UNIVERSITY OF ZULULAND

Phytosociology and vegetation ecology of uMlalazi Nature Reserve

by

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Dedication

I would like to give all praise to our Almighty, our creator who gave me life, strength, courage and reassurance that I can do it all the way.

I give my sincerely thanks to my supervisor Dr THC Mostert for his advices, guidance and assistance especially with the computer programs.

Thanks to my family and friends for their support and encouragements throughout the study.

"Having a place means that you know what a place means…what it means in a storied sense of myth, character and presence but also in an ecological sense…Integrating native consciousness with mythic consciousness"

***Gary Snyder*.**

Abstract

The need to conduct research on vegetation is important for identifying ecologically sensitive areas and understanding the major ecological processes driving these unique ecosystems in order to conserve and manage them effectively. The aim of this study was to identify, classify, map, describe and name the vegetation clusters in uMlalazi Nature Reserve. A total of 149 relevés were sampled. The sampling was carried out according to the Braun-Blanquet method with the plant data entered in TURBOVEG and exported into Juice. Classification was completed using the modified TWINSPAN algorithm, resulting in thirteen plant communities. These communities are described in terms of their structure, composition and distribution. These communities can be divided into those that occur on clay soils and those that occur on sandy soils. Ordination was carried out using the Non-metric Multidimensional Scaling to investigate the relationship between species and their underlying environmental factors. Ordination revealed that the presence or absence of some environmental factors such as, exposure to salt spray, salt content, moisture availability and clay content are important in shaping most of the communities in the study area. Differences in species richness, salt content, distance from the sea and human induced fire and grazing between plant communities are clearly articulated. Towards the end, the structure, distribution and ecology of the dune communities from pioneer to dune forest is given. The proposed classification, ordination clusters, vegetation map and description of communities can be used for the uMlalazi Nature Reserve management, land-use planning and even further research. The study showed that uMlalazi Nature Reserve serves as an important refuge for plant species and communities of biological and economic significance.

Key words: Plant communities, Mtunzini, Maputaland, Dune succession, Coastal dune forest, Botanical conservation importance ratings, ordination, wetlands, riverine woodlands, mangrove forests, secondary coastal grasslands, Indian Ocean Coastal Belt Biome.

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I acknowledge that I have read and understood the University's policies and rules applicable to postgraduate research, and I certify that I have, to the best of my knowledge and belief, complied with their requirements. In particular, I confirm that I had obtained an ethical clearance certificate for my research (Certificate Number: UZREC171110-030-PGM 2015/160) and that I have complied with the conditions set out in that certificate.

I further certify that this dissertation is original, and that the material has not been published elsewhere, or submitted, either in whole or in part, for a degree at this or any other university.

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To the best of my knowledge, the University Rules and the procedures stipulated in the Postgraduate Assessment Guide have been adhered to in respect of the above-mentioned candidate.

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CHAPTER ONE

Introduction

1.1 Background

On 22 May 1992 in Nairobi, world leaders adopted the global Convention on Biological Diversity (CBD). The main objective of the CBD was to ensure the conservation and sustainable use of biological diversity and to have a fair and equitable sharing of benefits arising from its utilization (DEAT, 1998). The CBD opened for signature on 5 June 1992, during the United Nations Conference on Environment and Development (UNCED). The meeting resulted in the recognition of the importance of biodiversity such that in the 10^{th} Conference of Parties, ten year global biodiversity targets were set. This resulted in the UN General Assembly declaring 2011-2020 as the UN Decade of Biodiversity. In doing so, the United Nations emphasized the economic, cultural, ecological, social and aesthetic dimension of biodiversity and its overall significance for sustainable development (DEAT, 2009).

South Africa (SA) became a signatory to the CBD in 1995. Goal four of the South African national report to the forth conference of the parties relates to expanding the human capacity to conserve biodiversity, to manage its use, and to address factors threatening it. This involves improving the understanding of biodiversity through conducting research on vegetation composition, its mapping and monitoring (DEAT, 2009).

The past 20 years have witnessed a sharp increase in biodiversity loss in South Africa (Algotsson, 2009). Vegetation is regarded as a key component of an ecosystem and is involved in the regulation of a number of biochemical cycles (carbon, water, nitrogen).

South Africa contains exceptionally high species and ecosystem diversity (DEAT, 1997). Unfortunately, much of the areas containing this high species diversity and ecosystem diversity have been transformed due to development and degradation (Rouget *et al*., 2003). However, notwithstanding its decline over time, extensive and significant biodiversity around the country still exist (Turpie *et al*., 2000). Several developments in South Africa's have resulted in long term changes to the natural vegetation and its underlying ecosystems. Population growth and urbanization in SA has increased pressure on the remaining natural ecosystems (Burger, 2008). In response to the loss of natural vegetation a number of legislations that support biodiversity conservation in SA were introduced, such as the White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity, National Environmental Management Act 107 of 1998, National Environmental Management Biodiversity Act 10 2004, National Environmental Management Protected Areas Act 57 of 2003 (DEAT, 2009). Based on such biodiversity and resource conservation legislation South Africa has expressed a clear need for the accurate inventorying, description and quantification of its remaining natural ecosystems.

Information derived from phytosociological survey's aid the Department of Environmental Affairs (DEA) to make informed and scientifically defendable decisions during the Environmental Impact Assessment process (DEAT, 2009). During this process, these studies indirectly contribute to the fulfilment of the Integrated Environmental Management (IEM) tools as per requirements of the National Environmental Management Act 107 of 1998. These IEM tools include Eco-labelling, Ecological and Environmental Footprinting, State of the Environment Reporting, Scenario Analysis, Sustainability Reporting and the Environmental Management Systems (EMS). Phytosociological studies can be used to identify ecosystems of high conservation value and those in need of management. These studies assist in the description of plant communities and the identification of their underlying other environmental drivers.

Recently there has been more interest in documenting biodiversity (Turpie *et al*., 2000). However, a lot of attention has been placed on the development of strategies to monitor biodiversity (Siebert, 2001). Before biodiversity can be monitored, an inventory of all the natural resources of the region is needed. These include plant species, plant communities, vegetation types, ecosystem, environmental strategies and management plans for the natural areas. Knowledge of the region`s plant communities forms the basis for understanding and managing its vegetation types and the environment at large. The dominant primary vegetation type in uMlalazi Nature Reserve (uMNR) is the dune coastal forest (Moll, 1972). Nevertheless, they have been increasing formation of fragmented patches of this vegetation type in the overall Maputaland due to timber plantations, mining and agriculture. Habitat fragmentation could trigger a decrease in species richness within the plant communities of the coastal forests.

The co-occurrence of plant species in a specific area is controlled and affected by environmental factors (Kent and Coker, 1996). Species tolerant to similar set of environmental factors and intolerant of another set of conditions would be restricted to certain habitats. These plant species that co-occur together in an area are called a plant community. These plant communities represent distinctive interactions of specific plant species composition and a unique set of environmental conditions, to form an ecosystem. Therefore, it is important to understand that plant communities not only indicate the plant species that occur in an area but also gives indication of the prevailing environmental factors (Bredenkamp and Brown, 2001). In order to manage and conserve any nature reserve, a profound knowledge of the ecology is a prerequisite, and to accomplish that prerequisite, an inventory of plant communities and prevailing environmental factors of the nature reserve must be undertaken (Van Staden, 2002).

The vegetation of uMlalazi Nature Reserve is diverse with at least eight vegetation types (Maputaland coastal belt (CB1), KwaZulu-Natal Coastal Belt grasslands (CB3), Riverine forests (FOa1), Subtropical Seashore Vegetation (AZd4), Subtropical Dune thicket (AZs3), swamp forests (FOa2), Mangrove forests (FOa3) and Northern Coastal forests (FOz7) described for the KwaZulu-Natal province. However, because the current study was conducted at a fine scale only six vegetation types are identified, classified and described. The Mangrove forests (FOa3), Northern Coastal forests (FOz7), Subtropical

Seashore Vegetation (AZd4), Riverine forests (FOa1), KwaZulu-Natal Coastal Belt grasslands (CB3) and Subtropical Dune thicket (AZs3). The swamp forests were described in an ealier study of Zungu (2012).

Two of these vegetation types are Northern coastal forest and subtropical dune forest. With the exception of the pioneering work of Moll (1972) on the dune communities at Pennington Park, very little detailed work has been done on the phytosociology of the uMNR vegetation types and plant communities. Moll's (1972) vegetation classification concentrated on the dune communities. Some detailed vegetation descriptions have, however, been published for Tshanini Game Reserve (Gaugris *et al*., 2004), Thembe Elephant Park (Matthews *et al*., 2001), Lake Eteza Nature Reserve (Neumann *et al*., 2010) and Sileza Nature Reserve (Matthews *et al*., 1999), but these studies focused mainly on sand forests and woody grasslands. Weisser (1978a); Weisser *et al*. (1982) and Weisser and Muller (1983) did some work on the vegetation of the area surrounding uMNR, but these studies were broad scale studies related to foredune advancement, dune vegetation changes and changes in area of grasslands. Floristic data on species diversity and detailed habitat relations are still required for uMNR and surrounding areas.

1.2 Motivation

Previously known vegetation studies in the uMNR were conducted on a relatively coarse scale aimed at providing a very general low detail description of the major vegetation types (Nevill and Nevill, 1995; Todd 1994 and Weisser 1978a and 1978b). Vegetation maps that were compiled in the past were based on dominant species and broad structural classes (Todd 1994 and Weisser 1978b). Many of the phytosociological studies done in the past have only focused on describing the vegetation of coastal sand dunes (Moll, 1972; Weisser and Marques 1979; Weisser and Muller; 1983 and Weisser, 1978b, 1982) and wetlands (Burger, 2008; Grundling *et al*. 2013; Pretorius *et al*. 2014 and Venter, 2003) but have not accounted for the complete description of plant communities in uMNR and surrounding areas. To date, no detailed plant community descriptions based on total floristic composition have been conducted for the uMNR. Ezemvelo KZN Wildlife (EKZNW) recently emphasized the need for a more comprehensive recent phytosociological study of the ecosystems within the nature reserve as a critical part of an ecosystems management and monitoring plan.

The present study has resulted in the classification, description, and mapping of vegetation of the uMlalazi Nature Reserve and the surrounding areas based on total floristic composition. The identified plant communities are assigned botanical conservation importance ratings. These ratings indicate which plant communities are worthy of receiving a high conservation status (Turpie *et al*., 2000). The botanical importance ratings of plant communities are allocated according to each community's species richness, the occurrence of rare and endangered species within it, levels of disturbance and invasion by alien species.

1.3 Aims of the study

- To identify all the broad vegetation types as well as the various plant communities occurring within uMNR.
- To map and describe the plant communities of uMNR.
- To assign botanical conservation importance ratings to all the identified plant communities of uMNR.
- To describe the correlations between the described plant communities and their underlying environmental drivers.

CHAPTER TWO

Literature review of local and regional vegetation and plant ecology studies

2.1 Introduction

Vegetation ecology includes the study of the plant cover and its relationships with the environment. Vegetation classification and mapping are some of the most widely used tools to assist in the interpretation of complex ecosystems and to simplify the spatial and temporal complexity of these ecosystems (Brown *et al*., 2013). Vegetation is regarded as the key component of an ecosystem and is involved in the regulation of a number of biochemical cycles (e.g. carbon, water, nitrogen). Unfortunately the remaining segments of natural vegetation are at risk of being exploited and reduced due to agriculture, urbanisation, invasion by alien plants, afforestation, development of transportation corridors, dams and mining, pollution of water and soil and atmosphere (Algotsson, 2009; Burger, 2008; Rouget *et al.* 2003, Turpie *et al.* 2000).

Matthews *et al*. (2001) studied the vegetation of the Tembe Elephant Park. However, their study focused mainly on the sand forests as they dominate the northern parts of Maputaland. They found that sand forests occur under drier conditions than most other forest types. They showed that in Maputaland sand forests are found on deep sand, periodically experiencing heavy dews and low-level mists especially in winter. They described eight plant communities, which four of them were sand forests. Gaugris *et al*. (2004) went on to study the vegetation of Tshanini Game Reserve and they compared it with equivalent units in the Tembe Elephant Park. Their study found that the sand forest in Tshanini Game Reserve is more dense than in Tembe Elephant Park. They also stated that the elephants may be affecting the sand forest in Tembe Elephant Park and there has already changed the plant cover significantly but not the species composition. However, in overall both Tembe Elephant Park and the Tshanini Game Reserve are underlain by the same type of soil and they share the same broad vegetation types.

Siebert *et al*. (2011) confirmed the occurrence of the Maputaland Woody Grassland vegetation unit west of Richards Bay. Their study described the vegetation structure of these grasslands as scattered patches of mixed woodland and interspersed with shallow seasonal wetlands. These dwarf woody plants (geoxylic suffritices) include *Ancyclobotrys petersiana*, *Elephantorrhiza elephantina*, *Diospyros galpinii*, *Eugenia capensis* and *Gymnosporia arenicola*. These grasslands were first observed by Matthews *et al*. (1999) in Sileza Nature Reserve. They observed that these grasslands occurred in relatively high lying, well-drained areas such as dune crests and slopes, the surface soils of which are never waterlogged. They also found that these grasslands are absent in the inter-dune depressions, which is the only area that is seasonally waterlogged.

2.2 Dune ecosystems

In this study, the phytosociology and vegetation ecology of UMlalazi Nature Reserve (uMNR) was investigated. A number of studies that have been conducted in this region have focused on the dune ecosystems. The following literature reviews attempt to demonstrate and support this. In the research article by Weisser (1978a), the changes in the area of grasslands on the dunes between Richards Bay and the Mfolozi River, from 1937 to 1974 were inspected. The study found that the majority of grasslands were secondary and they had their origin in clearing by some of the local inhabitants with the objective of obtaining wood, for shifting cultivation and for grazing for cattle. This study concluded that they have been a major change in the composition of sand dune vegetation between Richards Bay and Mfolozi River mouth in the last 34 years. In 1994, Todd went on to compare the reproductive strategies of eight key species of a prograding dune system in uMlalazi Nature Reserve (uMNR). These species included; *Scaevola plumieri, Chrysanthemoides monilifera, Passerina rigida, Stipagrostis zeyheri, Eugenia capensis, Imperata cylindrica, Mimusops cafra* and *Microsorium scolopendium.* These strategies are than adapted to the seed characteristics of the species.

The work done by Lubke and Moll (1996) was concerned with the post mining rehabilitation of coastal sand dunes. Their results demonstrated that the soil environment is destroyed in the process of dune mining and a soil profile takes a long time to recreate itself again. This study reports that there is an increase in soil nutrients within the rehabilitation sites. Van Aarde *et al*. (1998) supported these results found by Lubke and Moll in 1996 by stating that the high growth rate of *Vachellia karroo* affects the nutrients turnover in the rehabilitation stands. This is because most of the *Vachellia* species have the ability to fix free nitrogen. However, Redi *et al.* (2005) articulated that when they compared the millipede assemblages along a chronosequence of habitats developing in response to past mined coastal dune forest rehabilitation program, with those developing spontaneously in the same area. They found that the rehabilitation program mimics and also suppressers spontaneous successional development. Weisser (1978b) supported this when he found that most of the area in the study region rates as first priority for conservation and should not be mined. While the most recent work by Boyes *et al.* (2011) suggested that the initial changes in topography and landforms depend on the conditions of mining, mine paths location and the height and form of dunes being mined.

A number of coastal dune areas around the world are eroding as a result of rising sea levels. The beach at Mlalazi is propagrading rapidly and has advanced at least 120 m within the last 40 years. This has been caused by the large amounts of sand loads deposited into the sea by nearby Tugela River (van Daalen *et al.,* 1986). This sand is being transported northwards by the longshore drift associated with an inshore counter current and deposited along the beaches north of the Tugela River mouth (Weisser, 1978b). *Scaevola plumier* gradually colonise the exposed beach and dunes are formed through the accumulation of sand grains around the plants which inturn grow in the developing dune.

Van Daalen *et al*., (1986) described the dune field between the Tugela River mouth and the Mlalazi estuary as a unique site that is worthy of special conservation status. This site provides a classical example of primary succession, and a great opportunity to study the relative importance of soil development, exposure to environmental stress, changes in nutrient supply, seed immigration and biotic interactions in controlling the rate and direction of vegetation development (Weisser, 1978a and Weisser 1978b). This implication was first found by the pioneering work of Moll (1972), which articulated that the study area is the only place in Natal where there is significant active and extensive sand deposition, dune formation, dune stabilisation and colonisation.

Moll (1972), Todd (1994), Weisser *et al.* (1982) and Weisser and Muller (1983) all agreed that;

1. It takes 10 years for a dune ridge to be formed
2. It takes about 30 years for a dune to be invaded and later replaced by the *Passerina rigida* Open Dune Scrub.
3. It will take another 30 years before this scrub is replaced by Closed Dune Scrub.
4. If protection against seawards and salt spray is given by the seaward ridges and their vegetation, a dune forest could develop after about 90 years, beginning in the dune slacks and later spreading from there.

All these studies combined indicate that the coastal dunes are sensitive to development such as mining for heavy minerals. The effect of mining operations on the water table and beach erosion of dunes is a major concern. The sensitivity of these ecosystems is underlined by complex land, sea interactions and the uncertainties around the processes that influence them. Their sensitivity is most likely to increase over time due to the effects of climate change and sea level rise, as well as other driving forces such as sediment production.

It has been also apparent that the development of foredune-ridge topography always depends on a large sediment supply from the uMlalazi River over the long-term (Boyes *et al.* 2011 and Olivier, 1998). The periods of high discharge introduce a fresh source of sediment to the littoral zone. The reworking of fluvial sediment landwards in most cases results in wide beaches. The blowing onshore winds tend to transport the sand from the beaches to the foredunes (Todd, 1994; Redi *et al.,* 2005 and Maritz, 2007). Olivier (1988) even reported that *Scaevola thunbergii* encourages rapid vertical accretion and hummock dunes are formed. Lateral extensive invasion by seedlings may perhaps result in the hummock dunes joining to form coast parallel foredunes. When they are reduced sediment discharge, erosion of the shoreline results in steep narrow beaches. In spite of a negative beach budget, foredunes continue to accrete vertically. Marine erosion results in either the complete destruction of embryo foredunes or their landward shift (Olivier, 1998). One limitation to these studies is that they have focused on describing the post mined sand dunes but not describing the natural pristine vegetation of coastal sand dunes.

2.3 Wetlands

With the current loss and degradation of wetlands throughout the country it is not surprising that many researchers have increased their attention on them (Burger, 2008; Cowden *et al*., 2014; Grundling *et al*., 2013; Kotze and Malan, 2010; Pretorius *et al*., 2014; Sieben, 2011; Turpie *et al*., 2010 and Venter, 2003). All the different classes of wetlands are threatened by organic and inorganic pollutants, which may reach the wetland either directly or indirectly from point sources or diffuse sources (Cowden *et al*., 2014). Much of the recent work emphasised dominance. Pretorius *et al*. (2014) found that the wetlands in the Maputaland Coastal Plain are currently under stress as a result of drought and intensified forestation and agricultural practises. In the unprotected areas, these wetlands are currently being exploited on a large scale for their goods and services. They concluded that little has been done for the promotion of conservation and sustainable utilisation of these sensitive ecosystems.

Grundling *et al*. 2013 stated that the apparent distribution of wetlands varies in response to periods of water surplus or drought, and over the long-term has been reduced by resource (e.g. agriculture, forestry) and infrastructure (e.g. urbanisation) development. Turpie *et al*. (2010) stated that wetlands are valuable ecosystems which provide water, food and raw materials, services such as flood attenuation and water purification and intangible values such as cultural and religious value. In some areas they are even important for people's livelihoods thus they argue that wetlands are degraded beyond the socially optimal extent due to market failure (where markets do not reflect true values or costs) and government failure (perverse incentives, lack of well-defined property rights leading to open access and ignorance of decision markers as to the value of wetlands). Burger (2008) supported and further stated that many of the wetland plant communities and species composition and their distribution patterns are still relatively unexplored, more research is needed to contribute to a better understanding of these areas. This will then assist in the accurate management and conservation of these areas.

Some studies, however have taken a different approach by looking not so much on the threats and degradation of wetlands. In a typical study of this type; Sieben (2011) compiled the vegetation data for the wetlands in KwaZulu-Natal, Free State and Mpumalanga. This study reported that vegetation is the most visible aspect of wetland management. Plant growth and productivity responds relatively quickly to changes in the environment, so vegetation patterns will reflect the environment and hydrology of wetlands their management quite well. Kotze and Malan (2010) developed a wetland sustainable use system to assist in assessing the ecological sustainability of wetland use, focusing on grazing of wetlands by livestock, cultivation of wetlands and harvesting of wetland plants for crafts and thatching.

Sliva (2004) described the nature of swamp forests on the Maputaland Coastal Plain as lower-lying interdune valley bottom areas associated with drainage lines, underlain by low-permeability sediments, which receive sustained ground or surface-water inflow. This study further classified and described the types of wetlands that are found in the Maputaland. Permanent wetlands are those where groundwater seepage elevates the water table sufficiently in the valley bottoms, which results in permanently wet conditions and the promotion of peat accumulation. They usually have a relatively fixed boundary. Conversely, temporary moist/sedge grassland wetlands occur on the deep sandy soil in areas where the water table fluctuations are greater; conditions which are not ideal for the development of peat. While temporary wetlands are those whose boundaries may appear to grow or shrink in wet or dry periods, potentially causing their area to be underestimated in periods of water shortage. During very wet years, some areas including wetlands can be temporarily inundated with pools of open water for a short period. These are described as temporary open water. In contrast, some of the permanent open water areas are the Kosi Bay lake system and other smaller lakes (Grundling *et al*., 2013 and Sliva, 2004).

Marian and Ellery (2006) studied the plant community and landscape patterns of a floodplain wetland. They stated that the hydrological regime is the primary determinant of wetland ecosystem structure and function, while the geomorphological form of the channel and riparian zones within floodplain wetlands are creating the site specific conditions of depth, duration and timing of inundation. The lower Mkuze River floodplain is prograding in a west-east direction into the Mkuze Swamps as a result of sediment transport by the Mkuze River to the eastern floodplain margin during large flood events.

Next is the series of studies that have been done in a broader study area. Mucina and Rutherford (2006) described the broader study area as comprising of subtropical forest which occur as zonal vegetation, associated with a series of intra-zonal (edaphic grasslands) and azonal vegetation types. Some of the azonal forest types include the Northern Coastal Forest, Mangrove Forest, Swamp Forest, Lowveld Riverine Forest and azonal non-forest vegetation units such as Subtropical Dune Thicket, Subtropical

Freshwater Wetlands and Subtropical Coastal Vegetation. Nevill and Nevill (1995) conducted a survey of the *Culicoides* (*Doiptera ceratopogonidae*) at the uMlalazi Nature Reserve. *Culicoides* biting midges are regarded as transmitters of a number of protozoa's nematodes and viruses to man and animals. In South Africa only 115 *Culcoides* species have been recognised. A large number of these are rare and restricted in their distribution. However, in their study they found 34 *Culicoides* species in the uMNR, an area about 1000 ha. This is a large number of species in such a small area, they found that a large number of *C. leucostictus*, *C. rhizophorensis* and *C. ncavei* are as a result of presence of natural larval habitats and their main source of blood meals are birds, which are abundant in the reserve. In 2003, Venter did a vegetation survey on the plant communities of the Mfabeni peat swamp. While Marian (2001) described the vegetation ecology of the lower Mkuze river floodplain. Further north of the region, Grobler (2009) conducted a phytosociological study of the peat swamp in the Kosi bay takes system. The study found that cultivation practises modified the structure and species composition of the peat swamp forests and their recovery after gardening abandonment appeared to the related to the wetness regime and remaining peat body. Recently, Pretorius (2012) also did another quantitative survey on the five wetland systems and their respective zones on the Maputaland coastal plain.

The South African National Wetland Inventory (NWI) version 3 was incorporated in the National Freshwater Ecosystem Priority Area (NFEPA) wetland type layer but some wetland areas in South Africa are still insufficiently mapped such as those wetlands found in woodlands and savanna in lower altitude areas in KwaZulu-Natal, Limpopo and Mpumalanga provinces (Grundling *et al*., 2013). A number of wetland mapping initiatives for KwaZulu-Natal (KZN) have been created using different mapping methods and scales, including the KZN Land-Cover 2005 and 2008 and KZN Wetland layer (Scott-Shaw and Escott, 2011). Nonetheless, these datasets do not indicate whether wetland dynamics (extent and distribution) are related to seasonal and/or extreme rainfall events or whether they have well defined and relatively fixed boundaries.

Even though in the whole province there have been a high number of wetland and vegetation studies, there are still significant gaps in knowledge on phytosociology, vegetation ecology and wetland vegetation throughout the province. Maputaland which is part of the study area is very rich in wetlands and one of these wetlands is Mfabeni swamp, which has had three MSc studies conducted and a PhD on its hydrology. The other wetlands in Maputaland including the ones found in the study area have been largely ignored. The uMlalazi Nature Reserve consist of about eight vegetation types (Mangrove forests, Riverine forests, Coastal grasslands, Subtropical Seashore vegetation, Northern coastal forest, Subtropical dune forest, Swamp forest and Maputaland Coastal Belt). In the literature of the broader study area only three (swamp, dune and Maputaland Coastal Belt) have been documented in a fine scale. As a result a need for a study that will document the complete vegetation types of the reserve is important.

The primary aim of the present study was to identify and describe the plant communities of uMNR and compare them to those described by other vegetation scientists in order to establish any possible relationships between plant communities within the uMNR and those found in other areas, thereby determining whether we are dealing with unique ecosystems or merely similar communities that have affinity to other previously described ones. This will then help us to decide whether we need new unique management plans, or whether we can employ existing management techniques and plans that have proven to be successful in other similar ecosystems. Unique ecosystems and plant communities are unknown entities that require much more careful conservation measures. On the other hand, similar ecosystems may harbour populations of rare and endangered species that have not yet been discovered. This can guide our search efforts for the conservation of such new populations of rare species.

The secondary aim of the present study was to identify some correlations between the described plant communities and their underlying environmental drivers (such as soil type, water drainage, slope, aspect, distance from the sea, exposure to desiccation, etc). These correlations were inferred through an indirect gradient analysis by applying a Non metric Multidimensional Scaling (NMDS) ordination to the floristic data.

Chapter three

Study area

3.1 Location

Watkeys *et al*. (1993) and Reynierse (1988) described the Maputaland coastal plain as nearly flat and as a coastal plain that rises no higher than 150 m above sea level. It is characterised by wide, sandy beaches, scattered with rocky outcrops between a continuous barriers of vegetated dunes along the Indian Ocean.

The uMlalazi Nature Reserve (28^{o} 56’S, 31^{o} 46’E) is situated one kilometre south of the town of Mtunzini (Figure 3.1, 3.2 and 3.3), adjacent to the farms “Twinstreams” and “Fairbreeze” within the northern half of KwaZulu-Natal, South Africa (Traynor, 2008; Todd, 1994). This coastal reserve (1 469 ha) makes up part of the Maputaland-Pondoland Albany Hotspot (Conservation International Southern African Hotspots Programme, 2010). The reserve is part of the northern section of the Siyaya Coastal Park, which stretches from the mouth of the Mlalazi River to the southern boundary of the Amatikulu Nature Reserve (Mabaso, 2002). Outside the Reserve is the Raphia Palm Monument (part of the Mtunzini Conservancy) which is regarded as a specific type of swamp forest.

Figure 3.1: Map of South Africa, showing KwaZulu-Natal Province.

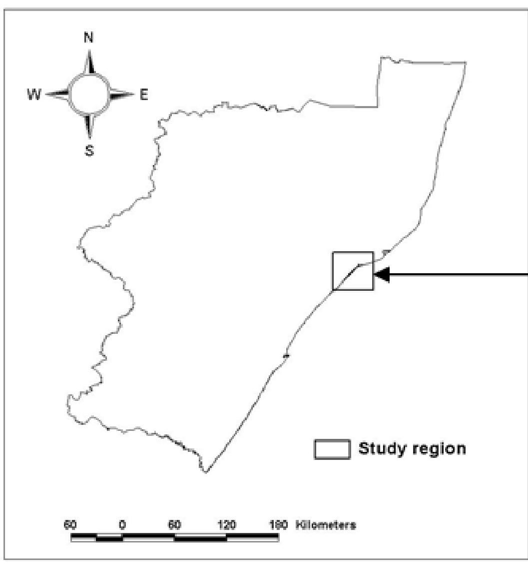


Figure 3.2 Map of KwaZulu-Natal Province showing the study area**.**

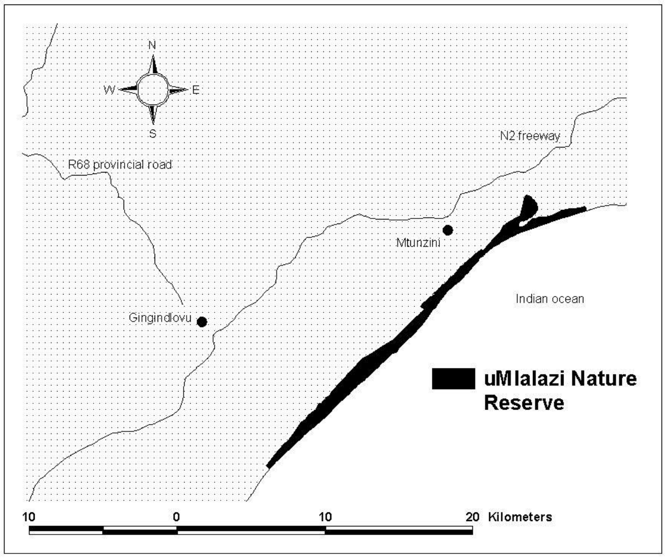


Figure 3.3: KwaZulu-Natal Province, showing the uMlalazi Nature Reserve.

3.2 Climate

In KwaZulu-Natal, rainfall decreases as one move from the coast inland (Figure 3.5). The prevailing winds are parallel to the coast; they are predominantly from the north-east and south-west. These winds are an important factor determining the coastal dune succession. The gale-force winds mainly occur from September to December, with the wind speeds greater than 50 $km.h^{-1}$. Sea Surface Temperature (SST) in the southwest Indian Ocean is of major significance for the rainfall in north-eastern KwaZulu-Natal.

Climate in the Maputaland varies from moist subtropical coastal eastern area to a moderately dry tropical inland western area. Humidity and evaporation are high. Humidity in summer usually exceeds 80% and during winter it often ranges between 50% and 60%. Evaporation exceeds precipitation for all months except January, February and December (Schulze, 1982). Evaporation rates vary from a peak in January of 190 mm per month to a minimum of 84 mm per month in June.

The overall climate in the study area is subtropical with hot, humid summers and cool winters (Todd, 1994; Nevill and Nevill, 1995). The mean maximum temperature in the uMlalazi Nature Reserve (uMNR) (Figure 3.4) for the hottest month (December) is 30 ^{0}C and the mean minimum temperature for the coldest month (July) is 11 ^{0}C. In the study area the months that have the highest maximum temperatures are (Figure 3.4) December (30 ^{0}C), January (28.9 ^{0}C) and November (28.7 ^{0}C) and those that are the coldest are July (11 ^{0}C) and June (12.6 ^{0}C).

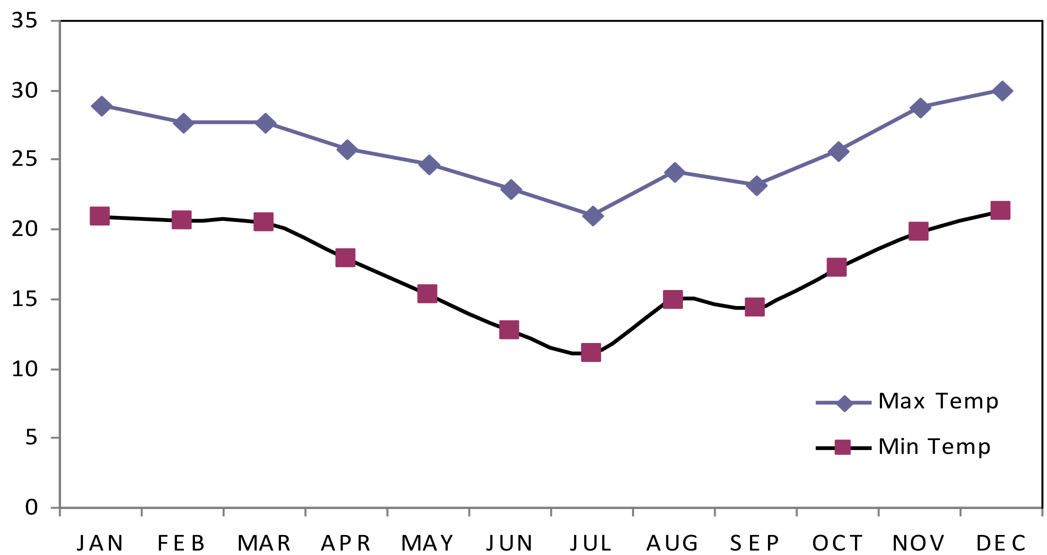


Figure 3.4: The mean maximum and minimum temperatures in the study area

The study area is located in a high rainfall area (Figure 3.5) with mean annual rainfall of 1 000 mm. The uMNR is located in the Indian Ocean Coastal Belt Biome. Rainfall in the study area is seasonal with most received in summer (November–March). However, because of the location of the study site, they are still a significant amount of rainfall which is received during the winter months as a result of trade winds and cold fronts (Tyson and Preston–White, 2000). The region is vulnerable to extreme rainfall leading to flooding due to tropical cyclones such as tropical cyclone Domonia in 1984 where 500 mm of rainfall was received in one day (Chikoore, 2005).

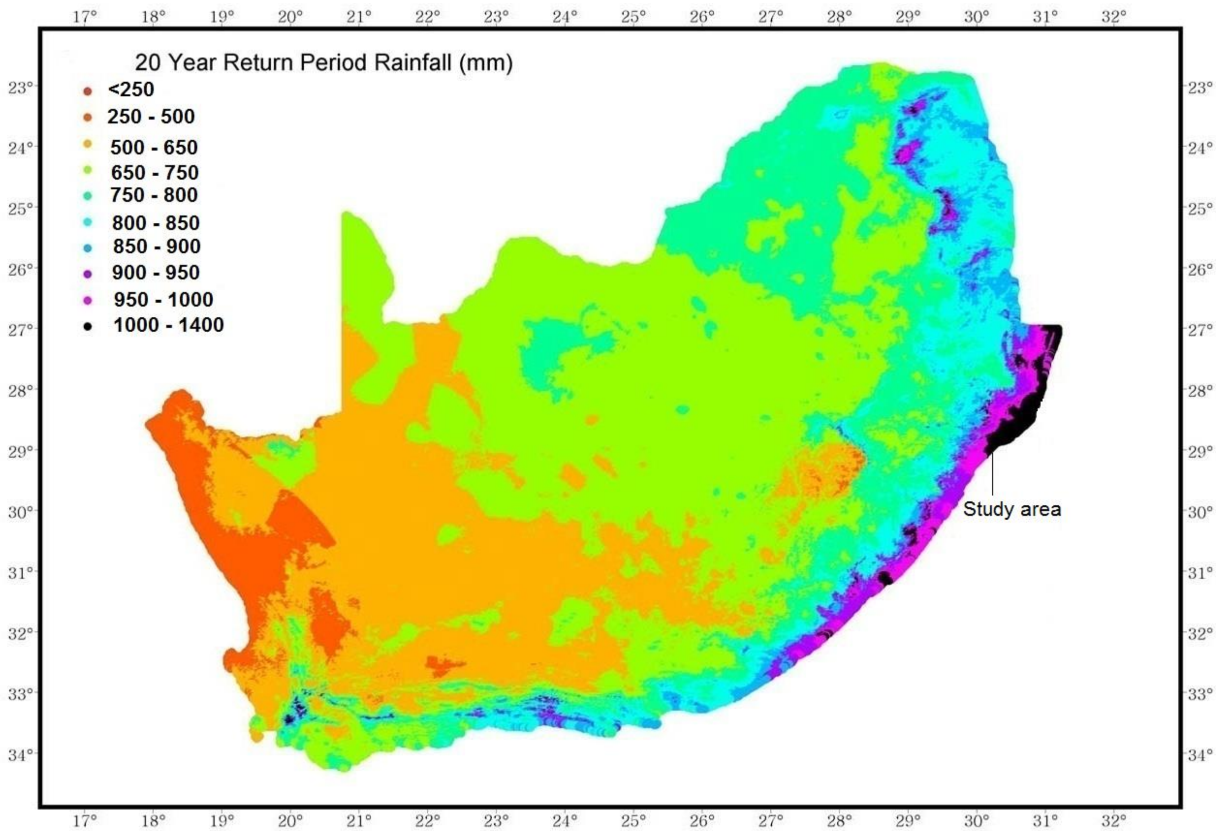


Figure 3.5: The surface rainfall (mm) in South Africa (after Smithers and Schulze, 2003)

3.3 Geology

Maputaland coastal plain is underlain by Mesozoic, Tertiary and Quaternary sequences (Table 3.1 and Figure 3.6). The development of this coastal plain was initiated by the Gondwana break-up (Watkeys *et al*., 1993). However, from then till recently it has been affected by a number of marine regressions and transgressions, which deposited, eroded and reworked a number of often fossiliferous sands, silts and clays.

The members of the Maputaland Group, deposited from the Miocene until the Holocene, comprise numerous fossiliferous beds, palaeodune deposits, and peats such as the

Middle Pleistocene Port Dunford Formation with mammalian fossils and Pleistocene pollen (Watkeys *et al*., 1993 and Neumann *et al*., 2010).

Table 3.1: The stratigraphic column for Maputaland (after Watkeys *et al*., 1993)

Era	Sub-Era	Period	Epoch	Group	Formation
Cenozoic	Quaternary	Pleistogene	Holocene	Maputaland	Redistributed sand
			Pleistocene		High dune sand
					Unconsolidated dune sand
	Tertiary	Pleistocene to Miocene	Early to Late		calcarenite
					Pecten Beds and Uloa Formation
Mesozoic		Cretaceous	Late	Zululand	St. Lucia Formation
			Early		Mzinene Formation
					Makatini Formation
					Bumbeni Complex
					Mpilo and Movene Formations
					Msunduze Formation
		Jurassic	Middle	Lebombo	Jozini Formation

During the last glacial period, which had a midpoint approximately 18 000 years ago, the sea level descended down to a minimum of approximately 120 m below modern sea level (Watkeys *et al*., 1993). Large areas of sands were then exposed on the coastal plain. Cretaceous sediments were also deposited unconformably onto this faulted, eastward-tilted, weathered igneous basement (Watkeys *et al*., 1993). Although badly exposed, their outcrop pattern forms north-south strips up to 10 km wide and have important implications for soils in the Maputaland coastal plain.

The current dune cordon was presumably built up as one of a series of dunes derived from these exposed sand deposits during a period when there were very high wind velocities (Von Maltitz *et al.,* 1996). After the stabilization of the sea-level at around present levels, parabolic blowout dune-building processes could have resulted in the growth of the coastal dunes to their current form (Von Maltitz *et al.,* 1996).

The oldest dunes of the Maputaland coastal plain date back to approximately 5 million years to the early Pleistocene. The recent dunes are as young as 10 000 years, from the late Pleistocene to 500 years ago for the current coastal dunes. These dunes of the Maputaland coastal plain are among the most recent geological formations that are found in southern Africa (Gaugris *et al*., 2004).

3.3.1 Quaternary sediments

Pleistocene sediments form a thin veneer on the Tertiary and Cretaceous rocks. The poorly exposed fossiliferous Port Durnford Formation consists of mudstone, lignite clay, sand and corals. Its age probably co-incides with the Eemian high sea levels (about 120 000 years BP) and it is largely covered by unconsolidated dune sand (Watkeys *et al*., 1993).

The geology and soils of the uMNR have been studied by various researchers in the past such as Todd (1994); Rawlins (1991) and Mabaso (2002). However, these studies had different priorities and as a result, they placed their emphasis on certain geological features. The Indian Ocean Coastal Belt Biome is considered to be geologically heterogeneous (Mucina and Rutherford, 2006). The geological history of the uMNR follows the rise and fall of the sea level. Over 50 million years ago, during the Cretaceous era (Figure 3.6), marine deposits formed the underlying Cretaceous System. The Cretaceous System consists of the consistent siltstone with irregular thin clay lenses and thin bonds of hardy limestone. It underlies the entire coastal plain of uMNR. During the Miocene Epoch the Cretaceous shore line was covered by thin Miocene deposits which are substantially permeable (Burger, 2008). The 70 000 years old Port Durnford system (Figure 3.6) (Mucina and Rutherford, 2006) was lain down more widespread than the Miocene deposits and is presently below most of the coastal barrier complex. It consists of poorly consolidated fine grain sands, silts, clays and lignite.

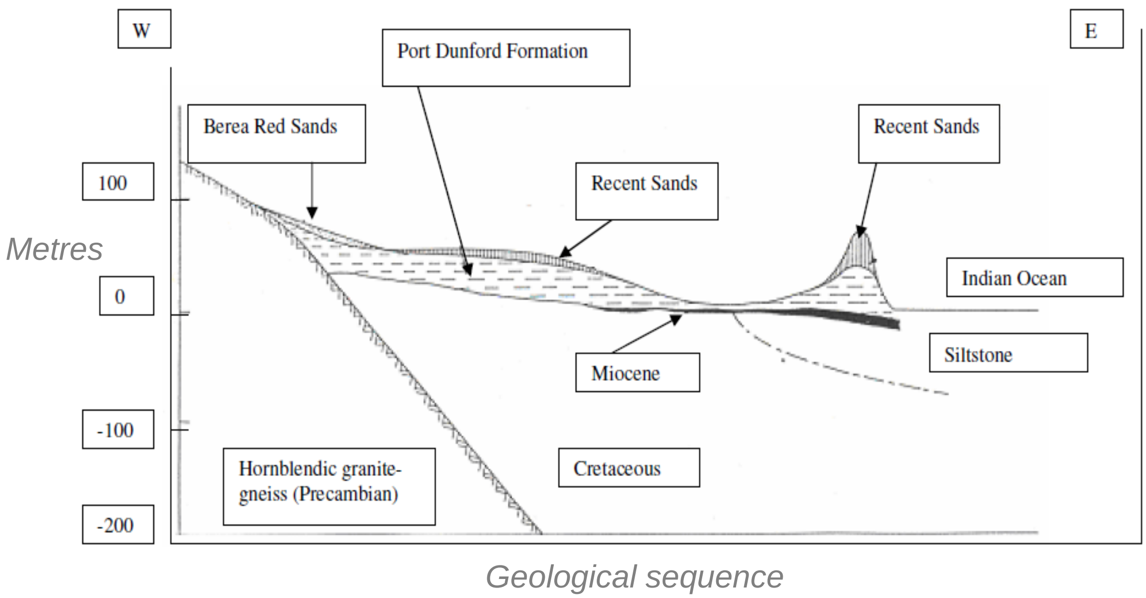


Figure 3.6: Geology of the study area (after Burger, 2008)

The Port Durnford formation has recently been covered by red, brown and grey sands which are as a result of wind action giving rise to the plateau features that distinguish the coastal plain (Burger, 2008). A number of edaphic changes occur along the successional gradient from beach into the dune forest. This has resulted in the soils of the frontal dunes to be light in colour and sandy compared to the soils of the dunes dominated by late successional stages of vegetative cover (Todd, 1994).

Recently, most of the uMNR is covered by a layer of unconsolidated fluvial and eolian sands. Sand dunes are composed of beach derived sand that is blown inland.

3.4 Soils

The soils of Maputaland are complex, with a number of generations being preserved. However, there are strong relations between these soils and the underlying geomorphology, geology, position, and hydrology. In most instances, the nature of the parent material has an overriding influence over other soil-forming factors. This is especially so for the volcanic strata and dune cordon sands (Watkeys *et al*., 1993).

The early Cretaceous sediments are characterized by soils of varying depths and mineralogical composition. Weathering and erosion have resulted in a gently undulating landform with moderate relief and drainage spacing. Soil depth and clay content increases from west to east and from upland to valley floor in Maputaland (Watkeys *et al*., 1993; Van Rensburg *et al*., 1999 and Gaugris *et al*., 2004). The late Cretaceous deposits however, have formed a uniformly deep soft mantle over a level to very gently sloping (0-2°) landform with very low relief. The calcimorphic clay to sandy clay loam soils predominate throughout this area, the fiat interfluves being characterised by brown calcimorphlc sandy clay loams (Grundling *et al*., 2013).

The most of Maputaland is covered by mainly sandy Tertiary and Quaternary deposits which give rise to infertile sandy soils. On the most westerly and oldest dunes, soils are mesotrophic and profiles are generally deep and reddish. On the younger dunes, soils are generally poorly developed yellow to orange. The coastal dunes are generally dystrophic pallid sands with high relief and steep slopes that have been stabilised by dune forest and scrub. Between the irregularly spaced dune ridges, the remainder of the coastal plain is flat to gently undulating and is covered with dystrophic loose sand. Towards the coast, high rainfall has further leached the soils and led to the development of impermeable horizons within the soil profile. This has resulted in the formation of a complex array of seepage-lines and wetlands in the lower lying areas (Watkeys *et al*., 1993 and Matthews *et al.,* 2001).

In uMNR the soils that are formed within the fine-grained dune sands are typically yellowish or grey apedal soils with incipient horizon development. These soils comprise of a thin, organic-enriched A-horizon underlain by sandy subsoil with alleviated lines forming sparse ferruginous mottles. These soils are classified according to the South African system as cover sands, Fernwood and Champagne Soil Forms (Fey, 2010). The areas with long slope lengths comprise degraded, low dunes that are characterised by sandy profiles with yellowish brown or light grey subsoil horizons. These profiles are moderately well-drained, although high water tables within low-lying interdune depressions result in bleached, grey soil profiles (Watkeys *et al*., 1993; Matthews *et al.,* 2001 and Fey, 2010). The aeolian sands of uMNR and the surrounding areas are leached and have low nutrient contents, resulting in low agricultural potential of the area.

3.5 Hydrology

The water table and ground water movements play a significant role in relation to vegetation pattern throughout the Maputaland Coastal Plain (Matthews *et al.,* 2001). Some comparisons and extrapolations were made from work done by Matthews *et al.* (2001) within the Thembe Elephant Reserve, which has soils similar to uMlalazi Nature Reserve. It is estimated that water table depths are on average approximately 35 m but depths of 60 m below surface have been recorded in some parts of Maputaland. This may be due to the fact that the Maputaland Coastal Plain is covered by deep sand.

The groundwater flow pattern in the uMNR is directed towards the sea, with a south-west to north-east dune cordon diverting streams temporarily before reaching the sea. The movement of water is strongly affected by topography (Rawlins, 1991). In the uMNR there is low permeability through the Pleistocene succession. However, the Pleistocene succession is overlain by permeable Holocene sand deposits. According to Mucina and Rutherford (2006) the water level measurements show a decrease since 1975.

The distinction between groundwater recharge and surface recharge is very unclear within the Maputaland coastal plain (Conservation International Southern African Hotspots Programme, 2010). Some of the processes that govern the bases from the total rainfall are evaporation from the unsaturated zone, evapotranspiration by the saturated zone, soil moisture storage replenishment and interception by vegetation (Burger, 2008).

The uMlalazi Nature Reserve is located at the margin of the southern Mozambique coastal plain at an altitude less than 100 m above sea level. This coastal plain is characterized by undulating surface of old dunes supporting forest and shrubland and swampy drainage courses. These dunes formed in an alternating sequence which is parallel to the present coastline by a receding Pleistocene sea (Burger, 2008).

In the Maputaland the Berea red dune sands overlay a thick layer of clay material which influences insitu water drainage (Rawlins, 1991). The wetting of the clay by water percolation and the seaward drainage which occurs through lateral piping at the point of contact between the dune sand and the clay zones creates unstable conditions along the dune front. In the uMNR the water table becomes exposed at the cirque (amphitheatre-shaped, fluvial-erosion features) floor surface (Sparrow, 1967). In South Africa there are only a few places where you will find the formation of cirque.

3.6 General vegetation of the study area

The study area falls within the Maputaland-Pondoland-Albany Biodiversity Hotspot (Figure 3.7) which is recognised as the second richest floristic region (after the Cape Floristic Region) in Africa (Conservation International Southern African Hotspots Programme, 2010). It contains approximately 80% of South Africa’s remaining forests, rich bird life and many other significant flora and fauna species (Conservation

International Southern African Hotspots Programme, 2010). Floristically, the Maputaland-Pondoland-Albany Biodiversity Hotspot is very complex, with centers of plant endemism and areas of high diversity throughout the region. Six of South Africa's nine terrestrial biomes and three of South Africa's six marine bioregions occur in the hotspot. The hotspot contains an eclectic mix of vegetation types with an unusually high level of endemism: one type of forest, three types of thicket, six types of savanna and five types of grassland are endemic to the hotspot.

The hotspot is roughly the size of New Zealand (274 000 km^2) and is located along the east coast of southern Africa, below the Great Escarpment (Conservation International Southern African Hotspots Programme, 2010). It extends from the Limpopo River in southern Mozambique and the Olifants River in Mpumalanga, South Africa in the north (see Figure 3.7), through Swaziland and the KwaZulu-Natal Province in South Africa, to the Eastern Cape Province in the south (Watkeys *et al*., 1993).

The Maputaland-Pondoland-Albany Centre of Plant Endemism also boasts a unique succulent flora and its forests have the highest species richness of any temperate forests on the planet. The region's freshwater systems are some of the most diverse in Southern Africa. In the less than 30 000 km^2 of forest vegetation cover in the hotspot; at least 598 tree species occur (Conservation International Southern African Hotspots Programme, 2010). There are more than 2 500 species of vascular plants that occur in the Maputaland centre and of these at least 230 species are endemic or near endemic to the region (Watkeys *et al*., 1993).

The biodiversity of Maputaland is extremely rich for three reasons. Firstly, because they are a large number of habitats found in the region. The high levels of endemism are spread across virtually the whole taxonomic spectrum, involving both plant and animals (Conservation International Southern African Hotspots Programme, 2010). Secondly, because of its position, the region is a tropical-subtropical transition zone. It lies within the Tongaland-Pondoland Regional Mosaic, which has a high level of endemism and forms part the Indian Ocean Coastal Belt biome. Thirdly, the biodiversity in the Maputaland is at the landscape level. The differences among the major land-types and their biota are effectively controlled by the physical and chemical characteristics of the environment. Climate plays a primary role but geology, topography and soils are also very important.

The KwaZulu-Natal coastal vegetation includes part of the Tongaland-Pondoland regional mosaic (Figure 3.7). It mainly consists of woody thicket and forest communities. Acocks (1988) classified coastal forest communities as part of the coastal subtropical forests including dune forest, coast belt forest and mangrove forest.

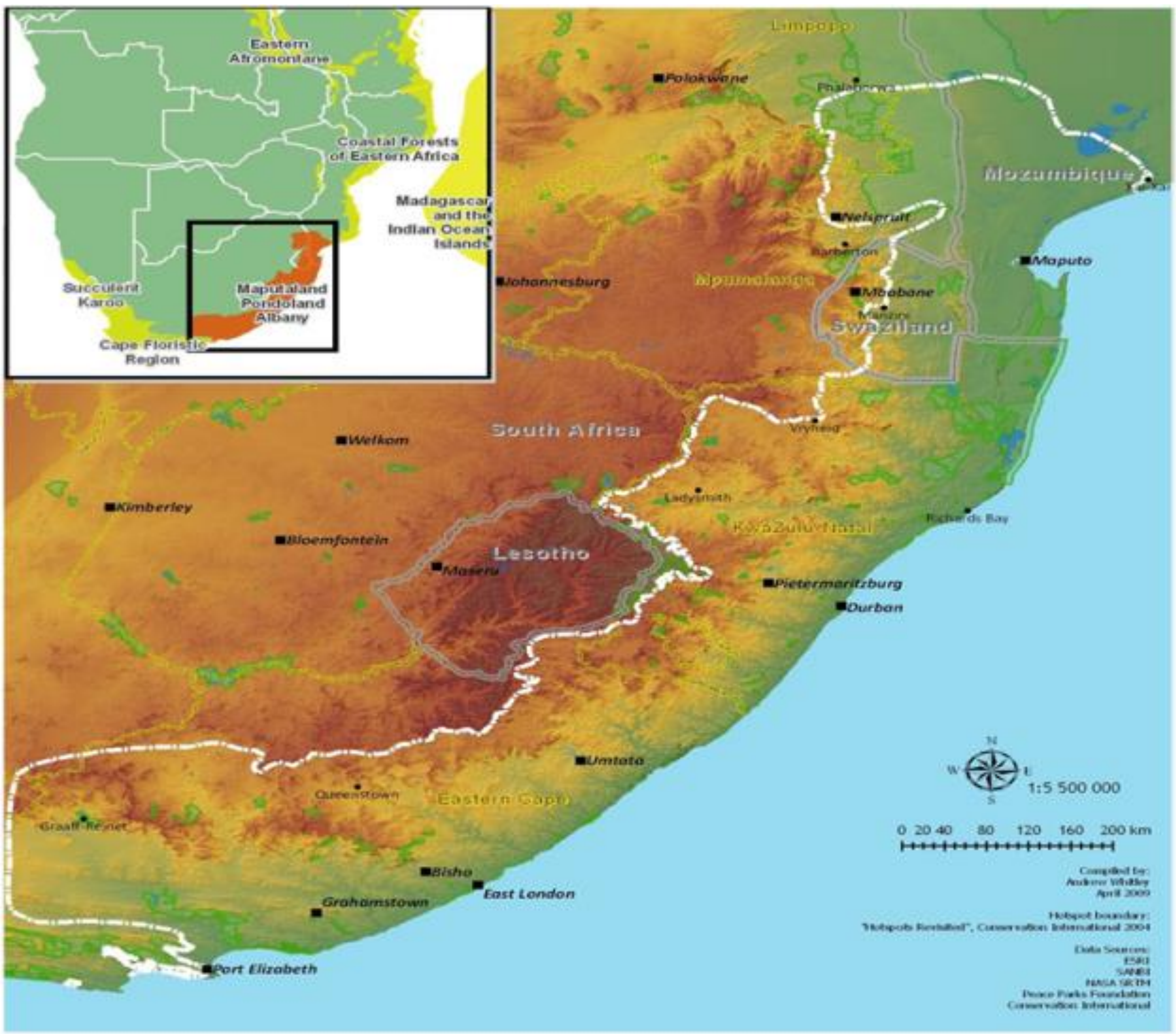


Figure 3.7: The Tongaland-Pondoland Regional Mosaic (after Conservation International Southern African Hotspots Programme, 2010)

The Maputaland centre has exceptional biogeographical interest because of the sharp biogeographical adaptation of both plant and animal taxa. The centre is located at the southern end of the tropics in Africa and many tropical organisms reach the southernmost limit of their range here. The flora and fauna of the Maputaland centre are predominantly of Paleotropical and Afrotropical derivation respectively (Smith *et al*., 2008 and Proches, 2005).

Efficient biological surveys are fundamental requirement for the effective management of biological resources. Out of more than 67 vegetation types that occur in the KwaZulu-Natal province, eight of them are represented in the uMNR. This is remarkably large number of vegetation types for a small area indicating high biodiversity in the uMNR. The vegetation types include the Maputaland coastal belt (CB1), KwaZulu-Natal Coastal Belt grasslands (CB3), Riverine forests (FOa1), Subtropical Seashore Vegetation (AZd4), Subtropical Dune thicket (AZs3), swamp forests (FOa2), Mangrove forests (FOa3) and Northern Coastal forests (FOz7).

The uMNR contain some salt marsh plant communities which are important for ensuring the high density growth of *Juncus kraussii* that is harvested by community members (see sustainable resource use). Salt marshes are found in the upper coastal intertidal zone between land and water (Adam, 1990). Their occurrence is largely depended on the relative sea levels and tidal range (Mucina and Rutherford, 2006). This plant community has been poorly described in the uMNR while it responds rapidly to changing environmental conditions.

3.7 Sustainable resource use in the uMNR

Ezemvelo KwaZulu-Natal Wildlife‘s (EKZNW) mission is to ensure effective management and sustainable use of KwaZulu-Natal’s (KZN) biodiversity, in collaboration with local communities (Traynor, 2008). The uMNR is one of the nature reserves in KZN that ensure that EKZNW mission is fulfilled. The uMNR allows for the harvesting of *Juncus kraussii* for use as fibre source in craftwork production. Within South Africa, *Juncus kraussii* forms part of the vegetation fringing estuaries. It predominantly occurs along the coastal areas and major stands exist in KwaZulu-Natal at St Lucia Estuary, Kosi Bay, uMlalazi Estuary and Umgababa Estuary (Mucina and Rutherford, 2006).

The reserve allows the surrounding communities to come and harvest *Juncus kraussii* bi-annually, depending on quantities, during the first two weeks of May. Harvesting, weaving and production of craftwork items from wetland plants are very important in the KwaZulu-Natal province. Many different types of sedge are used for weaving, including *Juncus kraussii* and *Scirpus* species are harvested in coastal wetlands and *Cyperus latifolius* harvested inland. Across many rural areas of KwaZulu-Natal, women harvest wetland sedges and weaving traditional sleeping mats (Traynor, 2008).

Harvesters in the uMNR produce a number of different items of craftwork. Such items include water tight baskets, calabash lids, foam removers for traditional beer, beer spoons, blinds and screens, lampshades, bags, washing baskets, door mats, table mats and sleeping mats for both home use and as gifts for special traditional occasions (Traynor, 2008). In Zulu culture some of the items produced become significant in social practices including, hospitality, beer production, courtship and rituals. In this ethnic group sleeping mats produced through craftwork are very important for wedding ceremonies such that the wedding can’t be done without them. Sleeping mats (amacansi) are one of the customary gifts which the bride gives to the groom’s family in a traditional Zulu marriage settlement. During the wedding the mother of the bridegroom unrolls a mat she has just received from her future daughter-in-law. These gifts are collectively known as uMabo, and incema has the highest status of all the materials used for making amacansi (Mthiyane, 2009).

Craftwork in the communities of uMlalazi is still among the most significant cultural and economic activities (Traynor, 2008). Crafting adds value as a livelihood strategy and compares favourably with income that most rural women generate in formal employment in the existing labour market (Marcus, 2001). In this region craftwork provide a tangible means by which the indigenous knowledge and culture of individuals, families and communities is kept alive and vibrant. Promotion of craft production that remains sensitive to local cultures and skills provide means for protecting the indigenous knowledge of the people of the Obanjeni area (Mthiyane, 2009).

While many jobs require formal education, the craft industry requires skill and dedication and does not require formal education and can be carried out at home. Therefore, it is usually done by young or old, the physically challenged, those carrying for the sick and even the sick themselves (Mthiyane, 2009). Ninety seven percent of harvesters in the uMNR are women and most of them are not educated. Almost all of them are unemployed and depend on craftwork as their livelihood (Traynor, 2008). As a result uMNR is very important for not only the conservation of plant communities but for ensuring a high socio-economic status for the unemployed, uneducated women of the neighbouring communities.

In this country, we are privileged to have an extremely rich cultural fabric that contributes towards the protection of wetlands. Many local communities have, over many generations, developed traditional practises and belief systems for regulating the use of wetlands. For instance, the respect afforded to some wetlands which are traditionally believed to be home to water spirits has helped ensure that these wetlands remain in good condition. These traditions and beliefs have stood the test of time for sustaining people and conserving wetlands. However as human population and tourism needs increase many of these traditions are under threat. The challenge therefore is to adapt these cultural practises to current needs and pressures, while continuing to make use of traditional knowledge and values (Mthiyane, 2009).

The harvesting of *Juncus kraussii* by local people encourages them not to destroy wetland areas. The destruction of the wetlands would destroy the very source of valuable raw materials that local crafters depend upon for their livelihood. Nevertheless, previous phytosociological studies done on this ecosystem were on a relatively coarse scale, which threatens the sustainability of this resource and the main environmental drivers for this ecosystem which are still unknown (Traynor, 2008). This study will assist us to appreciate the worth of wetlands and discover exciting opportunities for future management of these valuable systems. It will further help in ensuring sustainable use of this resource and monitoring the impact of harvesting activities on the ecosystem as a whole.

CHAPTER FOUR

Methods

4.1 Field survey methods

The following field survey methods were used:

Stratified random placement of sampling plots was determined during the desktop phase while preparing for the field work. Stratification of the study area's vegetation was done using Google Earth and a number of environmental data overlays in combination with satellite and aerial imagery. Applicable spatial environmental data overlays included landscapes, land types, terrain units, topography, altitude, geology, soil characteristics, land use, land cover, or any other relevant spatial data set. Overlaying these data sets onto available aerial and satellite imagery allowed the accurate delineation of relatively homogeneous vegetation units. Placement of sample plots within each homogeneous vegetation–*cum*–habitat unit was random. In the field, however, the randomly determined location of each sampling plot was critically evaluated according to the first rule of the Zùrich–Montpellier sampling method–placement. Therefore, the sampling plots were within a homogeneous vegetation patch representative of the perceived plant community. Where the sampling plot did not fall within such a homogeneous representative vegetation stand, it was moved to the nearest locality that does fulfil this criterion.

The plot sizes given in Table 4.1 were used as a guideline for the relevant vegetation that was sampled.

Table 4.1: Minimum area values (m^2) for various plant communities (after Brown *et al*., 2013).

Vegetation type	**Plot size (m^2)**
Lower salt marshes (e.g. *Salicornia* communities)	4,0–9,0
Open dune and sand grassland (e.g. *Scaevola* or *Arctotis* communities)	4,0–9,0
Upper salt marshes (e.g. *Juncus* communities)	9,0–25,0
Wetland vegetation (e.g. *Stipagrostis* or *Ammophyla* communities)	9,0–25,0
Dry and moist Grassland communities (e.g. *Themeda, Festuca* communities)	16,0–49,0
Coastal or Kalahari dune communities (e.g. *Stipagrostis* or *Ammophyla* communities)	16,0–49,0
Tall swamp communities (e.g. *Phragmites* or *Typha* communities)	16,0–49,0
Indian Ocean coastal belt communities (e.g. *Syzygium, Phoenix* or *Vachellia* communities)	100,0–400,0
Forest communities (e.g. *Androstachys* or *Podocarpus* communities)	400,0–1000,0

Apart from the compilation of all existing environmental data during the fieldwork preparation phase, the following environmental parameters were measured and determined in the field at each sampling plot during the actual fieldwork phase geology, surface rock cover, land type, soil depth, soil form, soil texture, altitude, GPS locality, aspect and slope (Brown *et al*., 2013).

South Africa's vegetation is highly dependent on rainfall which is in most cases seasonal and erratic in nature. Vegetation surveys were therefore conducted within the optimal growth period, ranging from October 2014 to February 2015.

Cover-abundance values for each species recorded within a sample plot were estimated using the modified Braun-Blanquet cover scale (r, +, 1, 2a, 2b, 3, 4 and 5) (Kent and Coker 1996).

4.1.1 Collection of environmental data

Environmental information that was recorded at each sample plot included landscape topography, aspect, soil profile and depth, soil texture of A-horizon, soil erosion, surface rock cover, structure, vegetation condition, water drainage and organic content as well as any other relevant information that may aid in the description and ecological interpretation of the floristic dataset.

4.1.2 Collection of vegetation data

Vegetation structure descriptions followed the broad-scale structural classification system devised by Edwards (1983). Canopy cover values were estimated for each life-form class identified (woody plants, forbs, grasses, succulents, geophytes, ferns and non-vascular plants). Woody layer descriptions included the estimates of canopy cover of five height classes (<1 m, 1–<2 m, 2–<5 m, 5–10 m, >10 m). The average height of the forbs and grass layers was also estimated.

4.2 Data Analysis

4.2.1 Ordination

Ecologists need to analyse the effects of multiple environmental factors on dozens of species simultaneously. Ordination techniques are used to describe relationships between species composition patterns and the underlying environmental gradients which influence these patterns (Anderson, 1971).

Ordination is an ecological tool that attempts to uncover the underlying structure of species compositional data that is assumed to arise as a consequence of environmental heterogeneity. The graphical output of ordination is a two dimensional arrangement of points, the coordinates of which are the sample scores computed during the ordination process (Anderson, 1971, Hill, 1979b; Marian, 2001). The arrangement of sample sites along the ordination axes is such that those samples close together correspond to samples of similar species composition and those samples far apart correspond to samples of dissimilar species composition. The ordination axes correspond to an assumed underlying environmental gradient(s) and are constructed in a way that maximises the dispersion of the sample (or species) scores (Brown *et al*., 2013).

Non-metric Multidimensional Scaling (NMDS) was used in this study to analyse the effects of environmental factors on plant communities.

4.2.2 Vegetation classification

Phytosociological data was fed into the data storage computer program TURBOVEG (Hennekens and Schaminèe 2001).
When classifying floristic data, the modified TWINSPAN (Two-Way-Indicator Species Analysis); as contained within JUICE was used. Unlike the original version by Hill (1979a) the modified TWINSPAN does not enforce a dichotomy of classification but instead, at each step, divides only the most heterogeneous cluster of the previous hierarchical level. Thus, the application of the modified TWINSPAN algorithm results in vegetation units of similar internal heterogeneity.

The choice of pseudospecies cut levels has an effect on the weight given to rare and / or dominant species during the classification process. Since the modified Braun–Blanquet scale was used, the pseudospecies cut levels were set at 0, 5, 15, 25, 50, and 75.

Further statistical analyses of the data were conducted using MS Excel.

The classification of different plant communities was based on total floristic composition, because they are recognized by their diagnostic species (character species and differential species). Character species were species that were mostly restricted to a specific plant community. They thus characterize the community by their occurrence in one community and by being absent or less frequent in other communities. Sub–communities were in many cases characterized by the presence or absence of certain species and these are referred to as differential species.

All diagnostic species identified using “objective” statistics (phi-coefficient) were also ecologically evaluated with regards to their “robustness” as reliable and predictable indicators of a given plant community. Long lived perennials were prioritised above fleeting annuals.

4.2.3 Classification and description of plant communities

Plant species names used, followed the latest comprehensive South African plant species list. If the names of certain plant taxa are outdated and inappropriate, the use of newer names for those specific taxa was clearly indicated and referenced form the relevant published taxonomic literature source.

4.2.4 Naming of plant communities

According to Brown *et al*. (2013) names are only labels to assist in the classification of plant communities and, as such, they will never be wholly adequate. It is however more important to understand what is meant by a name than to find one that is characteristic in every respect. The basic rules were followed when naming plant communities so as to avoid confusion and to enable consistency. The following protocol was therefore followed:

Plant community names were assigned following the same guidelines as presented in the International Code of Phytosociological Nomenclature similar to formal syntaxonomical classification, but specified taxon epithets were not used. According to this rule the dominant plant name or the one that dominates the structure is second. The first name is the diagnostic species or co-dominant.

Example: Community 1. *Themeda triandra*– *Vachellia karroo* community

4.2.5 Description of plant communities

A plant community is known by its dominant species, but total its floristic composition is characteristic where some species have a greater diagnostic value than other (Brown *et al*., 2013). The description of a plant community followed the standard format namely starting with the locality and habitat (e.g. geology, land type, soil, topography, rock cover, altitude, erosion). This was followed by the diagnostic species that can either be referred to in the table. The study listed the prominent (high cover and/or abundance) and conspicuous species, their cover, growth form or any other relevant information pertaining to the community that was useful in identifying and understanding the dynamics within the community.

4.2.6 Mapping of plant communities

Mapping (unprojected) of plant communities was done in Google Earth and completed in Quantum GIS. Only major vegetation types were described and mapped. Because all major swamp forest patches lay outside of the uMlalazi Nature Reserve (uMNR) (but inside the conservancy), they were not included in this study, however, it was described in detail by Zungu (2012).

4.2.7 Allocation of botanical importance ratings

The botanical importance rating of plant communities was used to rate the conservation values of each plant community based on a number of criteria. It assigned conservation values based on an objective evaluation, instead of the very subjective criteria often used in conservation assessments. Certain plant communities have little ecological value but receive high conservation efforts and some posses great ecological value but receive little conservation efforts (Turpie *et al*., 2000). The ratings were determined by the species richness, the occurrence of rare and endangered species within it, levels of disturbance and invasion by alien species infestation. The socio-economic importance for each plant community was also evaluated based on existing literature information.

CHAPTER FIVE

Results

5.1 Classification results

The results of the vegetation classification are presented in dendograms (Fig. 5.1 & 5.2). The hierarchical classification of the uMlalazi Nature Reserve vegetation data set by modified TWINSPAN algorithm revealed nine plant communities (Fig. 5.1). Based on field observations and knowledge of plant communities described in similar vegetation types elsewhere, two heterogeneous groups (the forests and mangroves) were further subjected to classification. This resulted in a total of thirteen plant communities (Fig. 5.2).

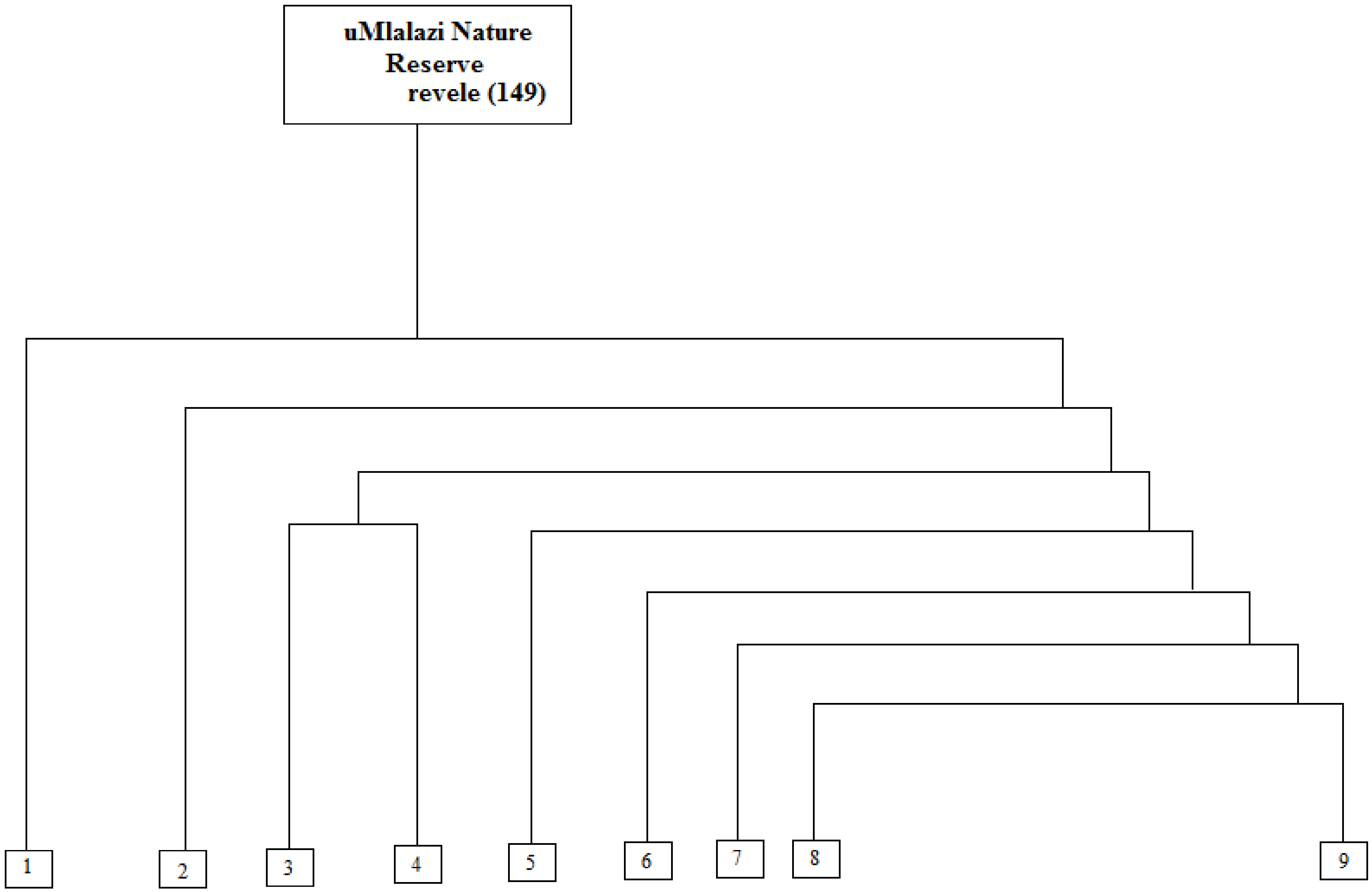


Figure 5.1: A dendogram depicting the Modified TWINSPAN division of vegetation of the uMlalazi Nature Reserve into nine plant communities.

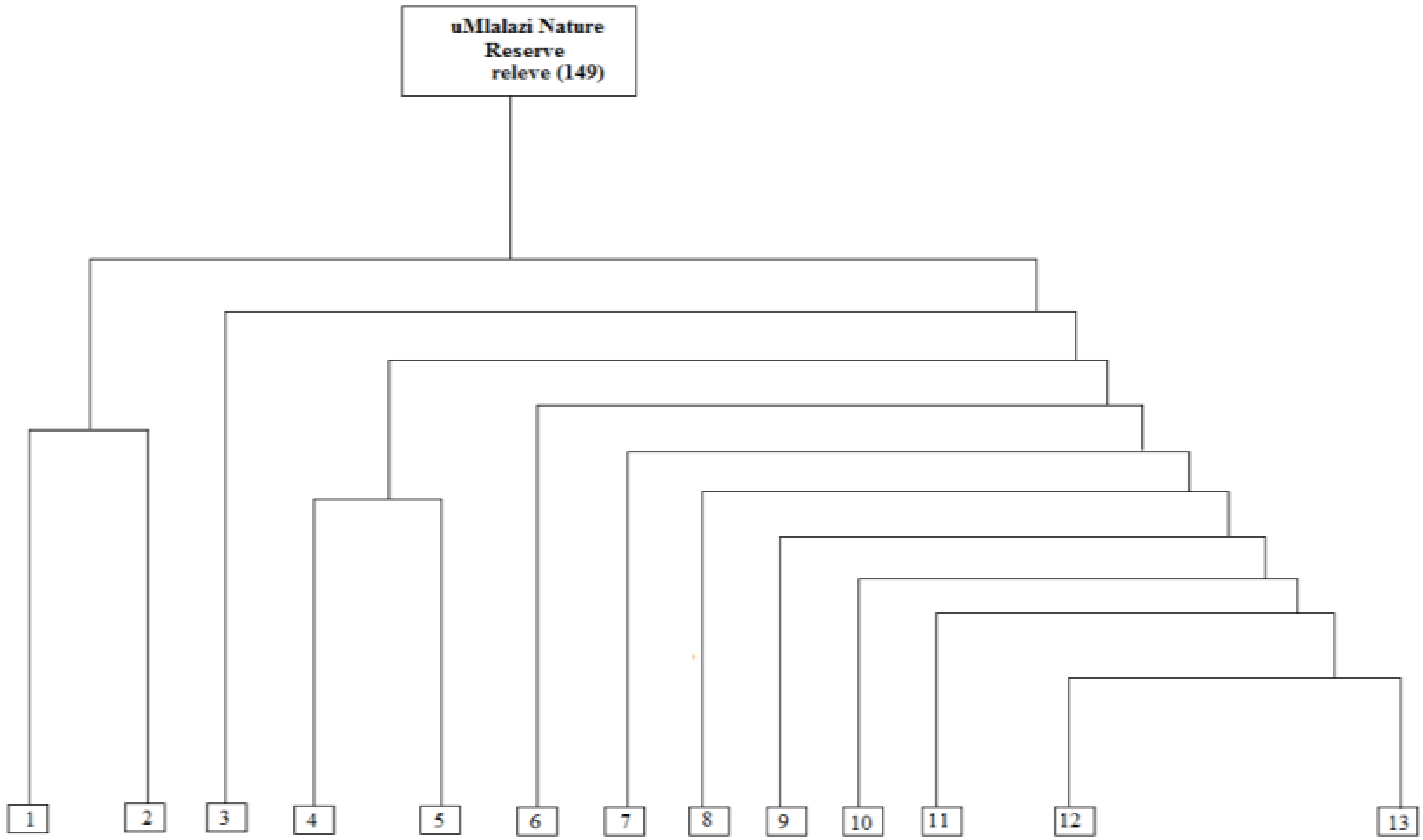


Figure 5.2: A dendogram depicting the Modified TWINSPAN division of vegetation of the uMlalazi Nature Reserve into thirteen communities.

5.1.1 TWINSPAN dendogram

The first division of the 149 sample plots resulted in the split-off of the vegetation groups 1 and 2, which are associated with the saline environment that is seasonally or permanently flooded (Table 5.1 & Fig. 5.7). The diagnostic species for this group include *Avicennia marina, Salicornia meyeriana* and *Bruguiera gymnorrhiza.* The second division liberated the *Phragmites australis–Juncus kraussii* saline wetland community (Group 3) from the other communities. The division is correlated with the high clay content in the soil within this community (community 3) compared to other communities on the right with medium to very low clay content. The third division separated those vegetation types with low organic matter in the soil from the rest. The vegetation on the low organic matter was further divided into two communities namely *Scaevola plumieri–Gazania rigens* foredune community and *Typha capensis–Cyperus dives* wetland community.

The fourth division produced the secondary coastal grasslands that are driven by human induced fire and illegal grazing. The fifth and sixth divisions resulted in the separation of the *Stenotaphrum secundatum–Phragmites australis* freshwater wetland and *Passerina rigida–Carpobrotus dimidiatus* dune scrub community (Groups 7 and 8). These communities are exposed to strong winds and salt spray from the sea, while the communities on the right experience low wind exposure. The split at the seventh division separated all the plant communities associated with deep, fine textured soils (Groups 9, 10, 11, 12 and 13). At eighth division the *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forests were isolated (Group 10). This community is associated with high disturbance that is experienced by this community (*Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest) that makes it different from the rest of the forest communities. At the ninth division, this split produces a community that is highly penetrated by sunlight on the lower strata (Group 11). Finally the 10th division separated into young and climax coastal dune forest, with deeper developed sandy-loam soils (Group 12 and 13).

Based on the modified TWINSPAN classification and the Non-metric Multidimensional Scaling ordination of the uMlalazi NR vegetation, the following plant communities were identified:

1. *Avicennia marina–Salicornia meyeriana* salt marsh community

2. *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest

3. *Phragmites australis–Juncus kraussii* saline wetland

4. *Scaevola plumieri–Gazania rigens* foredune community

5. *Typha capensis–Cyperus dives* wetland community

6. *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands

7. *Stenotaphrum secundatum–Phragmites australis* freshwater wetland.

8. *Passerina rigida–Carpobrotus dimidiatus* dune scrub community

9. *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community

10. *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest

11. *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin

12. *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest

13. *Carissa bispinosa–Mimusops caffra* climax coastal dune forest

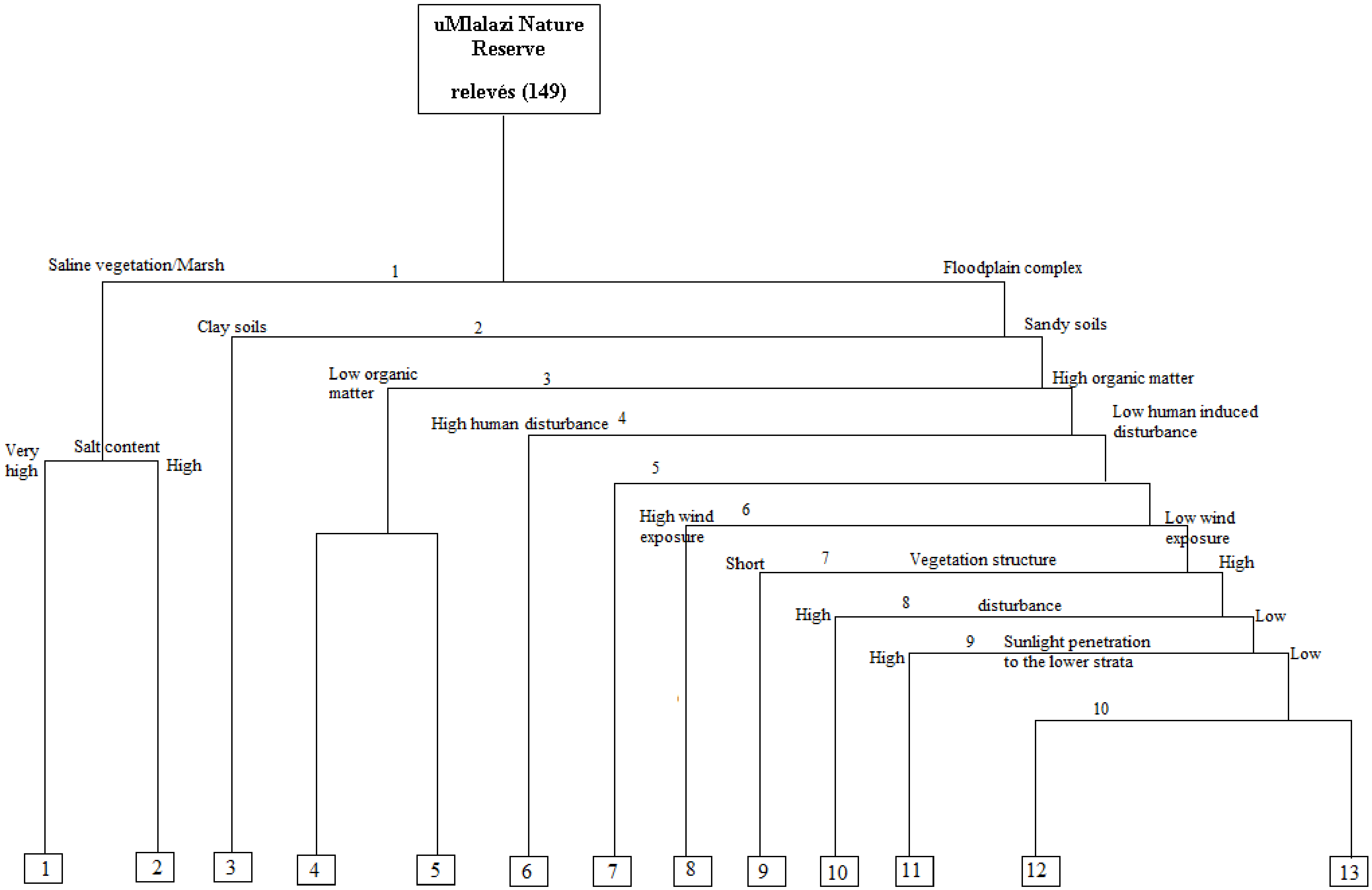


Figure 5.3: Dendogram illustrating underlying environmental determinants associated with the divisions between plant community types.

Table 5.1: Synoptic table of uMlalazi Nature Reserve, based on fidelity of species. Diagnostic species (values dark blue-shaded) are those with phi coefficient values > 0.25, ranked by decreasing value of phi. Dashes in (a) indicate species absence (b) indicate negative fidelity.

	(a) percentage frequency													(b) phi coefficient												
Vegetation unit	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of releves	8	7	23	11	5	9	11	9	9	5	6	9	37	8	7	23	11	5	9	11	9	9	5	6	9	37
Number of diagnostic species	1	2	1	3	7	25	7	16	29	20	4	4	34	1	2	1	3	7	25	7	16	29	20	4	4	34
Species Group A																										
Diagnostic species for *Avicennia marina–Salicornia meyeriana* salt marsh plant community																										
Salicornia meyeriana	100	29	13	.	.	.	.	.	.	.	.	.	.	82.6	16.4	2	---	---	---	---	---	---	---	---	---	---
Species Group B																										
Diagnostic species for *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest																										
Bruguiera gymnorrhiza	.	100	4	.	.	.	.	.	.	.	.	.	.	---	97.7	---	---	---	---	---	---	---	---	---	---	---
Avicennia marina	75	100	.	.	.	.	.	.	.	.	.	.	.	52	73.2	---	---	---	---	---	---	---	---	---	---	---
Species Group C																										
Diagnostic species for *Phragmities australis–Juncus kraussii* saline wetland																										
Juncus kraussii	25	57	100	.	.	44	.	.	.	.	.	.	.	5.8	30.2	62.8	---	---	20.6	---	---	---	---	---	---	---
Species Group D																										
Diagnostic species for *Scaevola plumieri–Gazania rigens* foredune community																										
Gazania rigens	.	.	.	82	.	.	.	.	.	.	.	.	.	---	---	---	89.8	---	---	---	---	---	---	---	---	---
Ipomoea pes-caprae	.	.	.	64	.	.	.	33	.	.	.	.	.	---	---	---	61.7	---	---	---	28.4	---	---	---	---	---
Scaevola plumieri	.	.	.	55	.	.	.	.	.	.	.	.	.	---	---	---	72.5	---	---	---	---	---	---	---	---	---
Species Group E																										
Diagnostic species for *Typha capensis–Cyperus dives* wetland community																										
Cyperus dives	.	.	4	.	100	.	.	.	.	.	.	.	.	---	---	---	---	97.7	---	---	---	---	---	---	---	---
Persicaria serrulata	.	.	.	.	80	.	.	.	.	.	.	.	.	---	---	---	---	88.7	---	---	---	---	---	---	---	---
Typha capensis	.	.	.	.	80	.	.	.	.	.	.	.	.	---	---	---	---	88.7	---	---	---	---	---	---	---	---
Phoenix reclinata	.	14	4	.	60	11	.	.	22	20	.	.	32	---	1.4	---	---	41.1	---	---	---	8.3	6.4	---	---	17.2
Cyclosorus interruptus	.	.	9	.	40	11	.	.	.	.	.	.	.	---	---	5.6	---	48.8	9	---	---	---	---	---	---	---
Cynodon species	.	.	.	.	20	.	.	.	.	.	.	.	.	---	---	---	---	43.3	---	---	---	---	---	---	---	---
Gomphocarpus fruticosus	.	.	.	.	20	.	.	.	.	.	.	.	.	---	---	---	---	43.3	---	---	---	---	---	---	---	---
Species Group F																										
Diagnostic species for *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands																										
Dactyloctenium australe	.	.	.	.	.	100	.	.	.	.	.	.	.	---	---	---	---	---	100	---	---	---	---	---	---	---
Imperata cylindrica	.	.	13	.	20	100	9	.	.	.	.	.	.	---	---	2	---	8.4	82.4	---	---	---	---	---	---	---
Sporobolus africanus	.	.	.	.	.	89	.	.	11	.	.	.	.	---	---	---	---	---	88	---	---	3.7	---	---	---	---

Stiburus alopecuroides	.	.	.	.	.	78	.	.	.	20	.	.	.	---	---	---	---	---	76.9	---	---	---	13.7	---	---	---
Commelina benghalensis	.	.	.	.	.	78	.	.	33	.	.	.	.	---	---	---	---	---	71.5	---	---	25.6	---	---	---	---
Kyllinga alata	.	.	.	.	.	67	.	.	.	.	.	.	.	---	---	---	---	---	80.5	---	---	---	---	---	---	---
Helichrysum ruderale	.	.	.	.	.	67	9	11	.	.	.	.	.	---	---	---	---	---	69.3	2.8	5.1	---	---	---	---	---
Digitaria eriantha	.	.	.	.	.	67	.	.	.	.	.	.	.	---	---	---	---	---	80.5	---	---	---	---	---	---	---
Wahlenbergia undulata	.	.	.	.	.	56	.	.	.	.	.	.	.	---	---	---	---	---	73.2	---	---	---	---	---	---	---
Manulea parviflora	.	.	.	.	.	56	.	22	.	.	.	.	.	---	---	---	---	---	60.3	---	19.8	---	---	---	---	---
Cyperus species	.	.	9	.	.	56	18	.	.	.	.	.	.	---	---	2.8	---	---	58.3	14	---	---	---	---	---	---
Hydrocotyle bonariensis	.	.	9	.	.	56	.	.	.	.	.	.	.	---	---	5	---	---	67.4	---	---	---	---	---	---	---
Rhynchosia caribaea	.	.	.	.	.	44	.	.	.	.	.	.	.	---	---	---	---	---	65.2	---	---	---	---	---	---	---
Ageratum species	.	.	.	.	.	33	.	.	.	.	.	.	.	---	---	---	---	---	56.2	---	---	---	---	---	---	---
Crotalaria globifera	.	.	.	.	.	33	.	.	.	.	.	.	.	---	---	---	---	---	56.2	---	---	---	---	---	---	---
Crotalaria natalitia	.	.	.	.	.	33	.	.	.	.	.	.	.	---	---	---	---	---	56.2	---	---	---	---	---	---	---
Verbena species	.	.	.	.	.	33	.	.	.	.	.	.	.	---	---	---	---	---	56.2	---	---	---	---	---	---	---
Eriosema psoraleoides	.	.	.	.	.	22	.	.	.	.	.	.	.	---	---	---	---	---	45.7	---	---	---	---	---	---	---
Hemarthria altissima	.	.	.	.	.	22	.	.	.	.	.	.	.	---	---	---	---	---	45.7	---	---	---	---	---	---	---
Desmodium incanum	.	.	.	.	.	22	.	.	.	.	.	.	.	---	---	---	---	---	45.7	---	---	---	---	---	---	---
Psidium guajava	.	.	.	.	.	22	.	.	.	.	.	.	.	---	---	---	---	---	45.7	---	---	---	---	---	---	---
Blumea species	.	.	.	.	.	11	.	.	.	.	.	.	.	---	---	---	---	---	32.2	---	---	---	---	---	---	---
Ficus trichopoda	.	.	.	.	.	11	.	.	.	.	.	.	.	---	---	---	---	---	32.2	---	---	---	---	---	---	---
Bulbostylis hispidula	.	.	.	.	.	11	.	.	.	.	.	.	.	---	---	---	---	---	32.2	---	---	---	---	---	---	---
Andropogon eucomus	.	.	.	.	.	11	.	.	.	.	.	.	.	---	---	---	---	---	32.2	---	---	---	---	---	---	---
Species Group G																										
Diagnostic species for *Stenotaphrum secundatum–Phragmities australis* freshwater wetland																										
Stenotaphrum secundatum	.	.	30	.	20	11	100	22	67	20	.	.	16	---	---	5.8	---	---	---	54.3	---	31.1	---	---	---	---
Ipomoea cairica	.	.	9	.	.	.	82	.	33	.	.	.	.	---	---	---	---	---	---	71.1	---	23.4	---	---	---	---
Hibiscus trionum	.	.	4	.	.	.	27	.	.	.	.	.	.	---	---	3.6	---	---	---	46.5	---	---	---	---	---	---
Cyperus eragrostis	.	.	.	.	.	.	27	.	11	.	.	.	.	---	---	---	---	---	---	41.5	---	13.9	---	---	---	---
Paspalum dilatatum	.	.	.	.	.	.	18	.	.	.	.	.	.	---	---	---	---	---	---	41.3	---	---	---	---	---	---
Cissampelos hirta	.	.	.	.	.	.	18	.	.	.	.	.	.	---	---	---	---	---	---	41.3	---	---	---	---	---	---
Species Group H																										
Prominent, dominant and common species shared among vegetation units 3 and 7																										
Phragmites australis	.	.	83	.	.	.	100	.	11	.	.	.	.	---	---	54.9	---	---	---	69	---	---	---	---	---	---
Species Group I																										
Diagnostic species for *Passerina rigida–Carpobrotus dimidiatus* dune scrub community																										
Carpobrotus dimidiatus	.	.	.	18	.	.	.	100	.	.	.	.	.	---	---	---	9.1	---	---	---	91.3	---	---	---	---	---
Passerina rigida	.	.	.	.	.	.	.	89	.	.	.	.	.	---	---	---	---	---	---	---	93.8	---	---	---	---	---
Chrysanthemoides monilifera	.	.	.	27	.	.	.	89	.	.	.	.	.	---	---	---	18.6	---	---	---	80.9	---	---	---	---	---
Stipagrostis zeyheri	.	.	.	.	.	33	.	78	11	.	.	.	.	---	---	---	---	---	23.7	---	67.6	1.7	---	---	---	---
Rhus nebulosa	.	.	.	.	.	44	.	67	22	20	17	11	.	---	---	---	---	---	25.4	---	44	6.9	5.1	2.3	---	---
Kyllinga species	.	.	.	.	.	.	.	56	.	.	.	.	19	---	---	---	---	---	---	---	61.9	---	---	---	---	16.4

Tephrosia purpurea	.	.	.	.	.	.	.	44	.	.	.	.	.	---	---	---	---	---	---	---	65.2	---	---	---	---	---
Senecio species	.	.	.	.	.	.	.	44	.	.	.	.	.	---	---	---	---	---	---	---	65.2	---	---	---	---	---
Rhynchosia nitens	.	.	.	27	.	.	.	33	.	.	.	.	.	---	---	---	31	---	---	---	39.3	---	---	---	---	---
Rhoicissus digitata	.	.	.	.	.	.	.	33	11	.	.	.	24	---	---	---	---	---	---	---	36.2	7.5	---	---	---	24.5
Mariscus species	.	.	.	.	.	.	.	22	.	.	.	.	.	---	---	---	---	---	---	---	45.7	---	---	---	---	---
Abrus precatorius	.	.	.	.	.	.	.	22	.	.	.	.	.	---	---	---	---	---	---	---	45.7	---	---	---	---	---
Helichrysum panduratum	.	.	.	.	.	.	.	11	.	.	.	.	.	---	---	---	---	---	---	---	32.2	---	---	---	---	---
Dichrostachys cinerea	.	.	.	.	.	.	.	11	.	.	.	.	.	---	---	---	---	---	---	---	32.2	---	---	---	---	---

Species Group J

Diagnostic species for *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community

Adenopodia spicata	.	.	.	.	.	.	.	.	89	.	.	.	5	---	---	---	---	---	---	---	---	90.9	---	---	---	---
Hibiscus tiliaceus	.	.	.	.	.	.	.	.	78	.	.	.	3	---	---	---	---	---	---	---	---	85.8	---	---	---	---
Canthium inerme	.	.	.	.	.	.	.	.	78	.	.	.	3	---	---	---	---	---	---	---	---	85.8	---	---	---	---
Vachellia robusta	.	.	.	.	.	.	9	.	78	.	.	.	.	---	---	---	---	---	---	2.8	---	82.2	---	---	---	---
Scutia myrtina	.	.	.	.	.	11	.	.	78	20	.	11	51	---	---	---	---	---	---	---	---	55.1	5.8	---	---	32.6
Pavetta lanceolata	.	.	.	.	.	.	.	.	67	.	.	.	5	---	---	---	---	---	---	---	---	77.1	---	---	---	---
Scadoxus puniceus	.	.	.	.	.	.	.	.	56	.	.	11	5	---	---	---	---	---	---	---	---	63.1	---	---	7	---
Rivina humilis	.	.	.	.	.	.	.	.	44	.	.	.	.	---	---	---	---	---	---	---	---	65.2	---	---	---	---
Tricalysia lanceolata	.	.	.	.	.	.	.	.	44	.	.	.	16	---	---	---	---	---	---	---	---	54.4	---	---	---	15.8
Scadoxus membranaceus	.	.	.	.	.	.	.	.	33	.	.	.	.	---	---	---	---	---	---	---	---	56.2	---	---	---	---
Tecoma capensis	.	.	.	.	.	.	.	.	33	.	.	.	.	---	---	---	---	---	---	---	---	56.2	---	---	---	---
Spermacoce natalensis	.	.	.	.	.	.	.	.	33	.	.	.	.	---	---	---	---	---	---	---	---	56.2	---	---	---	---
Tarenna pavettoides	.	.	.	.	.	.	.	.	33	.	.	.	3	---	---	---	---	---	---	---	---	53.7	---	---	---	---
Clausena anisata	.	.	.	.	.	.	.	.	33	.	.	.	3	---	---	---	---	---	---	---	---	53.7	---	---	---	---
Setaria megaphylla	.	.	.	.	.	.	.	.	22	.	.	.	.	---	---	---	---	---	---	---	---	45.7	---	---	---	---
Chenopodium ambrosioides	.	.	.	.	.	.	.	.	22	.	.	.	.	---	---	---	---	---	---	---	---	45.7	---	---	---	---
Oxalis droseroides	.	.	.	.	.	.	.	.	22	.	.	.	.	---	---	---	---	---	---	---	---	45.7	---	---	---	---
Nidorella undulata	.	.	.	.	.	.	.	.	22	.	.	.	3	---	---	---	---	---	---	---	---	42.7	---	---	---	1.7
Zanthoxylum capense	.	.	.	.	.	.	.	.	22	.	.	.	14	---	---	---	---	---	---	---	---	34.4	---	---	---	19
Canthium ciliatum	.	.	.	.	.	.	.	.	22	.	.	22	11	---	---	---	---	---	---	---	---	25.7	---	---	25.7	9.4
Olea woodiana	.	.	.	.	.	.	.	.	22	.	.	.	19	---	---	---	---	---	---	---	---	31.4	---	---	---	26
Voacanga thouarsii	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Drimiopsis maculata	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Solanum wrightii	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Denekia capensis	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Chaetachme aristata	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Cheilanthes viridis	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Oxalis latifolia	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---
Tabernaemontana ventricosa	.	.	.	.	.	.	.	.	11	.	.	.	.	---	---	---	---	---	---	---	---	32.2	---	---	---	---

Species Group K

Diagnostic species for *Albizia adianthifolia–Chromolaena odorata* disturbed coastal dune forest

Bidens pilosa	.	.	.	.	.	.	.	.	.	100	.	.	3	---	---	---	---	---	---	---	---	---	98.6	---	---	---
Trichilia emetica	.	.	.	.	.	.	.	.	.	100	.	.	3	---	---	---	---	---	---	---	---	---	98.6	---	---	---

Chromolaena odorata	.	.	.	.	.	.	.	.	22	100	.	.	.	---	---	---	---	---	---	---	---	12.7	89.6	---	---	---
Lantana camara	.	.	.	.	.	.	.	.	22	100	.	.	.	---	---	---	---	---	---	---	---	12.7	89.6	---	---	---
Ekebergia capensis	.	.	.	.	.	.	.	.	11	100	.	.	22	---	---	---	---	---	---	---	---	---	85.6	---	---	10.9
Clerodendrum glabrum	.	.	.	.	.	.	.	.	33	100	.	.	24	---	---	---	---	---	---	---	---	18.8	77.7	---	---	10.8
Albizia adianthifolia	.	.	.	.	.	.	.	.	.	80	.	.	.	---	---	---	---	---	---	---	---	---	88.7	---	---	---
Erythrina lysistemon	.	.	.	.	.	.	.	.	.	80	.	.	.	---	---	---	---	---	---	---	---	---	88.7	---	---	---
Rhynchosia totta	.	.	.	.	.	.	.	.	.	80	.	.	.	---	---	---	---	---	---	---	---	---	88.7	---	---	---
Gymnosporia senegalensis	.	.	.	.	.	.	.	.	.	80	.	11	3	---	---	---	---	---	---	---	---	---	81.2	---	4.3	---
Trimeria grandifolia	.	.	.	.	.	.	.	.	.	80	.	.	8	---	---	---	---	---	---	---	---	---	84.1	---	---	1.5
Cussonia zuluensis	.	.	.	.	.	.	.	.	.	80	.	.	8	---	---	---	---	---	---	---	---	---	84.1	---	---	1.5
Digitaria longiflora	.	.	.	.	.	.	.	.	.	80	.	.	11	---	---	---	---	---	---	---	---	---	82.7	---	---	4.3
Hibiscus fritzscheae	.	.	.	.	.	.	.	.	.	60	.	.	.	---	---	---	---	---	---	---	---	---	76.2	---	---	---
Deinbollia oblongifolia	.	.	.	.	.	.	.	.	.	60	.	.	8	---	---	---	---	---	---	---	---	---	70.9	---	---	3.7
Strychnos spinosa	.	.	.	.	.	.	.	.	.	60	.	.	8	---	---	---	---	---	---	---	---	---	70.9	---	---	3.7
Amaranthus hybridus	.	.	.	.	.	.	.	.	.	40	.	.	.	---	---	---	---	---	---	---	---	---	61.7	---	---	---
Dioscorea sylvatica	.	.	.	.	.	.	.	.	.	40	.	.	.	---	---	---	---	---	---	---	---	---	61.7	---	---	---
Kigelia africana	.	.	.	.	.	.	.	.	.	40	.	.	.	---	---	---	---	---	---	---	---	---	61.7	---	---	---
Species Group L																										
Diagnostic species for *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin																										
Rhoicissus species	.	.	.	.	.	.	.	.	.	.	100	.	5	---	---	---	---	---	---	---	---	---	---	97.2	---	---
Tricalysia sonderiana	.	.	.	.	.	.	.	.	.	.	100	.	.	---	---	---	---	---	---	---	---	---	---	100	---	---
Apodytes dimidiata	.	.	.	.	.	.	.	.	11	20	100	11	22	---	---	---	---	---	---	---	---	---	6.4	76	---	7.8
Species Group M																										
Prominent, dominant and common species shared among vegetation units 10 and 11																										
Euclea natalensis	.	.	.	.	.	.	.	.	.	100	100	33	22	---	---	---	---	---	---	---	---	---	58.4	58.4	10	1.5
Species Group N																										
Prominent, dominant and common species shared among vegetation units 8 and 11																										
Eugenia capensis	.	.	.	9	.	44	.	89	.	.	100	33	24	---	---	---	---	---	14.6	---	45.1	---	---	52.7	7	---
Species Group O																										
Diagnostic species for *Gymnosporia nemorosa–Psydrax obovata* young coastal dune forest																										
Gymnosporia nemorosa	.	.	.	.	.	.	.	.	.	.	.	78	30	---	---	---	---	---	---	---	---	---	---	---	72.9	22.5
Tricalysia capensis	.	.	.	.	.	.	.	11	.	.	.	67	32	---	---	---	---	---	---	---	2.7	---	---	---	60.3	24.8
Protorhus longifolia	.	.	.	.	.	.	.	.	.	.	.	56	11	---	---	---	---	---	---	---	---	---	---	---	66.2	7.5
Species Group P																										
Prominent, dominant and common species shared among vegetation units 8 and 12																										
Chironia baccifera	.	.	.	.	.	22	.	44	.	.	.	56	5	---	---	---	---	---	12	---	33.6	---	---	---	44.4	---
Species Group Q																										
Diagnostic species for *Carissa bispinosa–Mimusops caffra* climax coastal dune forest																										
Mimusops caffra	.	.	.	.	.	.	.	11	.	.	67	22	100	---	---	---	---	---	---	---	---	---	---	41	5.5	67.7

Carissa bispinosa	.	.	.	.	.	.	.	.	.	.	.	22	76	---	---	---	---	---	---	---	---	---	---	---	16.1	74.5
Brachylaena discolor	.	.	.	.	.	11	.	11	11	.	.	22	65	---	---	---	---	---	1.8	---	1.8	1.8	---	---	12.9	55.4
Dovyalis longispina	.	.	.	.	.	.	.	.	11	20	.	.	59	---	---	---	---	---	---	---	---	4.7	14.8	---	---	59.5
Rhoicissus rhomboidea	.	.	.	.	.	.	.	.	.	.	.	22	54	---	---	---	---	---	---	---	---	---	---	---	20.1	59.2
Putterlickia verrucosa	.	.	.	.	.	.	.	.	.	20	.	33	46	---	---	---	---	---	---	---	---	---	13.4	---	27.9	41.6
Oplismenus hirtellus	.	.	.	.	.	.	.	.	.	20	.	22	46	---	---	---	---	---	---	---	---	---	15.2	---	17.7	45
Bersama lucens	.	.	.	.	.	.	.	.	.	20	.	11	41	---	---	---	---	---	---	---	---	---	18.3	---	7.1	44.3
Dietes species	.	.	.	.	.	.	.	.	.	.	.	33	41	---	---	---	---	---	---	---	---	---	---	---	34.5	43.5
Rhoicissus tomentosa	.	.	.	.	.	.	.	.	.	.	.	11	41	---	---	---	---	---	---	---	---	---	---	---	10.5	54
Dalbergia armata	.	.	.	.	.	.	.	.	.	20	.	11	30	---	---	---	---	---	---	---	---	---	20.9	---	8.8	34.2
Psychotria capensis	.	.	.	.	.	.	.	.	.	.	.	.	22	---	---	---	---	---	---	---	---	---	---	---	---	45.1
Monanthotaxis caffra	.	.	.	.	.	.	.	.	11	.	.	.	22	---	---	---	---	---	---	---	---	15.8	---	---	---	35.2
Ansellia africana	.	.	.	.	.	.	.	.	.	.	.	.	19	---	---	---	---	---	---	---	---	---	---	---	---	42.1
Cussonia spicata	.	.	.	.	.	.	.	.	.	.	.	.	19	---	---	---	---	---	---	---	---	---	---	---	---	42.1
Dracaena aletriformis	.	.	.	.	.	.	.	.	.	.	.	22	16	---	---	---	---	---	---	---	---	---	---	---	32.8	22.6
Catunaregam species	.	.	.	.	.	.	.	.	.	.	.	11	16	---	---	---	---	---	---	---	---	---	---	---	18.1	28.4
Dalbergia obovata	.	.	.	.	.	.	.	.	.	.	.	.	16	---	---	---	---	---	---	---	---	---	---	---	---	38.9
Vepris lanceolata	.	.	.	.	.	.	.	.	11	.	.	.	14	---	---	---	---	---	---	---	---	19.5	---	---	---	24.6
Maytenus acuminata	.	.	.	.	.	.	.	.	.	.	.	.	14	---	---	---	---	---	---	---	---	---	---	---	---	35.5
Rhoicissus sessilifolia	.	.	.	.	.	.	.	.	.	.	.	11	14	---	---	---	---	---	---	---	---	---	---	---	19.5	24.6
Rhoicissus revoilii	.	.	.	.	.	.	.	.	.	.	.	.	14	---	---	---	---	---	---	---	---	---	---	---	---	35.5
Ficus lutea	.	.	.	.	.	.	.	.	.	.	.	.	11	---	---	---	---	---	---	---	---	---	---	---	---	31.7
Acokanthera oblongifolia	.	.	.	.	.	.	.	.	.	.	.	.	11	---	---	---	---	---	---	---	---	---	---	---	---	31.7
Ficus burtt-davyi	.	.	.	.	.	.	.	.	.	.	.	.	8	---	---	---	---	---	---	---	---	---	---	---	---	27.4
Cissampelos torulosa	.	.	.	.	.	.	.	.	.	.	.	.	8	---	---	---	---	---	---	---	---	---	---	---	---	27.4
Washingtonia robusta	.	.	.	.	.	.	.	.	.	.	.	.	8	---	---	---	---	---	---	---	---	---	---	---	---	27.4
Kiggelaria africana	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4
Mimusops obovata	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4
Polystachya sandersonii	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4
Cyrtorchis praetermiss	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4
Harpephyllum caffrum	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4
Teclea natalensis	.	.	.	.	.	.	.	.	.	.	.	.	5	---	---	---	---	---	---	---	---	---	---	---	---	22.4

Species Group R

Prominent, dominant and common species shared among vegetation units 11, 12 and 13

Kraussia floribunda	.	.	.	.	.	.	.	.	22	.	83	78	54	---	---	---	---	---	---	---	---	3	---	48.6	44.5	26.7
Psydrax obovata	.	.	.	.	.	.	.	.	.	.	83	100	49	---	---	---	---	---	---	---	---	---	---	49.4	61.9	23.2

Species Group S

Prominent, dominant and common species shared among vegetation units 11 and 13

Microsorum scolopendrium	.	.	.	.	.	.	.	33	.	.	67	.	38	---	---	---	---	---	---	---	21.3	---	---	52.6	---	25.5

Species Group T

Prominent, dominant and common species shared among vegetation units 12 and 13

Garcinia gerrardii	.	.	.	.	.	.	.	.	.	.	.	44	3	---	---	---	---	---	---	---	---	---	---	---	63	---

Smilax anceps	.	.	.	.	.	.	.	.	.	.	.	44	3	---	---	---	---	---	---	---	---	---	---	---	63	---
Maytenus peduncularis	.	.	.	.	.	.	.	.	.	.	.	11	11	---	---	---	---	---	---	---	---	---	---	---	21.1	20.5
Rhoicissus tridentata	.	.	.	.	.	.	.	.	.	.	.	22	5	---	---	---	---	---	---	---	---	---	---	---	40.2	6.6
Cyrtorchis arcuata	.	.	.	.	.	.	.	.	.	.	.	22	5	---	---	---	---	---	---	---	---	---	---	---	40.2	6.6
Teclea gerrardii	.	.	.	.	.	.	.	.	.	.	.	33	8	---	---	---	---	---	---	---	---	---	---	---	49.5	8.1
Ochna serrulata	.	.	.	.	.	.	.	.	.	.	.	33	14	---	---	---	---	---	---	---	---	---	---	---	46	15.3
Millettia grandis	.	.	.	.	.	.	.	.	.	.	.	33	30	---	---	---	---	---	---	---	---	---	---	---	38.3	33.4
Peddiea africana	.	.	.	.	.	.	.	.	.	.	.	33	57	---	---	---	---	---	---	---	---	---	---	---	30	56.6
Panicum coloratum	.	.	.	.	.	.	.	.	11	.	.	44	57	---	---	---	---	---	---	---	---	2.5	---	---	36.8	49.4
Sideroxylon inerme	.	.	.	.	.	.	.	.	22	20	17	44	68	---	---	---	---	---	---	---	---	7.8	5.9	3	26.7	46.5

Table 5.2: The full phytosociological table representing all plant communities of the uMlalazi Nature Reserve. Diagnostic species Group arrangements are based on the fidelity values of species as presented in the synoptic table (Table 4.3)

Plant community number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Original releve number in data base		1 1 1 1 1 1 1 1	1		1 1	1 1 1 1				1	1	1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	2 2 2 2 2 2 2 2	4 4 4 4 4 4 4 4	3 3 3 3 3 3 3 3 3 6 5 5 4 4 4 4 4 4 2 4 4 4	1 1	7 6 5 7 5	3 3 3 3 7 5 6 6 4	6 6 7 5 5 5 5 6 6 7 7	1 1 1 1 2 1 1 1 1	8 8 8 8 8 8 8 8 8	4 7 6 7 5	4 8 9 9 7 6	5 3 2 5 3 7 1 3 2	0 2 1 9 1 2 2 1 0 2 3 2 2 2 1 9 0 0 9 9 0 0 1 1 3 9 2 9 0 1 0 1 9 9 1 0 0
	3 4 1 6 7 8 2 5	8 7 4 3 2 5 6 1	4 7 0 1 6 7 5 3 2 4 7 6 9 8 7 3 5 4 9 1 0 6	1 2 4 6 7 0 1 9 3 8 5	7 7 1 6 0	5 6 8 9 5 8 0 9 2	1 5 2 0 2 5 3 6 3 1 3	4 2 9 7 0 6 3 8 5	0 7 5 1 2 3 4 8 6	0 0 2 9 1	9 9 3 0 4 8	4 4 9 9 3 8 8 0 6	9 3 0 9 5 7 4 7 0 1 2 5 0 8 9 6 8 3 4 7 2 5 2 4 1 8 2 5 1 6 4 1 1 2 3 6 7
Species Group A													
Diagnostic species for *Avicennia marina–Salicornia meyeriana* salt marsh plant community													
Salicornia meyeriana	3 4 4 4 5 5 5 4	+ + ...	. . r . . 1 1	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Species Group B													
Diagnostic species for *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest													
Bruguiera gymnorrhiza	. . . .	1 b 3 4 4 b 3 .	. . . . . r	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Avicennia marina	+ r + 1 r . . +	3 4 b b 5 3 4 .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Species Group C													
Diagnostic species for *Phragmities australis–Juncus kraussii* saline wetland													
Juncus kraussii	. + ... 1 .	r . + . . + r 3	5 + 5 5 4 4 3 5 4 + + + a 5 5 3 5 5 5 b 5 5	. . . .	. . . . .	a a + ... +	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Species Group D													
Diagnostic species for *Scaevola plumieri–Gazania rigens* foredune community													
Gazania rigens	. . . .	. . . .	. . . .	1 1 . . a a b a 1 1 1	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Scaevola plumieri	. . . .	. . . .	. . . .	a a 3 4 . a 3	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Ipomoea pes-caprae	. . . .	. . . .	. . . .	1 + . . a . 1 1 b a .	. . . . .	. . . .	. . . .	. + . . . 1 1 . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Species Group E													
Diagnostic species for *Typha capensis–Cyperus dives* wetland community													
Cyperus dives	. . . .	. . . .	. . . . + ...	. . . .	1 a a b a	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Persicaria serrulata	. . . .	. . . .	. . . .	. . . .	3 1 3 1 .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Typha capensis	. . . .	. . . .	. . . .	. . . .	3 5 5 4 .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Cyclosorus interruptus	. . . .	. . . . a	. b	. . . .	b . . a .	. . . + ...	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Phoenix reclinata	. . . .	. . . 1	. 1	. . . .	. . 1 + 1	. . . + ...	. . . .	. . . .	. 1 . . 1	1	. . . . . .	. . . .	. . . . . + . 3 a . . . . + + . 1 . . 1 . 1 . . . . a 1 . . . 1 1 .
Cynodon species	. . . .	. . . .	. . . .	. . . .	 4	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .
Gomphocarpus fruticosus	. . . .	. . . .	. . . .	. . . .	. . r . .	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . . . .	. . . .	. . . .

Species Group F													
Diagnostic species for *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands													
Dactyloctenium australe	....	....	....	....	.....	bb3b1abb1	....	....	....	.....	......	....	....
Sporobolus africanus	....	....	....	....	.....	+a111.11a	....	....	....+....	.....	......	....	....
Imperata cylindrica	....	3	.1.............+......	....	1	3abbb3aab	.......1...	....	....	.....	......	....	....
Kyllinga alata	....	....	....	....	.....	+++..+.1+	....	....	....	.....	......	....	....
Digitaria eriantha	....	....	....	....	.....	a.1..11++	....	....	....	.....	......	....	....
Stiburus alopecuroides	....	....	....	....	.....	1+1..11++	....	....	....	+....	......	....	....
Wahlenbergia undulata	....	....	....	....	.....	+.+..++.+	....	....	....	.....	......	....	....
Commelina benghalensis	....	....	....	....	.....	+++++..+1	....	....	.+....++.	.....	......	....	....
Hydrocotyle bonariensis	....	.......+	.+....................	....	.....	++.+++...	....	....	....	.....	......	....	....
Helichrysum ruderale	....	....	....	....	.....	a1+..+++.	......+....	.+.......	....	.....	......	....	....
Rhynchosia caribaea	....	....	....	....	.....	..+...+1+	....	....	....	.....	......	....	....
Manulea parviflora	....	....	....	....	.....	+.+...+11	....	+.....1..	....	.....	......	....	....
Cyperus species	....	....	.........1.....1......	....	.....	.++1+..+.	.+.......+.	....	....	.....	......	....	....
Ageratum species	....	....	....	....	.....	1++......	....	....	....	.....	......	....	....
Crotalaria globifera	....	....	....	....	.....	..+..++..	....	....	....	.....	......	....	....
Crotalaria natalitia	....	....	....	....	.....	..+..++..	....	....	....	.....	......	....	....
Verbena species	....	....	....	....	.....	++.+.....	....	....	....	.....	......	....	....
Eriosema psoraleoides	....	....	....	....	.....	a....1...	....	....	....	.....	......	....	....
Hemarthria altissima	....	....	....	....	.....	...++....	....	....	....	.....	......	....	....
Desmodium incanum	....	....	....	....	.....	++.......	....	....	....	.....	......	....	....
Psidium guajava	....	....	....	....	.....	rr.......	....	....	....	.....	......	....	....
Blumea species	....	....	....	....	.....	.+.......	....	....	....	.....	......	....	....
Ficus trichopoda	....	....	....	....	.....	...r.....	....	....	....	.....	......	....	....
Bulbostylis hispidula	....	....	....	....	.....	..+......	....	....	....	.....	......	....	....
Andropogon eucomus	....	....	....	....	.....	...+.....	....	....	....	.....	......	....	....
Species Group G													
Diagnostic species for *Stenotaphrum secundatum–Phragmities australis* freshwater wetland													
Ipomoea cairica	....	....	.........1+...........	....	.....	....	++++++.1.++	....	...+++...	.....	......	....	....
Stenotaphrum secundatum	....	.......a	.1..1+...a.a1.........	....	1	.1.......	1a3aa33aba3	...11....	.3.a.aa3a	+....	......	....	.....a.b...1...1.1.........1.........
Hibiscus trionum	....	....	.........1............	....	.....	....	.+.....1.+.	....	....	.....	......	....	....
Paspalum dilatatum	....	....	....	....	.....	....	....+..+...	....	....	.....	......	....	....
Cissampelos hirta	....	....	....	....	.....	....	..++.......	....	....	.....	......	....	....
Cyperus eragrostis	....	....	....	....	.....	....	.+.....1.+.	....	.....+...	.....	......	....	....
Species Group H													
Prominent, dominant and common species shared among vegetation units 3 and 7													
Phragmites australis	....	....	+4++b..++354311b.r+ar+	....	.....	....	445545534b5	....	.......+.	.....	......	....	....
Species Group I													
Diagnostic species for *Passerina rigida–Carpobrotus dimidiatus* dune scrub community													
Passerina rigida	....	....	....	....	.....	....	....	133.ab4ab	....	.....	......	....	....
Carpobrotus dimidiatus	....	....	....	+.........+	.....	....	....	a11aa1111	....	.....	......	....	....
Chrysanthemoides monilifera	....	....	....	r....1...1.	.....	....	....	+aa1a.111	....	.....	......	....	....
Stipagrostis zeyheri	....	....	....	....	.....	..+.1..+.	....	aa+.1111.	....+....	.....	......	....	....
Tephrosia purpurea	....	....	....	....	.....	....	....	11.+..+..	....	.....	......	....	....
Senecio species	....	....	....	....	.....	....	....	.+.1..1.1	....	.....	......	....	....
Kyllinga species	....	....	....	....	.....	....	....	+r1..1.1.	....	.....	......	....	+...++.1......+.1............1.......
Rhus nebulosa	....	....	....	....	.....	+r+...r..	....	.a+a..aa1	.r+......	a....	1.....	.......+.	....
Mariscus species	....	....	....	....	.....	....	....	+..+.....	....	.....	......	....	....
Abrus precatorius	....	....	....	....	.....	....	....	+.......1	....	.....	......	....	....
Rhynchosia nitens	....	....	....	+.....1..+.	.....	....	....	....1..11	....	.....	......	....	....
Rhoicissus digitata	....	....	....	....	.....	....	....	.r.+..1..	.+.......	.....	......	....	1.a.1...........1.....a..a.11..a.....
Helichrysum panduratum	....	....	....	....	.....	....	....	.+.......	....	.....	......	....	....
Dichrostachys cinerea	....	....	....	....	.....	....	....	.r.......	....	.....	......	....	....

Species Group J

Diagnostic species for *Hibiscus tiliaceus–Acacia robusta* riverine woodland community

Adenopodia spicata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. a a a 1 1 1 1 1	. . . . .	. . . . . .	. . . .	. . . . . a . . . . a . . . .
Hibiscus tiliaceus	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. a . b a 3 b b a	. . . . .	. . . . . .	. . . .	. . . . 5 . . . .
Canthium inerme	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	1 + b . 1 . 1 1 1	. . . . .	. . . . . .	. . . .	. . . . 1 . . . .
Acacia robusta	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . . 1 .	. . . .	a 3 . 3 3 b . 4 b	. . . . .	. . . . . .	. . . .	. . . .
Pavetta lanceolata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	1 a a . . 1 . a a	. . . . .	. . . . . .	. . . .	. . . . a . . . . 1 . . . .
Scadoxus puniceus	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ + . . + + . + .	. . . . .	. . . . . .	. . + ...	. 1 . . . . 1 . . . .
Rivina humilis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ + . + 1	. . . . .	. . . . . .	. . . .	. . . .
Scutia myrtina	. . . .	. . . .	. . . .	. . . .	. . . . .	. r	. . . .	. . . .	1 a a . . a a b a	a	. . . . . .	. . . . 1 .	a 1 . + 1 1 1 . . . a . . . 1 . 1 a . . . 1 a a . 1 1 . b a a . . . . 1 .
Tricalysia lanceolata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ + . 1 . . . 1 .	. . . . .	. . . . . .	. . . .	. a a + ... 1 . . . . . 1 . . . a . . . .
Scadoxus membranaceus	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . + + . . 1 .	. . . . .	. . . . . .	. . . .	. . . .
Tecoma capensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ + . . + ...	. . . . .	. . . . . .	. . . .	. . . .
Spermacoce natalensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ 1 . . . + . . .	. . . . .	. . . . . .	. . . .	. . . .
Tarenna pavettoides	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	1 . . . 1 + . . .	. . . . .	. . . . . .	. . . .	. . . . 1 . . . .
Clausena anisata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	1 . + 1	. . . . .	. . . . . .	. . . .	. . . . 1 . . . .
Setaria megaphylla	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. 1 + ...	. . . . .	. . . . . .	. . . .	. . . .
Chenopodium ambrosioides	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. + . . . + . . .	. . . . .	. . . . . .	. . . .	. . . .
Oxalis droseroides	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. + + ...	. . . . .	. . . . . .	. . . .	. . . .
Nidorella undulata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ . . . . +	. . . . .	. . . . . .	. . . .	. . . . + ...
Zanthoxylum capense	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. + + ...	. . . . .	. . . . . .	. . . .	. . . . 1 . 1 . . . . 1 . . . . 1 1 . . .
Canthium ciliatum	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . . . 1 1 . .	. . . . .	. . . . . .	1 . . 1	. . 1 . 1 . 1 . . . . 1 . . . .
Olea woodiana	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	a 1	. . . . .	. . . . . .	. . . .	1 . . . . a . . 1 1 . a 1 . . . . a . . . . .
Voacanga thouarsii	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+	. . . . .	. . . . . .	. . . .	. . . .
Drimiopsis maculata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. + ...	. . . . .	. . . . . .	. . . .	. . . .
Solanum wrightii	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+	. . . . .	. . . . . .	. . . .	. . . .
Denekia capensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . + ...	. . . . .	. . . . . .	. . . .	. . . .
Chaetachme aristata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+	. . . . .	. . . . . .	. . . .	. . . .
Cheilanthes viridis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+	. . . . .	. . . . . .	. . . .	. . . .
Oxalis latifolia	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . + ...	. . . . .	. . . . . .	. . . .	. . . .
Tabernaemontana ventricosa	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . + ...	. . . . .	. . . . . .	. . . .	. . . .

Species Group K

Diagnostic species for *Albizia adianthifolia–Chromolaena odorata* disturbed coastal dune forest

Bidens pilosa	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ a + 1 +	. . . . . .	. . . .	. . . . + . .
Trichilia emetica	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ 1 1 + 1	. . . . . .	. . . .	. . . . 1 . . . .
Chromolaena odorata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ . + ...	+ 1 1 1 1	. . . . . .	. . . .	. . . .
Lantana camara	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	+ . . + ...	b 1 + 1 +	. . . . . .	. . . .	. . . .
Albizia adianthifolia	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	1 . a 1 a	. . . . . .	. . . .	. . . .
Erythrina lysistemon	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ 1 + . 1	. . . . . .	. . . .	. . . .
Rhynchosia totta	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ 1 . 1 1	. . . . . .	. . . .	. . . .
Ekebergia capensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . + ...	1 a a b a	. . . . . .	. . . .	. . . . + ... 1 1 . . 1 . . . . a . . . . 1 b . . 1 . .
Maytenus senegalensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ . 1 1 1	. . . . . .	. . . . +	. . . . + ...
Trimeria grandifolia	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ a . 1 +	. . . . . .	. . . .	. . . . 1 . . . 1 . . . . + ...
Cussonia zuluensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ . a 1 1	. . . . . .	. . . .	. . . . 1 . . . . . . + ... 1 . . . . . .
Digitaria longiflora	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	+ 1 a . 1	. . . . . .	. . . .	. . . . . . + ... r . . . . + ... 1 . .
Clerodendrum glabrum	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	a + ... 1 .	a a a 1 1	. . . . . .	. . . .	. . . 1 . . . . 1 . a . 1 . 1 a 1 . . . . a . +
Hibiscus fritzscheae	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. 1 + . 1	. . . . . .	. . . .	. . . .
Deinbollia oblongifolia	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	1 1 . a .	. . . . . .	. . . .	. . . . + + . . + ...
Strychnos spinosa	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	1 + . + .	. . . . . .	. . . .	. . . . + . . . 1 . + ...
Amaranthus hybridus	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. 1 . 1 .	. . . . . .	. . . .	. . . .
Dioscorea sylvatica	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . b 1 .	. . . . . .	. . . .	. . . .
Kigelia africana	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . 1 1	. . . . . .	. . . .	. . . .

Species Group L

Diagnostic species for *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin

Rhoicissus species	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	r 1 + 1 + 1	. . . .	1 1 . . . .
Tricalysia sonderiana	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	a a a 1 1 a	. . . .	. . . .
Apodytes dimidiata	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	3	a	a b a b a a	 1	. 1 . . 1 . . . . 1 . . 1 1 . 1 . . . 1 . . . . 1 . .

Species Group M

Prominent, dominant and common species shared among vegetation units 10 and 11

Euclea natalensis	. . . .	. . . .	. . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	1 a 1 1 1	1 a a 1 b b	. . . . 1 . . 1 1	. . . . 1 . . 1 1 a . 1 . 1 . . . a . . . . . . 1 . .

Species	Cover-abundance values (recorded values in relevé order, left to right; "|" = block boundary)
Species Group N	
Prominent, dominant and common species shared among vegetation units 8 and 11	
Eugenia capensis	1 + r + r | 3 1 . 3 3 a a b a | 3 a a a a a | a 1 1 | 1 a a 1 + 1 1 a 1
Species Group O	
Diagnostic species for *Gymnosporia nemorosa–Protorhus longifolia* young coastal dune forest	
Protorhus longifolia	| a . . . a b a . a | a 1 1 1
Tricalysia capensis	a | a . a 1 1 1 . a . | 1 1 a a a 1 1 a a a 1 a
Gymnosporia nemorosa	| 1 a . . a 1 1 a 1 | b a a 1 a + 1 1 a 1 +
Smilax anceps	| 1 . . a . 1 . . 1 | 1
Species Group P	
Prominent, dominant and common species shared among vegetation units 8 and 12	
Chironia baccifera	+ r | + + 1 1 | 1 1 . a . a 1 . . | 1 a
Species Group Q	
Diagnostic species for *Carissa bispinosa–Mimusops caffra* climax coastal dune forest	
Mimusops caffra	b r + + 1 a a | 3 a 4 3 4 a a 1 3 1 a a a 1 a 3 4 1 3 4 a 3 3 4 a 3 1 b 3 4 3 4 3 4 3 b 3
Carissa bispinosa	1 1 | a a b a 1 + a 1 1 + a 1 1 a 1 a a 1 1 b a a b a a a a a
Rhoicissus rhomboidea	1 1 | 1 1 1 1 + 1 a a 1 1 a 1 a 1 1 a + a 1 1
Dietes species	a a a | a 1 a 1 a 1 a a 3 a 1 1 b a a
Rhoicissus tomentosa	1 | 1 a 1 1 a 1 a 1 1 a 1 1 1 1 1
Brachylaena discolor	r + 1 1 1 | a 1 1 + a 1 b 1 1 a 1 1 1 1 1 1 a 1 a + 1 1 a 1
Putterlickia verrucosa	+ 1 + 1 | a 1 1 1 1 a 1 1 a a 1 1 a 1 1 a 1
Dovyalis longispina	1 1 | 1 1 1 1 a a 1 1 a 1 1 b 1 a 1 a 1 a 1 a 1 a
Oplismenus hirtellus	+ + 1 | 1 1 a a 1 a 1 1 1 1 a 1 1 a 1 1 a
Bersama lucens	+ 1 | a 1 a a 1 1 1 a 1 1 1 1 a 1 a
Dracaena aletriformis	a 1 | + 1 + 1 + +
Psychotria capensis	a 1 1 1 1 1 1 1
Ansellia africana	1 + + 1 1 + +
Cussonia spicata	1 b b a a 1 a
Catunaregam species	1 | 1 a a 1 1 1
Dalbergia obovata	a a 1 1 a +
Rhoicissus sessilifolia	1 | a 1 1 + +
Dalbergia armata	+ 1 | 1 1 a 1 1 1 1 1 1 + 1
Maytenus acuminata	1 a 1 1 1
Monanthotaxis caffra	+ | 1 1 + 1 a 1 1 1
Rhoicissus revoilii	1 1 1 + +
Ficus lutea	a 1 a a
Polystachya sandersonii	+ +
Ficus burtt-davyi	1 a 1
Cissampelos torulosa	+ + 1
Washingtonia robusta	+ + +
Kiggelaria africana	1 1
Mimusops obovata	+ +
Cyrtorchis praetermiss	1 +
Harpephyllum caffrum	1 1
Teclea natalensis	1 1
Vepris lanceolata	1 | a a 1 a a
Acokanthera oblongifolia	a 1 1 1
Species Group R	
Prominent, dominant and common species shared among vegetation units 11, 12 and 13	
Kraussia floribunda	1 + | 3 3 3 . b 3 | a a 1 a a a 1 | a a a a a a 1 a a b 1 a 1 1 a a 1 a a a
Psydrax obovata	| 1 . 1 1 + + | 4 3 3 3 4 4 b 3 3 | 1 3 1 a 3 3 3 4 b 3 b 3 1 b 1 a 4 1
Species Group S	
Prominent, dominant and common species shared among vegetation units 11 and 13	
Microsorum scolopendrium	a r 1 | a 1 b 1 | 1 1 1 1 1 1 1 a 1 1 + + + 1
Species Group T	
Prominent, dominant and common species shared among vegetation units 12 and 13	
Garcinia gerrardii	| a 1 1 1 | 1
Maytenus penduncularis	| 1 | a a 1 +
Rhoicissus tridentata	| 1 + | + 1
Cyrtorchis arcuata	| + + | + 1
Peddiea africana	| 1 1 1 | a 1 a 1 1 + a 1 1 a a 1 1 a 1 a a 1 1 a a
Millettia grandis	| 1 a 1 | a 1 a 1 1 a 1 1 1 1 1
Sideroxylon inerme	b 1 + 1 | a 1 1 a | b a b 1 b a b b 3 1 a b b b a b a 1 b 1 b b a a a
Panicum coloratum	r | + a + 1 | 1 1 1 a + 1 1 1 a + 1 1 1 1 + 1 1 a 1 1 1
Ochna serrulata	| 1 1 1 | 1 1 1 1 1
Teclea gerrardii	| 1 1 + | 1 1 1

Species Group U	
Prominent, dominant and common species shared among vegetation units 2, 3, 4, 5, 6, 7, 8, 9, 10, 12 and 13	
Gomphocarpus physocarpus	+ + +
Ficus natalensis	1 a a b
Scolopia zeyheri	+ 1 1 1 1
Microsorium punctatum	+ 1 1 1 +
Ochna natalitia	+ 1 1 1 a 1
Panicum maximum	1 + 1
Ficus thonningii	1 a 1 1
Carissa macrocarpa	+ 1 a a + a 1 1 1 1 1
Grewia occidentalis	+ + a a a 1 1 1 a a 1 1 1 1 1 a 1
Secamone alpini	1 a 1 1 1 1 1 1
Allophylus natalensis	+ a 1 + 1 1 a 1
Distephanus anisochaetoides	1 + r
Asparagus falcatus	+ a + 1 1 a + a 1 a 1 a a a 1
Cyperus albostriatus	+ + + + +
Psydrax obovata s. obovata	1
Capparis brassii	+ 1 1 1
Osyris species	1 1 1 a
Diospyros natalensis	+ 1 1 1
Adenia gummifera	1 + 1 1 1
Acacia karroo	+ b 1
Barringtonia racemosa	r r
Ricinus communis	+
Passiflora subpeltata	+
Solanum nigrum	+ +
Ficus sur	1 r 1
Helichrysum kraussii	+ + 1 + 1 + 1 1 1 + 1 + r 1 1 +
Acacia natalitia	r a
Dovyalis rhamnoides	+ a 1 +
Senecio deltoideus	+ 1 + + r
Arctotheca populifolia	1 + +
Acacia kraussiana	r 1 1
Asystasia gangetica	+ + + + + + + 1 +

5.2 Ordination results

The Non-metric Multidimensional Scaling (NMDS) ordination run with full set of 149 vegetation plots resulted in a scatter plot with ten clusters of sample plots (Figure 5.4 and 5.5). The ordination scatter diagram (Figure 5.4 & 5.5) illustrated that the distribution of plant communities of the uMlalazi Nature Reserve follows the gradients of specific environmental factors (Figure 5.6). The main gradients that control plant community development in uMNR are the moisture gradient, clay gradient and salt content gradient. The moisture gradient is found along the vertical axis (the wetter communities at the top and the drier communities on the bottom) and horizontal axis (the wetter communities in the left and the drier communities on the right) (Figure 5.6). The clay communities (Figure 5.6) (communities 1–3) are positioned distinctly to the right of the ordination diagram. The communities which are located on predominantly sandy substrates (e.g. community 8) are found on the furthest opposite end from the clay communities. The salt content gradient is found in the vertical axis of the ordination scatter diagram with the more salt-tolerant communities that are also exposed to salt spray and have low organic content located in the bottom and the less salty communities that experiences less salt spray and have high organic content on the top in the ordination diagram. The salt content varies from being very low in the riverine woodland and forests to very high in the salt marsh community (Figure 5.6).

The cluster of relevés on the top center represents the secondary coastal grasslands and dune coastal forests. The close proximity between the grasslands (community 6), and the dune coastal forests (community 11–13) is because both these vegetation types share the same environmental drivers such as sandy soils, low moisture availability, low salt content and organic content that ranges from medium to high (Figure 5.6 and Table 5.1). Secondly this cluster is dynamic in nature. If fire is excluded for a number of years this community (*Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands) can become wooded where grasslands gives a way to coastal forests (Figure 5.5 and 5.6). This explains the reason why the grassland communities do not form a strong group restricted to a specific area of the scatter diagram. The significant distance between the *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest (community 10) and *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest (community 12) is because community 10 experiences a number of disturbances arising from the neighboring community despite similar environmental settings that these communities require (Table 5.3 and Figure 5.6).

Community 13 has a wide distribution, as some of its dominant species occur in other communities as well. Of these the grass *Panicum coloratum,* the shrub *Brachylaena discolor* and the tree *Millettia grandis* are known to be variable in their habitat preference within the Indian Ocean Coastal Belt Biome, and are not limited to a certain environment. These clusters also show a gradient of density from top to bottom, with the more closed thickets at the top and the open communities at the bottom. This pattern can clearly be seen in the field as well.

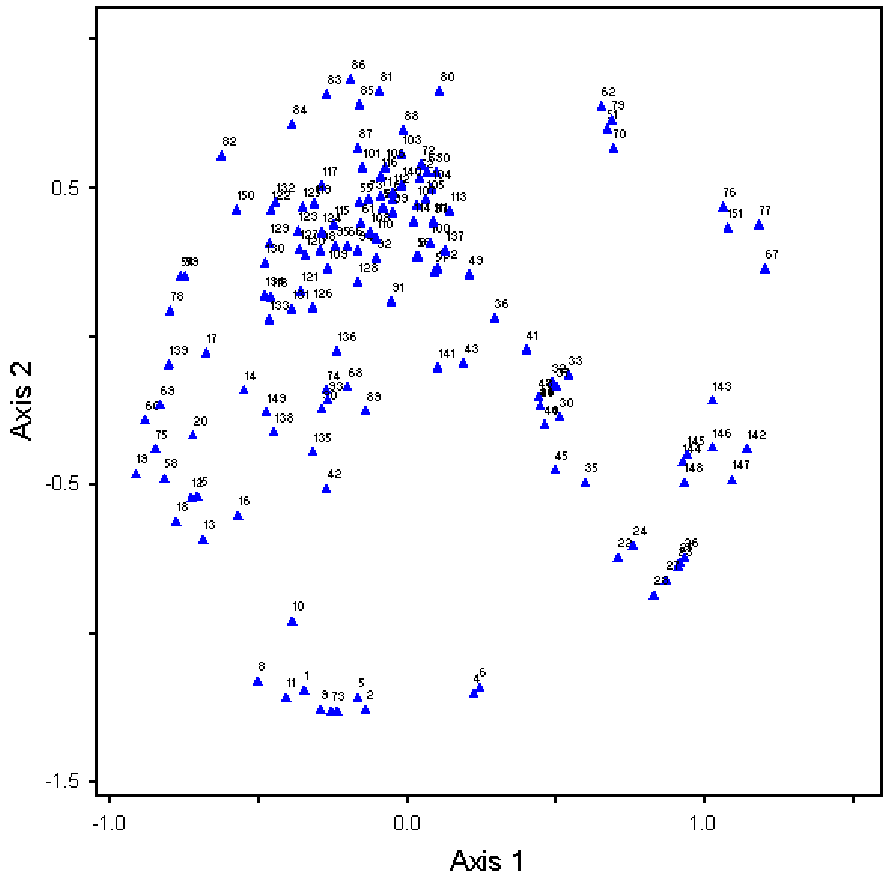


Figure 5.4: A scatter plot diagram resulting from a Non-metric Multidimensional Scaling Ordination of the vegetation of the uMlalazi Nature Reserve.

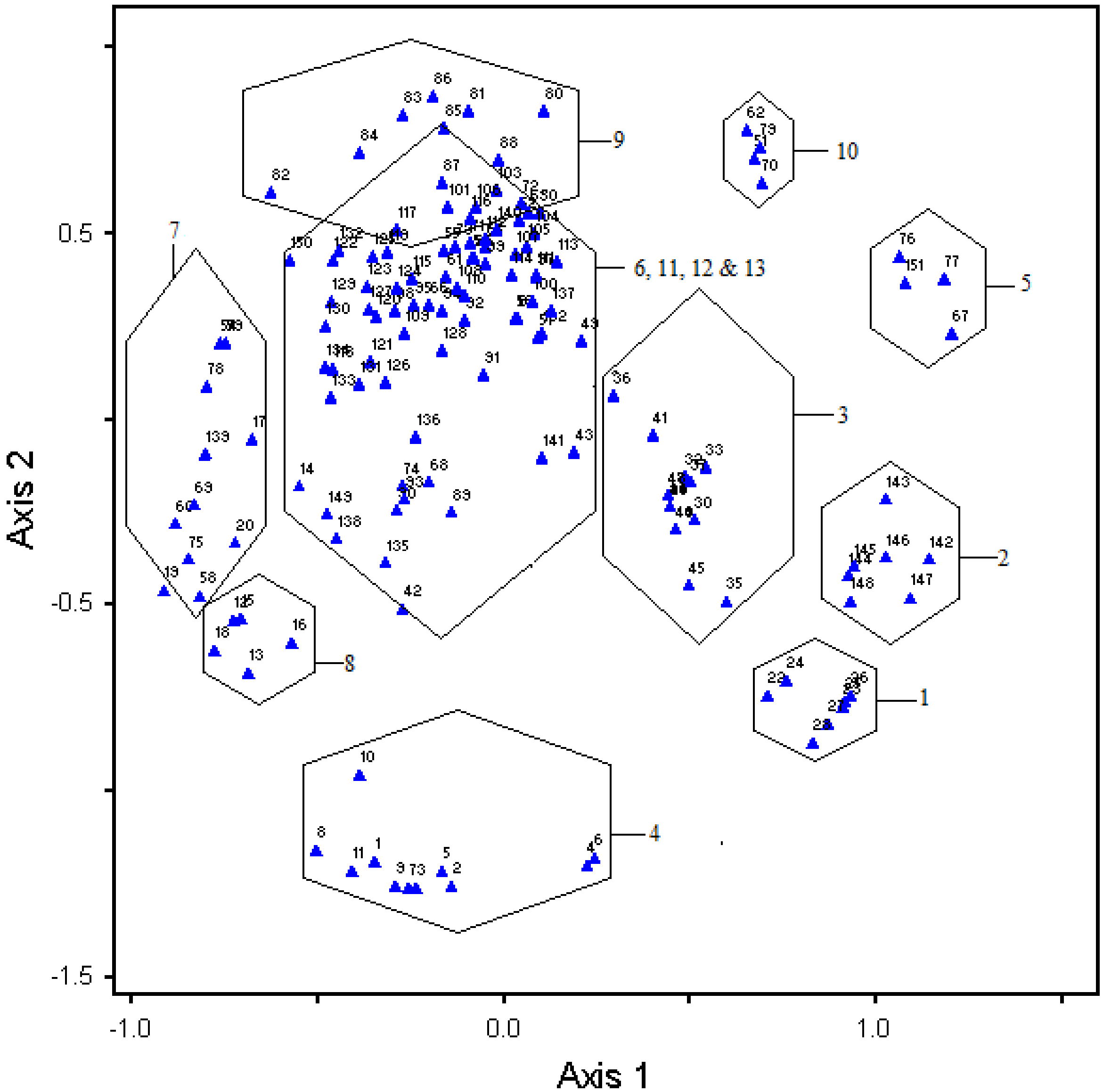
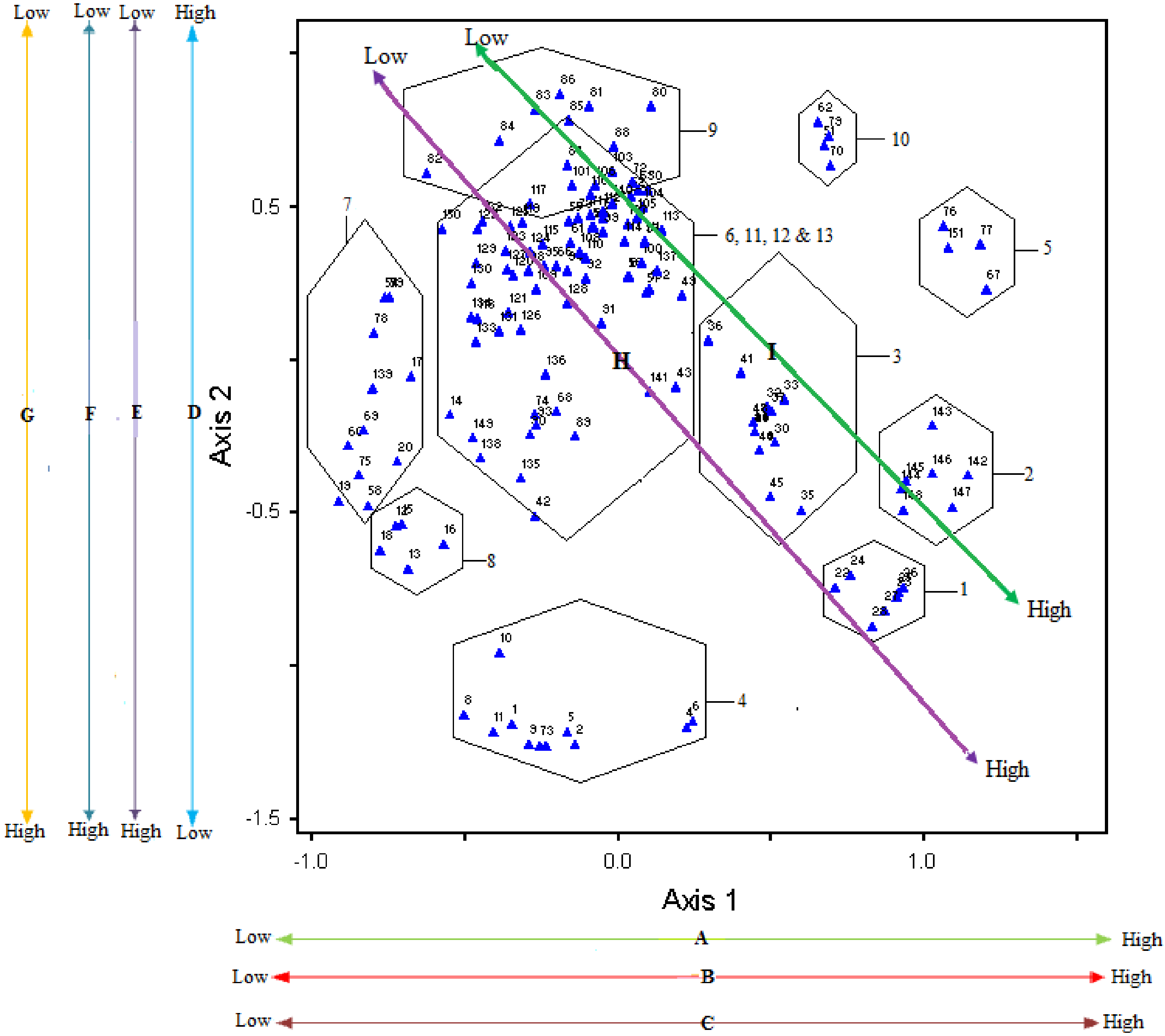


Figure 5.5: Non-Metric Multidimensional Scaling Ordination axis 1 and 2 illustrating plant community clusters of the uMlalazi Nature Reserve (large font numbers correspond with plant community numbers).



Legend
A-Moisture content, **B**-Clay content, **C**-Human induced fire and grazing, **D**-Moisture availability, **E**-Wind exposure, **F**-Exposure to salt spray, **G**-Organic content, **H**-Salt content, **I**-Sunlight penetration to lower strata.

Figure 5.6: Ordination axis 1 and 2 illustrating plant community clusters in relation to environmental gradients (large font numbers correspond with plant community numbers).

Table 5.3: The range of environmental variables identified as potentially important for plant community cluster distribution produced through ordination (large font numbers correspond with plant community numbers).

Plant Communi-ties	Clay	Organic matter	Human Induced fire & grazing	Salt content	Moisture availability	Wind exposure	Distance from the sea (~m)
1	Very high	Low	Low	Very high	High	High	300-360
2	Very High	Medium	Low	High	High	High	340-400
3	High	Low	Medium	Medium	Medium	High	400-450
4	Low	Low	Low	Medium	Low	Very high	90-100
5	High	Low	Medium	Medium	High	Medium	350-500
6,11,12 & 13	Low	Very high	Medium	Low	High	Medium	578-650
7	Medium	Medium	Medium	Low	Medium	High	500-600
8	Low	Low	Low	Medium	Medium	Very high	180-199
9	Low	Very high	Low	Low	Very high	High	700-810
10	Low	High	Very high	Low	High	Medium	500-680

5.3 Vegetation mapping

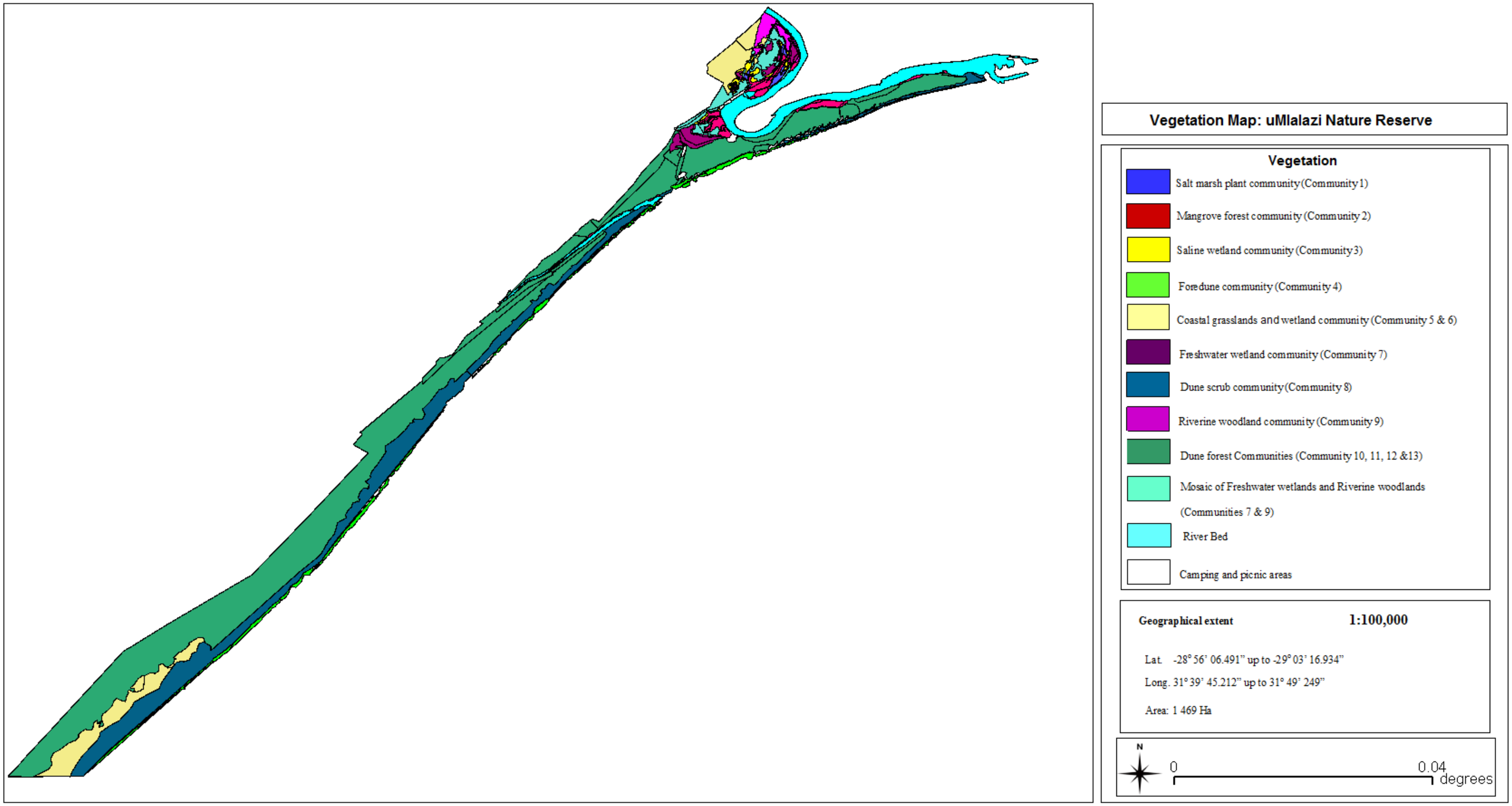


Figure 5.7: Vegetation map of uMlalazi Nature Reserve.

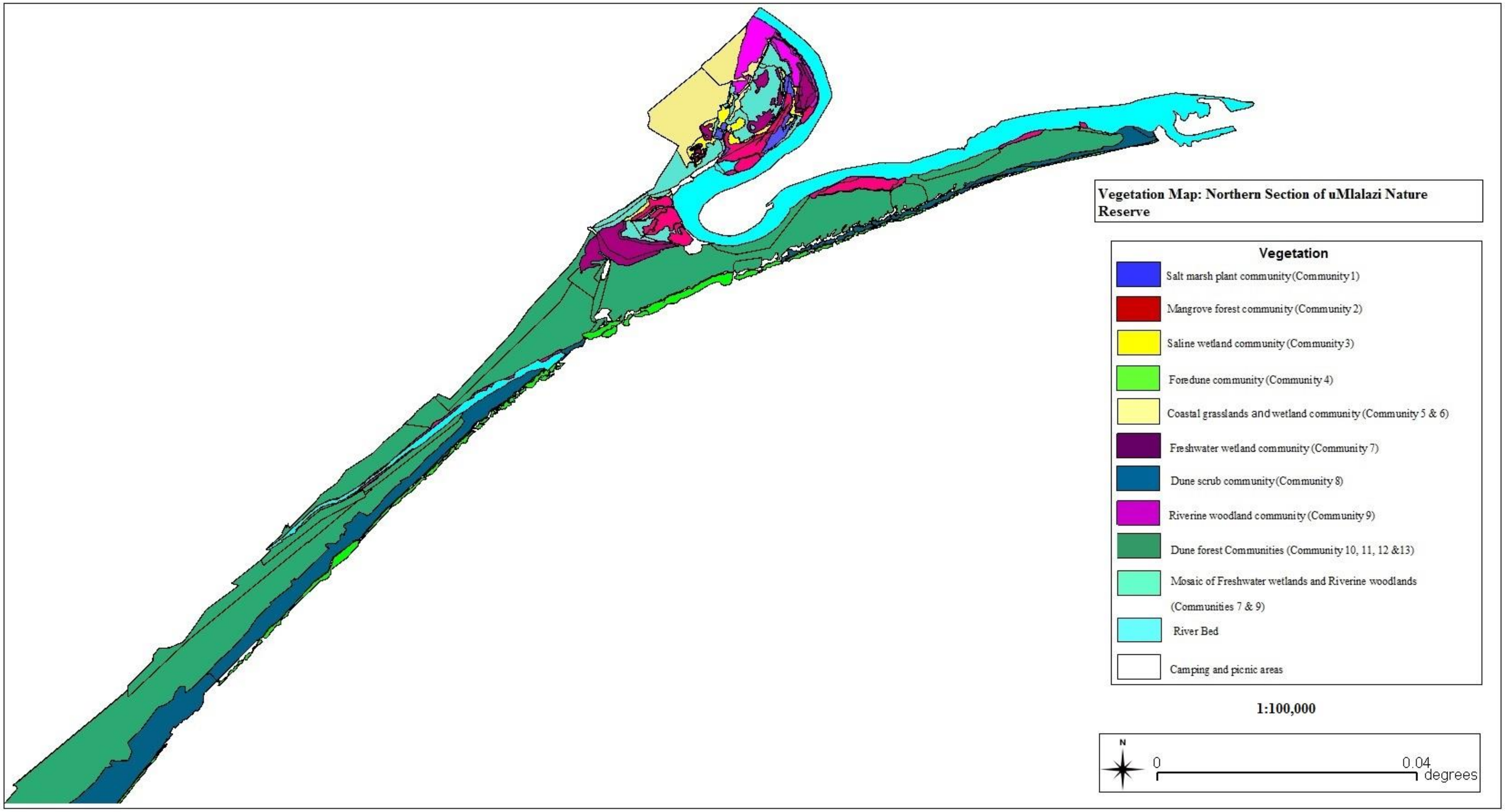


Figure 5.8: Vegetation map: Northern Section of uMlalazi Nature Reserve.

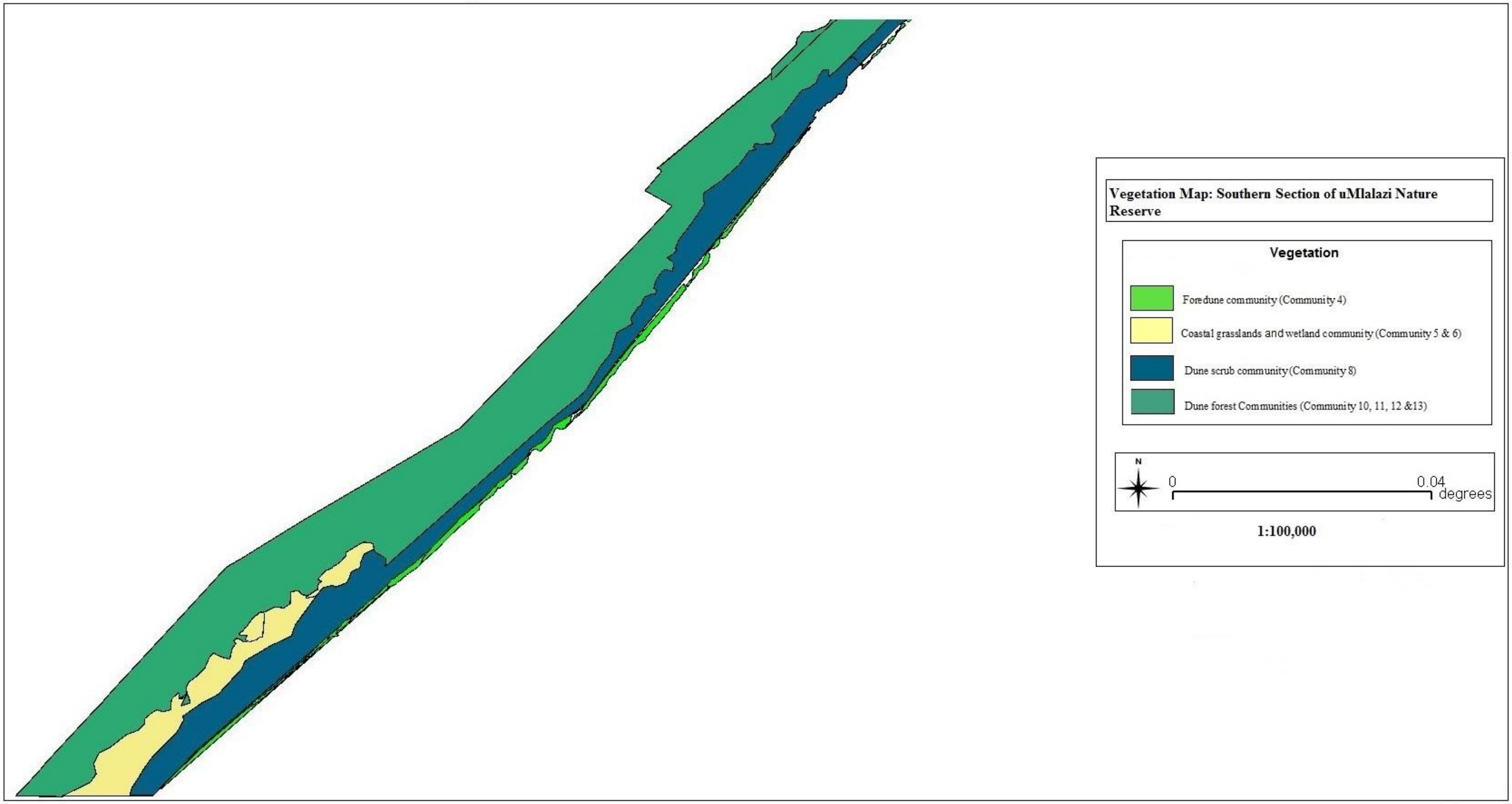


Figure 5.9: Vegetation map: Southern section of uMlalazi Nature Reserve.

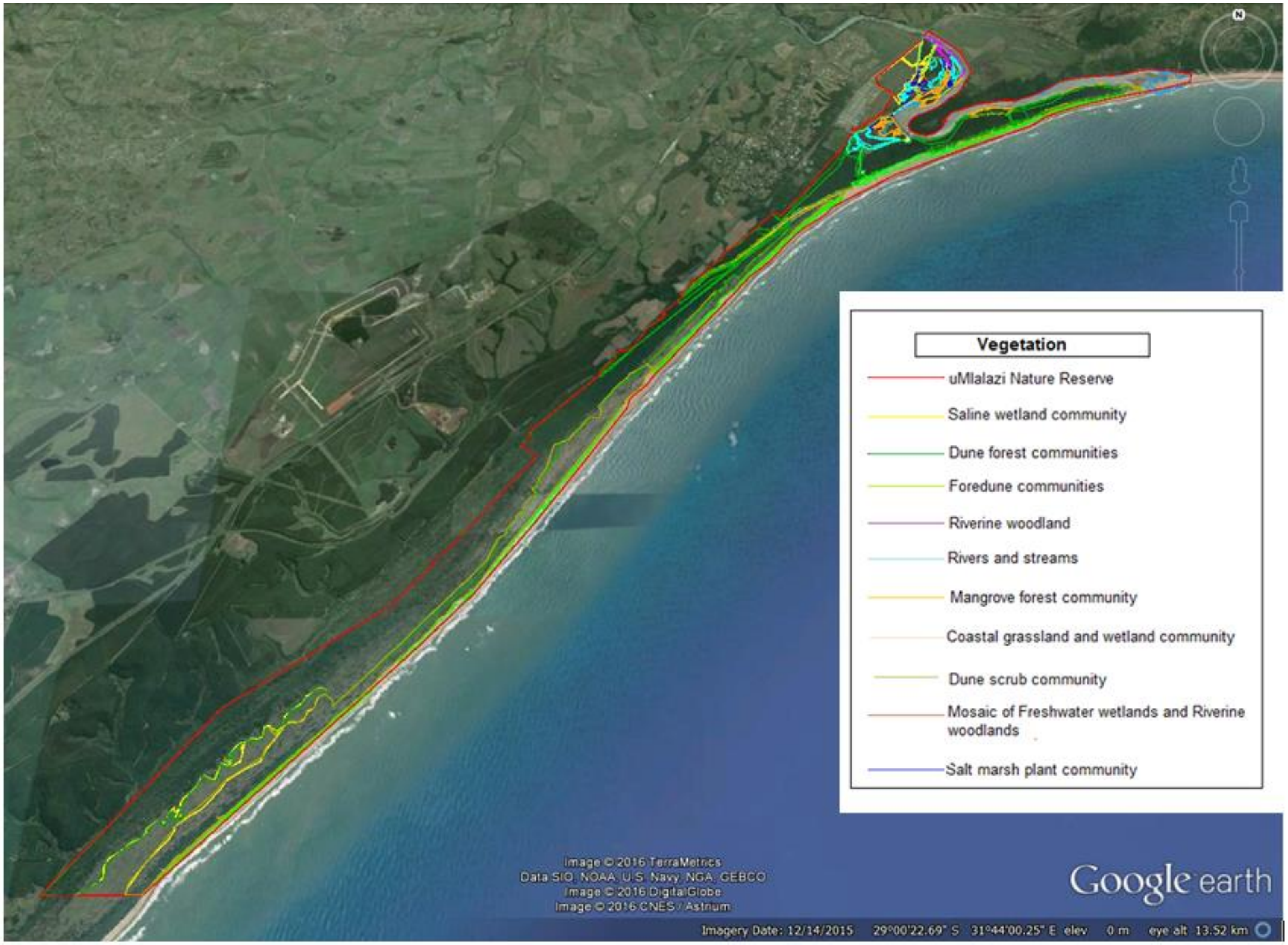


Figure 5.10: Google Earth image of uMlalazi Nature Reserve with the plant community lines (after Google Earth, 2016).

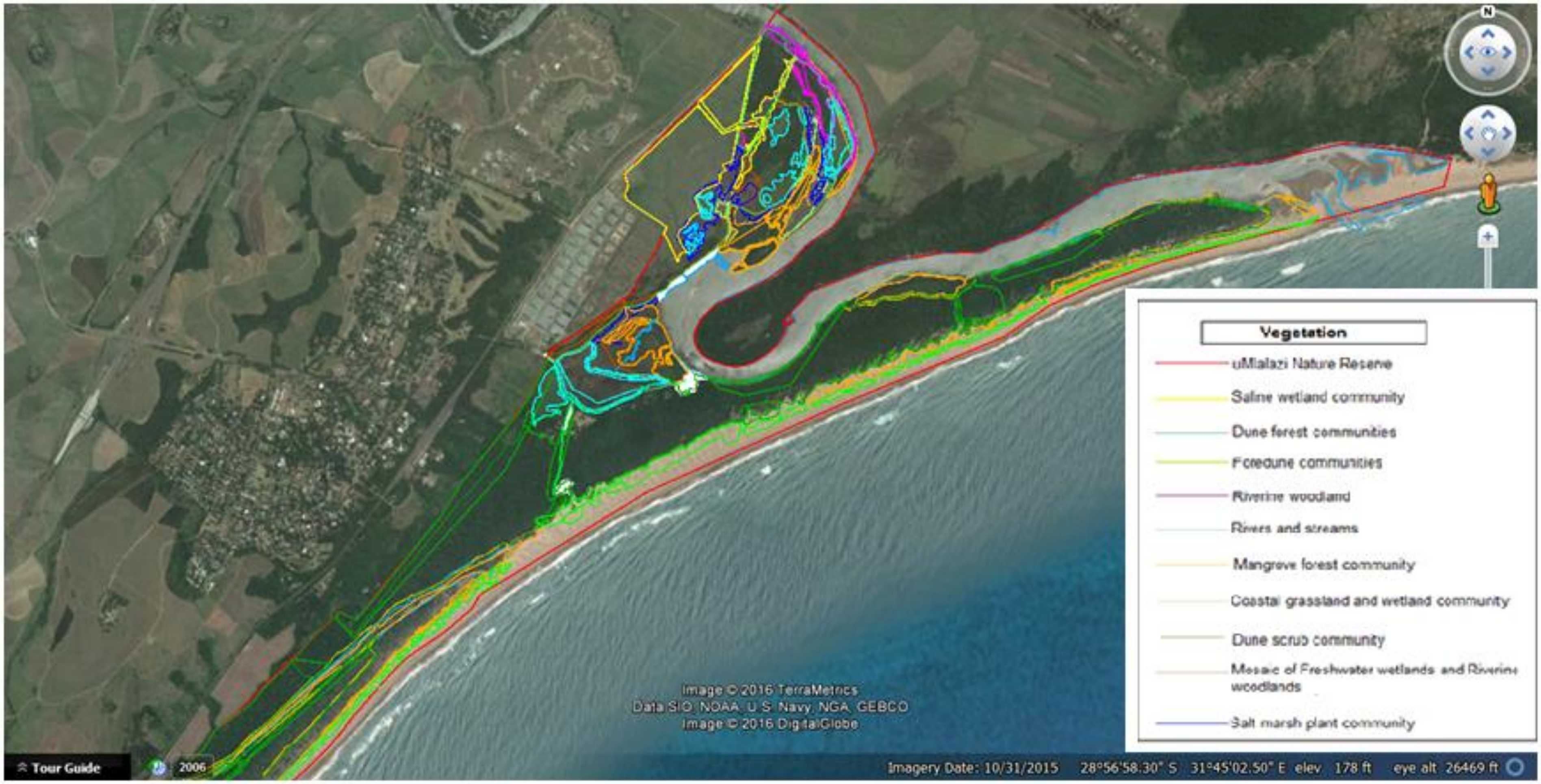


Figure 5.11: Google Earth image: Plant community lines of the northern section of uMlalazi Nature Reserve (after Google Earth, 2016).

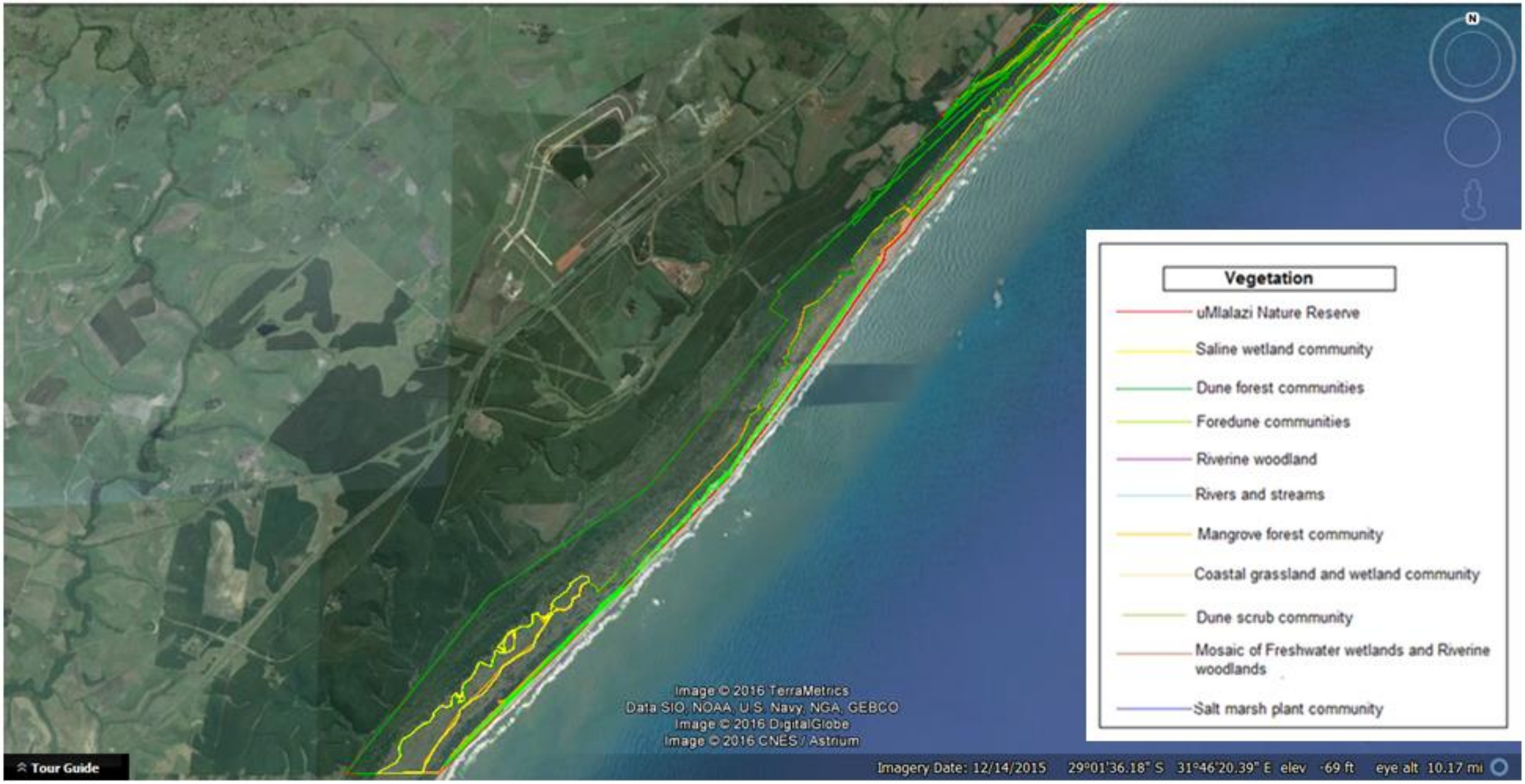


Figure 5.12: Google Earth image: Plant community lines of the southern section of uMlalazi Nature Reserve (after Google Earth, 2016).

5.4 Species richness

The total species richness of all the releves of the various plant communities are indicated in Figure 5.13. The average species richness is lower in communities 1–3 (the seasonal zone of the clay wetlands) than in the rest of the communities. The average species richness is regarded as intermediate in communities 4–7. The *Digitaria eriantha–Dactyloctenium australe* sphotoecondary coastal grasslands (community 6) have the highest number of forb species than any other community in uMlalazi Nature Reserve.

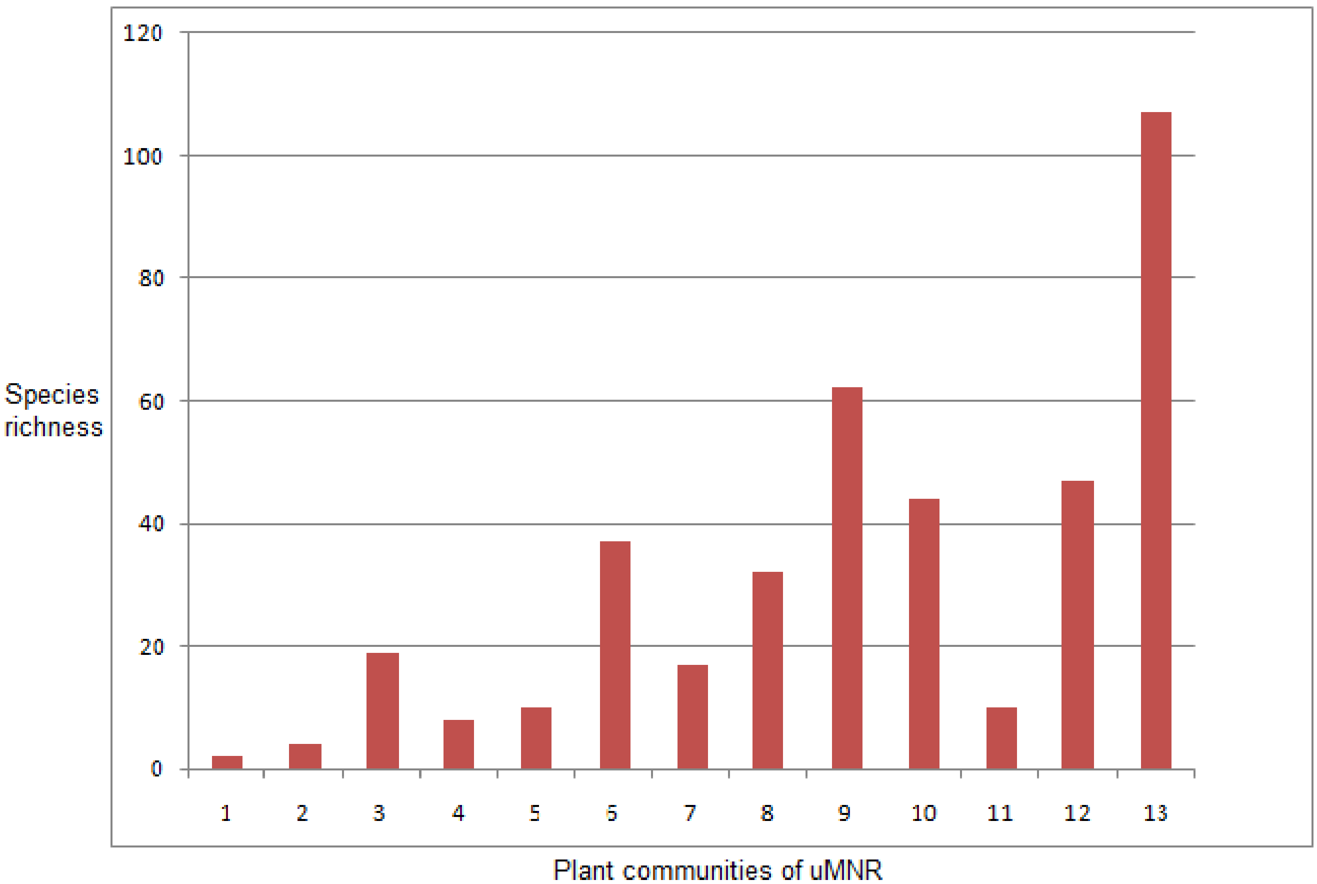


Figure 5.13: Species richness in the thirteen plant communities of uMNR.

The grass layer has a cover of about 75% and the forb layer has a cover of up to 25%. Both the forbs and grasses in this community have a mean height of 0.6 m. Woody species occur frequently in this community but they have a cover of less than 10%.

Although the pioneer zone communities (Table 5.4) and saline wetland communities does not have high species richness they both fulfill a very important role in vegetation succession. These communities are important in stabilizing and formulation of dunes. These communities act as a barrier providing some protection to the dune scrub community. The average species richness is higher in communities 8-13. These secondary communities (Table 5.4) have higher species richness mainly because they develop after the dunes have been stabilized and there is clear modification of the soil by pioneer species.

Table 5.4: Species richness in relation to plant community zones of uMlalazi Nature Reserve.

Zone	Plant Community no.	Species richness
Saline environment	1,2,3	25
Pioneer zone	4	08
Dune forests	11,12,13	164
Secondary community	5,6,7,8	96

5.5 Plant community descriptions

5.5.1 *Avicennia marina–Salicornia meyeriana* salt marsh community

Avicennia marina–Salicornia meyeriana salt marsh community is not widely distributed in the study area. It only covers the small patches next to the mangrove forest. This community was found at relatively low elevations within the floodplains of the uMlalazi River. These sections of the floodplains do not drain freely after flooding events and act as natural evaporation pans. The combination of salt water contamination from incoming tides and the evaporation of water from the evaporation pans lead to the accumulation of salt in this community. The soils underlying this community have low organic content and are saline. They contain large proportions of silt and clay deposits, derived from the uMlalazi River sediment after flooding events. *Avicennia marina–Salicornia meyeriana* salt marsh community has a very low vegetation cover and a simple vegetation structure. Its structure varies from open to closed low herbaceous vegetation (Photo-plate 1), mostly clumped into colonies of *Salicornia meyeriana*.

The diagnostic species for this community are listed in Species Group A of the synoptic table (Table 5.1) as the herbaceous succulent species *Salicornia meyeriana.* The prominent species for this community are displayed in the full phytosociological table (Table 5.2) and include the low growing halophytic succulent *Salicornia meyeriana* (Species Group A) and the tree species *Avicennia marina* (Species Group B). However, *Avicennia marina* has a low cover-abundance value within this community. This community is floristically the poorest of all the plant communities recorded within the uMNR (Figure 5.13), which contribute only 2% of the species richness in uMNR. This community is floristically similar to the *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest. There were no dominant species in this community.

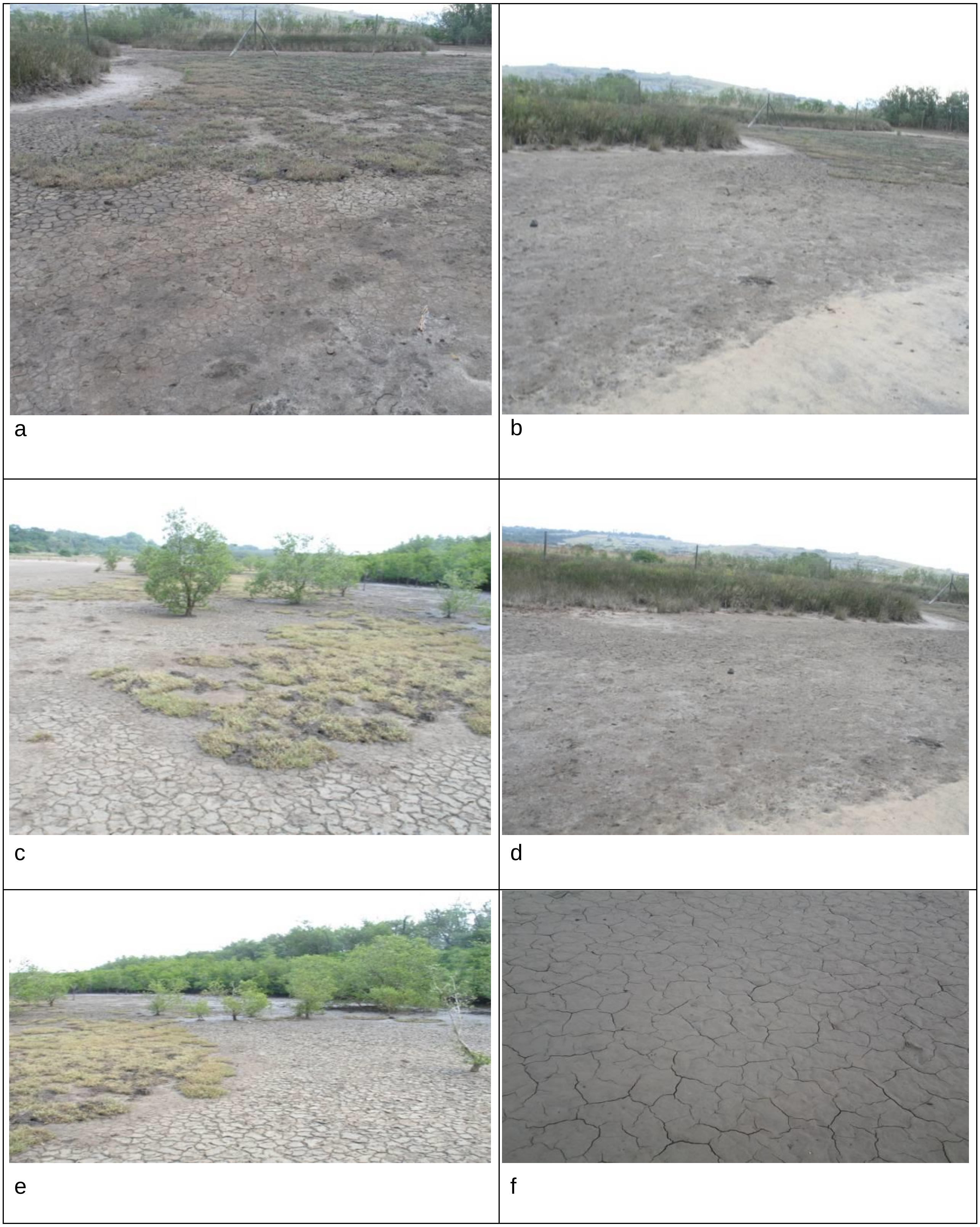


Photo-plate 1: *Avicennia marina–Salicornia meyeriana* salt marsh community.

5.5.2 ***Bruguiera gymnorrhiza–Avicennia marina* mangrove forest**

Bruguiera gymnorrhiza–Avicennia marina mangrove forest community occurs in an intertidal zone of the uMlalazi River in the study area. It forms one of three plant communities (*Avicennia marina–Salicornia meyeriana* salt marsh community, *Phragmites australis–Juncus kraussii* saline wetland and *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest) that occur in the saline environment within the study area. The soils of this community are poorly drained, saline, anoxic and fine-grained. These soils are made up of sand, silt and clay in different combinations, with high organic content. This community is typically species poor and dense. Structurally, this community varies from medium to tall closed mangrove forest (Photo-plate 2). *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest community is restricted to the edges of uMlalazi River.

The diagnostic tree species for this community are *Bruguiera gymnorrhiza* and *Avicennia marina* (Species Group B, Table 5.1). The most dominant tree species in this community are presented in the full phytosociological table (Table 5.2) and include the tree *Avicennia marina* (Species Group B), with other prominent species such as the perennial sedge *Juncus kraussii* (Species Group C).

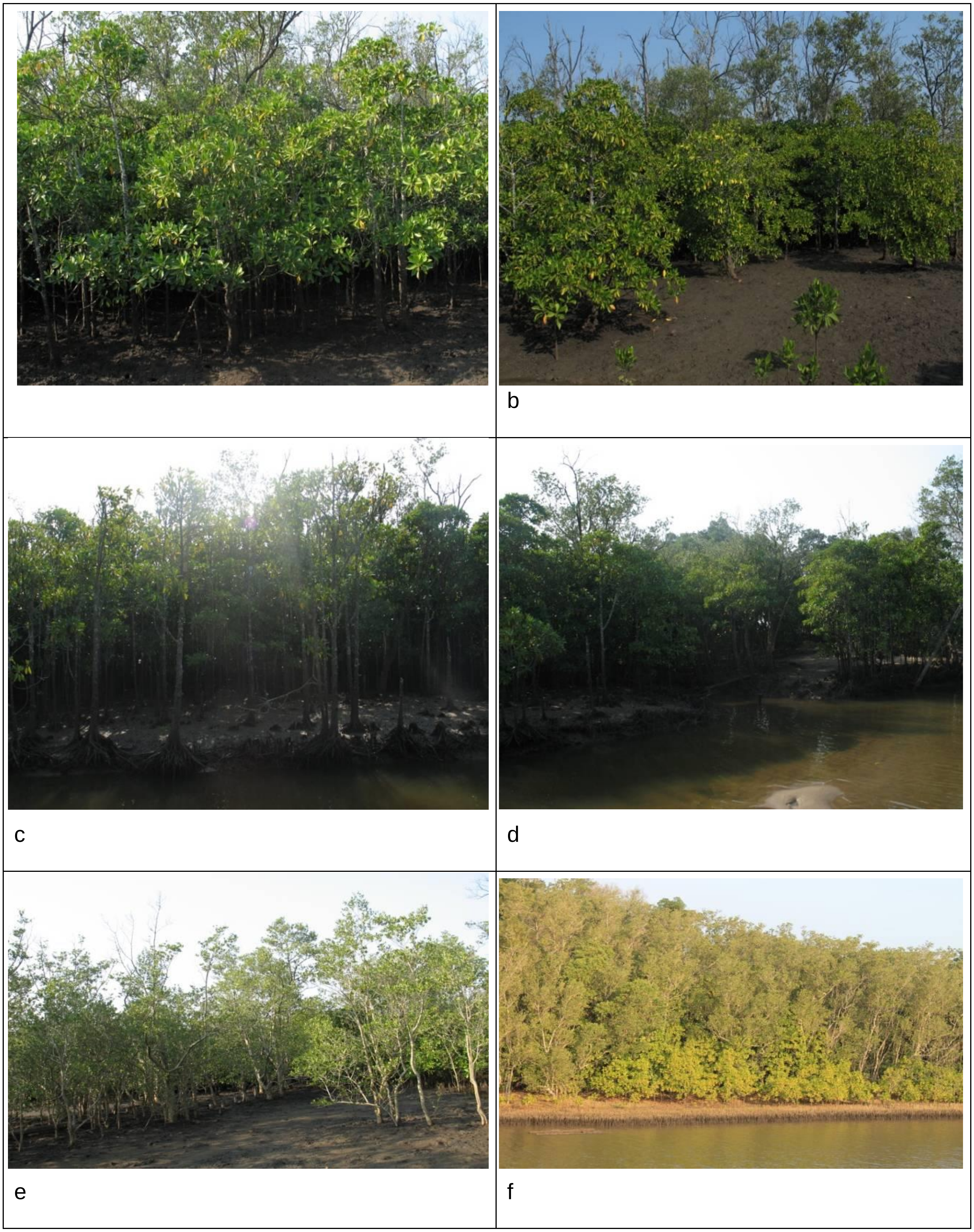


Photo-plate 2: *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest.

5.5.3 *Phragmites australis–Juncus kraussii* saline wetland

Phragmites australis–Juncus kraussii saline wetland is widespread in the study area. However, most parts of this community are relatively disturbed due to harvesting of the sedge species *Juncus kraussii* for the weaving industry. Within the study area, where this community occurs it borders the *Avicennia marina–Salicornia meyeriana* salt marsh community. This community has saline soils that have low organic content. However, the organic content in this community is significantly higher than that of the *Avicennia marina–Salicornia meyeriana* salt marsh community. Water drainage is slow and even stagnant in some cases. The vegetation is structurally characterised by a medium to tall closed reed and sedgeland (Photo-plate 3).

The only diagnostic species for this community is the sedge species *Juncus kraussii* (Species Group C, Table 5.1). The dominant species for this community are presented in the full phytosociological table (Table 5.2) and include the reed species *Phragmites australis* (Species Group H) and the sedge species *Juncus kraussii* (Species Group C), the herb species *Ipomoea cairica* (Species Group G) and the grass species *Stenotaphrum secundatum* (Species Group G).

a b

Photo-plate 3: *Phragmites australis–Juncus kraussii* saline wetland

5.5.4 *Scaevola plumieri–Gazania rigens* foredune community

Scaevola plumieri–Gazania rigens foredune community forms at the top of the beach when the onshore winds blow sand from the lower shore to the top. It has sandy soils and a low organic content. Water drainage is fast in this community mainly because this community develops on sand dunes. *Scaevola plumieri–Gazania rigens* foredune community has low species richness and is structurally simple. It contains mainly one layer of herbaceous plants which usually reaches an average height of 0.72 m (Photo-plate 4). As a result the vegetation structure for this community can be described as patches of low, closed herblands, with large stretches of open uncolonised mobile sand between vegetation patches.

The diagnostic species for this community are listed in Species Group D of the synoptic table (Table 5.1) and include the succulent shrublet, *Scaevola plumieri,* the perennial trailing herb *Ipomoea pes-caprae* and creeping perennial herb *Gazania rigens. Scaevola plumieri* occurred in approximately 60% of sample plots with cover values that ranged from 5 to 70% in this community.

The most dominant species in this community are presented in the full phytosociological table (Table 5.2) and include the creeping perennial herb *Gazania rigens* which occurred in approximately 90% of sample plots in this community*.* Other diagnostic species include the herbs *Ipomoea pes-caprae* and *Scaevola plumieri* (Species Group D); herb *Carpobrotus dimidiatus* (Species Group I); shrubs *Rhynchosia nitens* and *Chrysanthemoides monilifera* (Species Group I).


a


b


c


d


e


f

Photo-plate 4: *Scaevola plumieri–Gazania rigens* foredune community.

5.5.5 *Typha capensis–Cyperus dives* wetland community

Typha capensis–Cyperus dives wetland community is found between 1 and 5 m above mean sea level within the study area. However, outside the study area and further inland this community is not restricted to an altitude between 1 and 5 m. This community have soils that are waterlogged and contain high amounts of clay and decaying organic matter. However, the highest water levels are found in summer, during periods of high seasonal rainfall. The structure of this community can be described as a tall closed reedland (Photo-plate 5). This community has over the years experienced disturbance through cattle grazing and fire.

The perennial sedge *Cyperus dives* is the most diagnostic sedge species (Species Group E, Table 5.1) for this community which occurred in all sample plots of this community with cover values of 25% to 75%. Other diagnostic species for this community include the herbs *Persicaria serrulata, Gomphocarpus fruiticosus*, and *Typha capensis*, the fern *Cyclosorus interruptus* and the palm *Phoenix reclinata* (Species Group E).

The most dominant species in this community are presented in the full phytosociological table (Table 5.2) and include the perennial bulrush *Typha capensis,* aquatic herb *Persicaria serrulata,* the sedge *Cyperus dives,* the fern *Cyclosorus interruptus* and the palm *Phoenix reclinata.*

a b

Photo-plate 5: *Typha capensis–Cyperus dives* wetland community.

5.5.6 *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands

Digitaria eriantha–Dactyloctenium australe secondary coastal grasslands community covers only a small surface area within the study area. It covers only a small patch (~2% of the study area) within the southern section of the uMNR, where they are also disturbances form the neighbouring human community. This community has sandy soils with organic content levels that range from medium to low. It is located in the habitats that are frequently disturbed by cattle grazing and fire (Photo-plate 6). These disturbances prevent the establishment of woody species. This fire suppressed subclimax community has a short closed vegetation structure (Photo-plate 6).

The diagnostic species for this community are listed in Species Group F of the synoptic table (Table 5.1) with the grass *Digitaria eriantha* being the most diagnostic species for this community. Other grass species that are diagnostic to this community include; *Dactyloctenium australe, Sporobolus africanus, Imperata cylindrica, Kyllinga alata, Stiburus alopecuroides, Wahlenbergia benghalensis* and *Cyperus species* (Species Group F, Table 5.1). The diagnostic forbs include; *Helichrysum ruderale, Rhynchosia caribaea* and *Manulea parviflora* (Species Group F, Table 5.1).

The dominant species in this community are presented in the full phytosociological table (Species Group F, Table 5.2) and include grass species *Dactyloctenium australe*. This is the stoloniferous perennial grass with slender erect ascending culmes 32–80 cm high. This makes this species be able to withstand salty or saline conditions. It can also grow in the shade. Other dominant grass species include *Sporobolus africanus*, *Imperata cylindrica, Kyllinga alata* and *Digitaria eriantha.* Some other woody species that occur within this community include low shrub *Eugenia capensis,* straggling shrub *Searsia nebulosa* and branched shrublet *Chironia baccifera* (Species Group H, Table 5.2).

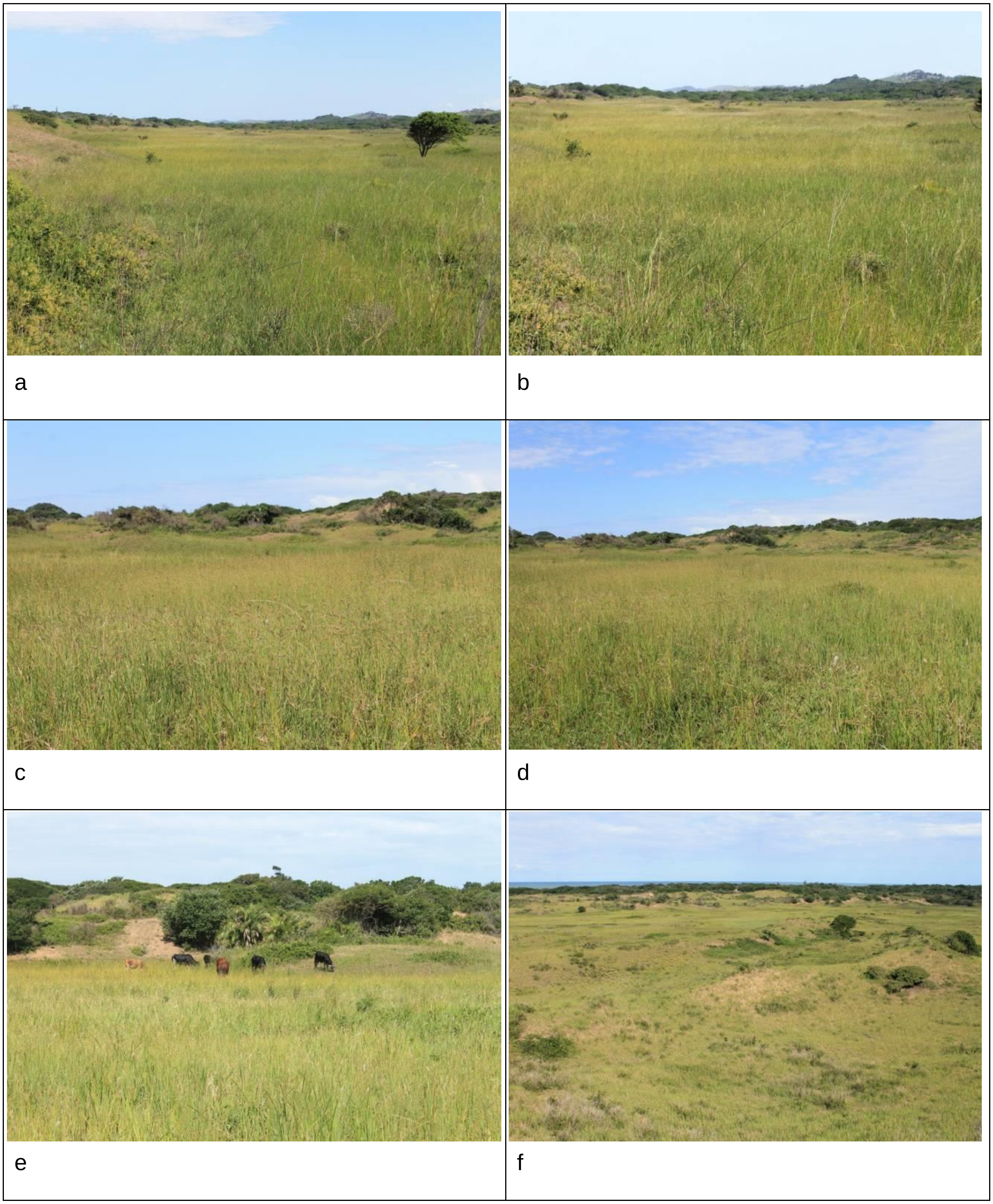


Photo-plate 6: *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands

5.5.7 *Stenotaphrum secundatum–Phragmites australis* freshwater wetland.

Stenotaphrum secundatum–Phragmites australis freshwater wetland community occurs as scattered patches in the study area. However, certain parts of this community have been invaded by invasive alien plants such as *Chromoleana odorata and Lantana camara.* This freshwater wetland community has soils that are sandy with some accumulation of clay. These soils are also waterlogged and have high levels of decaying organic matter. It has a vegetation structure that varies from medium to tall closed freshwater wetland (Photo-plate 7).

The diagnostic species for this community are listed in Species Group G of the synoptic table (Table 5.1) and include the grass *Stenotaphrum secundatum* and the herbs such as *Ipomoea cairica, Hibiscus trionum, Paspalum dilatatum, Cissampelos hirta* and *Cyperus eragrostis.*

The dominant species for this community are displayed in the full phytosociological table (Species Group G, Table 5.2) and the sedge *Phragmites australis* is the most dominant species for this community. Other dominant species in this community include the grass *Stenotaphrum secundatum*, and the herbs *Ipomoea cairica*, *Hibiscus trionum, Cyperus eragrostis* (Species Group G) and *Asystasia gangetica* (Species Group U).

Phragmites autralis is a tall (1.5–4 m) coarse perennial reed that occurs in brackish and freshwater wetlands (Photo-plate 7). This species has a natural worldwide distribution. The seeds of *Phragmites* spread by a vigorous system of rhizomes and stolons. The seeds are dispersed primarily by wind during the winter months. When *Phragmites autralis* gets established, either by seeds or rhizome segments, colony expansion occurs primarily by rhizomes in wet organic soils. Within uMNR *Phragmites autralis* serves as an excellent stabilizer of soil and an efficient nutrient sink through its accumulation of large quantities of persistent biomass. It has also proven to be the most efficient herbaceous aquatic plant for transpiring large volumes of water. This species can also tolerate high salinity and therefore also occurs in the salty *Juncus kraussii* wetland.

At the time of the field surveys Zululand ecperienced severe drought conditions, with below average rainfall recorded for the last three years. In times of average to high rainfall it is predicted that the *Stenotaphrum secundatum* component will diminish drastically and will be confined to the better drained edges of the wetland. However, currently the upper 50 mm of soil is sufficiently dry for this species to proliferate.

 a	 b

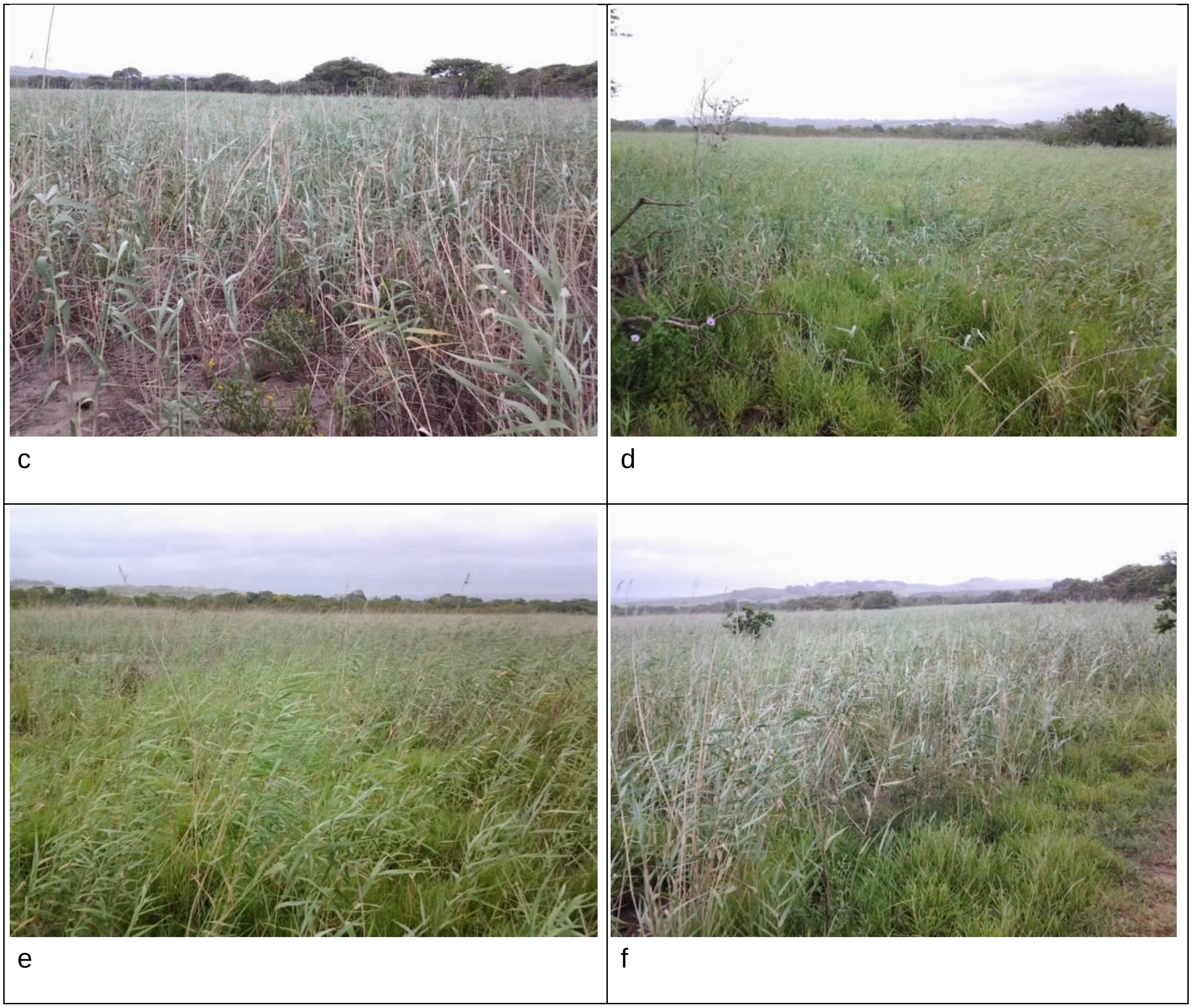


Photo-plate 7: *Stenotaphrum secundatum–Phragmites australis* freshwater wetland.

5.5.8 *Passerina rigida–Carpobrotus dimidiatus* dune scrub community

Passerina rigida–Carpobrotus dimidiatus dune scrub community begin on the back dunes (Photo-plate 8). This community contains young dunes soils, which are enriched by humus. It has a dense cover and their wind-ward stands of coastal thicket are low and wind-sheared. The trees and shrubs that grow in this community are dwarfed with a compact canopy flattened by wind pruning (Photo-plate 8). However, on leeward slopes of the older dunes, there is a significantly taller thicket vegetation structure. Structurally, this community can be classified as a moderately dense short to medium shrubland.

The most diagnostic species for this community is the shrub *Passerina rigida* (Species Group I, Table 5.1) (Photo-plate 8). It usually grows up to 1.5 m in height. Other diagnostic species in this community include the shrubs; *Carissa bispinosa*, *Chrysanthemoides monilifera*, *Osyris compressa*, *Brachylaena discolor, Tephrosia purpurea, Dichrostachys cinerea* and *Rhus nebulosa* (Species Group I)*.* The diagnostic grasses are *Stipagrostis zeyheri, Kyllinga species* and *Mariscus species,* herbs *Senecio species* and *Rhynchosia nitens,* the creeper *Abrus precatorius* and woody climber *Rhoicissus digitata.*

The dominant species in this community are presented in the full phytosociological table (Table 5.2) and include the perennial trailing succulent *Carpobrotus dimidiatus*, the grasses *Stipagrostis zeyheri, Kyllinga species* and *Mariscus* species*,* the herbs *Senecio sp* and *Rhynchosia nitens* (Species Group I)*,* the shrubs; *Eugenia capensis* (Species Group N), *Carissa bispinosa* (Species Group Q), *Chrysanthemoides monilifera*, *Osyris compressa*, *Brachylaena discolour, Tephrosia purpurea, Dichrostachys cinerea, Searsia nebulosa* (Species Group I) and *Chironia baccifera* (Species Group P)*.* Other prominent trees in this community include *Mimusops caffra* (Species Group Q), *Apodytes dimidiata* (Species Group L), *Krausia floribunda* (Species Group R) and *Allophylus natalensis* (Species Group U).

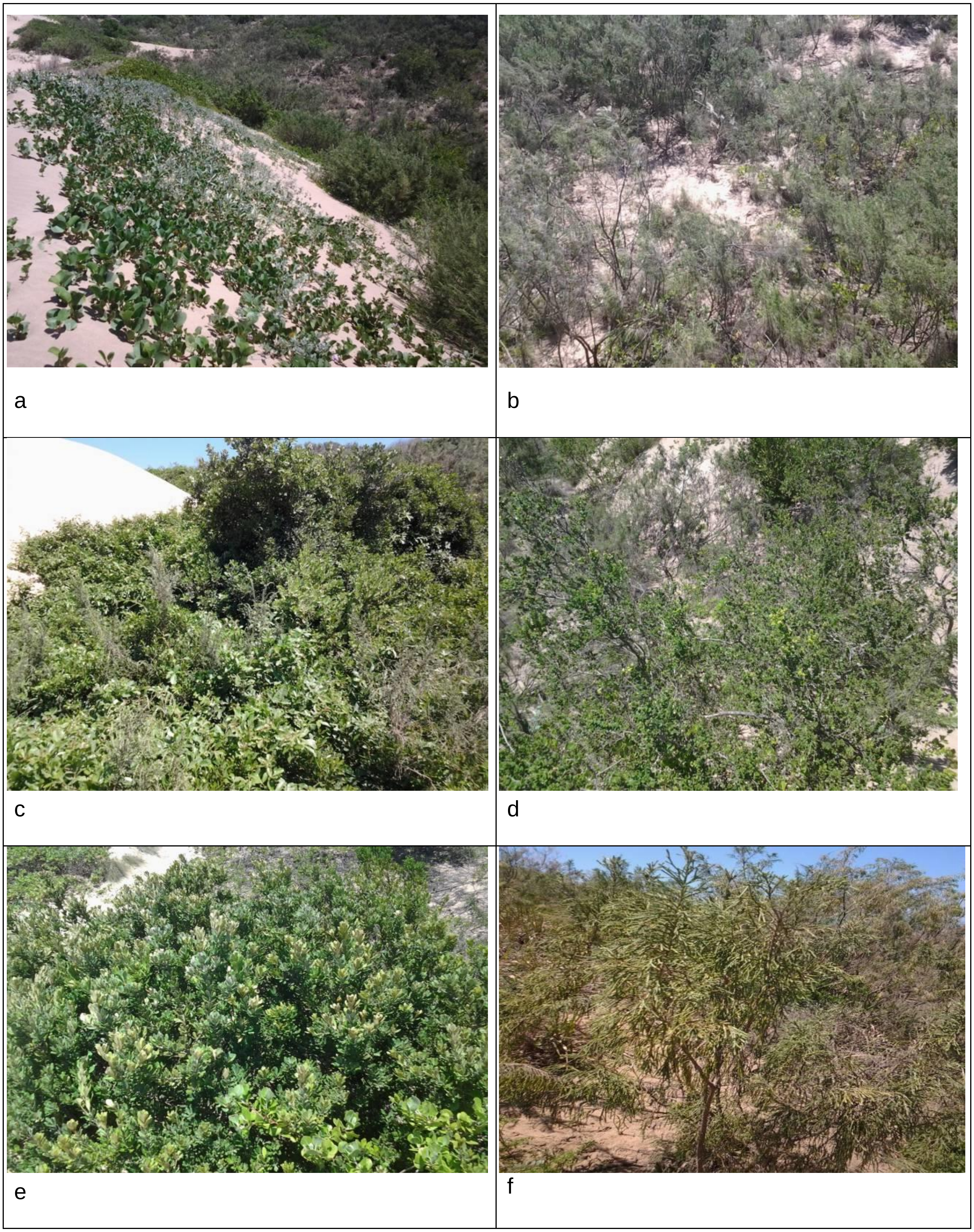


Photo-plate 8: *Passerina rigida–Carpobrotus dimidiatus* dune scrub community.

5.5.9 *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community

Hibiscus tiliaceus–Vachellia robusta riverine woodland community is restricted to the edges of uMlalazi River. It is very tall, dense and has a well-developed dense shrub layer (Photo-plate 9). It has deep, fine textured soils of recent alluvial deposits that are subject to frequent flooding. Soils drain freely and do not stay waterlogged for extended periods of time. This community is part of the Lowveld Riverine Forest (FOa1) vegetation type. It is regarded as critically endangered as many of the areas with this vegetation unit have been lost to agriculture, building of dams, and invasion by invasive alien plant species. Structurally, this community can be described as tall closed riverine woodland, with a dense shrub layer.

The diagnostic species for this community are listed in Species Group J of the synoptic table (Table 5.1) and include the shrubs *Adenopodia spicata, Hibiscus tiliaceus, Canthium inerme, Pavetta lanceolata, Rivina humilis, Scutia myrtina, Tecoma capensis* and *Clausena anisata.* The diagnostic herbs include *Scadoxus membranaceus, Oxalis latifolia, Chenopodium ambrosiodes, Oxalis droseroides, Nidorella droseroides* and *Scadoxus puniceus.* The diagnostic trees include *Vachellia robusta, Tricalysia lanceolata, Tarenna pavettoides, Zanthoxylum capense, Voacanga thouarsii* and *Olea woodiana* (Species Group J).

The dominant species for this community are displayed in the full phytosociological table (Table 5.2) and include the most dominant tree species *Vachellia robusta*. This plant species grows in higher rainfall areas and on the edges of rivers and streams. *Vachellia robusta* is regarded as a very important diagnostic species for the *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community. Other dominant species include the shrubs *Adenopodia spicata, Hibiscus tiliaceus, Canthium inerme, Pavetta lanceolata, Rivina humilis, Scutia myrtina, Tecoma capensis* and *Clausena anisata;* the herbs

Scadoxus membranaceus, Scadoxus puniceus (Species Group J) and *Asystasia gangetica* (Species Group U).


a


b


c


d

	
e	f

Photo-plate 9: *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community.

5.5.10 *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest

Albizia adianthifolia–Trichilia emetica disturbed coastal dune forest community has developed sandy-loamy soils with high organic content. The average total cover for this community is 80% and bare patches make up 20–25%. Structurally this community can be described as tall closed disturbed dune forest (Photo-plate 10). Various types of forest disturbances were found throughout this community. Some other disturbances that shape this community include; fire, wind, recreational activities, the presence of charcoal pits, animal traps, footpaths and roads, subtropical storms, harvesting of timber, firewood and medicinal plants, alien plant invasions and slumping of unstable dunes and substrates. Footpaths were particularly widespread throughout the study area and to varying degrees affected all investigated forest areas.

The diagnostic species for this community are listed in Species Group K of the synoptic table (Table 5.1) and include the most diagnostic tree species *Albizia adianthifolia.* Other diagnostic species for this community include; trees *Erythrina lysitemon, Trichilia emetica, Euclea natalensis, Apodytes dimidiata, Clerodendrum glabrum, Cussonia zuluensis* and

Ekebergia capensis; the shrubs; *Chromoleana odorata, Lantana camara, Rhynchosia totta, Trimeria grandifolia, Deinbollia oblongifolia* and *Searsia nebulosa* and the herb *Bidens pilosa* as well as the grass species *Digitaria longiflora*.

The prominent species for this community are displayed in the full phytosociological table (Table 5.2) and include the most dominant the herb *Bidens pilosa* and the evergreen tree *Trichilia emetica*. Other prominent species in this community include the trees *Erythrina lysistemon, Trichilia emetica Apodytes dimidiata, Clerodendrum glabrum, Cussonia zuluensis* and *Ekebergia capensis* (Species Group K)*;* the shrubs; *Chromoleana odorata, Lantana camara, Rhynchosia totta, Hibiscus fritzscheae, Trimeria grandifolia, Deinbollia oblongifolia, Searsia nebulosa* (Species Group K) and *Euclea natalensis* (Species Group M).


a


b

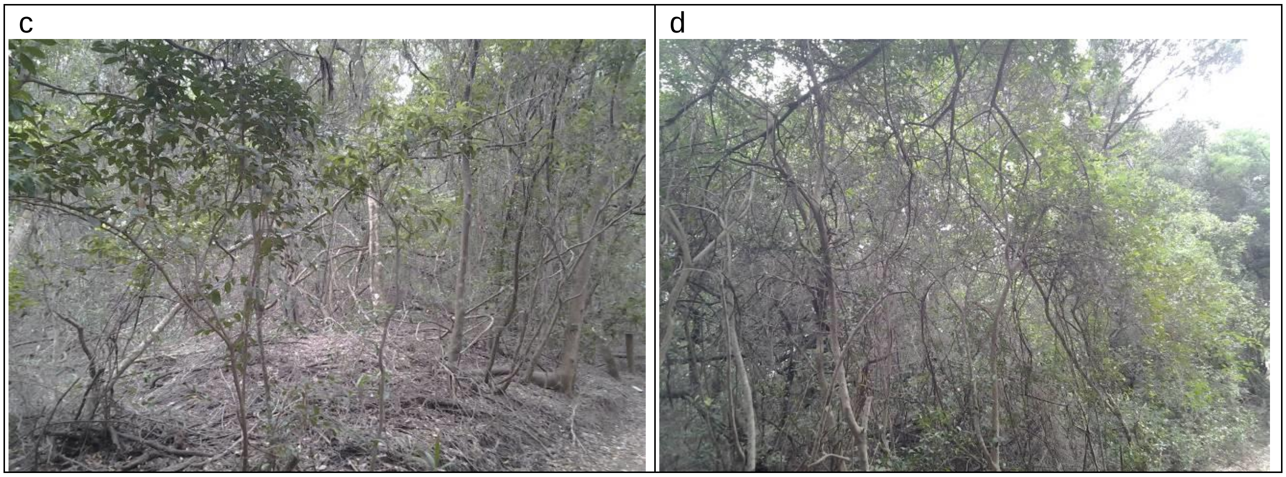


Photo-plate 10: *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest.

5.5.11 *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin

Tricalysia sonderiana–Apodytes dimidiata dune forest margin community occurs along the forest edges. It is demarcated as a narrow band in front of the dune forest (Photo-plate 11). It has deep, consolidated, developed sandy-loam soils. Water drainage in this community is very fast. Structurally, this community can be described as medium to tall dune forest. This community is floristically most similar to the *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest.

The diagnostic species for this community are listed in Species Group L of the synoptic table (Table 5.1) and include the most diagnostic species which is the small tree species *Tricalysia sonderiana*. Other diagnostic species include the woody climber *Rhoicissus* species and the tree species *Apodytes dimidiata*.

The most dominant species for this community are displayed in the full phytosociological table (Table 5.2) and include the most dominant tree *Apodytes dimidiata*. One of the reasons why this species occupies the forest margin might be that it needs light to grow to its best and it is fire resistant when growing along forest margins and it generally have a faster growth rate compared to other dune forest trees. As a result it grows best in these well-drained, rich soils of the forest margin. Other dominant trees include *Kraussia floribunda* and *Psydrax obovata* (Species Group R). The woody climber *Rhoicissus* species (Species Group L) and the shrubs *Euclea natalensis* (Species Group M) and *Eugenia capensis* (Species Group N) and the fern *Microsorum scolopendrium* (Species Group S).

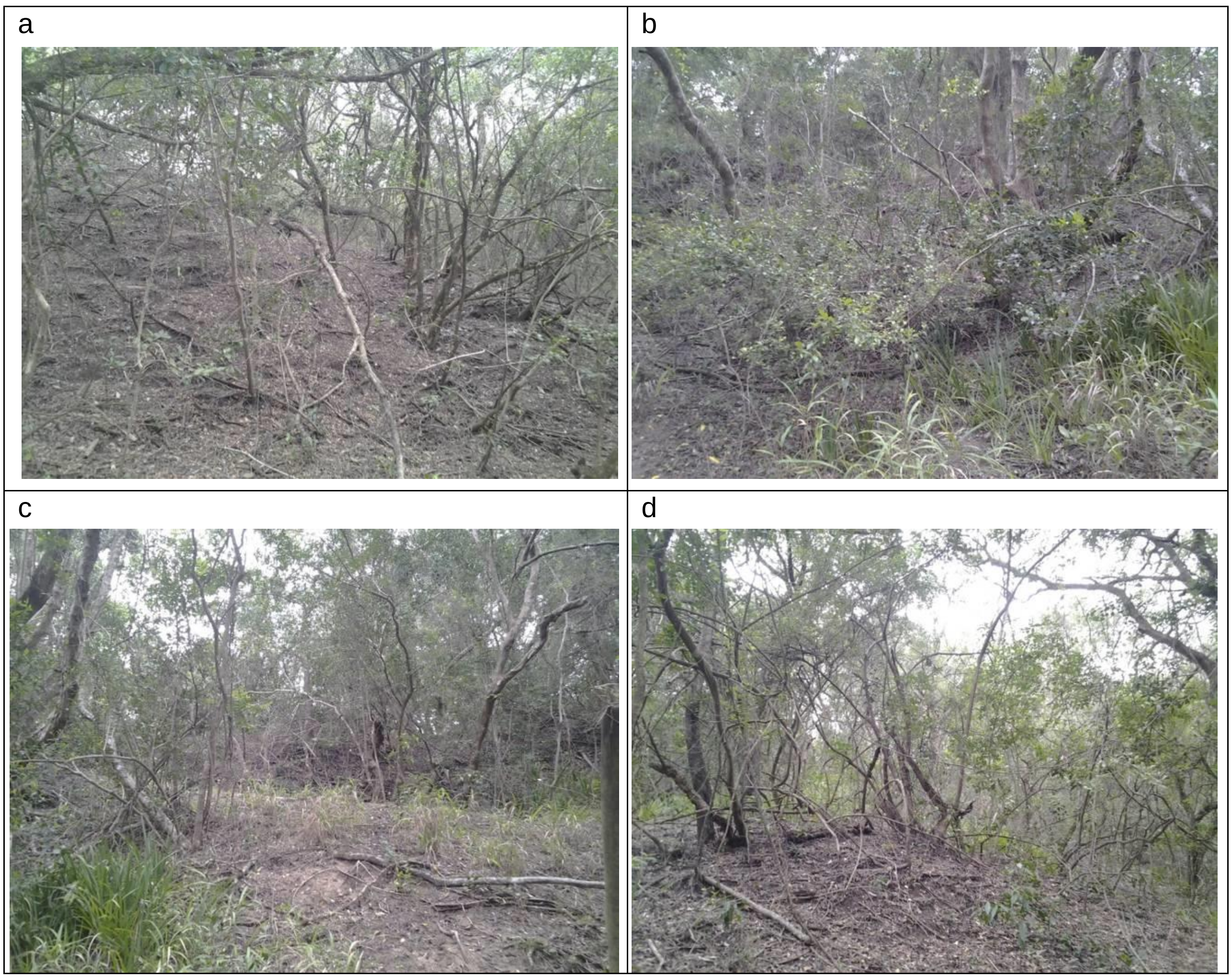


Photo-plate 11: *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin community.

5.5.12 *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest

Gymnosporia arenicola–Protorhus longifolia young coastal dune forest is found between the *Tricalysia sonderana–Apodytes dimidiata* dune forest margin and *Carissa bispinosa–Mimusops caffra* climax coastal dune forest and as a result displays strong floristic affinities towards these plant communities. Soils underlying this community are deep sands, and range from medium to course grained, with a high organic component. Structurally this community is classified as tall dune forest (Photo-plate 12). The forest canopy is less dense than the climax dune forest patched within uMNR, with more light reaching the forest floor.

The diagnostic species for this community are listed in Species Group O of the synoptic table (Table 5.1) and include; tree species *Protorhus longifolia* and *Tricalysia capensis,* straggling shrub *Gymnosporia arenicola* and straggling climber *Smilax anceps.*

The dominant species for this community are displayed in the full phytosociological table (Table 5.2) and include *Psydrax obovata* (Species Group R) as the most dominant tree species for this community. Other dominant species include the tree species *Protorhus longifolia, Maytenus procumbens, Sideroxylon inerme* (Species Group T) and *Garcinia gerradii* (Species Group T), climbers; *Smilax anceps* (Species Group O) *Kraussia floribunda* (Species Group R) and *Rhoicissus tomentosa* (Species Group Q) shrubs; *Gymnosporia arenicola* (Species Group O), *Peddia africana* (Species Group T), *Putterlickia verrucosa* (Species Group Q), *Chironia baccifera* (Species Group P) and the grasses *Panicum coloratum* and *Dietes* species (Species Group M).

a

b

c

d

e

f

Photo-plate 12: *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest.

5.5.13 *Carissa bispinosa–Mimusops caffra* climax coastal dune forest

Carissa bispinosa–Mimusops caffra climax coastal dune forest is associated with the oldest dunes extending up to the Mtunzini Conservancy of uMNR. This community covers the largest area of the study area. The dominant soil form underlying this community is deep sandy soil. Structurally, it can be described as a tall closed coastal dune forest (Photo-plate 13).

The diagnostic species for this community are listed in Species Group Q of the synoptic table (Table 5.1) and the most diagnostic are tree species *Mimusops caffra, Dovyalis longispina, Vepris lanceolata* and *Cussonia spicata.* The diagnostic variable shrubs to small trees are *Carissa bispinosa, Putterlickia verrucosa, Brachylaena discolor and Bersama lucens.* The diagnostic woody climbers include *Monanthotaxis caffra, Rhoicissus rhomboidea, Dalbergia armata, Rhoicissus tomentosa* and *Dalbergia obovata.* The diagnostic grasses include *Oplismenus hirtellus* and *Dietes* species as well as the orchirds *Cyrtorchis praetermissa, Polystachya sandersonii* and *Ansellia africana* (Species Group Q, Table 5.1).

The dominant species for this community are displayed in the full phytosociological table (Table 5.2) and include the tree species *Mimusops caffra* and shrub *Carissa bispinosa*. Other dominant species include the trees *Psydrax obovata*, *Kraussia floribunda* (Species Group R), *Ficus natalensis* (Species Group U), *Sideroxylon inerme* (Species Group T), *Psydrax obovata* (Species Group R), *Dovyalis longispina* (Species Group Q), shrub to small tree *Peddia africana, Brachylaena discolor* (Species Group Q), *Grewia occidentalis* (Species Group U), *Putterlickia verrucosa* (Species Group Q), *Allophylus natalensis* (Species Group U), *Carissa microcarpa* (Species Group U) and *Bersama lucens* (Species Group Q), woody climbers *Rhoicissus rhomboidea, Asparagus falcutus* (Species Group U), *Rhoicissus tomentosa (Species Group Q)* and the grasses *Oplismenus hirtellus*

(Species Group Q)*, Panicum coloratum* (Species Group T) and *Dietes* species (Species Group Q,) and the fern *Microsorum scolopendrium* (Species Group S) and *Microsorium punctatum*. Total species count for this community is 107, which is the highest for the entire study area (Fig. 5.13).

a

b

c

d


e


f

Photo-plate 13: *Carissa bispinosa–Mimusops caffra* climax coastal dune forest

CHAPTER SIX

Discussion, conclusions and conservation implications

6.1 Discussion

The uMlalazi Nature Reserve consists of a variety of vegetation types and it is fairly heterogeneous in terms of its floristic and community composition. It is therefore, not surprising that the study area have diverse plant communities (Figure 5.7, 5.8 & 5.9). The results of the present study reiterate the statements of Moll (1972) and Weisser (1978a) that uMlalazi Nature Reserve (uMNR) provides a classical example of primary succession and a great opportunity to study the relative importance of soil development, exposure to environmental stress, changes in nutrient supply, seed immigration, sand deposition, dune formation, dune stabilisation and dune colonisation.

The present study is an attempt to produce a more detailed fine scale phytosociological classification of some of the Maputaland communities. A correlation between the plant communities of the present study and other syntaxa described by many workers has been attempted. Thirteen ecologically interpretable plant communities have been distinguished, described and mapped. This data can be used in the uMlalazi Nature Reserve management, comparisons to other parts of Maputaland and even for further ecological studies.

The vegetation of uMlalazi Nature Reserve includes salt marsh on low elevations within floodplains, mangroves on intertidal zones, foredunes on top of the beach, grasslands and wetlands on interdune depressions, dune scrub on stabilised dunes, riverine woodlands on the edges of uMlalazi River and coastal dune forests on the oldest dunes (Figure 5.7 and 5.10).

6.1.1 Plant community relationships

To determine the floristic and habitat relationships between plant communities (based on environmental gradients, growth form and species composition) a table of all the related plant communities was prepared (Table 6.1). These comparisons should be used to indicate how these different communities could be grouped together, especially for the management of vegetation types in uMNR.

Table 6.1: Related plant communities and their underlying environmental gradients in uMlalazi Nature Reserve.

<table>
<tr><th>Plant community No.</th><th>Plant communities</th><th>Environmental gradients</th></tr>
<tr><td>1</td><td>Avicennia marina–Salicornia meyeriana salt marsh community</td><td rowspan="3">High moisture availability
High salt content
High clay content</td></tr>
<tr><td>2</td><td>Bruguiera gymnorrhiza–Avicennia marina mangrove forest</td></tr>
<tr><td>3</td><td>Phragmites australis–Juncus kraussii saline wetland</td></tr>
<tr><td>4</td><td>Scaevola plumieri–Gazania rigens foredune community</td><td rowspan="2">Low moisture availability
High wind exposure
High exposure to salt spray</td></tr>
<tr><td>8</td><td>Passerina rigida–Carpobrotus dimidiatus dune scrub community</td></tr>
<tr><td>6</td><td>Digitaria eriantha–Dactyloctenium australe secondary coastal grasslands</td><td></td></tr>
</table>

11	*Tricalysia sonderiana–Apodytes dimidiata* dune forest margin	Sandy soils Low moisture availability Low salt content Medium to high organic content
12	*Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest	
13	*Carissa bispinosa–Mimusops caffra* climax coastal dune forest	

The *Avicennia marina–Salicornia meyeriana* salt marsh community (community 1, Table 5.2), *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest (community 2, Table 5.2) and *Phragmites australis–Juncus kraussii* saline wetland (community 3, Table 5.2) are floristically related. This is ascribed to the high moisture availability, high salt content and high clay content on these communities. The salt content between these communities varies from each community with the *Avicennia marina–Salicornia meyeriana* salt marsh community having the highest, followed by the *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest having high salt content and *Phragmites australis–Juncus kraussii* saline wetland with moderate salt content. Although these communities are floristically and habitat relatives, they are easily distinguishable on the field based on structure, species composition and character species.

The *Scaevola plumieri–Gazania rigens* foredune community (community 4, Table 5.2) is related to *Passerina rigida–Carpobrotus dimidiatus* dune scrub community (community 8, Table 5.2). This indicates a habitat with low moisture availability, high wind exposure and high exposure to salt spray. These communities are floristically similar to those described by Weisser and Muller (1983) and Moll (1972) as Dune pioneers and *Passerina rigida* low scrub. The *Scaevola plumieri–Gazania rigens* foredune community is also similar *Carpobrotus dimidiatus–Gazania rigens* Dune vegetation described by Burger (2008).

The *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands (community 6, Table 5.2), *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin (community 11, Table 5.2), *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest (community 12, Table 5.2) and *Carissa bispinosa–Mimusops caffra* climax coastal dune forest (community 13, Table 5.2) are related. These communities develop in an environment with low moisture availability, low salt content and medium to high organic content. Their preferred soil type is deep sandy soil. These communities are similar to those described by Weisser (1982) and Weisser and Muller (1983) as the climax dune forest and secondary mixed dune grassland and dwarf shrubland.

The wetland communities *Typha capensis–Cyperus dives* wetland community (community 5, Table 5.2) and *Stenotaphrum secundatum–Phragmites australis* freshwater wetland (community 7, Table 5.2) are also floristically related to *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands, mostly due to the presence of herbaceous species. The *Typha capensis–Cyperus dives* wetland community is also floristically related to *Phragmites australis–Typha capensis* Tall closed Hygrophilous grassland described by Burger (2008) in Richards Bay. These communities are also floristically similar to that described by Venter (2003) as *Typha capensis–Ludwigia octovalvis* closed high peatland in Mfabeni Swamp.

6.1.2 Ordination and habitat interpretation

The results of an ordination indicate the position of releves in a multi-dimensional space (Figure 5.4 & 5.5) with relevés that are floristically similar close to each other, while relevés that are floristically different far from each other.

Ordination results indicate the classification of plant communities and they also give an indication of floristic and associated habitat gradients. All these proposed plant communities are distinguishable in the field based on structure, species composition and character species. This is regardless of the gradual environmental gradients that make these communities to fuse into one another especially in the case of the forests. The coastal forest margin, young dune coastal forest and climax dune forest are often difficult to distinguish based on floristics alone, but structure and growth form assist to distinguish them.

In the habitat ordinations the influence of certain environmental variables on the community distribution is illustrated in Table 5.3 and Figure 5.6. The distinct groupings of relevés in the ordination scatter diagram are a good indication of the unique nature of each and every community in uMlalazi Nature Reserve. The environmental variables that seem to have the strongest influence on plant species and community distribution are exposure to salt spray, salt content, moisture regime and human induced fire and grazing.

The results from ordination are interesting and seven aspects are noteworthy. Firstly, some communities with different dominant species such as communities 6, 11, 12 and 13 occur where similar environmental conditions prevail. This was unexpected since community 6 is the *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands community and the other communities are dune coastal forests. The author expected that community 6 would be in the same cluster with community 10 because they are both influenced by disturbance from the neighbouring community (Figure 5.6 & Table 5.3). However, this was not the case as ordination placed community 10 as a separate cluster and community 6 was placed together with the coastal forests. These results reiterate the statement of Bredenkamp and Brown (2003) that they are a close affinity between grasslands and bushveld communities, especially if these communities exist on the same geological substrate.

Secondly, the ordination cluster diagram also presented the evidence of dune vegetation succession in uMlalazi Nature Reserve. The *Scaevola plumieri–Gazania rigens* foredune community (community 4) are positioned on the bottom left corner of the ordination diagram. Next to them is the *Passerina rigida–Carpobrotus dimidiatus* dune scrub (community 8) followed by the large cluster of the dune coastal forests (community 11, 12 & 13) and secondary grasslands (community 6). Next to this community is the *Stenotaphrum secundatum–Phragmites australis* freshwater wetland (Community 7) followed by the *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community (community 9) on the very left top corner of the ordination cluster diagram. This was also observed in the field where one community of plants progressively gets replaced by another throughout the successional stages. This happened till a climax community was reached where the vegetation was in a state of relative equilibrium with the environment and there were no further influx of new species. Succession is the evolution of plant communities at a site over time from pioneer species to climax vegetation. During each stage of succession the community alters the soil and microclimate, allowing the establishment of another group of species (Goble *et al*., 2014).

Thirdly, the non-metric Multidimensional scaling ordination (Figure 5.4 & 5.5) of all relevés shows the wetland communities clearly separated from other terrestrial communities. The wetland communities are numbered as community 1, 2, 3, 5 and 7 respectively in Figure 5.5 and 5.6. However, a clay gradient still prevails between these wetlands, where the wetland communities close to the right corner of the ordination scatter diagram (*Avicennia marina–Salicornia meyeriana* salt marsh community and *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest) have high clay content and the wetland communities on just below community 10 (*Typha capensis–Cyperus dives* wetland community and *Phragmites australis–Juncus kraussii* saline wetland) have medium to low clay content.

Fourthly, all the communities that develop in a saline environment formed three strong groups that are restricted to the right of the ordination scatter diagram separated from the rest of other communities (Figure 5.6, 5.8 & 5.11). The *Avicennia marina–Salicornia meyeriana* salt marsh community (community 1), *Bruguiera gymnorrhiza–Avicennia* *marina* mangrove forest (community 2) and *Phragmites australis–Juncus kraussii* saline wetland (community 3) are positioned distinctly to the right of the ordination cluster plot while the other communities are positioned on the opposite end from these communities. The amount of salt content in the soil plays a major role in the development of plant communities. There is also a soil moisture gradient between these three communities. However, they all have a strong ability to capture and store moisture within reachable depth of the plant roots.

The fifth aspect and is that sandy particles are angular with a relatively low surface area, because of their size. While on the other hand clay soils have a smaller size relative to sandy soils and a large surface area. This surface area allows them to absorb more water and other substances. This is shown by the positioning of clusters of *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community and the *Avicennia marina–Salicornia meyeriana* salt marsh community. They are a very long distance between these two communities which is a result of the different soil types that these communities develop on. As a result soil type and moisture regime seems to play a significant role in the development of the communities in uMNR.

The *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest (community 10) is positioned as a separate cluster in the top right corner of the ordination scatter diagram (Figure 5.4 & 5.5). This is was not surprising since this community is different from the rest of other communities. The habitat of this community has been largely altered by disturbances from the neighbouring community and even tourists in some cases. This community has become dominated by shrubs instead of trees and it occurs as patches which is evidence that this community is now fragmented.

The *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community (community 10) is positioned on the left corner of the ordination cluster diagram (Figure 5.4 & 5.5). Although some of the relevés of this community overlap to the coastal dune forest, they have proven to be unique from the rest of other communities (Figure 5.8, 5.11 & 5.12). When comparing their position to that of the *Scaevola plumieri–Gazania rigens* foredune community (community 4) on the bottom left corner of the ordination cluster diagram. There is a significant difference between these communities. These communities present three gradients from top (*Hibiscus tiliaceus–Vachellia robusta* riverine woodland community) to bottom (*Scaevola plumieri–Gazania rigens* foredune community). Moisture availability decreases from top to bottom, while organic content increases from top to bottom. Wind exposure increases from top to bottom and exposure to salt spray also increases from top to bottom as well.

6.1.3 Botanical importance ratings of plant communities

The botanical importance ratings were used to rate the conservation values of each community. Certain plant communities have little botanical value but receive high conservation efforts and some communities posses great botanical value but receive little conservation efforts. An effort was made in this study to determine the botanical importance of the different communities purely from a botanical perspective. The ecological value of each community within the greater landscape was not incorporated into the rating. A good example would be a *Phragmites* dominated wetland. Although it is generally considered to have an extremely high value in terms of hydrological funtion for the entire surrounding landscape, it is also generally considered to be species poor and of a low botanical importance.

- **High botanical Importance**
    - *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community
    - *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest
    - *Carissa bispinosa–Mimusops caffra* climax coastal dune forest

  - *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest
  - *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands
  - *Tricalysia sonderana–Apodytes dimidiata* dune forest margin

- **Intermediate to low botanical Importance**
  - *Avicennia marina–Salicornia meyeriana* salt marsh community
  - *Phragmites australis–Juncus kraussii* salt wetland
  - *Typha capensis–Cyperus dives* wetland community
  - *Passerina rigida–Carpobrotus dimidiatus* low shrub community
  - *Scaevola plumieri–Gazania rigens* foredune community
  - *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest
  - *Stenotaphrum secundatum–Phragmites australis* freshwater wetland

The *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community is one of the most important plant communities in uMlalazi Nature Reserve (Figure 5.8, 5.11 & 5.12). This community forms part of the Lowveld Riverine Forest (FOa1) vegetation type. This vegetation type has been regarded as critically endangered as many of the areas with this vegetation unit have been lost to agriculture, building of dams and invasion by alien plants. The association of this *Hibiscus tiliaceus–Vachellia robusta* riverine woodland community with the floodplains indicates its particular importance both as woodland habitat and as nesting sites for water birds. Although this community is listed as critically endangered due to land clearing and fragmentation, it is highly preserved in uMNR and for this reason it should be valued as an important natural riverine forest reference.

Table 6.2: Criteria used for botanical importance ratings

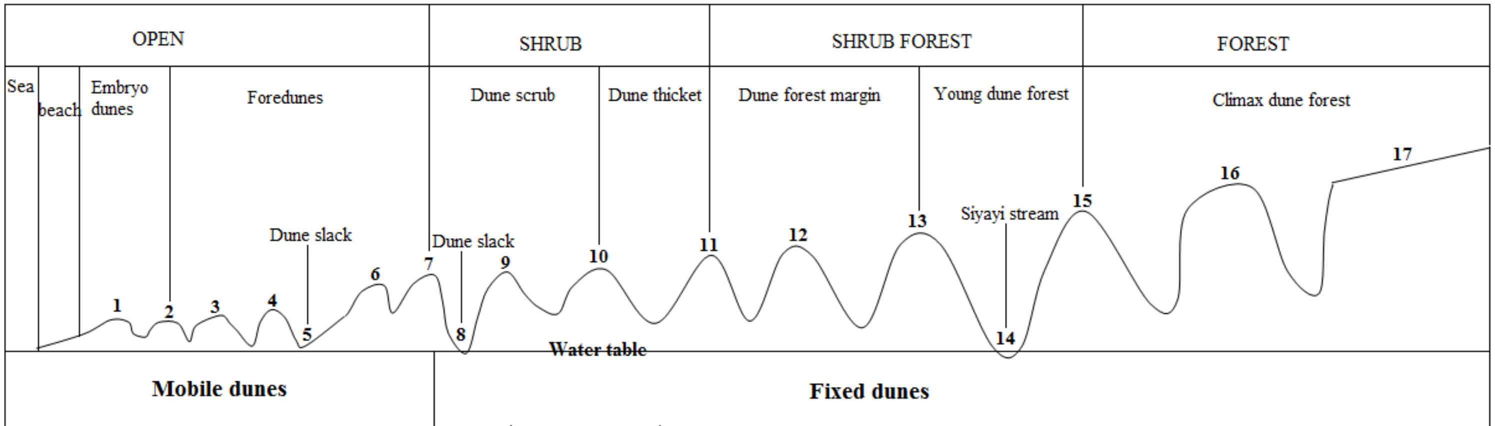
Plant community	Species richness	Conservation status (SANBI, 2010)	Human disturbance	Socio-economic importance	No. medicinal plants recorded
1	Low	Least threatened	Low	Low	None
2	Low	Critically endangered	Low	Low	None
3	Low	Least concern	Medium	Very high	None
4	Low	Least threatened	Low	Low	02
5	Low	Least threatened	Medium	High	02
6	Medium	Least threatened	Very high	Medium	03
7	Low	Least threatened	Medium	High	02
8	Medium	Least threatened	Low	Low	05
9	High	Critically endangered	Low	Low	05
10	High	Least threatened	Very high	Medium	08
11	Low	Least threatened	Low	Low	06
12	Very high	Least threatened	Low	Low	18
13	Very high	Least threatened	Low	Low	32

This community is distinctive and occur as a narrow band along the uMlalazi River. They are very dynamic systems with some continuous changes in their extent, structure and composition taking place. Within the uMlalazi Nature Reserve, *Vachellia robusta* is a very good indicator of the *Hibiscus tiliaceus*–*Vachellia robusta* riverine woodland community. This plant species is identified through its robust way that it reaches high together with its strong upright branches. According to Guldemond and Van Aarde (2010) the topographical and climatic conditions have caused the discontinuous distribution of these forests, while fire and other anthropogenic activities may have further fragmented this vegetation unit. Nevertheless, in the study area this community has an important value especially with its unique *Vachellia robusta* woodlands stand out as habitats for bird life, which is currently threatened by agriculture and invasion by invasive alien plants. As a result, this community may after some years, be floristically and environmentally different or more diverse than at present state. Therefore, this community should receive very high conservation efforts. A floristic analysis of this community will also need more attention in the nearby future since it also plays a major role in the ecosystem as the habitat for birds.

The *Tricalysia sonderiana–Apodytes dimidiata* dune forest margin, *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest and *Carissa bispinosa–Mimusops caffra* climax coastal dune forest are the second communities that require high conservation efforts (Figure 5.7–5.13 & Table 6.2). These communities combined have the highest species richness (Table 5.3) of all communities in uMNR. Many areas with this community have been disturbed elsewhere in the Maputaland region. The uMNR represents one of a few natural dune coastal forests in the Maputaland region.

Tricalysia sonderiana–Apodytes dimidiata dune forest margin of the dune forest is sharply demarcated beginning just behind the dune thicket (Figure 6.1 & 6.2). Some of the species that occur in this community include *Microsorium scolopendium*, *Apodytes dimidiata*, *Eugenia capensis*, *Euclea natalensis*, *Tricalysia sondreana* and *Rhoicissus* species. According to Mold (2007) in the dune forest sand accumulation stops and fixed dunes become established, shell material is no longer delivered to the dune and $CaCO_3$ begins to leach out, as a result pH decreases. Nitrogen mineralisation increases as more soil organic matter collects, soil moisture also increases. In a study of the dune communities at Pennington Park where they were similar species composition, Moll (1972) found that the change in the physiochemical conditions produces an environment favourable to more plant species and therefore more species can become established in this community.

The *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest and *Carissa bispinosa–Mimusops caffra* climax coastal dune forest (Figure 5.4) consists of at least three strata, namely a grass and herb layer, a shrub and a tree layer. In some parts of this community lianas are present interconnecting the three layers of vegetation. Weisser (1978b) considered this type of the forest as a "Decompositional phase" owing to an overmaturity of the forest. When the old trees die and fall climbers soon invade the area with a blanket of lush vegetation. Whether or how quickly the trees can reconquer the spaces invaded by climbers is unknown. If the forest is able to re-instate itself with a species composition similar to the original, we could have a cyclical climax, in which a forest stage and climber stage would be alternating. The occurrences of this invasion by climbers at different times and in small areas result in a mosaic landscape, formed by high forest and areas densely covered with climbers. Some of the orchid species that grow on the stems of the trees in this community include *Polystachya sandersonii, Cytorchis praetermiss* and *Anselia africana*. All these orchids seem to be associated only with the climax dune forest. As a result the conservation of this community is important for the protection of these orchids.



	Embryo dunes	Foredunes	Dune slacks	Dune scrub	Dune thicket	Dune forest margin	Young dune forest	Climax dune forest
Distance form the sea (~m)	90-100	120-180	184-190	189-199	201-299	300-380	420-517	578-650
Approximate age (years)	10	30	50	60	90	120-145	150-180	250-350
Dominant species	1. *Scaevola plumieri* 2. *Gazania rigens*	1. *Gazania rigens* 2. *Scaevola plumieri* 3. *Ipomoea pes-caprae*	1. *Stipagrostis zeyheri* 2. *Microsorum scolopendrium*	1. *Carpobrotus dimidiatus* 2. *Passerina rigida* 3. *Eugenia capensis*	1. *Krausia floribunda* 2. *Eugenia capensis* 3. *Mimusops caffra*	1. *Apodytes dimidiata* 2. *Psydrax obovata* 3. *Euclea natalensis*	1. *Psydrax obovata* 2. *Protorhus longifolia* 3. *Sideroxylon inerme*	1. *Mimusops caffra* 2. *Carissa bispinosa* 3. *Dovyalis longispina*

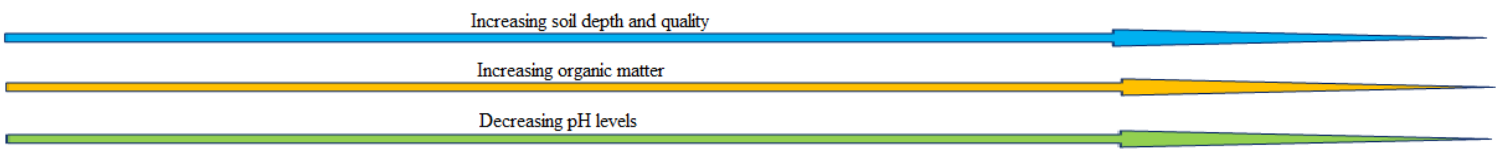


Figure 6.1: A profile of the dune system ranging from pioneer communities to climax forest vegetation in uMlalazi Nature Reserve.

Figure 6.2: Aerial photograph of dune succession in uMlalazi Nature Reserve (after Google Earth, 2015).

The *Carissa bispinosa–Mimusops caffra* climax coastal dune forest community forms part of the East African Tropical Coastal Forests which extends along Mozambique, Tanzania, Kenya and Southern Sudan coast. Nevertheless, in east Africa these forests have a larger inland extent than in the study area. The *Carissa bispinosa–Mimusops caffra* climax coastal dune forest is significantly denser than the *Gymnosporia arenicola–Protorhus longifolia* young coastal dune forest. It has a more complex structure and even richer floristic composition compared to a young dune forest. These results were also found by Moll (1972). According to Moll, (1972) a number of canopy trees that were not present in the previous communities start to appear in this community. They include; *Vepris* *lanceolata*, *Olea woodiana*, *Sideroxylon inerme* and *Dovyalis longispina*. This tall closed coastal forest is rich in tree and liana species.

In terms of tree and shrub species, the uMNR dune forests and the entire Maputaland are the most species rich dune vegetation in South Africa. MacDevette (1993) stated that the forests also represent a highly diverse store of genetic material. As species numbers increase inter-species competition becomes the dominant factor controlling species presence or absence in this community. The sand disappears and the dunes change colour from yellow to grey. Then, taller plants such as *Mimusops caffra*, *Psydrax obovata* and *Sideroxylon inerme* and more complex plant species can now grow. As a result plants from the earlier stages die out because of competition for light and water. Von Maltitz *et al*. (2003) found that endemism is very rare with the coastal dune forest, although a large number of trees and birds reach their southern most limits in this ecoregion. MacDevette (1993) even stated that the Zululand dune forests exhibit one of the highest levels of alpha diversity of the forests in South Africa and conserve a large variety of woody species. The age of dunes varies from approximately 10 years in the foredunes to about 250–350 years in the climax dune forest (Goble *et al*., 2014) (Figure 6.1).

Thirdly, the *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest should also receive high conservation efforts due to its sensitivity and complex environmental requirements. The *Bruguiera gymnorrhiza–Avicennia marina* mangrove forest is the best example of a mangrove forest within the study area. They are only two mangrove species that occur in the study area, *Avicennia marina* (White mangrove) and *Bruguiera gymnorrhiza* (Black mangrove) and they can cope with the varying conditions of salinity, tidal inundation and anaerobic mud. The roots of both these tree species are specially adapted to cope with episodic flooding and drying out. These trees are therefore halophytes (salt loving) and have special mechanisms for coping with conditions of high salinity. Aerial roots in both species adapt them to cope with the low levels of oxygen available in waterlogged soil.

Avicennia marina acts as a pioneer species in the mangrove community that has wide tolerance ranges for salinity, tidal inundation and salinity and colonises new suitable habitats. This species has an extensive shallow system of horizontal cable roots that radiate out from the base of the trunk. The unbranched pensel roots grow up from the cable roots, providing the tree with pneumatophores by which the subterranean portion of the tree is able to breathe. As mangroves expand into new available habitats they contribute additionally to the sedimentation process by trapping sediment between their roots. However, excessive sedimentation in mangrove stands may also result in higher elevation and dieback when sediment accretion causes smothering of pneumatophores.

Bruguiera gymnorrhiza however, was the most widely distributed species within the mangrove forest. This is possibly because it survives in lower salinity and drier habitats than *Avicennia marina*. *Bruguiera gymnorrhiza* has the knee roots that protrude from the mud and serve as the aerial breathing roots. Nevertheless, both these mangrove species have leaves adapted for the exclusion of salt and seeds adapted for quick germination in the muddy, unstable soils.

Further north of the study area in St Lucia estuary, the mangroves are dominated by more than two species compared to uMNR where only two mangrove species occur. The mangrove forests at Kosi Bay have six species (Grobler, 2009). These include *Avicennia marina*, *Bruguiera gymnorrhiza, Ceriops tagal, Lumnitzera racemosa, Acrostichum areum* and *Rhizophora mucronata*. The mangroves of uMNR lack the occurrence of these species especially *Rhizophora mucronata* which is a widespread mangrove tree further north of the study area.

In fourth is *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands. This community should be maintained through burning to prevent the establishment of woody species.

The *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands (community 6) are wet and moist grasslands. This community is severely affected by disturbances such as cattle grazing and fire. Burning should be the main management tool used in uMNR to arrest the encroachment of woody species in these grasslands. White (1983) distinguished two broad types of grassland in the Maputaland-Pondoland Regional Mosaic, the edaphically controlled grassland which is associated with scattered palms on poorly drained soil and secondary fire maintained grassland that has replaced the anthropogenically disturbed coastal dune forest. MacDavette (1993) described this vegetation type as occurring on forest margins and on old disturbed areas.

These grasslands have been burnt annually to biannual for quite some time already. These burns are either natural or often anthropogenic. The current fire regimes, where not combined with high numbers of cattle, seems to have no detrimental effect on the biodiversity of these grasslands but is essential for their maintenance. As a result in the case of the management of this community, annual random mosaic burns is a useful strategy if the current habitats are to be maintained in a reasonable natural state, although cattle grazing should be kept at the lower levels. These grasslands occur along the interdune depressions in uMNR. They have high species richness.

Siebert *et al*. (2011) confirmed the occurrence of the MWG vegetation unit west of Richards Bay, where it probably forms the southernmost outlier population of this vegetation unit in the Indian Ocean Coastal Belt Biome. The study by Siebert *et al*. (2011) also found that there is a relationship that exists between the Woody Grassland of the study KwaMbonambi area and the Maputaland Woody Grassland of Sileza Nature Reserve. Fire has been identified as an important determinant of vegetation structure on the grasslands of uMNR. However, in future, fuel loads may be low should grazing persist in these grasslands. Future research should look at the influence of fire on vegetation structure, and determine how best to control frequent burning in these grasslands.

Next is a series of communities that are regarded to have intermediate to low botanical importance in uMlalazi Nature Reserve.

6.1.3.1 Wetlands

They are four types of wetlands that occur in uMlalazi Nature Reserve. They include *Avicennia marina–Salicornia meyeriana* salt marsh community, *Phragmites australis–Juncus kraussii* saline wetland, *Typha capensis–Cyperus dives* wetland community and *Stenotaphrum secundatum–Phragmites australis* freshwater wetland. These wetlands cover ~ 30% of the total study area. The *Stenotaphrum secundatum–Phragmites australis* freshwater wetland covering ~ 15%, *Phragmites australis–Juncus kraussii* saline wetland covering about 10%, *Avicennia marina–Salicornia meyeriana* salt marsh community covering approximately 2% and the *Typha capensis–Cyperus dives* wetland community covering almost 3%.

Some of these wetlands become temporarily inundated with some open water for a short period during very wet seasons. However, land-use activities such as agriculture, forestry, mining and water supply schemes have impacted the distribution of wetlands in the entire south of the Maputaland region. Wetland loss in the uMNR will be significant problem for many local communities that depend on them as a natural resource. This is supported by Pretorius *et al*. (2014). Although Pretorius *et al*. (2014) studied wetlands that are not in a protected area compared to the current study where only protected wetlands were sampled. Pretorius *et al*. (2014) found that the wetlands of the Maputaland Coastal Plain are currently under stress as a result of intensified forestation and agricultural practises. These wetlands are currently being exploited on a large scale for their goods and services. Human population increases are also putting a demand on these resources which they cannot be sustained.

In a study on the distribution of wetlands over wet and dry periods by Grundling *et al*. (2013), similar wetland plant communities were mapped and described. However, the study focused on using Landsat remote sensing imagery with ancillary datasets to establish wetland extent and permanence, as well as land-use activities and its change. Some of the similar plant communities were described by Venter (2003) and Burger (2008). Although these communities have some similar dominant species (*Typha capensis*, *Juncus kraussii, Phragmites australis, Cyperus dives* and *Cynodon species*) as communities 5 and 7 respectively, it seems that these communities do differ significantly as far as total species composition is concerned from those found in uMlalazi Nature Reserve. In the study area, *Juncus kraussii* (Photo-plate 3) form dense stands of nearly homogenous vegetation, whereas in Mfabeni swamp their cover abundance values are much less. This may however be caused by the fact that Mfabeni swamp is largely dominated by swamp forests or it might be caused by differences in plot sizes used in uMlalazi Nature Reserve and those used in Mfabeni swamp. Nevertheless, *Phragmites australis*, *Cyperus dives* and *Typha capensis* have high cover abundance values in Mfabeni swamp, Richards Bay and in the uMNR.

These wetland communities are influenced by the topography of the study area, which plays a significant role in the origin and the maintenance of these wetland communities. These communities are unique in the study area with the absence of trees and shrubs distinguishing them from other communities in uMNR. Nevertheless, the cover abundance of *Phragmites mauritianus* is very low in the study area. This species have been found to have higher cover abundance values in the studies of Marian and Ellery, (2006) and Burger (2008).

On the south parts of uMNR, *Typha capensis–Cyperus dives* wetland community display a seldom growth of *Phragmites australis* and *Typha capensis*. This was also found by Burger (2008) in Richards Bay.

Wetlands in general are considered to have low-value in their normal condition because they cannot be used for most agricultural activities and increasing pressure still exists to drain the marshes to provide high-value land for urban development (Mitsch and Gosselink, 2000 and Keddy, 2010). In the study area, wetlands are very important in providing valuable ecosystem services to an increasing population and tourism demand. The uMNR management allows the surrounding communities to come and harvest *Juncus kraussii* bi-annually during the first two weeks of May. Harvesting, weaving and production of craftwork items from wetland plants are very important in the KwaZulu-Natal province. The plant species that are harvested include *Juncus kraussii* and *Phragmites australis.* Harvesters in the uMNR produce a number of different items of craftwork. Such items include water tight buskets, calabash lids, foam removers for traditional beer, beer spoons, blinds and screens, bags, door mats, washing baskets, table and sleeping mats for both home use and as gifts for special traditional occasions (Traynor, 2008).

The cutting of *Juncus kraussii* and *Phragmites australis* stimulates new growth of these species. However, Traynor *et al*. (2010) suggested that both these plants display strong seasonal aboveground productivity patterns, therefore cutting should take place after shoot senescence and before new shoot emergence to minimise damage to plants.

Since speculation on uMlalazi Nature Reserve's wetland ecology and hydrology do not fulfil one of the major objectives of the study, no in-depth wetland ecology and hydrology was undertaken, although such future in-depth study is recommended.

6.1.3.2 Pioneer communities

The dune pioneer plants of uMNR are able to colonise the bare shifting sand above the intertidal beach zone by means of special adaptations and plant modifications. These pioneer plants display a creeping rhizomatous growth form with leaves covered by a thick waxy cuticle tolerant to salt spray and abrasion. These species can withstand burying for some time and have adaptations to prevent water loss. In this area the key pioneer species that is able to stabilize the sand and grow in response to the accumulation of sand (accretion) is *Scaevola plumieri*. The colonies of *Scaevola* usually form an open, scattered community which grow up to about 1 m in height (Figure 6.1 & 6.2). *Scaevola* has a continuous stem elongation and adventitious root production in the sand covered stems. *Scaevola* is tolerant to salt spray and in the reserve it occurs up to the third dune. However, vigorous *Scaevola* colonies are dominant only on the first dune.

Moll (1972) did not formally describe any of the saline wetlands, coastal grasslands and related communities but rather concentrated only on the dune succession from pioneers to dune forest. He did, however, give a basic species composition list for the foredunes, dune scrub, thicket and dune forest. The dune communities described by Moll (1972) correspond closely with the dune communities described in the study area.

According to Moll (1972) interspecies competition is not dominant on many dunes, but salt spray, mechanical stress, nutrient availability and water supply are key factors determining the species present and species diversity. This was further supported by the most recent study done by Goble *et al*. (2014) which stated that salt spray and a high permeability are major factors affecting the strandline and embryo dunes and so colonising plant species need to have xerophytic and halophytic characteristics. As more sand accumulates, the embryo dunes are colonised by other species of grass as well such as *Ipomoea pes-caprae* and *Gazania rigens*. The roots and rhizomes of these grasses have a stabilising effect on the sand.

Goble *et al*. (2014) found that the types of pioneer plants that colonise the dune usually determine the type of vegetation that will establish in that particular region. In the coast of KwaZulu Natal, there is a prevalence of longitudinal foredunes if the pioneer plant species are *Scaevola plumieri* and *Ipomoea pes-caprae*, but dune hummocks are formed if the pioneer species are *Arctotheca populifolia*.

6.1.3.3 Secondary communities

In the uMlalazi Nature Reserve distinct scrublands occur landward of the pioneer zone. These scrublands form the *Passerina rigida–Carpobrotus dimidiatus* dune scrub community. This community develop after the dunes have been stabilised and there is clear modification of the soil by pioneer species (Figure 6.1 & 6.2). The most common and dominant shrub species are *Passerina rigida* and *Eugenia capensis*. This community compare very well with those described by Burger (2008) in Richards Bay. Nevertheless, Burger (2008) represented this community as *Chrysanthemoides monilifera–Casaurina equisetifolia* dune scrub. The species *Chrysanthemoides monilifera* is also widespread in the study area but the alien tree *Casaurina equisetifolia* is absent in the uMlalazi Nature Reserve. This is due to the fact that the dune scrub community in Richards Bay is highly affected by disturbances compared to the one in uMNR where it is protected. Also in Richards Bay there were only two diagnostic species to this community compared to this study where they are more than fifteen diagnostic species in this community.

In overall species composition of the dune vegetation described in this study exhibit many similarities with those described in the previous studies (Burger, 2008; Moll, 1972; Weisser and Marques 1979; Weisser and Muller; 1983 and Weisser, 1978a, 1982).

The *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest was found in uMlalazi Nature Reserve. Coastal dune forests are highly dynamic transitional ecosystems, connecting the marine and terrestrial environments (Lucrezi *et al*., 2014 and

Grainger and Van Aarde 2011). Some of the main disturbances that shape this community in uMlalazi Nature Reserve include recreational activities, fire, and invasion by alien plants, footpaths and roads. Within the heart of the reserve dune forests are highly protected. However, the increasing demand for coastal exploitation (tourism) has over the years put pressure on the uMNR management to provide new infrastructure and facilities such as toilets, car parks, resorts and houses which has resulted in the establishment of this community. Nevertheless, some other good initiates have been taken by the uMNR management to ensure that they is controlled access to the dunes as they is signage that educate the visitors on the value of the dunes and beaches and the threats they are facing.

Further south of the uMNR this community is impacted by fire and the neighbouring community who exploit this community through harvesting of timber and medicinal plants. As a result in this part of uMNR anthropogenic disturbances are the main influencing factors. Most of the diagnostic species in this community are invasive alien plant species. They include *Bidens pilosa, Chromoleana odorata* and *Lantana camara.* Palmer and Parak, (2012) developed the Coastal Vulnerability Index (CVI) for the KZN coast. CVI assess the relative physical vulnerability of the KZN coast. They found that as development pressure increases the natural functioning of the coast is lost. The changes in the natural functioning of the coast coupled with the threat of future sea level rise and climate change makes it very important that the coastal managers gain a better understanding of the vulnerability of the coast to these events.

We are most likely to see more establishment of this community in the areas surrounding the study area. This is due to the fact that an Environmental Authorisation (EA) was issued by the Department of Economic Development, Tourism and Environmental Affairs (DEDTEA) which was formally known as the Department of Agriculture and Environmental Affairs (DAEA) to Tronox KZN Sands for the mining of sand dunes. We might even see the growth of the plant species such as *Casuarina equisetifolia* which was identified by Burger (2008) further north of the study area in Richards Bay, where sand dune mining have been happening for a number of years. MacDevette (1993) found that coastal dune forests are resilient to disturbances. If they experience disturbance they become patchily distributed.

The Convention on Biological Diversity states in its preamble that the contracting parties should recognise the dependence of local communities on biological resources (DEAT, 1998). Therefore, it is proposed that future research be conducted in the people inhabiting south of uMNR and especially their traditional dependence on the vegetation should be taken into consideration. The recognition of the human component is important to the conservation and sustainable use of biodiversity (Siebert, 1998). This will also assist us understand that how can the plant communities be protected whilst at the same time also benefiting the local communities.

6.2 The ecology and conservation of uMlalazi Nature Reserve

The results of both the ordination and the classification indicate a substantial difference between the vegetation types associated with the clay soils and the vegetation types associated with the sandy soils. Species Group A, B and C of the synoptic table (Table 5.1) presents the plant communities that are restricted to the saline environment and these are one of the most unique vegetation types in uMNR. Although these communities are species poor compared to other communities, their occurrence is extremely important in uMNR.

Species Group D, I, L, O and Q of the synoptic table (Table 5.1) presents the communities that are as a result of dune succession. The vegetation of these plant communities is very important because in the absence of it, the dune systems can exhibit significant mobility, where all or part of the dune migrate. The type of vegetation that grows on dunes has special adaptation characteristics that allow it to establish, grow and trap sand in the harsh conditions of coastal areas (Mold, 2007). Those harsh conditions include rapid sand accumulation, flooding, salt spray, sandblast, wind and water erosion, drought, wide temperature fluctuations and low nutrient levels.

All these heterogeneous vegetation types and plant communities fall within an estimated area of only 1 469 hectares. The conservation of such a biological hotspot should be a regional, provincial and national priority. The uMlalazi Nature Reserve represent a number of vegetation types that are important for conservation of vegetation of the entire KwaZulu-Natal province. This nature reserve should act as a benchmark site for the monitoring of the impact of development on the surrounding unprotected areas.

The high diversity in the vegetation patterns in the uMNR and the entire Maputaland is the results of the three reasons; (1) because they are a large number of habitats found in the region. The levels of endemism are spread across throughout the taxonomic spectrum, involving both plants and animals. (2) Because of its position, the Maputaland region is a tropical–subtropical transition zone. It lies within the Tongaland-Pondoland Regional Mosaic, which has high levels of endemism and forms part of the new Indian Ocean Coastal Belt biome. (3) The biodiversity in the uMNR is at the landscape level. The difference among the major land types and their biota are effectively controlled by the physical and chemical characteristics of the environment. Climate plays a primary role but geology, topography and soil are also very important (Conservation International Southern Hotspots Programme, 2010).

The interpretation of the vegetation data suggests that the present human pressure on the uMNR is still low. However, certain parts of the study area have been altered through intense anthropogenic activities over extended periods of time. The anthropogenic activities have shaped some of the plant communities found in the study area such as the *Digitaria eriantha–Dactyloctenium australe* secondary coastal grasslands and *Albizia adianthifolia–Trichilia emetica* disturbed coastal dune forest.

It is important to identify and to understand the major ecological processes driving this unique ecosystem in order to conserve and manage it effectively

6.3 Conclusion

Plant communities are recognizable and complex assemblage of plant species which interact with each and sharing the common elements of their environment that is distinct from adjacent assemblages. As these plant communities tend to co-occur on the landscape due to shared environmental factors, they offer a valuable framework for arranging biological information for land management and conservation planning. Plant communities are not static entities; rather they may vary in appearance and species composition from place to place and over time.

The main aim of the study was to provide the uMlalazi Nature Reserve management a yardstick by which different plant communities can be identified, monitored, evaluated, managed and protected. Without these scientifically based classifications conservation authorities will not be able to report meaningfully on the state of their vegetation, nor set and adapt conservation priorities as required by the National Environmental Management Biodiversity Act (Act 10 of 2004) (Von Maltitz *et al*., 2003). On the contrary, we cannot manage something we cannot describe; we therefore need to define what plant communities of the uMlalazi Nature Reserve are, so that we can define the performance and accountability of the uMNR management in managing and conserving these plant communities.

The Braun-Blanquet approach showed to be an accurate and successful way to identify and classify plant communities based on their floristics. An ordination was effectively used to validate and refine the classification and to determine any environmental gradients. Most of the plant communities identified in this study were also described from other areas in the Maputaland region.

The aims of the study were adequately achieved. The vegetation of uMNR was efficiently assessed, classified and described. The vegetation of uMNR was classified into thirteen plant communities. The communities that occur in the heart of the reserve are relatively undisturbed. The main reason for this is the fact that humans do not have a significant influence on the vegetation as it is not easily accessible. The communities that occur further south in the uMNR are relatively disturbed with the occurrence of alien invasive plant species, grazing and even uncontrolled burning. These disturbances are caused by humans and their impacts on these plant communities. These plant communities can be maintained by eliminating alien invasion, uncontrolled burning and overgrazing in order to ensure that remain in their natural state.

The described plant communities of uMNR can be seen as surrogates for the underlying ecosystems. These plant communities should form the basis for conservation and management planning within the uMNR. They should further be used as a benchmark and as reference examples of undisturbed primary vegetation in order to measure the ecological integrity of similar systems within the Maputaland region.

When the state of the environment in the uMNR and surrounding areas is considered in light of the current proposed and ongoing developments in the region, the future of conservation doesn’t look good. The existing pressure from the mining industry and a growing human population are not likely to disappear anytime soon. This study suggests that the future conservation of the region is dependent on the formation or strengthening the partnership for ecosystem conservation (Swanepoel, 2006). This partnership should include the mining industry, local conservation agencies, the provincial environmental management departments, local people and all other interested and affected parties (I&APs).

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Appendix A–Field survey form

BRAUN-BLANQUET SURVEY: uMLALAZI NATURE RESERVE

Contact details: Mr N.S Zungu cell: 073 478 4404, Dr THC Mostert cell: 082 7839 801

Relevé no.: __________ Date_____________ Aspect_____________ Slope_____________%

Vegetation type________________________________

Soil: Clay: __________ Organic Content in top soil: H M L

Water drainage: ____

Other: ____

____ Soil form________________________

	Height	Cover
Tree (tall):	_________m	________%
Tree (short)	_________m	________%
Shrub:	_________m	________%
Grass:	_________m	________%
Forb:	_________m	________%
Rock size	_________mmØ	________%

Total_________%

Topography

Bare patches: _________%

Structure: ____

____

Vegetation condition: ____

Notes____

____

No.	Tree	BB	Grasses	BB	Forbs	BB	Invasive alien plants	BB

Appendix B–Species checklist

Acanthaceae

Asystasia gangetica

Achariaceae

Kiggelaria africana

Anacardiaceae

Harpephyllum caffrum

Protorhus longifolia

Searsia nebulosa

Annonaceae

Monanthotaxis caffra

Amaranthaceae

Amaranthus hybridus

Chenopodium ambrosioides

Amaryllidaceae

Scadoxus puniceus

Scadoxus membranaceus

Apocynaceae

Acokanthera oblongifolia

Carissa bispinosa

Carissa macrocarpa

Gomphocarpus fruticosus

Gomphocarpus physocarpus

Secamone alpine

Tabernaemontana ventricosa

Voacanga thouarsii

Araliaceae

Cussonia zuluensis

Cussonia spicata

Hydrocotyle bonariensis

Arecaceae

Washingtonia robusta

Phoenix reclinata

Asteraceae

Ageratum species

Arctotheca populifolia

Bidens pilosa

Blumea species

Brachylaena discolour

Chromolaena odorata

Chrysanthemoides monilifera

Denekia capensis

Distephanus anisochaetoides

Gazania rigens

Helichrysum kraussii

Helichrysum ruderale

Helichrysum panduratum

Nidorella undulate

Senecio deltoideus

Senecio species

Asparagaceae

Asparagus falcutus

Drimiopsis maculate

Bignoniaceae

Kigelia africana

Tecoma capensis

Campanulaceae

Wahlenbergia undulata

Capparaceae

Capparis brassii

Celastraceae

Gymnosporia arenicola

Gymnosporia senegalensis

Maytenus acuminata

Maytenus penduncularis

Putterlickia verrucosa

Chenopodiaceae

Salicornia meyeriana

Clusiaceae

Garcinia gerrardii

Commelinaceae

Commelina benghalensis

Convolvulaceae

Ipomoea cairica

Ipomoea pes-caprae

Cyperaceae

Bulbostylis hispidula

Cyperus albostriatus

Cyperus species

Cyperus dives

Cyperus eragrostis

Kyllinga alata

Kyllinga species

Mariscus species

Dioscoreaceae

Dioscorea sylvatica

Dracaenaceae

Dracaena aletriformis

Ebenaceae

Diospyros natalensis

Euclea natalensis

Euphorbiaceae

Ricinus communis

Fabaceae

Abrus precatorius

Adenopodia spicata

Albizia adianthifolia

Crotalaria globifera

Crotalaria natalitia

Vachellia karroo

Vachellia natalitia

Vachellia robusta

Dalbergia armata

Dalbergia obovata

Desmodium incanum

Dichrostachys cinerea

Millettia grandis

Tephrosia purpurea

Rhynchosia caribaea

Rhynchosia nitens

Rhynchosia totta

Senegalia kraussiana

Flacourtiaceae

Trimeria grandifolia

Gentianaceae

Chironia baccifera

Goodeniaceae

Scaevola plumieri

Icacinaceae

Apodytes dimidiate

Iridaceae

Dietes species

Juncaceae

Juncus kraussii

Lecythidaceae

Barringtonia racemosa

Leguminosae

Eriosema psoraleoides

Erythrina lysistemon

Loganiaceae

Strychnos spinosa

Malpighiaceae

Spermacoce natalensis

Malvaceae

Grewia occidentalis

Hibiscus fritzscheae

Hibiscus tiliaceus

Hibiscus trionum

Meliaceae

Ekebergia capensis

Trichilia emetica

Melianthaceae

Bersama lucens

Menispermaceae

Cissampelos hirta

Cissampelos torulosa

Mesembryanthemaceae

Carpobrotus dimidiatus

Moraceae

Ficus burtt-davyi

Ficus lutea

Ficus natalensis

Ficus sur

Ficus burkei

Ficus trichopoda

Myrtaceae

Eugenia capensis

Psidium guajava

Ochnaceae

Ochna serrulata

Ochna natalitia

Oleaceae

Olea woodiana

Orchidaceae

Ansellia africana

Cyrtorchis arcuata

Cyrtorchis praetermiss

Polystachya sandersonii

Oxalidaceae

Oxalis latifolia

Oxalis droseroides

Passifloraceae

Adenia gummifera

Passiflora subpeltata

Petiveriaceae

Rivina humilis

Poaceae

Andropogon eucomus

Cynodon species

Dactyloctenium austral

Digitaria eriantha

Digitaria longiflora

Hemarthria altissima

Imperata cylindrical

Microsorium punctatum

Microsorum scolopendrium

Oplismenus hirtellus

Panicum coloratum

Panicum maximum

Paspalum dilatatum

Phragmites australis

Setaria megaphylla

Sporobolus africanus

Stenotaphrum secundatum

Stiburus alopecuroides

Stipagrostis zeyheri

Polygonaceae

Persicaria serrulata

Pteridaceae

Cheilanthes viridis

Rhamnaceae

Scutia myrtina

Rhizophoraceae

Bruguiera gymnorrhiza

Rosaceae

Peddiea africana

Rubiaceae

Canthium ciliatum

Canthium inerme

Catunaregam species

Pavetta lanceolata

Kraussia floribunda

Tricalysia capensis

Tricalysia lanceolata

Tricalysia sonderiana

Psychotria capensis

Psydrax obovata

Psydrax obovata s. obovata

Tarenna pavettoides

Rutaceae

Clausena anisata

Teclea gerrardii

Teclea natalensis

Vepris lanceolata

Zanthoxylum capense

Salicaceae

Dovyalis longispina

Dovyalis rhamnoides

Scolopia zeyheri

Santalaceae

Osyris compressa

Sapindaceae

Allophylus natalensis

Deinbollia oblongifolia

Sapotaceae

Mimusops caffra

Mimusops obovata

Sideroxylon inerme

Scrophulariaceae

Manulea parviflora

Smilacaceae

Smilax anceps

Solanaceae

Solanum nigrum

Solanum wrightii

Thelypteridaceae

Cyclosorus interruptus

Thymelaeaceae

Passerina rigida

Typhaceae

Typha capensis

Ulmaceae

Chaetachme aristata

Verbenaceae

Avicennia marina

Clerodendrum glabrum

Lantana camara

Verbena species

Vitaceae

Rhoicissus digitata

Rhoicissus rhomboidea

Rhoicissus revoilii

Rhoicissus sessilifolia

Rhoicissus species

Rhoicissus tomentosa

Rhoicissus tridentata