–	–
Triumfetta rhomboidea	–	x	–	–	+	–	–	–	–	+	–	–	–	–	3	21,4	–	–	–
Stipagrostis zeyheri	–	–	1	1	–	–	–	–	–	–	–	+	–	–	3	21,4	–	–	–
Othonna carnosa	x	–	R	+	–	–	–	–	–	–	–	–	–	–	3	21,4	–	–	–
Acacia karroo	–	–	+	+	–	–	–	1	–	–	–	–	–	–	3	21,4	–	–	–
Senecio sp.	–	–	–	+	–	–	–	–	–	–	–	+	–	+	3	21,4	–	–	–
Fimbristylis hispidula	–	–	–	–	+	1	–	–	+	–	–	–	–	–	3	21,4	–	–	–
Dichrostachys cinerea	–	–	–	–	3	2	–	–	1	–	–	–	–	–	3	21,4	–	–	–
Helichrysum kraussii	–	–	–	–	–	+	–	–	2	2	–	–	–	–	3	21,4	–	–	–
Microsorium scolopendrium	–	–	–	–	1	–	–	–	2	1	–	–	–	–	3	21,4	–	–	–
Helichrysum decorum	–	–	–	–	–	–	–	–	–	–	+	2	–	+	3	21,4	–	–	–
Indigofera tetragonoloba	–	–	–	–	–	–	–	–	–	–	1	+	–	R	3	21,4	–	–	–
Juncus kraussii	–	–	–	–	+	+	–	–	–	–	–	+	–	–	3	21,4	–	–	–
Allophylus natalensis	x	–	–	–	–	1	–	–	–	–	–	–	–	–	2	14,3	–	–	–
Rhoicissus digitata	x	–	–	–	+	–	–	–	–	–	–	–	–	–	2	14,3	–	–	–
Commelina benghalensis	x	–	–	–	–	–	+	–	–	–	–	–	–	–	2	14,3	–	–	–
Mimusops caffra	–	–	–	–	1	1	–	–	–	–	–	–	–	–	2	14,3	–	–	–
Carissa macrocarpa	–	–	–	–	1	+	–	–	–	–	–	–	–	–	2	14,3	–	–	–
Momordica involucrata	–	–	–	–	–	–	2	2	–	–	–	–	–	–	2	14,3	–	–	–
Euclea sp.	–	–	–	–	–	–	1	2	–	–	–	–	–	–	2	14,3	–	–	–
Vigna vexillata	–	–	–	–	–	–	–	–	+	+	–	–	–	–	2	14,3	–	–	–
Vernonia aurantiaca	–	–	–	–	–	–	–	–	+	+	–	–	–	–	2	14,3	–	–	–
Apodytes dimidiata	–	–	–	–	+	–	–	–	–	+	–	–	–	–	2	14,3	–	–	–
Ipomoea brasiliensis	–	–	–	–	–	–	–	–	–	–	1	+	–	–	2	14,3	–	–	–
Vernonia aurantiaca	–	–	–	–	–	–	–	–	–	–	1	–	–	+	2	14,3	–	–	–
Kyllinga alba	–	–	–	–	–	–	–	–	–	–	–	1	–	–	2	14,3	–	–	–
Manulea parviflora	–	–	–	–	–	–	–	–	–	–	+	–	–	R	2	14,3	–	–	–
Spec. indet. (P.W. 7665)	–	–	–	–	1	+	–	–	–	–	–	–	–	–	2	14,3	–	–	–

Evaluation

Most of the few areas present today are outside the intended mining area. Because of their secondary nature, this mapping unit was usually rated as second priority in conservation.

(27) Built-up area

This unit includes forestry buildings and their surroundings and they covered an area of only 2,24 ha in 1976.

Evaluation

Because these areas are usually intensively disturbed and easy to re-establish and have low scientific value, this mapping unit is rated third priority.

Some forestry installations such as fire lookouts are of practical importance and should be conserved, moved or be reconstructed after mining.

Table 17 Comparative figures of areas (in hectares) occupied by the mapping units in 1976 on the six vegetation maps. The % columns indicate the percentage area of the map occupied by the mapping unit.

	Map 1		Map 2		Map 3		Map 4		Map 5		Map 6		Total ha	Total %
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%		
Water	13,40	1,881	0,144	0,014	–	–	5,02	1,133	0,712	0,159	–	–	19,276	0,538
Mud-Flats	3,44	0,483	–	–	–	–	–	–	–	–	0,27	0,377	3,71	0,104
Beach	26,26	3,686	24,97	2,472	21,8	2,429	18,81	4,245	17,27	3,856	–	–	109,11	3,046
Sand at Richards Bay	15,46	2,170	–	–	–	–	–	–	–	–	–	–	15,46	0,432
Mouth Area														
Inland sand	0,786	0,110	1,21	0,12	–	–	–	–	–	–	–	–	1,996	0,056
Borrow Pit	–	–	–	–	–	–	0,344	0,078	–	–	–	–	0,344	0,0096
Dune Pioneer	1,43	0,201	–	–	–	–	3,6	0,812	7,08	1,581	–	–	12,11	0,338
Open Dune Scrub	–	–	–	–	–	–	–	–	3,65	0,815	–	–	3,65	0,102
First Seaward Dune Slope	56,49	7,93	48,17	4,768	59,91	6,676	43,0	9,704	44,99	10,046	7,22	10,088	259,78	7,251
"Arcuate scar", Littoral														
Dune Valley	4,22	0,592	15,16	1,501	0,845	0,094	0,54	0,122	–	–	–	–	20,765	0,580
Low Forest	–	–	–	–	–	–	–	–	–	–	2,19	3,06	2,19	0,061
Climax Dune Forest	187,03	26,255	59,05	5,846	9,57	1,066	3,35	0,756	20,49	4,575	27,75	35,979	305,24	8,520
Mangrove swamp	6,52	0,915	–	–	–	–	–	–	–	–	7,04	9,836	13,56	0,379
Destroyed *Phoenix/Hibiscus*	7,20	1,011	–	–	–	–	–	–	–	–	–	–	7,20	0,201
Hibiscus Tiliaceus Thicket	–	–	–	–	–	–	–	–	0,358	0,080	0,18	0,25	0,538	0,015
Swamp Forest	–	–	–	–	–	–	–	–	0,52	0,116	–	–	0,52	0,0145
Hygrophilous Forest	–	–	1,43	0,142	–	–	4,17	0,941	–	–	–	–	–	5,60
Primary *Acacia karroo*	–	–	–	–	–	–	–	–	–	–	2,66	3,717	2,66	0,074
Secondary *Acacia karroo* or														
Trema orientalis	150,24	21,091	297,53	29,454	63,74	7,102	129,12	29,14	6,77	1,512	4,55	6,357	651,95	18,198
Secondary Dune Scrub and														
Forest	214,20	30,070	204,18	20,213	86,45	9,633	103,54	23,366	234,17	52,29	19,84	27,72	862,38	24,072
Casuarina equisetifolia														
afforestation	–	–	199,88	19,707	67,05	7,471	70,81	15,98	22,15	4,946	–	–	359,89	10,046
Eucalypt and Pine														
Afforestation	–	–	101,23	10,021	572,02	63,739	35,85	8,090	77,02	17,198	–	–	786,12	21,944
Reedswamp	1,085	0,152	–	–	–	–	–	–	–	–	0,77	1,076	1,855	0,0517
Marsh	–	–	1,76	0,174	5,72	0,581	2,75	0,621	2,47	0,551	0,541	0,756	12,791	0,357
Primary Grassland	–	–	–	–	–	–	–	–	–	–	0,309	0,432	0,309	0,0086
Fields and Mixed														
Secondary Grassland	24,59	3,452	54,62	5,407	9,37	1,044	22,21	5,012	10,18	2,27	0,25	0,349	121,22	3,384
Built-up Area	–	–	0,828	0,032	1,41	0,157	–	–	–	–	–	–	2,238	0,062
Total Area for each Map (ha)	712,351	–	1010,162	–	897,435	–	443,114	–	447,83	–	71,57	–	–	–
Total Study Area (ha)	3 582,462													

(28) Kraals

In 1937 seventy-five kraal areas were present in the dunes, an indication of the high degree of human impact exerted at that time on the dunes (Weisser & Müller, 1983).

When the then Department of Forestry took over management of the area, the people moved and no kraals were detected on the aerial photos of 1976.

(29) Other

Other symbols appearing on the maps are: road or firebreak, lookout tower, lighthouse and pipeline.

6.1.2 Surfaces occupied by mapping units and discussion

Having enumerated the main plant communities (mapping units) present, attention can be briefly directed to the area occupied by the different communities in the study area. The survey results are presented in Table 17 to provide a comparative overall picture of the extent of each mapping unit. This is important because the extent of a community is an important criterion to consider when establishing conservation priorities.

6.2 VEGETATION MAPS AND CONSERVATION PRIORITIES

In Section 6.1.1, conservation priority evaluations of the different mapping units were given and in Section 3.3 the criteria for evaluation are set out. The result of the application of these criteria to the areas covered by each of the six vegetation maps of the study area follows, as well as an overall appraisal. Features of scientific or other conservation value found are specifically mentioned.

The results are condensed in three 1:25 000 maps, each comprising the coverage of two vegetation maps (Figs 9, 10 & 11). The lack of detailed information about the areas to be mined and the situation of the ore bodies made the evaluation and considerations of possible trade-offs difficult, as only one side of the equation was known. Therefore, a re-assessment of the conservation priorities is suggested once this information is available, to optimize exploitation and to minimize environmental damage.

6.2.1 Conservation priority maps and their discussion

The conservation priorities will be discussed using the maps as a base and will therefore be considered according to the areas covered by each map. Of the area mapped, 56,4% was evaluated as third priority, 30,15% as first priority and 13,45% as second priority for conservation. This reflects the high degree of environmental degradation of the study area. The distribution of priority areas on the three conservation maps is illustrated in Table 18.

(1) Vegetation Map 1

The conservation priority ratings of the northern area are mapped in Figure 9. The first priority areas are mainly the seaward and landward slopes of the dune barrier, the mangroves, areas of Climax Dune Forest and the successionally advanced Secondary Dune Forest in the central area of the dune cordon. Around the Climax Dune Forest, a buffer zone of secondary vegetation was frequently included.

The northern area is occupied by secondary, recent communities that followed the disturbances and denudation caused by works related to the opening of the mouth for the Richards Bay Sanctuary.

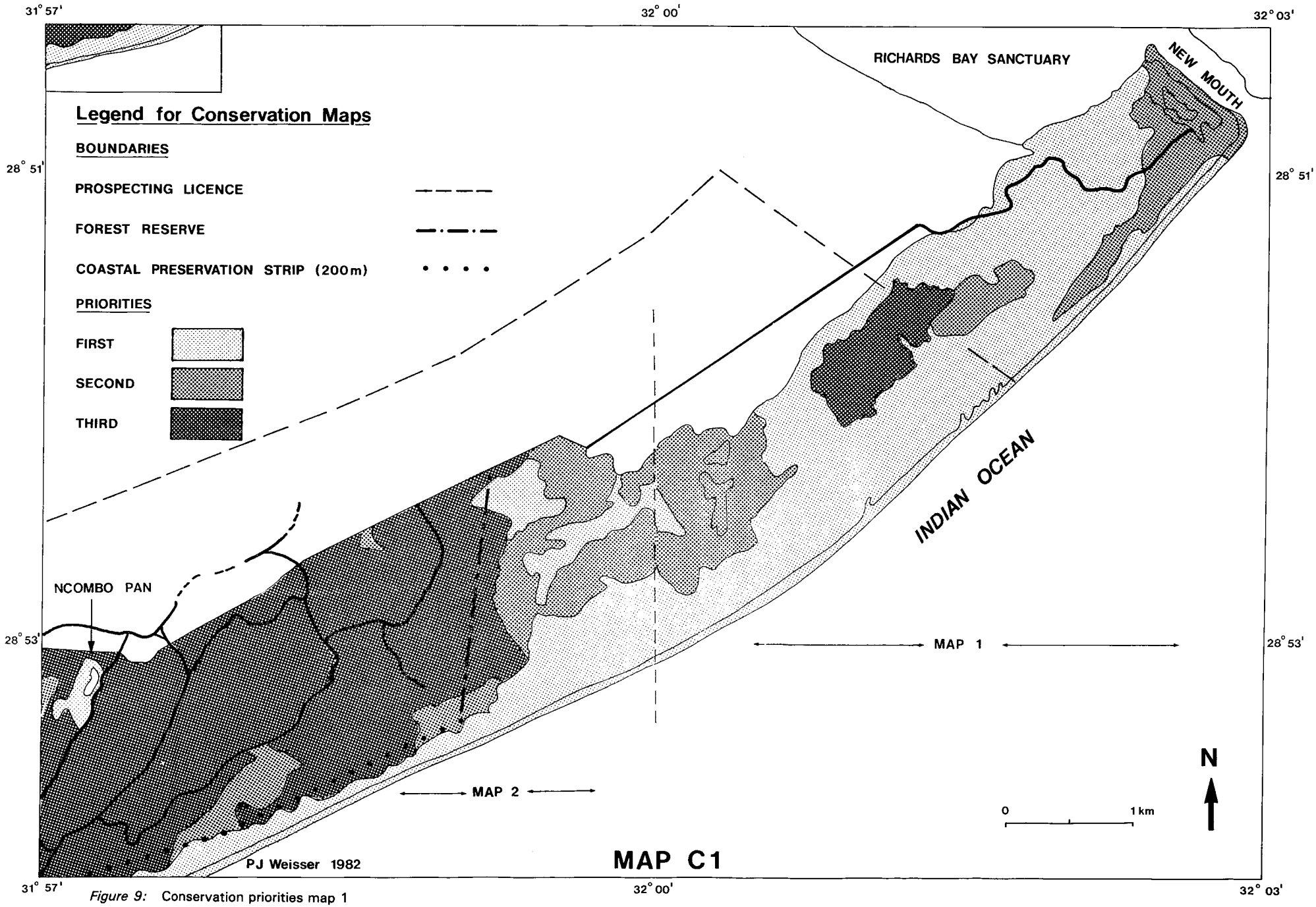

Figure 9: Conservation priorities map 1

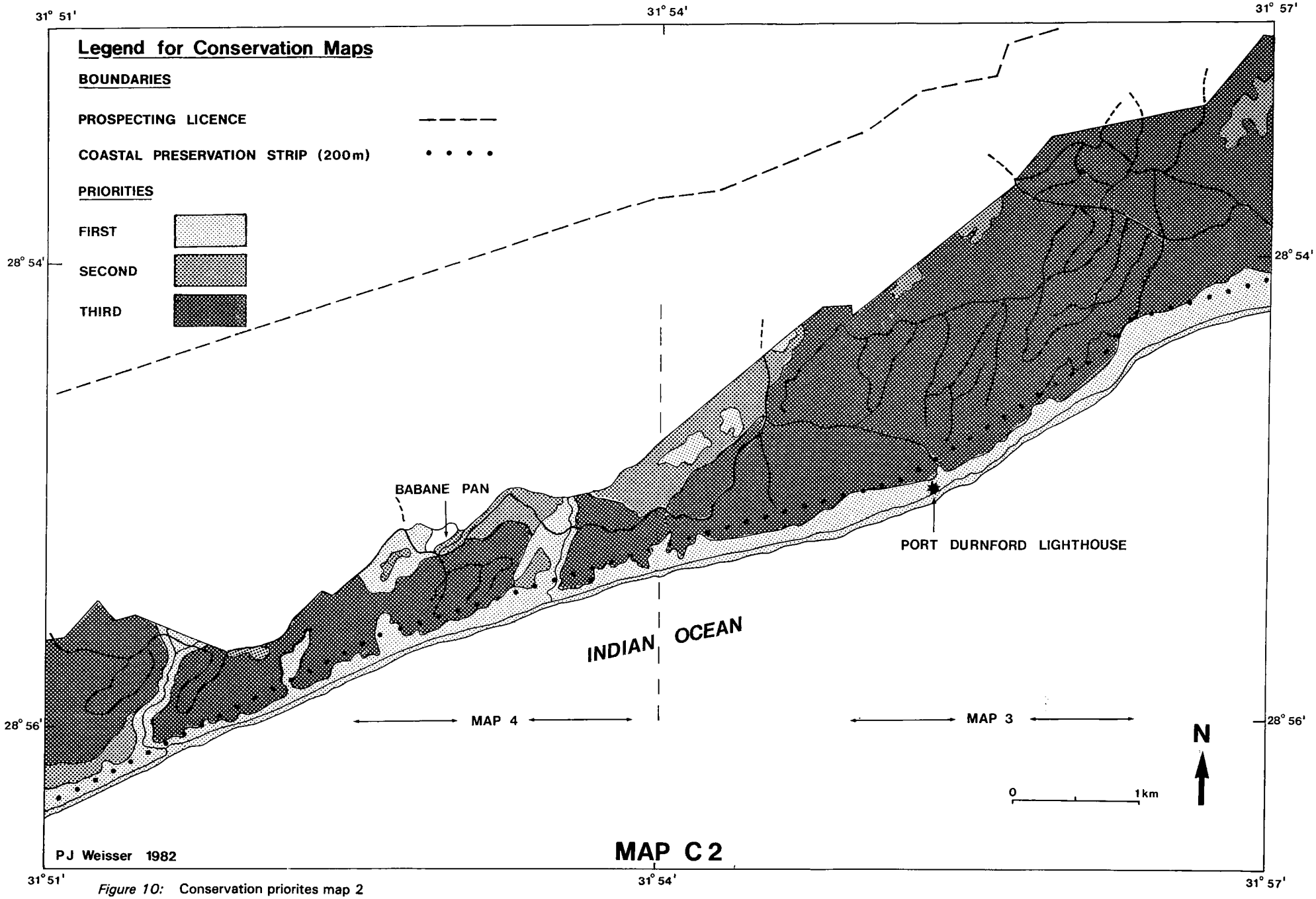

Figure 10: Conservation priorites map 2

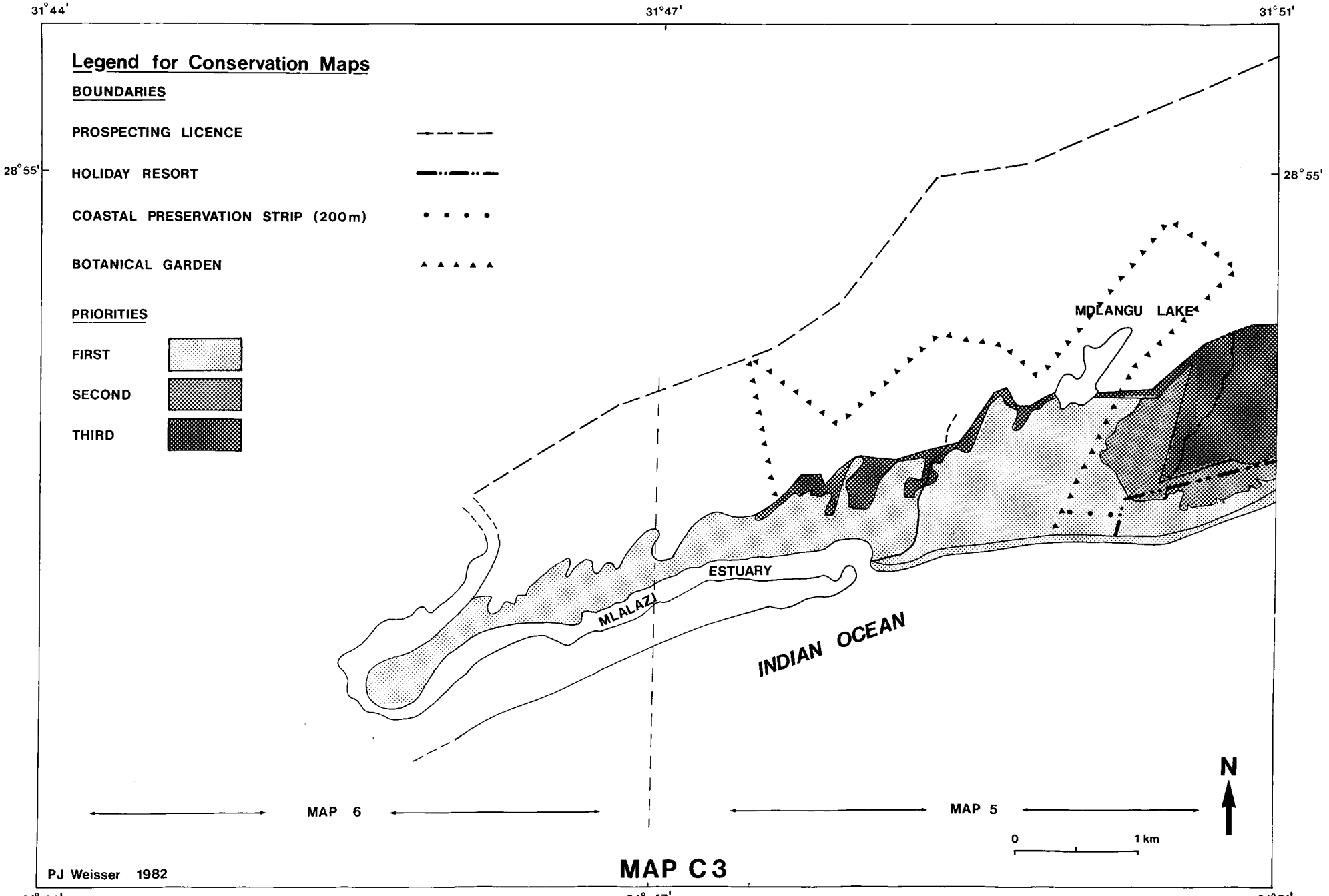

Figure 11: Conservation priorities map 3

Evaluation and recommendations

No mining is intended in this area and the exclusion of this zone from the prospecting lease was a wise decision because of the overall high priority for conservation.

It is urged that the area should be included within the Richards Bay Sanctuary as soon as possible. This area contains the best and most extensive examples of Climax Dune Forest, which are an important asset from the nature conservation point of view.

(2) Vegetation Map 2

First-priority areas are situated mainly on the seaward front, second-priority areas on the eastern limit and most of the central zone is occupied by third-priority areas.

Along the coastal cliffs, the presence of densely vegetated valleys and "arcuate scars" is noteworthy. They usually contain primary vegetation and are of high conservation value, being known to occur at only two places on the South African coast. Work on these rare geomorphological and botanical structures is in preparation (Weisser & Smith, MS).

Landwards outside the study area, the presence of primary hygrophilous forest patches was observed. The area of this type of forest is shrinking rapidly, owing to clearing for cultivation. The conservation of a few witness stands by incorporating them into the Richards Bay Sanctuary is a matter of the utmost urgency as the clearing is progressing at a rapid rate.

Evaluation

There is no objection to mining the areas south of the Forestry Reserve Limit (Fig. 9) that are today mostly covered by secondary or artificially planted vegetation. The 200 m "ecostrip" along the coast from the beginning of the dune barrier inland is sufficient to protect the first dune front face exposed to the sea winds.

(3) Vegetation Map 3

This map covers the area that was the most degraded on the 1937 air photos and conservation priorities are shown on Figure 10. It was covered at that time by extensive driftsands, secondary grasslands and dwarf shrub. Today it is mainly covered by afforestation. The only main area rated as first priority for conservation is a strip along the coast, where relics of vegetation were preserved in arcuate scars. Most of them were not mapped, as they were too small to map or not clearly distinguishable and are therefore part of the First Seaward Dune Slope Mapping Unit.

Landwards from the sewage plant, a seemingly well conserved forest was found. No special study was made of these areas because of other priorities. The exclusion of this area from mining could be considered, because its position approximately halfway between Richards Bay and Mlalazi will enable it to act as a seed reservoir and provide seeds for the recolonization of the area after mining.

Evaluation and Recommendations

There is no objection to mining for most of the area, except for the discovery of a few small patches of natural forest farther inland that could serve as a natural reserve area, from which the reseeding with original species could proceed. Whereas most of the area is of low botanical value, the undisturbed patches of dune forest are, on the contrary, very rare and of high value. It is this rarity that makes them more important rather than their actual species content. Over extensive areas there are no forest

patches from which reseeding could occur. Consequently the few patches available are irreplaceable centres from which to re-establish some areas to natural vegetation.

The area is of interest because of the geological exposures of the Port Durnford Formation. The coastal part of this formation is protected by the 200 m buffer zone. However, the bedding of the different layers would be destroyed if mining were allowed, and bedding data on geological structure and geomorphological processes lost. Therefore, the preservation of a witness area from the coast to the landward slope of the dune is recommended. A passage could be considered to allow the dredger to cross the witness area. Geologists should determine the breadth of the witness area.

In the coastal section covered by this map, only two rocky outcrops occur. As rocky outcrops are rare along the Zululand Coast (Weisser & Cooper, MS), the few existing outcrops have a high priority for conservation. They both fall outside the prospecting area.

(4) Vegetation Map 4

The dune barrier narrows down to only about 350 m and is crossed by the only two streamlets crossing the dunes. The 1937 aerial photographs reveal extreme degradation. The conservation map on Fig. 10 indicates the areas rated as third, second and first priority for conservation. These areas are a strip along the coast, a strip along the water courses and a few areas of well conserved vegetation near two waterbodies. Noteworthy for conservation is the Babane Pan and surroundings that have recovered well under the conservative management.

The surroundings of the Babane Pan and the nearby forest should be excluded from mining because of their importance for wildlife (fauna and flora). Because it is low lying, and on the landward side of the dune barrier, it is assumed that there is no intention to mine in this area.

The vegetation found along the streamlets is remarkable, because of the luxuriant growth and the speed with which it has established itself after having been destroyed before 1937. Before mining an *ad hoc* ecological study is recommended.

Table 18 Distribution of conservation priorities on the three conservation priority maps expressed as percentages of the total study area.

	Map 1	Map 2	Map 3	Total study area
Priority 1	13,18	7,30	9,67	30,15
Priority 2	9,18	2,78	1,49	13,45
Priority 3	25,62	27,44	3,35	56,40

(5) Vegetation Map 5

This map covers an area progressively changing from low to high conservation priority towards the Mlalazi Estuary Mouth. Apart from a coastal strip with Climax Dune Forest, which in parts exceeds the 200 m line and the surroundings of the Mdlangu Lake, most of the central dune area rate as second and occasionally as third priority for conservation (Fig. 11).

Evaluation and recommendations

Most of the area has been excluded from mining by the planned KwaZulu Botanical Garden and the construction of a recreation area. The recreation area itself was rated as a first-priority conservation area and a specific study on diminishing the impact of such a facility is strongly recommended. From preliminary, unofficial information, it seems to be partly positioned in a Climax Dune Forest. A southwards or northwards shift of these plans could minimize the possible damage to such important conservation areas.

A shift southwards would probably be best because the beaches are much broader in that area than northwards.

Outside the study area remnants of a dense hygrophilous forest are being cleared by the local inhabitants for cropland.Considering how few of these patches are left it is of utmost urgency to secure this patch by incorporating it into the Botanical Garden.

Efforts made by Prof. H.B. Rycroft to expedite the implementation of these plans have been unsuccessful to date.

(6) Vegetation Map 6 (figure 3)

The map of the Mlalazi Peninsula was drawn directly from aerial photos as no orthophoto map was available at that time. Together with the Richards Bay area, it contains the best examples of natural, mostly undisturbed vegetation and was rated as first priority for conservation (Fig. 11). This area is envisaged as part of the KwaZulu Botanical Garden (Weisser *et al.* MS).

Evaluation

This area falls outside the mining lease zone. However, the use made by local people for poaching and wood gathering poses a threat to the area, mainly because of the fire hazard. Fires have already occurred and caused considerable damage.

6.2.2 The 200 m Coastal Reserve

The prospecting lease excluded a zone of 200 m from the beginning of the dune barrier landwards because of the ecological sensitivity of area, the aesthetic landscape value and to keep the seaward face of the dune barrier intact. This decision was partly based on findings for the area north of Richards Bay, where good examples of undisturbed vegetation were found along the coast and led to the proposal of the creation of a coastal reserve (Weisser, 1978).

In addition, the dune mining operations in the Kwambonambi area had a greater impact on the first dune than expected. The proximity of the mining operation to the beach had as consequence the clearing of first-priority vegetation that was thought to be outside the mining operations. It also accelerated water percolation through the dune, thus the naturally occurring coastal slumping was considerably accelerated (*vide* Tinley, 1985).

In some situations, the Coastal Reserve Areas include zones with low conservation priority and in some instances areas with high priority are left out. It is therefore recommended that the line should be adjusted, following a detailed study just before the mining is due to commence. The intensity of the study required is outside the possibilities and scope of this work, but could be incorporated into the planning of mining operations without difficulty. Also the erection of a fence separating the Coastal Reserve from the mining area is strongly recommended.

6.3 DUNE VEGETATION DYNAMICS

Weisser and Müller (1983) studied the dune vegetation changes with the aid of aerial photos. The findings are similar to those obtained for the dune area between Richards Bay and the Mfolozi River Mouth (Weisser & Marques, 1979). They revealed that most of the dune area was covered with secondary vegetation. Figure 12 summarizes the vegetation dynamics observed. It is assumed that Climax Dune Forest covered most of the dune barrier before colonization by man. Iron Age human settlements of the Zululand coast date back to the forth century A.D. (Hall & Vogel, 1978) and marked the beginning of extensive forest clearing for shifting cultivation and pastures. In three wind-exposed areas, the vegetation cover was destroyed which then gave rise to three major driftsands visible on the 1937 air photos. In the fifties, the trend of vegetation degradation was reversed by the implementation of an afforestation programme by the then Department of Forestry. Drift sand was reclaimed using *Casuarina equisetifolia.* Secondary Mixed Grassland and Dwarf Shrublands were afforested with species of *Pinus* and *Eucalyptus.*

The 1976 air photos indicate that the post-cultivation seral stages of 1937 had been mostly replaced by forest plantations. In secondary, unafforested areas the vegetation is rapidly evolving towards a Secondary Dune Forest.

The dune vegetation dynamics discovered allows a better understanding of the basic vegetation processes occurring on the dunes. The knowledge of these processes is essential for taking management decisions.

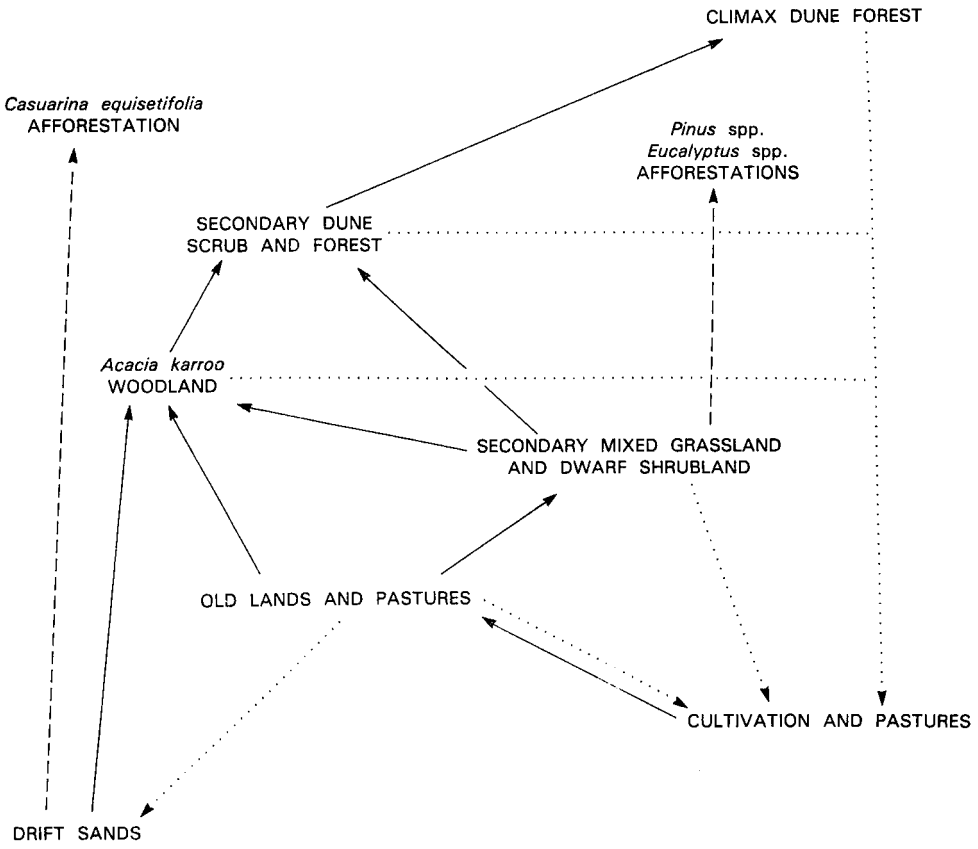

Figure 12: Succession pathways (solid lines), retrogression pathways (stippled lines), and afforestation pathways (dashed lines) as shown on aerial photos from 1937 to 1976 after clearing of Climax Dune Forest (Weisser & Müller, 1983).

7. Discussion, Conclusions and Recommendations

7.1 BACKGROUND INFORMATION TO ENVIRONMENTAL RESEARCH AND MANAGEMENT AS FRAMEWORK OF RECOMMENDATIONS.

Disappointing experiences in the United States of America have highlighted the complexity of the problem of environmental research and management. Fox (1974) distinguishes three stages in the history of lake management also applicable to the terrestrial situation and to South Africa. He calls the first stage the "optimization approach", the second the "alternatives approach" and the last the "creative learning" approach. In the optimization approach it was assumed that the rôle of the resource manager was to identify and carry out the best management plan. Although successful to a certain degree, serious limitations in this approach became evident and it was replaced by the alternatives approach. In this approach in essence "we concluded that since some of the values associated with water resources can only be determined subjectively, the task of the planner-manager is not to determine what is best, but to specify the consequences of alternative courses of action in physical, biological, economic and social terms, so that the public and its representatives can make an intelligent choice about the management plan that best serves the public interest" (Fox 1974). Although some progress in lake management was achieved, serious limitations in this approach also became evident.

It was discovered that in almost every situation involving natural resources, there are many alternatives and there is great difficulty in identifying them. Also, it was soon recognized that "we will never be able to predict with complete assurance the consequences of alternative courses of action," because of the complex interplay of abiotic and biotic factors (human factors included). The selection of alternatives is governed by human values and the value framework applied is decisive. Previously "We've wanted to believe that our selection of alternatives could be value free..... We eventually recognized that there is no such a thing as an objectively-determined set of alternatives."

Fox (1974) believes that a new approach is emerging that builds on the best of the optimization and alternative approaches and that he calls the "creative learning" approach. He states: "We must recognize at the outset that plans - any resource management plans - are not based on firm predictions of outcomes, but on hypotheses of what the outcomes are likely to be. The planner must have the humility to accept the obligation to inform others that his alternative plans and estimates of their consequences are, in fact, alternative hypotheses and that whatever alternative is adopted, will be in the nature of an experiment rather than being a program that will achieve a predetermined result. He must be prepared to make changes as experience is

gained with the experiment." In the spirit of this third approach the conclusions and recommendations are presented, with the understanding that there is no guarantee of achieving any predetermined results, and that changes must be made as experience is gained.

Finally, "Ecologists might best contribute to resource management by stressing the ambiguities in our knowledge about natural communities, and induce managers and politicians to make decisions that openly acknowledge that they are sometimes based on tentative information" (Hedgpeth & Obrebski, 1976 in Hedgpeth 1978).

7.2 GENERAL

This report attempts to cover the main conservation aspects of the study area. Detailed environmental information is still needed and should be obtained by the mining company concerned while doing the planning of the mining operations.

(1) Most of the study area was rated as third and second priority for conservation. The main reason for the overall low priority for conservation of the dune area is the high degree of degradation caused by local inhabitants, revealed in the aerial photos of 1937. Since the Department of Forestry assumed responsibility for managing the area (1952), most of the vegetation cover has recovered well and today most of the area is covered by tree plantations and secondary scrub or forest. First-priority areas for conservation were mainly found in the northern and southern part, a strip along the coast and some isolated patches usually near pans. Most of these areas were excluded from prospecting rights in the prospecting lease and therefore potential conflict areas are few. From a conservation point of view, there is therefore no major objection to the granting of mining rights, provided the companies involved agree to exclude from mining some minor areas of first priority for conservation.

(2) The vegetation and conservation priority maps will assist the mining companies to become aware of areas of conservation value. Whereas from the available information the overall situation is clear, follow-up research is needed, where information not presently available can be taken into account. Such information includes precise mining plans, intended mining height, position of ore bodies and mining facilities and origin of the water to be used at the pond. It is considered that follow-up research and refinement in detail is essential for some areas if the impact of dune mining is to be minimized. Therefore, it is recommended that detailed studies, that would be a refinement of the present findings, be made in the future.

(3) Even the best possible rehabilitation, whereas being pleasing to the eye and, at a first glance, conveying the impression of being the same as before mining, can on no account replace completely features such as rare species and communities, original topography, stratifications of the sediments, and exact chemical and physical characteristics of the sand. No rehabilitation can claim to regenerate the exact habitat conditions and biotic characteristics existing before. This fact has been basic in the prohibition of dune mining in some stretches along the coast of Australia. On the other side, the exploitation of resources is in the interest of South Africa. It is a positive fact that mining operations stretch over decades. This gives time and resources to specifically study the area to be mined in detail. This detail is sometimes necessary to optimize decision making concerning conservation or exploitation. This is an additional justification for conducting follow-up research.

7.3 SUGGESTIONS IN RELATION TO MINING OPERATIONS

The following suggestions are based on those given in the previous report (Weisser, 1979) and are reiterated and amended in some aspects.

The first four recommendations and principles are derived from personal communications of Dr A.C. Thatcher and Dr W.E. Westman (1975), who made corresponding studies at sand-mining areas in Australia.

(1) "Close proximity of unmined vegetation appears to aid substantially in the rate of re-establishment of vegetation by increasing the rate of immigration of seeds of native species."

From this the following recommendation is derived: keep viable stretches of indigenous vegetation adjacent to the mining place for the longest period possible.

(2) "The retention of strips of native vegetation throughout the mined area would provide a continuous source of seeds of all species represented in the original vegetation."

"In this regard the making of a botanical survey is important to preserve areas where rare species are to be found" ... "The principal of retention of strips of native vegetation within the mined area is of the utmost importance and should be incorporated as a condition in the mining lease" ... "At times it may entail leaving some deposits of good minerals but this is a small price in comparison with the long term advantages of such a policy."

"The strips of vegetation should be capable of self-maintenace" ... "Another advantage of this policy is that the vegetation will provide a buffer against wind erosion of the mined area."

(3) Clark, as cited by Thatcher and Westman (1975), noted a slight tendency for successional rates to be slowed with increased time of stockpiling top soil and the presumed associated loss of *in situ* seed viability. Therefore, stockpiling time should be kept as short as possible.

(4) The evidence regarding the efficacy of fertilizer application for reclamation is conflicting. The extrapolation of the results obtained in Australia under different ecological conditions with different plant species studied, is problematic. In a comparable situation in Queensland, Weston found that the application of fertilizer substantially increased the biomass and foliage cover of native species permitting in turn a greater species diversity, at least in the first two years.

On balance the available evidence suggests that dressings should be only moderate to start with until more information is available on the basis of pilot studies done by the mining companies. It must be borne in mind that reclamation will be taking place in a relatively high rainfall area and that a considerable proportion of the fertilizer will probably be removed by leaching before it can be effective.

(5) The dredging operation could be planned in such a way that adjacent parts are mined over the longest timelag possible. This will mean a longer period in which the seeds and diaspores coming from the unmined sites have time to recolonize the mined area. This principle could be enunciated as: principle of the longest possible timelag in mining adjacent areas.

(6) When planning their operations, especially when creating the infrastructure for mining such as roads and pipelines, areas identified as first priority for conservation should be avoided wherever possible or the impact when passing through these areas should be kept to a minimum. Sometimes moving a road or a pipeline by only a few metres would make all the difference. This report is intended to provide a basis for this kind of decision and it would be unfortunate if it were not consulted.

(7) The mining area should be fenced off and thereby clearly delimited from the area not to be mined, because bulldozer drivers can too easily exceed the allocated limits during vegetation clearing operations. A fence would be a clear guideline up to where the vegetation must be cleared and should be a condition incorporated in the mining lease.

(8) As a general rule, both the dune ridge closest to the beach and that farthest landwards should be kept under natural vegetation. The seaward slope of the dune is unsuitable for forestry purposes owing to saltspray and seawinds.

(9) It is suggested that a few special areas with high species diversity and sometimes with a variety of communities, be left unmined as seed sources for the mined area. Areas suggested only cover a small area and could make a great difference to the end results of the rehabilitation. The Coastal Reserve will not suffice as seed source, because some species growing in the interior are not represented in this strip.

(10) The Richards Bay - Mlalazi Estuary Mouth coastline is mostly retreating and the beach is sometimes very narrow. Replenishing the beach with mine tailings could be considered.

(11) The landward limit of the 200m coastal protection zone should be physically marked with a fence to limit destruction during mining operations.

7.4 RECOMMENDATIONS CONCERNING DUNE MINING PROSPECTING LEASES

The cases of granting prospecting rights for dune mining to date reveal the shortcomings of the system employed in granting prospecting rights. Many problems would be avoided if the unique areas were to be excluded from prospecting prior to the granting of rights. Reports on conservation priorities are often prepared only after prospecting rights have been granted. The companies involved have already invested a considerable amount of time, money and effort in prospecting an area. In Australia the mining companies are obliged to submit an Environmental Impact Study (Lewis 1977, pers. comm).* This makes the companies more environment conscious and increases the available knowledge of the area under consideration. It would be better for all the parties concerned to set aside areas not to be mined before the prospecting rights are granted. In this way, the high prospecting expenses could be avoided as well as the clashes in interests between mining and conservation.

Also, the conservation-priority evaluation could be done by an independent contractor appointed by the leasing authority paid by the mining company with prospecting rights.

7.5 OTHER RECOMMENDATIONS

(1) The Dune Forest and other vegetation of the northern part of the study area should be incorporated into the Richards Bay Sanctuary and thus be protected as soon as possible. This should include some of the existing patches of Swamp Forest (outside the study area), that are being cleared to obtain lands (Fig. 13).

(2) The proclamation of the KwaZulu Botanical Garden, incorporating the nearby Swamp Forest in the process of being cleared by local inhabitants should be regarded as urgent. To avoid moving people a change of the proposed limits is suggested, covering the area already managed by the Department of Forestry and including a corridor to the Swamp Forest and the Swamp Forest itself.

(3) The Botanical Garden could be extended to the north-east by re-establishing natural vegetation after mining. This extension in area is essential for its viability

in the future. Too much human use of the southern part would destroy the asset to be protected and the new areas suggested for inclusion could help to absorb the user's impact.

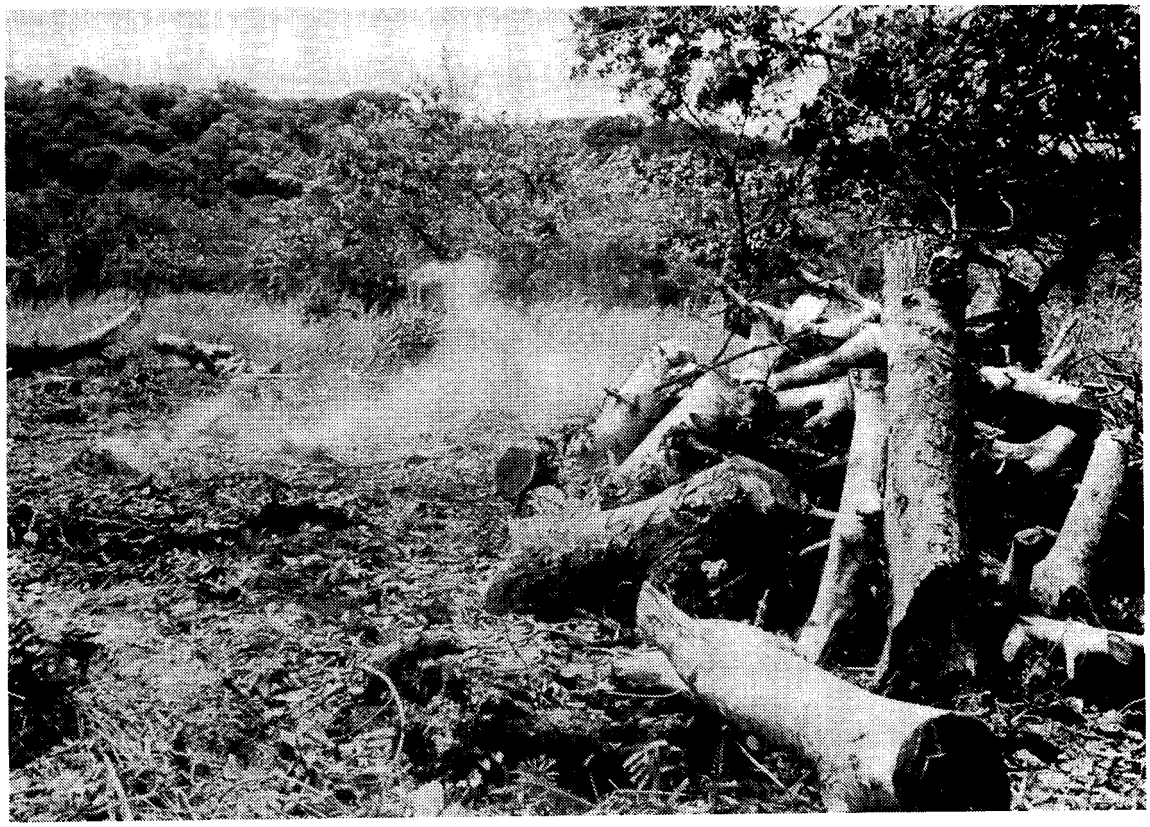

Figure 13: Swamp Forest being destroyed along the road to the Richards Bay Sanctuary. The cleared land will then be used for cultivation. In the background the forested dune barrier can be seen. Some of the few remaining Hygrophilous Forest patches should be included into the Richards Bay Sanctuary before they also vanish (1980/11/22).

7.6 FURTHER INVESTIGATIONS REQUIRED

This report gives an overall picture of the conservation priorities pinpointing the important conservation areas. It does not give, nor can it provide the detail required for planning specific mining operations near sensitive areas, e.g. near the coast line or in proximity of streamlets and pans. From this it becomes essential that, concurrently with the planning of the mining operations, more detailed botanical information be gathered to obtain the necessary facts on which to base decisions for finalizing the details of the operations. At the same time as the mining plan is prepared parallel and in interaction with it, an environmental protection plan should be concurrently developed.

If followed, the measures recommended in this report will ensure the conservation of the most outstanding natural features of the area concerned. It does not absolve the mining companies from doing research work on the flora and the fauna themselves.

In the same way, this study does not purport to cover all management possibilities and therefore does not exonerate conservation agencies from their responsibilities for drawing up management plans.

8. Dune Vegetation Rehabilitation after Dune Mining

P.D. Camp, ecologist of Richards Bay Minerals. *

8.1 INTRODUCTION

The purpose of this contribution is to document rehabilitation methods currently employed by Richards Bay Minerals Co. Ltd. The methods giving the best results have been developed over a period of five years.

The replanting and stabilizing of the mined dunes is an integral part of the mining operations, and is adequately provided for in the mining lease under which Richards Bay Minerals operates.

Bearing in mind that the dune area is currently administered by the KwaZulu Department of Forestry, it was necessary that they be consulted as to the final cover crop required after mining. Their ruling was that where plantations of commercial exotic trees existed prior to mining, they should be replanted after mining; and that where indigenous cover existed, an indigenous plan cover should be created.

A further requirement was that, regardless of the pre-mining vegetation on the seaward-bounding mining path, this be rehabilitated to an indigenous cover, and exotics be restricted to the landward areas of this path. Seaward areas are severely affected by the salt laden on-shore winds and are therefore not suitable for sustaining exotic plants except *Casuarina equisetifolia.*

Dune mining operations north of Richards Bay commenced in July 1977 and rehabilitation began in September of that year.

8.2 REHABILITATION WORK

There are four phases in the dune mining and rehabilitation process:

(1) Pre-mining vegetation clearing
(2) Mining
(3) Tails stacking and landscape restitution
(4) Vegetation restitution
    (a) Topsoil restitution
    (b) Windbreak erection
        (i) Shade cloth

* The willingness of Richards Bay Minerals to share their dune-rehabilitation expertise is gratefully acknowledged.

(ii) *Casuarina equisetifolia* plantings

(c) Sowing of cover crop

(d) Removing of windbreaks

(e) Establishment of indigenous vegetation

(1) Pre-mining vegetation clearing

Prior to the actual commencement of mining, the area has to be cleared of vegetation. Where this vegetation consists of exotic commercial plantations, the timber is cleared by KwaZulu or their contractors and timber disposed of by themselves. The plantation slash which is left, together with stumps and dry non-commercial indigenous vegetation, is bulldozed into heaps and burned.

A bulldozer-mounted brush-rake then rakes the cleared area, removing any remaining plant litter that is over 5 cm in diameter. The dune is now ready to be mined.

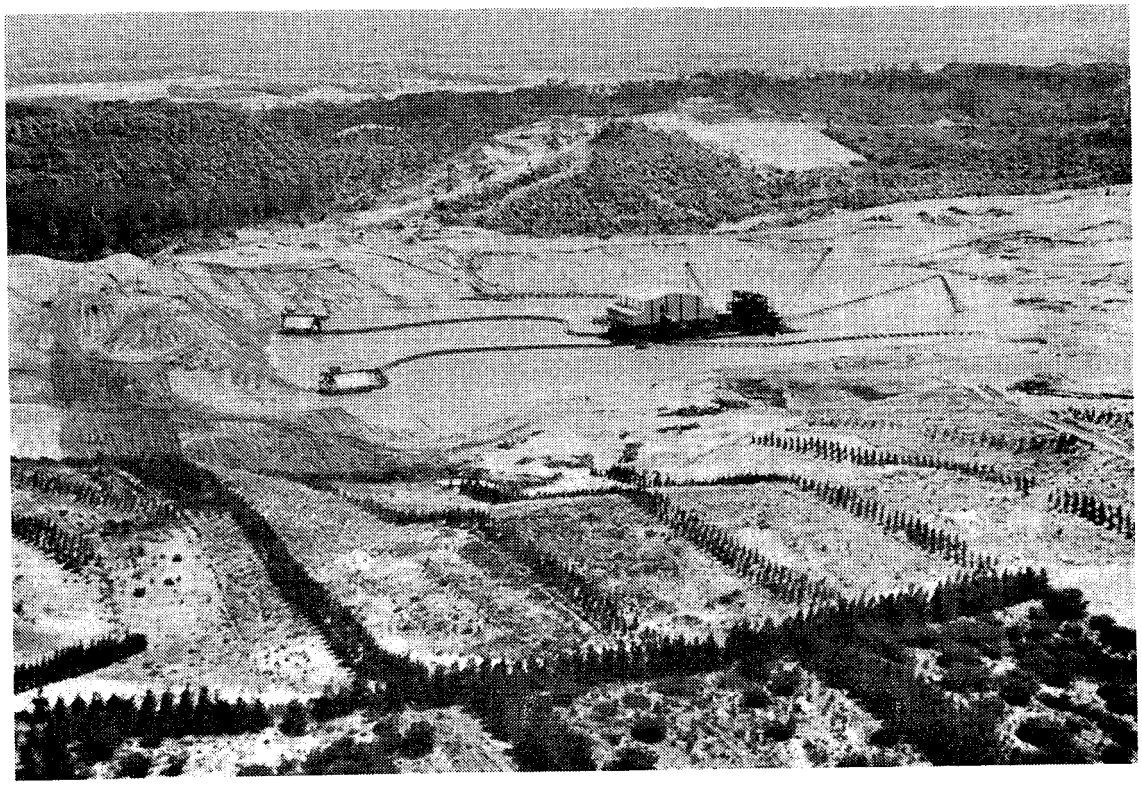

Figure 14: Aerial view of dune mining operation by Richards Bay Minerals near Kwambonambi. Two dredgers, the floating mineral concentration plant and the tailing disposal system can be seen in the centre of the photograph (1982/02/07).

(2) Mining

The mining method consists of two dredges and a concentrator floating on a pond of water maintained in the dunes. The dredges suck up the sand from the front of the pond and feed it to the concentrator where the heavy minerals are separated from the sand by means of gravity and pumped to a stockpile on the land. The tailings (or sand minus the minerals) are then pumped to the back of the pond.

(3) Tails stacking and landscape restitution

In mining terminology the word "tailings" means the discarded portion of the mined sand, and in the case of dune sand ± 90% of the bulk, prior to mining, is returned after

the heavy minerals have been extracted. This sand is returned by means of tailing stackers, whereby the sand from the mine concentrator is pumped to wherever it is to be stacked. The sand is dewatered at the point of stacking by means of cyclones, and a relatively dry material is deposited and shaped to conform with the pre-mining topography. After final shaping by means of bulldozers, the area is ready for re-planting.

(4) Vegetation restitution work

(a) Topsoil restitution

The first step in the rehabilitation programme is to spread topsoil over the mined sand. This is done by removing topsoil from the area cleared in front of the mine and transporting it to the tailings where it is mechanically spread over the prepared area to a depth of ± 10 cm.

This material is a humus-rich sand more than a true topsoil, but is nevertheless relatively rich in plant nutrients viz. nitrogen and phosphorous. It is also relatively rich in viable seed of species occurring naturally on the dunes as well as in plant material which acts as a mulch, stopping sand movement and reducing moisture loss.

(b) Windbreak erection

(i) Artificial windbreaks

Once this topsoil has been spread, it is necessary to erect windbreaks by placing synthetic shade cloth fences transversely across the dunes and facing the direction of the dominant winds. These fences are 1,5 m high and are placed in strategic positions where wind damage is most likely to occur (Fig. 15).

(ii) *Casuarina equisetifolia* windbreaks

Next to these fences three rows of *Casuarina equisetifolia* are planted. These plantings eventually replace the artificial (shade cloth) barrier and act as permanent wind breaks for future commercial plantings. It takes at least two years before the casuarinas are large enough to provide effective wind protection, and for this reason the mesh fences are indispensable in exposed areas.

(c) Sowing of cover crop

The next stage is to sow a cover crop in order to rapidly cover the sand and afford protection to the slower-germinating indigenous seeds.

A mixture of seeds comprised predominantly of *Pennisetum* sp. and *Crotalaria* sp. is used in conjunction with as large a variety of local indigenous seeds as possible. After good rains, this mixture is sown mechanically over the topsoiled area and harrowed in. Within 3 - 4 days the seeds germinate and quickly form a dense cover crop, thus protecting the indigenous seedlings from sandblast and harsh sun. After ± 18 months the cover crop dies off completely and a purely indigenous cover is left.

One lesson learned to date with regard to the espacement of this crop has been not to plant too densely. Should the cover crop be too dense, it is too demanding on the surface moisture, especially during the hot, dry periods.

(d) Removing of windbreaks

After ± 3 months the windbreak nets are removed and re-used in newer areas. At this stage the area is well on its way to recovery, and after 5 years a dense vegetation covers the mined area.

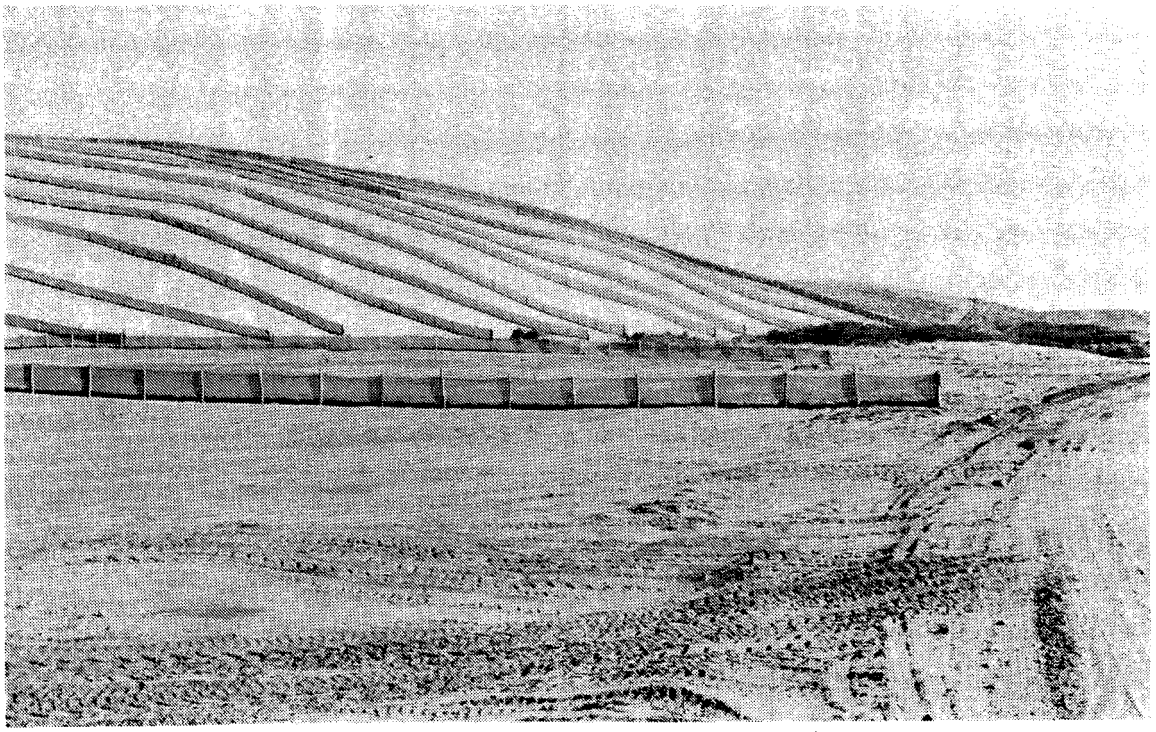

Figure 15: Landscape of an area recently mined and where rehabilitation work has begun by erection of windbreaks. These are fences of nylon 'shade cloth' transversely placed across the dunes and facing the direction of the dominating winds.

Figure 16: On the right side of the road a rehabilitated area covered by a dense vegetation of grasses such as *Cymbopogon sp., Imperata cylindrica, Chloris gayana, Panicum sp.* and *Dactyloctenium sp.)* and up to 1 m high shrubs of *Acacia karroo, Chrysanthemoides monilifera* and *Passerina rigida* can be seen. This species composition is similar to what would become established naturally in a pioneer situation.

(e) The establishment of indigenous vegetation

Experience has shown that it is more economical to sow seed *in situ* than to plant out from a nursery. However, certain important dune species such as *Brachylaena discolor,* do not germinate well when sown *in situ* and must therefore be raised in a nursery. Figure 16 shows a rehabilitated area with a varied and dense vegetation cover.

A list of 109 species identified in rehabilitation areas is given in Appendix II.

8.3 EVALUATION

Overall, the restitution of vegetation on mined areas of the Zululand Coast north of Richards Bay has been very successful. This is mainly due to the favourable ecological conditions, such as year round rainfall and high temperatures. Afforestation has not offered major problems and, where indigenous vegetation is aimed for, the plant cover obtained is quite similar to that which would be established naturally. From evidence in similar situations, we can be quite confident that in time, the vegetation will progressively approximate that which was originally there. Consequently, the ugly scars caused by mining operations will have disappeared and been replaced by a landscape quite similar to that of the pre-mining situation.

9. Summary

The coastal zone between the Richards Bay Sanctuary and the Mlalazi Estuary was studied. It is a 28 km strip of vegetated dunes along the Natal Coast between 28°50′ and 28°57½′ South and 31°46½′ and 32°03′ East. The maximum width of the dune field is 2 250 m, averaging about 1 500 m. The study area is about 3 582 ha in extent.

The aims of this study were: to gather information on the vegetation and natural features of the dune area between Richards Bay and Mlalazi Estuary; to assess the desirability of dune mining; to identify areas as suitable and unsuitable for mining in terms of their nature conservation status; to gather base - line data on plant cover for vegetation monitoring and as guide lines for dune rehabilitation.

This would be achieved by

(1) making an inventory and description of the main plant communities in the study area;
(2) providing 1:10 000 vegetation maps, that could serve for management and vegetation-monitoring purposes;
(3) evaluating the vegetation, and establishing conservation priorities with special reference to the intended dune mining;
(4) mapping conservation-priority areas;
(5) gathering information for the re-establishment of vegetation after mining; and
(6) providing a list of plants recorded during the survey.

Six 1:10 000 vegetation maps based on aerial photographs (1976) were prepared and used to assess conservation priorities with special reference to proposed dune mining. The evaluation was summarized on three conservation-priority maps (1:25 000). Map No. 1 (*vide* Weisser, 1982) reveals first-priority conservation areas mainly on the seaward and the landward slopes of the dune barrier, the mangroves, areas of Climax Dune Forest and the successionally advanced Secondary Dune Forest in the central area of the dune cordon.

No mining is intended in this area and the exclusion of this zone from the prospecting lease was a wise decision because of the overall high priority in conservation. It is urged that the area should be included into the Richards Bay Sanctuary as soon as possible. This area contains the best and most extensive examples of Climax Dune Forest, which are important nature conservation assets.

Map No. 2 shows first-priority conservation areas situated mainly on the seaward front, and second-priority conservation areas on the eastern limit with most of the central zone occupied by third-priority areas.

Along the coastal cliffs the presence of densely vegetated valleys and "arcuate scars" is noteworthy. The latter usually contain primary vegetation and are of high conservation value. "Arcuate scars" are known from only two places on the South African coast.

Primary hygrophilous forest patches were observed outside the study area. The area of this type of forest is dwindling rapidly because of clearing for cultivation. The conservation of representative sample patches by incorporating them into the Richards Bay Sanctuary is a matter of urgency.

There is no objection to mine the areas south of the Forestry Reserve Limit that are today mostly covered by secondary or artificially planted vegetation. The 200 m "ecostrip" along the coast from the beginning of the dune barrier landwards is sufficient to protect the first dune front exposed to the sea winds.

Map No. 3 covers the area that can be seen as the most degraded on the 1937 air photos. It was covered at that time by extensive driftsands, secondary grassland and dwarf shrubland. Today it is mainly covered by afforestation. The only extensive area rated as first priority for conservation is a strip along the coast, where relics of vegetation were preserved in "arcuate scars."

No objection to mining exists for most of the area, except for the discovery of a few small patches of natural forest that were found landwards and that could serve as natural reserve areas, from which reseeding with original dune species can take place.

Whereas most of the area is of low botanical value, the undisturbed patches of dune forest are in contrast very rare and of high value. It is this rarity that makes them more important than the actual content of species. Over extensive areas, there are no forest patches from which reseeding can occur and therefore the few patches available are irreplaceable should some areas be rehabilitated to natural vegetation.

In the coastal section covered by this map, two rocky outcrops occur. As rocky outcrops are rare along the Zululand Coast, the few sites existing have a high priority for conservation. They both fall outside the prospecting area.

Vegetation Map No. 4 shows the dune barrier narrowing down to only about 350 m and it is crossed by two streamlets. The 1937 aerial photographs reveal a high degree of degradation. Areas classified as first priority in conservation are a strip along the coast, a protection strip as stipulated in the prospecting licence of 50 m along the water courses and a few areas of well conserved vegetation near the water courses.

Noteworthy for conservation is the Babane Pan and surroundings, because of their wildlife (fauna and flora). Because it is low lying, and on the landward side of the dune barrier, it is assumed that there is no intention to mine this area.

The vegetation found along the streamlets is remarkable, because of the luxuriant growth and the speed with which it has established itself after having been destroyed prior to 1937.

Map No. 5 reveals the area of the Mlalazi Estuary Mouth and surroundings to have high priority for conservation. Apart from a coastal strip with Climax Dune Forest which in parts exceeds the 200 m line and the surroundings of the Mdlangu Lake, most of the central dune area falls into second and occasionally into third priority for conservation.

Most of the area has been excluded from mining by the envisaged KwaZulu Botanical Garden and the construction of a recreation area.

Outside the study area, remnants of a dense hygrophilous forest is being cleared by local inhabitants for cropland. This is deplorable considering how few of these patches are left, and it is of the utmost urgency to secure this patch by incorporating it into the Botanical Garden.

Map No. 6 covering the Mlalazi Peninsula contains the best examples of natural vegetation, mostly undisturbed and rated as first priority for conservation. This area is envisaged as part of the KwaZulu Botanical Garden. This area falls outside the mining lease zone. However, its use by local people for poaching and fuel gathering poses a threat to the area, mainly because of the fire hazard. Fires have already occurred and considerable damage has resulted.

From the information gathered the following additional recommendations are made:

(1) The dune forest and other vegetation of the northern part of the study area should be incorporated into the Richards Bay Sanctuary and thus protected as soon as possible. This should include some of the existing patches of Swamp Forest (outside the study area), that are being cleared for cultivation.

(2) The proclamation of the KwaZulu Botanical Garden, incorporating the nearby Swamp Forest in the process of being cleared by local inhabitants, should be regarded as urgent. To avoid moving people, a change of the proposed limits is suggested, covering the area already under the control of the Directorate of Forestry and including a corridor to the Swamp Forest and the Swamp Forest itself.

(3) The Botanical Garden could be extended to the north-east, by re-establishing natural vegetation after mining. This extension in area is essential for its future viability. Too much human use of the southern part would destroy the assets to be protected and the new areas suggested for inclusion could help to absorb the users' impact.

10. References

BEGG, G., 1978. The Estuaries of Natal. *Natal Town and Regional Planning Report.* Vol. 41.

BOWER, M., MS. Driftsand reclamation Zululand Coast. Dept. Forestry, KwaZulu, Eshowe.

BRAUN-BLANQUET, J., 1964. Pflanzensoziologie. Wien: Springer.

BRUTON, M.N. & COOPER, K.H., 1980. Studies of the Ecology of Maputaland. Grahamstown: Rhodes University, Durban: Wildlife Society of Sth. Africa.

CHAPMAN, D.M., GEARY, M., ROY, P.S., & THOM, B.G., 1982. Coastal Evolution and Coastal Erosion in New South Wales. Published by the Coastal Council of New South Wales, Sydney.

DIAMOND, J.M., 1975. The Island Dilemma. *Biological Conservation* 7: 129-146.

EDWARDS, D., 1967. A plant ecological survey of the Tugela River Basin. *Mem. bot. Surv. S. Afr.* No. 36.

EDWARDS, D., 1972. Remote sensing in the evaluation of the natural vegetation resources of South Africa. *Proc. 5th Symposium on Remote Sensing,* Pretoria, CSIR, May 1972. pp. 99 - 102.

FOX, I.K., 1974. Public objectives of lake management. Unpublished paper presented at the Conference on Lake Protection and Management, Madison (U.S.A.).

GIBBS RUSSELL, G.E. *et al.,* 1984. List of species of southern african plants. *Mem. bot. Surv. S. Afr.* No. 48, pp. 144.

HALL, M. & VOGEL, J.C., 1978. Enkwazini: Fourth Century Iron Age Site on the Zululand Coast. *S. Afr. J. Sci* 74: 70 - 71.

HEDGPETH, J.W., 1978. As blind men see the elephant: the dilemma of marine ecosystem research. In: Wiley, M.L. (ed.), *Estuarine Interactions.* New York: Academic Press.

JARMAN, M.L., JARMAN, N.G. & EDWARDS, D., 1983. Remote sensing and vegetation mapping in South Africa. *Bothalia* 14: 271 - 282.

KEET, J.D.M., 1936. Report on drift sands in South Africa. *Department of Agriculture and Forestry,* Bulletin No. 172.

MACDONALD, I.A.W., PAMMENTER, N.W., (MS). Regeneration of a coastal dune forest following fire. Paper presented at the 5th Annual Congress, South African Association of Botanists, 1979.

MOLL, E.J., 1972. A preliminary account of the dune communities at Pennington Park, Mtunzini, Natal. *Bothalia* 10: 615-626.

SCHULZE, B.R., 1965. *General Survey.* Climate of South Africa Series Part 8. Weather Bureau Publications. Pretoria: Dept. of Transport.

STEPHENS, H.B., 1939. Inspection of crown lands on Zululand coast between Richards Bay and Sodwana Bay July-September. Unpublished report, Forestry Department, Pietermaritzburg.

THATCHER, A.C. & WESTMAN W.E., 1975. Succession following mining on high dunes of coastal South-east Queensland. *Managing Terrestrial Ecosystems,* 17-33.

TINLEY, K.L., 1985. Coastal Dunes of South Africa. *South African National Scientific Programmes Report* No 109. Pretoria, CSIR.

VENTER, H.J.T., 1972. *Die plantekologie van Richardsbaai, Natal. D.Sc. thesis. Universiteit van Pretoria.*

WARD, C.J., 1980. The plant ecology of the Isipingo Beach Area, Natal, South Africa. *Mem. bot. Surv. S. Afr.* No. 45.

WARD, C.J. & STEINKE, T.D., 1982. A note on the distribution and approximate areas of mangroves in South Africa. *S. Afr. J. Bot.,* 1: 51-53.

WEISSER, P.J., 1978 a. Changes in area of grasslands on the dunes between Richards Bay and the Mfolozi River 1937 to 1974. *Proc. Grassld. Soc. Sth. Afr. 13:95-97.*

WEISSER, P.J., 1978 b. A vegetation study of the Zululand dune areas. Conservation priorities in the dune area between Richards Bay and Mfolozi River Mouth based on a vegetation survey. *Natal Town and Regional Planning Report* Vol. 38, Pietermaritzburg.

WEISSER, P.J., 1979 a. Suitability of air-photo interpretation for monitoring coastal dune vegetation of the Zululand Dunes, South Africa. In: *The Use of Ecological Variables in Environmental Monitoring.* The National Swedish Environment Protection Board, Report PM 1151, pp. 62-72.

WEISSER, P.J., 1979 b. Mining prospecting activities and their environmental impact in Reserve 10, Zululand. Unpublished report, Botanical Research Institute, Pretoria.

WEISSER, P.J., 1980. The dune forest of Maputaland. In: Bruton, M.W. & Cooper K.H. (eds.) *Studies on the ecology of Maputaland,* Rhodes University, Grahamstown, and the Wildlife Society, Durban, pp. 78-90.

WEISSER, P.J., 1982. Conservation priorities in the dune area between Richards Bay and Mlalazi Estuary based on a vegetation survey. Unpublished report Botanical Research Institute, Pretoria, South Africa, 111 pp.

WEISSER, P.J. & BACKER, A.P., 1983. Monitoring beach and dune advancement and vegetation changes 1937-1977 at the farm Twinstreams, Mtunzini, Natal, South Africa. In: MacLachlan, A & Erasmus, T. (eds), *Developments in Hydrobiology;* 19:727-732. The Hague: Junk.

WEISSER, P.J., BACKER, A.P. & GARLAND, I.F., (MS). Vegetation of the proposed KwaZulu National Botanical Garden at Mlalazi.

WEISSER, P.J. & COOPER, K.H., (MS). The Dry Coastal Ecosystems of the South African East Coast.

WEISSER, P.J., GARLAND, I.F. & DREWS, B.K., 1982. Dune advancement 1937-1977 at the Mlalazi Nature Reserve, Mtunzini, Natal, South Africa, and a preliminary vegetation-succession chronology. *Bothalia* 14: 127-130.

WEISSER, P.J. & MARQUES, F., 1979. Gross vegetation changes in the dune area between Richards Bay and the Mfolozi River, 1937 - 1974. *Bothalia* 12: 711 - 721.

WEISSER, P.J. & MÜLLER, R., 1983. Dune Vegetation Dynamics from 1937 to 1976 in the Mlalazi-Richards Bay Area of Natal, South Africa. *Bothalia* 14: 661-667.

WEISSER, P.J. & SMITH, E.C.A., (MS). Vegetation of the "arcuate scars" on the Zululand Dune Barrier and their importance for Nature Conservation.

WEISSER, P.J. & WARD. C.J., 1982. Destruction of the *Phoenix/Hibiscus* and *Barringtonia racemosa* Communities (Venter 1972) in Richards Bay, Natal, South Africa. *Bothalia* 14: 123-125.

Appendix 1:

CHECK–LIST OF VASCULAR PLANTS FOUND DURING FIELD WORK IN THE STUDY AREA

The nomenclature followed was generally that of Gibbs Russel *et al.*(1984) except for some recent name changes. Specimens were identified by the staff of the Herbarium of the Botanical Research Institute, whose essential contribution is gratefully acknowledged.

The genus name is used as entry. The species name and the author, as well as the family to which the plant belongs, is given. For additional information the plant list in the work of Venter (1972) can be consulted. As this checklist was only a secondary objective in this project, no special effort was invested in it and therefore it is far from complete. The help of Mrs E. van Hoepen and Misses A.P. Backer and A. Stadler in preparing this list is gratefully acknowledged.

Abutilon grantii A. Meeuse	MALVACEAE
Abrus precatorius L. subsp. *africanus* Verdc.	FABACEAE
Acacia karroo Hayne	FABACEAE
Acacia kraussiana Meisn. ex Benth.	FABACEAE
Acacia schweinfurthii Brenan & Exell var. *schweinfurthii*	FABACEAE
Acalypha petiolaris Hochst.	EUPHORBIACEAE
Acalypha sonderiana Muell. Arg.	EUPHORBIACEAE
Achyranthes sicula (L.) All.	AMARANTHACEAE
Achyropsis avicularis (E. Mey. ex Moq.) Hook. f.	AMARANTHACEAE
Acokanthera oblongifolia (Hochst.) Codd	APOCYNACEAE
Acrostichum aureum L.	ADIANTACEAE
Adenia gummifera (Harv.) Harms var. *gummifera*	PASSIFLORACEAE
Adiantum capillus-veneris L.	ADIANTACEAE
Albizia adianthifolia (Schumach.) W.F. Wight	FABACEAE
Allophylus natalensis (Sond.) De Winter	SAPINDACEAE
Aloe thraskii Bak.	LILIACEAE

Aneilema schlechteri K. Schum.	COMMELINACEAE
Annona senegalensis Pers.	ANNONACEAE
Ansellia gigantea Reichb. f. var. *nilotica* (Bak.) Summerh.	ORCHIDACEAE
Antidesma venosum E. Mey. ex Tul.	EUPHORBIACEAE
Anthericum saundersiae Bak.	LILIACEAE
Anthospermum littoreum L. Bol.	RUBIACEAE
Asplenium prionitis Kunze	ASPLENIACEAE
Apodytes dimidiata E. Mey. ex Arn. subsp. *dimidiata*	ICACINACEAE
Arctotheca populifolia (Berg.) T. Norl.	ASTERACEAE
Aristida junciformis Trin. & Rupr. subsp. *junciformis*	POACEAE
Asystasia gangetica (L.) T. Anders.	ACANTHACEAE
Avicennia marina (Forsk.) Vierh.	VERBENACEAE
Barleria obtusa Nees	ACANTHACEAE
Barleria repens Nees	ACANTHACEAE
Barringtonia racemosa (L.) Roxb.	LECYTHIDACEAE
Bersama lucens (Hochst.) Szyszyl.	MELIANTHACEAE
Bidens biternata (Lour.) Merr. & Sherff	ASTERACEAE
Bidens pilosa L.	ASTERACEAE
Blumea lacera (Burm. f.) DC.	ASTERACEAE
Blumea mollis (D. Don) Merr.	ASTERACEAE
Bonatea sp.	ORCHIDACEAE
Brachylaena discolor DC. subsp. *discolor*	ASTERACEAE
Bridelia micrantha (Hochst.) Baill.	EUPHORBIACEAE
Bruguiera gymnorrhiza (L.) Lam.	RHIZOPHORACEAE
Canthium gueinzii Sond.	RUBIACEAE
Canthium inerme (L.f.) Kuntze	RUBIACEAE
Canthium obovatum Klotzsch	RUBIACEAE
Capparis sp.	CAPPARACEAE
Capparis tomentosa Lam.	CAPPARACEAE
Carissa bispinosa (L.) Desf. ex Brenan	APOCYNACEAE
Carissa macrocarpa (Eckl.) A. DC.	APOCYNACEAE
Carpobrotus dimidiatus (Haw.) L. Bol.	MESEMBRYANTHEMACEAE
Cassine aethiopica Thunb.	CELASTRACEAE
Cassine papillosa (Hochst.) Kuntze	CELASTRACEAE
Cassytha filiformis L.	LAURACEAE
Casuarina equisetifolia L.	CASUARINACEAE
Catunaregam spinosa (Thunb.) Tirvengadum subsp. *spinosa*	RUBIACEAE
Celtis africana Burm. f.	ULMACEAE
Centella asiatica (L.) Urb.	APIACEAE
Ceratophyllum demersum L.	CERATOPHYLLACEAE

Cestrum laevigatum Schlechtd.	SOLANACEAE
Cheilanthes viridis (Forssk.) Swartz	ADIANTACEAE
Cheirostylis gymnochiloides (Ridley) Reichb. f.	ORCHIDACEAE
Chionanthus peglerae (C.H. Wr.) Stearn	OLEACEAE
Chironia baccifera L.	GENTIANACEAE
Chromolaena odorata (L.) R.M. King & H. Robinson	ASTERACEAE
Chrysanthemoides monilifera (L.) T. Norl.	ASTERACEAE
Cissampelos torulosa E. Mey. ex Harv.	MENISPERMACEAE
Cissus fragilis E. Mey.	VITACEAE
Clausena anisata (Willd.) Hook. f. ex Benth.	RUTACEAE
Clerodendrum glabrum E. Mey. var. *glabrum*	VERBENACEAE
Coccinia adoensis (Hochst. ex A. Rich.) Cogn.	CUCURBITACEAE
Coccinia rehmannii Cogn. var. *littoralis* A. Meeuse	CUCURBITCEAE
Coddia rudis (E. Mey. ex Harv.) Verdc.	RUBIACEAE
Colpoon compressum Berg.	SANTALACEAE
Commelina sp.	COMMELINACEAE
Conyza sumatrensis (Retz.) E.H. Walker	ASTERACEAE
Cordia caffra Sond.	BORAGINACEAE
Crassula alba Forssk.	CRASSULACEAE
Crocosmia aurea Planch.	IRIDACEAE
Crotalaria capensis Jacq.	FABACEAE
Cussonia sphaerocephala Strey	ARALIACEAE
Cussonia zuluensis Strey	ARALIACEAE
Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy	POACEAE
Cynanchum ellipticum (Harv.) R.A. Dyer	ASCLEPIADACEAE
Cynanchum obtusifolium L.f.	ASCLEPIADACEAE
Cynanchum sp.	ASCLEPIADACEAE
Cyperus albostriatus Schrad.	CYPERACEAE
Cyperus papyrus L.	CYPERACEAE
Cyperus prolifer Lam. var. *isocladus* (Kunth) Kuekenth. (= *C.isocladus* Kunth)	CYPERACEAE
Cyperus sexangularis Nees	CYPERACEAE
Cyperus textilis Thunb.	CYPERACEAE
Cyphostemma cirrhosum (Thunb.) Desc. ex Wild & Drum.	VITACEAE
Cyrtorchis arcuata (Lindl.) Schltr.	ORCHIDACEAE
Dactyloctenium geminatum Hack.	POACEAE
Dalbergia armata E. Mey.	FABACEAE
Dalbergia obovata E. Mey.	FABACEAE
Deinbollia oblongifolia (E. Mey. ex Arn.) Radlk.	SAPINDACEAE

Desmodium canum (J.F. Gmel.) Schinz & Thell.	FABACEAE
Desmodium hirtum Guill. & Perr.	FABACEAE
Dichrostachys cinerea (L.) Wight & Arn. subsp. *africana* Brenan & Brumm.	FABACEAE
Didymoplexis verrucosa J. Stewart & E.F. Hennessy	ORCHIDACEAE
Dietes sp.	IRIDACEAE
Digitaria natalensis Stent (= *D. macroglossa* Henr.)	POACEAE
Dioscorea cotinifolia Kunth	DIOSCOREACEAE
Dioscorea crinita Hook. f.	DIOSCOREACEAE
Dioscorea sylvatica (Kunth) Eckl.	DIOSCOREACEAE
Dovyalis longispina (Harv.) Warb.	FLACOURTIACEAE
Dovyalis rhamnoides (Burch. ex DC.) Harv.	FLACOURTIACEAE
Dovyalis zeyheri (Sond.) Warb.	FLACOURTIACEAE
Dracaena hookeriana K. Koch.	AGAVACEAE
Drimiopsis maculata Lindl.	LILIACEAE
Ekebergia capensis Sparrm.	MELIACEAE
Embelia ruminata (E. Mey. ex A. DC.) Mez	MYRSINACEAE
Entada spicata (E. Mey.) Druce	FABACEAE
Equisetum ramosissimum Desf.	EQUISETACEAE
Erythrina caffra Thunb.	FABACEAE
Erythrina lysistemon Hutch.	FABACEAE
Euclea natalensis A. DC.	EBENACEAE
Eugenia capensis (Eckl. & Zeyh.) Harv. ex Sond.	MYRTACEAE
Eulophia speciosa (R. Br. ex Lindl.) H. Bol.	ORCHIDACEAE
Ficus burtt-davyi Hutch.	MORACEAE
Ficus craterostoma Warb. ex Mildbr. & Burret	MORACEAE
Ficus lutea Vahl. (= *Ficus vogelii* (Miq.) Miq.)	MORACEAE
Ficus natalensis Hochst.	MORACEAE
Ficus sur Forssk. (= *Ficus capensis* Thunb.)	MORACEAE
Ficus trichopoda Bak.	MORACEAE
Fimbristylis hispidula (Vahl) Kunth	CYPERACEAE
Flagellaria guineensis Schumach.	FLAGELLARIACEAE
Gazania rigens (L.) Gaertn. var. *uniflora* (L.f.) Roessl.	ASTERACEAE
Gerrardina foliosa Oliv.	FLACOURTIACEAE
Gloriosa superba L.	LILIACEAE
Grewia occidentalis L.	TILIACEAE
Halleria lucida L.	SCROPHULARIACEAE
Harpephyllum caffrum Bernh.	ANACARDIACEAE
Hebenstreitia dentata L.	SELAGINACEAE
Helichrysum asperum (Thunb.) Hilliard	

& Burtt var. *comosum* (Sch. Bip.) Hilliard	ASTERACEAE
Helichrysum cymosum (L.) D. Don	ASTERACEAE
Helichrysum decorum DC.	ASTERACEAE
Helichrysum ecklonis Sond. (= *Helichrysum lamprocephalum* H. Bol.)	ASTERACEAE
Helichrysum kraussii Sch. Bip.	ASTERACEAE
Hibiscus surattensis L.	MALVACEAE
Hibiscus tiliaceus L.	MALVACEAE
Hydrocotyle bonariensis Lam.	APIACEAE
Hyphaene natalensis Kunze	ARECACEAE
Hypoëstes aristata R. Br.	ACANTHACEAE
Hypoxis acuminata Bak.	HYPOXIDACEAE
Imperata cylindrica (L.) Raeuschel	POACEAE
Indigofera sp.	FABACEAE
Indigofera spicata Forssk.	FABACEAE
Ipomoea brasiliensis (L.) Sweet	CONVOLVULACEAE
Ipomoea cairica (L.) Sweet	CONVOLVULACEAE
Ipomoea congesta R. Br.	CONVOLVULACEAE
Ipomoea hochstetteri House	CONVOLVULACEAE
Ipomoea wightii (Wall.) Choisy	CONVOLVULACEAE
Isoglossa woodii C.B. Cl.	ACANTHACEAE
Juncus kraussii Hochst.	JUNCACEAE
Kalanchoe rotundifolia (Haw.) Haw.	CRASSULACEAE
Kraussia floribunda Harv.	RUBIACEAE
Kyllinga alba Nees	CYPERACEAE
Lablab purpureus (L.) Sweet	FABACEAE
Lagenaria sphaerica (Sond.) Naud. (= *Lagenaria mascarena* Naud.)	CUCURBITACEAE
Laportea peduncularis (Wedd.) Chew	URTICACEAE
Launaea sarmentosa (Willd.) Sch. Bip. ex Kuntze	ASTERACEAE
Lemna aequinoctialis Welw. (= *L. perpusilla* Torrey)	LEMNACEAE
Macaranga capensis (Baill.) Benth. ex Sim	EUPHORBIACEAE
Maesa lanceolata Forssk. var. *rufescens* (A. DC.) Taton	MYRSINACEAE
Manulea parviflora Benth.	SCROPHULARIACEAE
Maytenus heterophylla (Eckl. & Zeyh.) N.K.B. Robson	CELASTRACEAE
Maytenus nemorosa (Eckl. & Zeyh.) Marais	CELASTRACEAE
Maytenus procumbens (L.f.) Loes.	CELASTRACEAE
Maytenus undata (Thunb.) Blakelock	CELASTRACEAE
Melia azedarach L.	MELIACEAE
Microglossa mespilifolia (Less.) B.L. Robinson	ASTERACEAE
Microsorium punctatum (L.) Copel.	POLYPODIACEAE

Microsorium scolopendrium (Burm. f.) Copel.	POLYPODIACEAE
Mikania natalensis DC. (= *Mikania cordata* Hilliard)	ASTERACEAE
Mimusops caffra E. Mey. ex A. DC.	SAPOTACEAE
Momordica involucrata E. Mey. ex Sond.	CUCURBITACEAE
Monanthotaxis caffra (Sond.) Verdc.	ANNONACEAE
Myrica serrata Lam.	MYRICACEAE
Nephrolepis biserrata (Swartz) Schott	DAVALLIACEAE
Nidorella auriculata DC.	ASTERACEAE
Ochna holstii Engl.	OCHNACEAE
Ochna natalitia (Meisn.) Walp.	OCHNACEAE
Ochna serrulata (Hochst.) Walp.	OCHNACEAE
Olea woodiana Knobl.	OLEACEAE
Oplismenus hirtellus (L.) Beauv.	POACEAE
Opuntia sp.	CACTACEAE
Othonna carnosa Less.	ASTERACEAE
Pancovia golungensis (Hiern) Exell & Mendonca	SAPINDACEAE
Panicum aequinerve Nees	POACEAE
Panicum deustum Thunb.	POACEAE
Passerina rigida Wikstr.	THYMELAEACEAE
Pavetta revoluta Hochst.	RUBIACEAE
Pavetta sp.	RUBIACEAE
Peddiea africana Harv.	THYMELAEACEAE
Phoenix reclinata Jacq.	ARECACEAE
Phragmites australis (Cav.) Steud.	POACEAE
Phragmites mauritianus Kunth	POACEAE
Pisonia aculeata L.	NYCTAGINACEAE
Polygonum pulchrum Blume	POLYGONACEAE
Protasparagus densiflorus (Kunth) Oberm. (= *Asparagus sprengeri* Regel)	LILIACEAE
Protasparagus falcatus (L.) Oberm.	LILIACEAE
Protasparagus setaceus (Kunth) Oberm. (= *Asparagus plumosus* Bak.)	LILIACEAE
Protorhus longifolia (Bernh.) Engl.	ANACARDIACEAE
Psidium guajava L.	MYRTACEAE
Psychotria capensis (Eckl.) Vatke	RUBIACEAE
Ptaeroxylon obliquum (Thunb.) Radlk.	PTAEROXYLACEAE
Pteridium aquilinum (L.) Kuhn	DENNSTAEDTIACEAE
Pupalia atropurpurea Moq.	AMARANTHACEAE
Putterlickia verrucosa (E. Mey. ex Sond.) Szyszyl.	CELASTRACEAE
Rauvolfia caffra Sond.	APOCYNACEAE
Rhoicissus sp.	VITACEAE
**Rhoicissus cf. digitata* (L.f.) Gilg & Brandt	VITACEAE
**Rhoicissus cf. revoilii* Planch.	VITACEAE
Rhoicissus rhomboidea (E. Mey. ex Harv.)	

* The identification of these species was problematic and they may have been confounded

Planch.	VITACEAE
Rhoicissus spec. nov.	VITACEAE
Rhoicissus tomentosa (Lam.) Wild & Drummond	VITACEAE
Rhoicissus tridentata (L.f.) Wild & Drummond	VITACEAE
Rhus dentata Thunb.	ANACARDIACEAE
Rhus macowanii Schonl.	ANACARDIACEAE
Rhus natalensis Bernh.	ANACARDIACEAE
Rhus nebulosa Schonl.	ANACARDIACEAE
Rhynchosia caribaea (Jacq.) DC. var. *caribaea*	FABACEAE
Ricinus communis L.	EUPHORBIACEAE
Rubia cordifolia L. subsp. *conotricha* (Gand.) Verdc.	RUBIACEAE
Rubus sp.	ROSACEAE
Salacia gerrardii Harv.	CELASTRACEAE
Salacia kraussii (Harv.) Harv.	CELASTRACEAE
Samolus valerandi L.	PRIMULACEAE
Sansevieria hyacinthoides (L.) Druce	AGAVACEAE
Sapium integerrimum (Hochst.) J. Leónard	EUPHORBIACEAE
Sarcostemma viminale (L.) R. Br.	ASCLEPIADACEAE
Scabiosa columbaria L.	DIPSACACEAE
Scadoxus membranaceus (Bak.) Friis & Nordal	AMARYLLIDACEAE
Scadoxus puniceus (L.) Friis & Nordal	AMARYLLIDACEAE
Scaevola plumieri (L.) Vahl.	GOODENIACEAE
Schefflera umbellifera (Sond.) Baill.	ARALIACEAE
Scleria angusta Nees ex Kunth	CYPERACEAE
Sclerocarya birrea (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwaro (= *S. caffra* Sond.)	ANACARDIACEAE
Scolopia mundii (Eckl. & Zeyh.) Warb.	FLACOURTIACEAE
Scolopia zeyheri (Nees) Harv.	FLACOURTIACEAE
Scutia myrtina (Burm. f.) Kurz	RHAMNACEAE
Secamone alpinii Schultes	ASCLEPIADACEAE
Secamone filiformis (L.f.) J.H. Ross (= *Secamone frutescens* Decne.)	ASCLEPIADACEAE
Senecio mikanioides Otto ex Harv.	ASTERACEAE
Senecio pterophorus DC.	ASTERACEAE
Senecio quinquelobus (Thunb.) DC.	ASTERACEAE
Senecio skirrhodon DC.	ASTERACEAE
Senecio spp.	ASTERACEAE
Senecio tamoides DC.	ASTERACEAE
Sesbania bispinosa (Jacq.) W.F. Wight var. *bispinosa*	FABACEAE
Sesbania punicea (Cav.) Benth.	FABACEAE
Setaria megaphylla (Steud.) Dur. & Schinz (= *S. chevalieri* Stapf ex Stapf & C.E. Hubb.)	POACEAE

Sideroxylon inerme L.	SAPOTACEAE
Smilax kraussiana Meisn.	LILIACEAE
Solanum hermannii Dun. (= *S. sodomaeum* L.)	SOLANACEAE
Solanum seaforthianum Andr.	SOLANACEAE
Sonchus oleraceus L.	ASTERACEAE
Stenochlaena tenuifolia (Desv.) T. Moore	BLECHNACEAE
Stenotaphrum secundatum (Walt.) Kuntze	POACEAE
Stipagrostis zeyheri (Nees) De Winter	POACEAE
Strelitzia nicolai Regel & Koern.	MUSACEAE
Strychnos spinosa Lam.	LOGANIACEAE
Syzygium cordatum Hochst.	MYRTACEAE
Syzygium guineense (Willd) DC.	MYRTACEAE
Tarenna pavettoides (Harv.) Sim	RUBIACEAE
Teclea gerrardii Verdoorn	RUTACEAE
Tephrosia multijuga R.G.N. Young	FABACEAE
Tephrosia purpurea (L.) Pers. subsp. *canescens* (E. Mey.) Brummitt	FABACEAE
Thelypteris sp.	THELYPTERIDACEAE
Thelypteris dentata (Forssk.) E. St. John var. *dentata*	THELYPTERIDACEAE
Tragia durbanensis Kuntze	EUPHORBIACEAE
Trema orientalis (L.) Blume	ULMACEAE
Tricalysia sonderiana Hiern	RUBIACEAE
Trichilia emetica Vahl	MELIACEAE
Triglochin striata Ruiz & Pav.	JUNCAGINACEAE
Trimeria grandifolia (Hochst.) Warb.	FLACOURTIACEAE
Triumfetta rhomboidea Jacq.	TILIACEAE
Turraea floribunda Hochst.	MELIACEAE
Typha capensis (Rohrb.) N.E. Br. (= *T. latifolia* L.)	TYPHACEAE
Urera cameroonensis Wedd.	URTICACEAE
Uvaria caffra E. Mey. ex Sond.	ANNONACEAE
Vangueria infausta Burch. subsp. *infausta*	RUBIACEAE
Vepris lanceolata (Lam.) G. Don (= *V. undulata* (Thunb.) Verdoorn ex C.A. Sm.)	RUTACEAE
Vernonia aurantiaca (O. Hoffm.)N.E. Br.	ASTERACEAE
Vigna vexillata (L.) A. Rich.	FABACEAE
Voacanga thouarsii Roem. & Schult.	APOCYNACEAE
Wahlenbergia sp.	CAMPANULACEAE
Zanthoxylum capense (Thunb.) Harv. (= *Fagara capensis* Thunb.)	RUTACEAE

Appendix 2:

LIST OF PLANTS IDENTIFIED ON MINED AREAS AFTER REHABILITATION (1982)
P.D. Camp, ecologist Richards Bay Minerals

Abutilon grantii A. Meeuse	MALVACEAE
Acacia karroo Hayne	FABACEAE
Acalypha petiolaris Hochst.	EUPHORBIACEAE
Acanthospermum glabratum (DC.) Wild	ASTERACEAE
Albizia adianthifolia (Schumach.) W.F. Wight	FABACEAE
Alysicarpus vaginalis (L.) DC. var. *vaginalis*	FABACEAE
Amaranthus spinosus L.	AMARANTHACEAE
Ambrosia artemisiifolia L.	ASTERACEAE
Aneilema aequinoctiale (Beauv.) Kunth	COMMELINACEAE
Anthericum saundersiae Bak.	LILIACEAE
Argemone subfusiformis G.B. Ownbey	PAPAVERACEAE
Asclepias physocarpa (E. Mey.) Schltr.	ASCLEPIADACEAE
Asystasia gangetica (L.) T. Anders.	ACANTHACEAE
Bidens pilosa L.	ASTERACEAE
Brachiaria humidicola (Rendle) Schweick.	POACEAE
Brachylaena discolor DC.	ASTERACEAE
Bulbostylis contexta (Nees) Bodard	CYPERACEAE
Canavalia maritima (Aubl.) Thouars	FABACEAE
Carissa bispinosa (L.) Desf. ex Brenan	APOCYNACEAE
Carpobrotus dimidiatus (Haw.) L. Bol.	MESEMBRYANTHEMACEAE
Cassia mimosoides L.	FABACEAE
Catharanthus roseus (L.) G. Don	APOCYNACEAE
Chloris gayana Kunth	POACEAE
Chrysanthemoides monilifera (L.) T. Nor.	ASTERACEAE
Commelina modesta Oberm.	COMMELINACEAE
Commelina undulata R. Br.	COMMELINACEAE
Conyza bonariensis (L.) Cronq.	ASTERACEAE
Conyza sumatrensis (Retz.) E.H. Walker (= *Conyza floribunda* H.B.K.)	ASTERACEAE
Crassula pellucida L.	CRASSULACEAE
Crotalaria capensis (Jacq.) Pers.	FABACEAE

Crotalaria globifera E. Mey.	FABACEAE
Crotalaria juncea L.	FABACEAE
Crotalaria lanceolata E. Mey.	FABACEAE
Crotalaria vasculosa Wall. ex Benth.	FABACEAE
Cuscuta gerrardii Bak.	CONVOLVULACEAE
Cymbopogon validus (Stapf) Stapf ex Burtt Davy	POACEAE
Cyperus natalensis Hochst.	CYPERACEAE
Cyperus obtusiflorus Vahl	CYPERACEAE
Cyperus tenax Boeck.	CYPERACEAE
Dactyloctenium australe Steud.	POACEAE
Dactyloctenium geminatum Hack.	POACEAE
Desmodium canum (J.F. Gmel.) Schinz & Thell.	FABACEAE
Digitaria natalensis Stent (= *D. macroglossa* Henr.)	POACEAE
Dodonaea angustifolia L.f. (= *Dodonaea viscosa*)	SAPINDACEAE
Drimiopsis maculata Lindl.	LILIACEAE
Ehrharta calycina J.C. Sm. dr.	POACEAE
Eragrostis capensis (Thunb.) Trin.	POACEAE
Eragrostis ciliaris (L.) R. Br.	POACEAE
Eriosema psoraleoides (Lam.) G. Don	FABACEAE
Eugenia capensis (Eckl. & Zeyh.) Harv. ex Sond.	MYRTACEAE
Eulophia speciosa (R. Br. ex Lindl.) H. Bol.	ORCHIDACEAE
Ficus burtt-davyi Hutch.	MORACEAE
Gnaphalium declinatum L.f.	ASTERACEAE
Hebenstreitia dentata L.	SELAGINACEAE
Helichrysum asperum (Thunb.) Hilliard Burtt var. *asperum*	ASTERACEAE
Helichrysum candolleanum Buck.	ASTERACEAE
Helichrysum cymosum (L.) D. Don subsp. *cymosum*	ASTERACEAE
Helichrysum decorum DC.	ASTERACEAE
Helichrysum longifolium DC.	ASTERACEAE
Hewittia sublobata (L.f.) Kuntze	CONVOLVULACEAE
Hibiscus surattensis L.	MALVACEAE
Hypoxis rooperi S. Moore	HYPOXIDACEAE
Imperata cylindrica (L.) Raeuschel	POACEAE
Indigofera inhambanensis Klotzsch	FABACEAE
Indigofera sanguinea N.E. Br.	FABACEAE
Indigofera spicata Forssk.	FABACEAE
Indigofera trita L.f.	FABACEAE
Indigofera vicioides Jaub. & Spach	FABACEAE
Ipomoea spp.	CONVOLVULACEAE
Lactuca indica L.	ASTERACEAE
Limeum viscosum (Gay) Fenzl subsp.	AIZOACEAE

viscosum var. *viscosum*	
Lobelia pinifolia L. var. *pinifolia*	LOBELIACEAE
Lotononis florifera Duemmer	FABACEAE
Macrotyloma axillare (E. Mey.) Verdc. var. *axillare*	FABACEAE
Manulea crassifolia Benth.	SCROPHULARIACEAE
Manulea parviflora Benth.	SCROPHULARIACEAE
Mariscus albomarginatus C.B. Cl.	CYPERACEAE
Mariscus dubius (Rottb.) Kuekenth. ex G.E.C. Fischer	CYPERACEAE
Ocimum urticifolium Roth. subsp. *urticifolium*	LAMIACEAE
Oenothera parodiana Munz subsp. *parodiana*	ONAGRACEAE
Oxygonum dregeanum Meisn. var. *dregeanum*	POLYGONACEAE
Panicum maximum Jacq.	POACEAE
Passerina rigida Wikstr.	THYMELAEACEAE
Pennisetum glaucum (L.) R. Br.	POACEAE
Phoenix reclinata Jacq.	ARECACEAE
Phragmites australis (Cav.) Steud.	POACEAE
Phyllanthus burchellii Muell. Arg.	EUPHORBIACEAE
Rhus nebulosa Schonl.	ANACARDIACEAE
Rhynchelytrum repens (Willd.) C.E. Hubb.	POACEAE
Richardia brasiliensis Gomes	RUBIACEAE
Ricinus communis L.	EUPHORBIACEAE
Selago woodii Rolfe	SELAGINACEAE
Senecio madagascariensis Poir.	ASTERACEAE
Senecio polyanthemoides Sch. Bip.	ASTERACEAE
Sesbania bispinosa (Jacq.) W.F. Wight var. *bispinosa*	LEGUMINOSAE
Smilax kraussiana Meisn.	LILIACEAE
Sonchus oleraceus L.	ASTERACEAE
Sorghum spp.	POACEAE
Sporobolus africanus (Poir.) Robyns & Tournay	POACEAE
Strelitzia nicolai Regel & Koern.	MUSACEAE
Sutera floribunda (Benth.) Kuntze	SCROPHULARIACEAE
Tephrosia burchellii Burtt Davy	FABACEAE
Tephrosia grandiflora (Ait.) Pers.	FABACEAE
Trema orientalis (L.) Blume	ULMACEAE
Triumfetta rhomboidea Jacq.	TILICACEAE
Typha capensis (Rohrb.) N.E. Br. (= *Typha latifolia* L.)	TYPHACEAE
Wahlenbergia undulata (Thunb.) A. DC.	CAMPANULACEAE
Xanthium strumarium L.	ASTERACEAE
Zornia capensis Pers.	FABACEAE