CHAPTER 1: INTRODUCTION

A sound knowledge of the ecology of the area is an essential prerequisite for the establishment of efficient wildlife management programs and compilation of conservation policies for any area (Edwards 1972).

According to Bredenkamp *et al.* (1983) it has often been demonstrated that different ecosystems of a particular area can be recognized by the delimitation of the plant communities within the area. According to Scheepers (1983) vegetation science has been applied in the fields of nature conservation for years, but recent developments relate to the application of plant ecological knowledge to environmental management. The use of plant communities as a reliable basis for any ecological planning and management, is emphasized by Bredenkamp & Brown (2001).

To obtain knowledge of the ecology of the study area, a study of the vegetation of the area should be made on the plant community level of organization (Bredenkamp & Brown 2001). Studying the vegetation of the study area allows the following goals to be met:

- Identify, describe and classify plant communities.
- Delineate management units.
- Identify ecological sensitive areas.
- Identify bush encroached areas or areas infested with alien plants or degraded areas, all in need of rehabilitation measures.
- Identify the habitats of rare or endangered plant species
- Identify the habitats of specific animals.

LOCATION AND AREA

The study area is approximately 979 ha in extent and consists of Andrew's Field (+/-129 ha) and Tsaba-Tsaba Nature Reserve (+/-850 ha), which are adjacent areas on the same farm (portion 7 and remainder portions of 8 of the farm Zoetendalsvlei No. 280). The study area is situated on the Agulhas Plain, Bredasdorp district, Western Cape; between Struisbaai North in the south and De Mond State Forest in the north and is bordered in the west by the Bredasdorp/Struisbaai road, and in the south by the sea (Figure 1).

INFRASTRUCTURE

The infrastructure of the study area consists of a network of small gravel roads or tracks in Tsaba-Tsaba Nature reserve, and two gravel main roads in Andrew's Field. A stone wall, probably constructed by previous owners, separates Tsaba-Tsaba Nature Reserve and Andrew's Field. There is one open entrance road between the two areas. Andrew's Field contains an office, several chalets, caretaker's house, aeroplane hangers and two wind- mills. There is a small dam on Andrew's Field, and a bigger dam in Tsaba-Tsaba Nature Reserve. There is one gate into Andrew's Field and two gates into Tsaba-Tsaba Nature Reserve, from the public road. A connection road, inside the Nature Reserve, exists between the two gates of the Nature Reserve. The distribution of the infrastructure is shown in Figure 2.

PHYSIOGRAPHICAL COMPONENTS

TOPOGRAPHY

According to Jefferey (1996) the majority of the study area falls below the 10m contour with a ridge running roughly north south reaching 31m above sea level in places. An approximately 600m wide strip of unvegetated or sparsely vegetated sand dunes, separates the more stabilized, densely vegetated parts of the study area, from the sea (Jeffery 1996).

GEOLOGY

The dominant mother material of the study area is the Bredasdorp group (Malan *et al.* 1994). Two formations of the Bredasdorp group namely Strandveld and Waenhuiskrans are found in the study area (Malan *et al.* 1994). Strand and terrace deposits, not formally named as a formation, but forming part of the Bredasdorp group, is found in the form of roll-stones, in the coastal strand part of the study area (Malan *et al.* 1994).

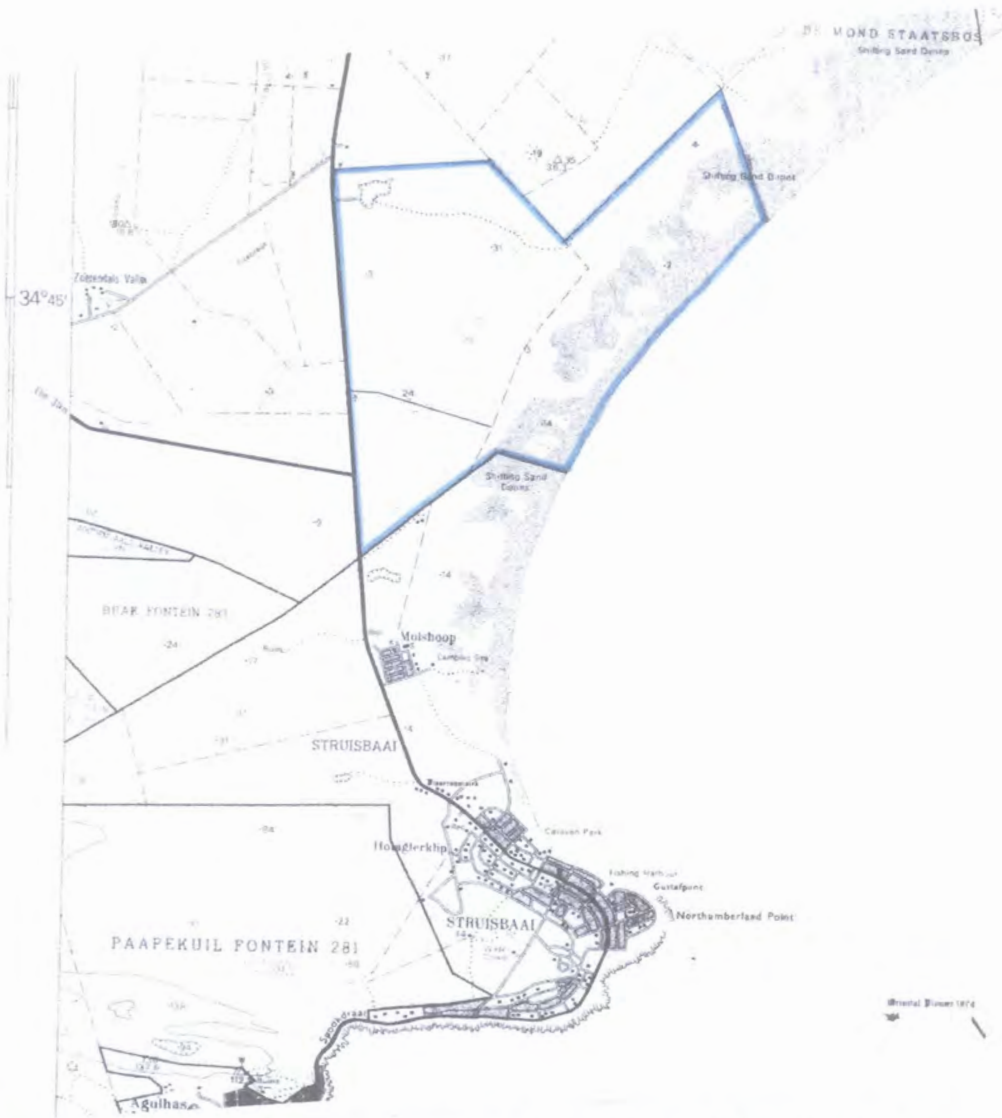


Figure 1. A map showing the exact location of Andrew's Field and Tsaba-Tsaba nature reserve.

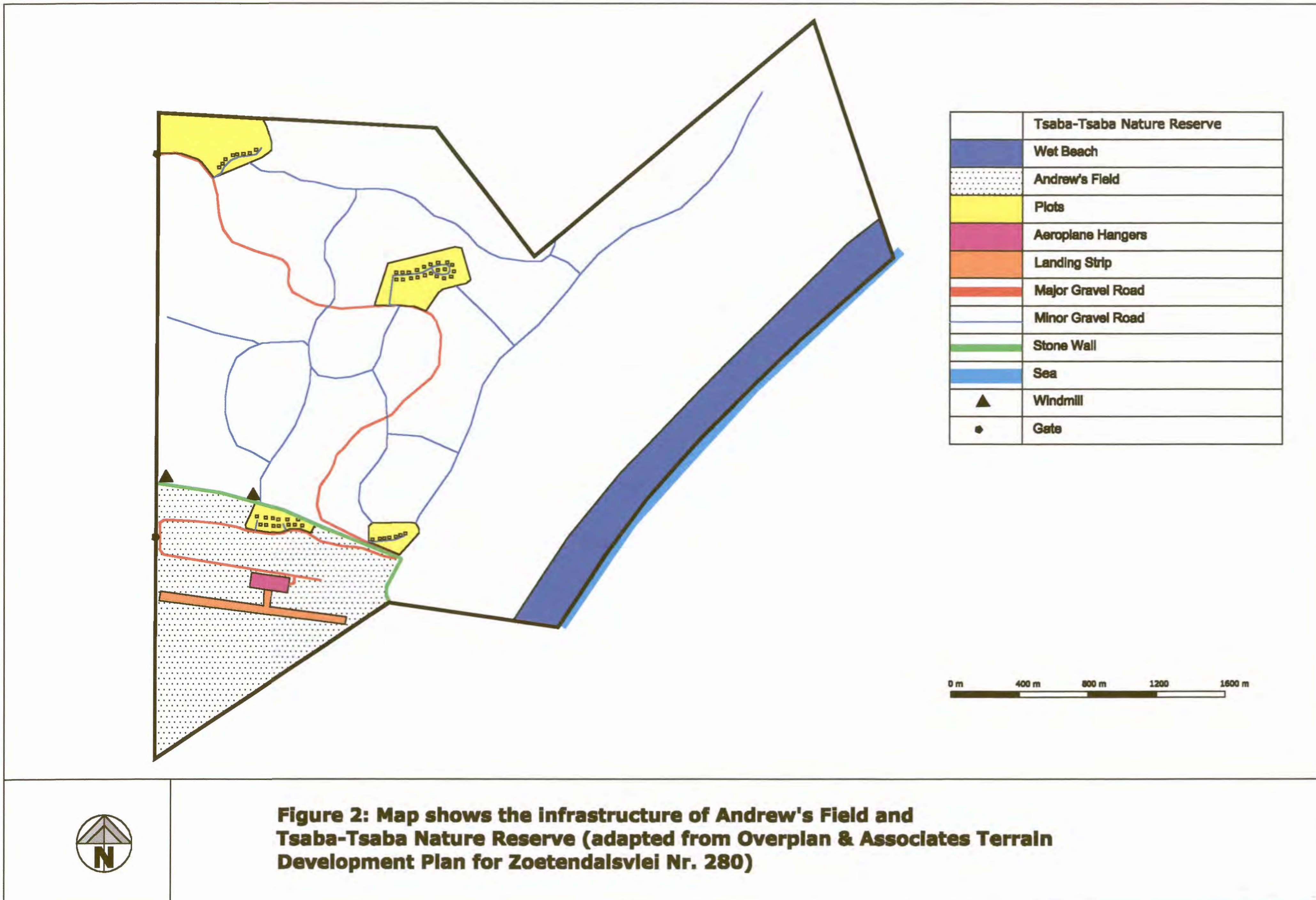


Figure 2: Map shows the infrastructure of Andrew's Field and Tsaba-Tsaba Nature Reserve (adapted from Overplan & Associates Terrain Development Plan for Zoetendalsvlei Nr. 280)

The roll-stones of Table mountain sandstone can be explained by a prior increase in sea level. The Bredasdorp group is described by Malan *et al.* (1994) as Cenozoic sediments of marine- and marine related origin, and stretches up to 22 kminland from the current coastline. The rocks are laid down discordant on marine paved rocks of the Table Mountain, Bokkeveld and Uitenhage groups (Malan *et al.* 1994).

The Standveld formation is found along the coast (Malan *et al.* 1994). It consists of white to light-gray dune sands with a high percentage shell fragments (Malan *et al.* 1994). Partial cementing of sands with a high calcium carbonate-content took place (Malan *et al.* 1994). The lythology of this formation can be described as white dune sand, strand sand with finely divided shell and alluvial stones (Malan *et al.* 1994).

The geology of the study area can be seen in Figure 3.

The Waenhuiskrans Formation day-seams next to the current coastline (Malan *et al.* 1994). The Waenhuiskrans unit stratiotype, 12.4 m deep, and locally overlaid with 1 m thick calcretes, consists of medium granulate cross-layered calcarenite with well-rounded quarts and a few glauconite grains (Malan *et al.* 1994). Large-scale eolic cross-layers is characteristic of the unit (Malan *et al.* 1994). The lythology of this formation can be described as partially calcified dune sand (Manlan *et al.* 1994).

A small portion of the study area's mother material consists of sedimentary rocks (light gray to pale-red sandy soil), underlain by the Waenhuiskrans formation (partly calcified dune sand with calcrete lenses) (Malan *et al.* 1994).

SOILS

The soil can be described as mostly either shallow sandy soil, overlying limestone, or shallow to deep sandy soil, overlying clay, silt and gravel. Four different soil forms have been distinguished in the area. Coega (Ortic A on hard bank carbonate horison), family Marydale (Lime containing A-horison); Immerpan (Melanic A on hard bank carbonate

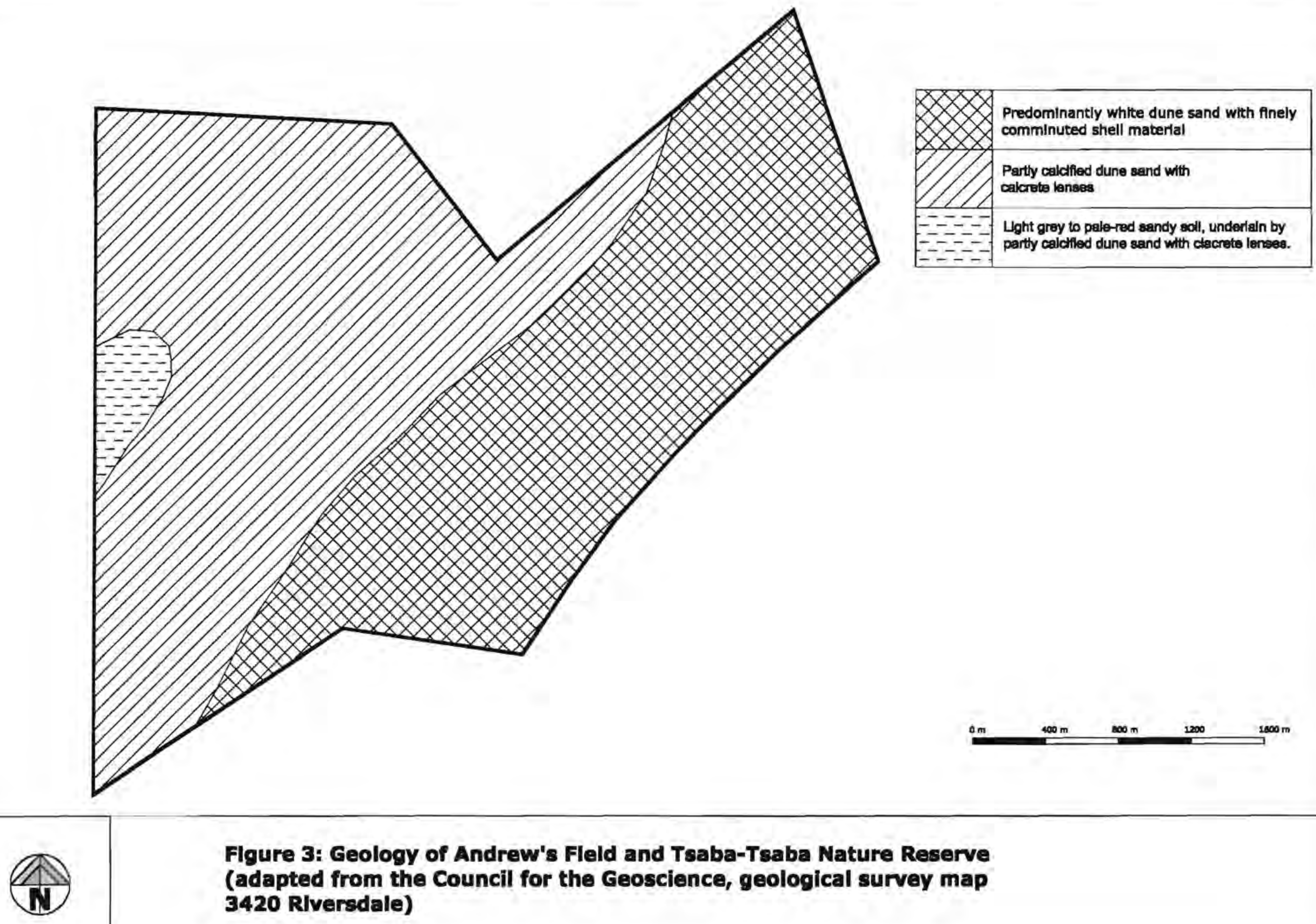


Figure 3: Geology of Andrew's Field and Tsaba-Tsaba Nature Reserve (adapted from the Council for the Geoscience, geological survey map 3420 Riversdale)

horison), family Kalkpan (Lime containing A-horison); Brandvlei (Ortic A on soft carbonate horison), family Kolke (Signs of wetness in carbonate horison) and Namib (Ortic A on regic sand), family Beachwood (Containing lime within 1500 mm from soil surface) (Macvicar 1991).

The Coega soil form is found on the limestone hills and shallow-soil limestone plain. Immerpan soil form is found on the deeper-soil, Proteoid dominated limestone plain. Brandvlei soil form is found in the marsh area, as well as the Renosterveld plain, while the Namib soil form is found on the shifting sand dune area, the dune plain and the deep sand Proteoid dominated foothills and plains.

According to Tinley (1985) two distinct sand characteristics occur in dune fields. Bare dune sands, beige or yellow in color, absorbs all rain, with no surface runoff. Grey sands, stained by humus, covered with woody vegetation, have a water repellent layer near the surface, beneath the litter, causing a massive surface runoff, when heavy rains follow a dry period (Tinley 1985). When recurring light rains previously wet the gray sands, minimum runoff, with deep percolation occurs (Tinley 1985). According to Tinley (1985) the water repelling is caused by organic skins coating individual sand particles, the hydrophobic substances originating from secondary plant products such as waxes, phenols and amines, from fungal mycelia and fungal metabolites, and substances produced as a normal consequence of litter decomposition. According to Tinley (1985) the degree of water repellency of the soil depends on the type of plants, their byproducts and breakdown products. Water repellence is also influenced by the occurrence of fire, which transforms and volatizes much of the organic matter at the soil surface (Tinley 1985).

CLIMATE

Climatic processes are of basic and fundamental importance to determine the ecological properties of any region (Heydorn & Tinley 1980). The main factors affecting the climate, conditioning air masses are: the contrasting sea surface temperatures of the two major ocean currents and the inshore circulation's (Tinley 1985). According to Heydorn & Tinley (1980) the Cape Coast can be divided into four distinct geographical regions. Using this geographical division, the study area is situated on the south coast. The south coast is a transitional zone, between tropical and temperate waters and offshore is the major retroflex area of Agulhas Current waters recurving eastwards and landwards (Heydorn & Tinley 1980).

The south coast has a warm temperate climate with all-seasons- and bimodal equinoctial rainfall (Strydom 1992).

Precipitation

According to Heydorn & Tinley (1980) the marked feature of rainfall in the Cape coastal region is the strong orographic control, where the rainfall curve closely follows the relief undulations. The low rainfall regime associated with the majority of Cape coast stations, appears to be due to the occurrence of cold inshore waters which inhibit shoreline rains.

According to Heydorn & Tinley (1980) the study area is situated in a low rainfall region, an arid inland tongue, reaching the coast.

The average monthly precipitation of the area can be seen in Table 1.
A Walter climatic diagram was compiled (Figure 4) from data obtained from Agulhas weather station.

The average annual precipitation of the area is 444 mm. As can be seen in Figure 3, the wet season is only slightly shorter than the dry season. The maximum precipitation is in June, and the minimum precipitation during February and December.

The increase of cold fronts in the winter season due to the northward shift of the 'Roaring Forties' westerly belt brings rain tot the coastal regions (Heydorn & Tinley 1980). Southwest Cape winter precipitation is associated with successions of east moving cyclones, the rain falling with pre-frontal NW winds (Heydorn & Tinley 1980).

Fog is usually associated with the development and along shore movement of coastal lows after cold water upwelling has occurred

(Heydorn & Tinley 1980). The lows contain warm, moist air off the Agulhas Current on the south and southeast coasts, which cools and condenses when flowing across the cold inshore water (Heydorn & Tinley 1980). In autumn and winter, cold air catabolic fog is formed on clear nights, intensifying at dawn (Heydorn & Tinley 1980).

According to Barbour *et al.* (1987) knowledge about the total rainfall does not always convey a clear picture of the availability of water tot the plant community. The season, atmospheric condition, type of rainfall, intensity, yearly variation, soil type and vegetation physiognomy, influences the availability of rain and distribution within the habitat (Vermeulen 1995). The presence of water repellent sands in the study area (see soils) has a big influence on the availability of precipitation to the plants.

Temperature

The average monthly temperature for the area can be seen in Table 1. The average annual maximum and minimum temperatures for the area are 6°C and 13.3°C respectively (Table 1). The maximum temperature for the area is 36.1°C, obtained in February. The minimum temperature for the area is 3.9°C, obtained in June.

Wind

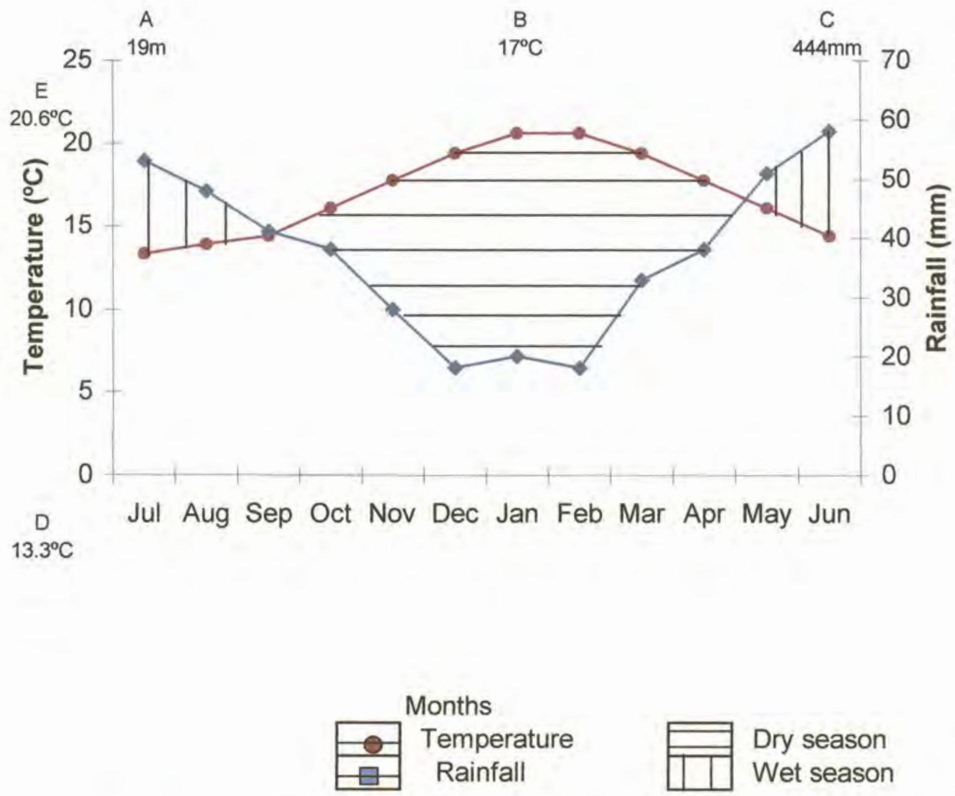
According to Scriba (1984) research has indicated that wind is an important environmental factor in vegetation research.

According to Heydorn & Tinley (1980) the wind climate along the south coast, where the study area is situated, is bi-directional. Southeasterly winds alternate with northwesterly and southwesterly winds (Heydorn & Tinley 1980).

Due to the major changes in configuration that the southern coasts show, the subcontinent is exposed to the disparate influences of cold and warm ocean currents, circumpolar westerlies and subtropical high pressure anticyclones, with neither one predominating to the exclusion of the others (Heydorn & Tinley 1980). Initial climatic asymmetry is imposed by a cold

Table 1.
The average temperature and precipitation for Andrew's Field and Tsaba-Tsaba Nature Reserve 1968 - 1994.

	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April.	May.	Jun.
Temp.	13	13.9	14.4	16	18	19.4	21	20.6	19	17.8	16.1	14
Pres.	53	48	41	38	28	18	20	18	33	38	51	58



A = Altitude
B = Mean annual temperature
C = Mean annual rainfall
D = Mean daily minimum (coldest month)
E = Mean daily maximum (hottest month)

Figure 4. A Walter-climatic diagram for Andrew's Field and Tsaba-Tsaba Nature reserve.

current on the west coast, inhibiting rainfall development, and a sub-tropical warm current off the east and south coasts, enhancing convectional processes (Heydorn & Tinley 1980). The weather regime is dominated by the alternating succession of east moving cyclones from the circumpolar westerlies, interacting with subtropical high-pressure anticyclones which are centered over the South Atlantic seaward of the west coast, and over the old eastern Transvaal and adjacent South Indian Ocean (Heydorn & Tinley 1980). Both the anticyclones including the landward extension over the old Eastern Transvaal of the South Indian Ocean High, fluctuate in position, ridging in south of the subcontinent where they cause a predominance of easterly winds along the coasts particularly in summer (Heydorn & Tinley 1980).

Cold snaps occur when strongly developed cold fronts are immediately followed by an anticyclone, which advects subpolar air landwards (Heydorn & Tinley 1980). Cold snaps occur mostly in the winter with a peak in August (Jackson & Tyson 1971). The high frequency of cold fronts in the winter is due to the fact that during winter the amplitude of westerly disturbances is the greatest (Tyson 1987).

Nocturnal cold air drainage catabolic winds are typical of clear nights on all coasts, and are most frequent in the winter months (Heydorn & Tinley 1980).

The predominance of easterly winds, some of gale force, in the spring and summer, is caused by the fact that South Atlantic and Indian anticyclones ridge in systematically of the southern coast as part of the alternating cyclone-anticyclone sequence (Heydorn & Tinley 1980).

The predominance of anticyclonic and cyclonic, change in accordance with seasonal movement of the pressure systems (Heydorn & Tinley 1980). In the winter prevailing, opposing wind along the coasts blows almost parallel to the coastline (Heydorn & Tinley 1980). Gale force winds are less frequent in summer and on the south coast these strong winds are mainly SW to SE (Heydorn & Tinley 1980).

According to Heydorn & Tinley (1980) wind is probably the most important factor controlling the development of dunes; directly in transporting sand on land, as well as generating coastal currents which are important in marine sand transport.

Maritime conditions

According to Strydom (1992) the configuration and orientation of the coast plays an important role in the way it is exposed to climatic factors.
According to Heydorn & Tinley (1980) the climatic asymmetry of the Cape south coast is due to the cold Benguela currents on the west coast (inhibiting rainfall development) and the subtropical warm currents (mainly Agulhas) of the south and east coasts (enhancing convectional processes).

Radiation

According to Heydorn & Tinley (1980) the summer and winter isoline distribution of values of radiation are largely determined by the seasonal cloud cover patterns. According to Tinley (1985) cloud cover affects the radiation and isolation values, the diurnal temperature variations, evaporative power and air and ground moisture content. An increase in cloud cover results in increased "greenhouse" effect, while a decrease in cloud cover leads to greater temperature extremes (Strydom 1992). In the winter radiation density isolines are mainly zonal due to the general cloudiness over the greater part of the country's southern coasts. The southern coast of South Africa generally receives radiant flux densities below 110 x 10^5 Jm^{-2} per day^{-1} over the southwest Cape to 230 x $10^5 Jm^2$ per day^{-1} where conditions are cloudier over the southeast coast (Heydorn & Tinley 1980).

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CHAPTER 2: LITERATURE STUDY

HISTORY OF PHYTOSOSIOLOGY AND THE BRAUN-BLANQUET METHOD IN SOUTH AFRICA:

The science of Plant ecology has been practised in South Africa since the beginning of the twentieth century (Werger 1974). Of the early ecological studies in South Africa the work of Marloth in 1908 was the most significant (Werger 1974). For more than half a century South African ecology was predominantly inspired by the writings of Clements. The early twentieth century studies were mainly of an informal, descriptive kind. Early during the second half of the century Acocks conducted an ecological study of considerable local importance (Werger 1974). In 1953 Acocks published his 'Veld Types of South Africa', which classified South African vegetation into 70 veld types and 75 variations, based on a floristic comparison of stand data. According to Werger (1974) the development of statistical techniques in ecology, received attention in South Africa, shortly after the introduction of these techniques in Europe and America, for example the study of Van Vuuren (1961) on the vegetation of the Magaliesberg west of Pretoria.

According to Westhoff & Van der Maarel (1973) the systematic description of plant communities and the idea of community types can be traced from great students of plant geography like Humbolt, Swchouw, Heer and Grisebach from 1805 to1838. Two main approaches developed from their work, the physiognomic and floristic (Westhoff & Van der Maarel 1973). Through the work of students dealing with smaller scale units, in Europe, there developed the essential idea of the floristic-sociological approach: plant communities as units of classification based primarily on species composition (Westhoff & Van der Maarel 1973).

Much of the further development leading to the Braun-Blanquet approach was centred in Zurich and Montpellier, where Jozias Braun-Blanquet lived and worked (Westhoff & Van der Maarel 1973).

The Zurich-Montpellier (Braun-Blanquet) approach to the study of vegetation has proved, since the beginning of the approach in Europe, as well as other continents, to be an effective and reliable method for vegetation survey and classification (Werger 1974).The Braun-Blanquet approach however remained virtually unknown in most parts of Africa, south of the equator, until 1969 (Werger 1974). In 1969 Marinus J.A.

Werger was secunded from the Netherlands to the then Botanical Research Institute (BRI), now the National Botanical Institute (NBI), to conduct a phytosociological survey of the Upper-Orange-River, where he introduced the use of the Braun-Blanquet method to South Africa. This work resulted in a doctoral thesis (Werger 1973). Werger strongly influenced Ben J. Coetzee and George J. Bredenkamp, two students enrolled for Master degree studies at the University of Pretoria, under supervision of Prof G.K. Theron, resulting in the first theses by South African students using the Braun-Blanquet approach (Coetzee 1974b, Bredenkamp 1975). Afterwards the method was used with success in a number of small surveys, mostly on the vegetation of nature reserves or other conservation areas (Werger 1974). Due to these studies Werger (1974) foresaw the wider acceptation of the Braun-Blanquet method in South Africa, which indeed realised in a large number theses and publications by researchers of the BRI and students of various South African universities, especially the Universities of Pretoria, Stellenbosch, Free State and Rhodes.

EFFECTIVENESS OF THE BRAUN-BLANQUET METHOD:

According to Moore *et al.* (1970) the efficiency of an ecological method is defined as its capacity of yielding a maximum understanding of the complexity of vegetation and of its relation to environmental factors for a minimum of time input. The Braun-Blanquet method was found to be most efficient for a general ecological survey, being the most economical in time, yielding results at least as informative as any of the other methods tested when taken on their own (Moore *et al.* 1970, Werger 1973, 1974, Westhoff & Van der Maarel 1973).

APPLICABILITY OF BRAUN-BLANQUET TO THE WESTERN CAPE PROVINCE:

According to Boucher (1977) a vegetation study of Cape Hangklip area, using association-analysis, Braun-Blanquet and homogeneity function methods, revealed that the Braun-Blanquet method is consistently more efficient and more exact, even in the floristically rich vegetation of the South Western Cape Province of South Africa. Some of the important phytosociological studies applying Braun-Blanquet methodology in Fynbos vegetation include those of Werger *et* al. (1972) from Jonkershoek, Boucher (1978) of the Cape Hangklip area, Glyphis *et al.* (1978), Cowling (1984) from the Humansdorp area, Taylor (1984a, 1984b) from the Cape of Good Hope Nature Reserve, Boucher (1987) of coastal Fynbos, McDonald (1993a, 1993b, 1993c, 1995) from the Langeberg, Mustert *et al.* (1993) from Table Mountain, Taylor (1996) from the Cederberg and Boucher & McDonald (1982) about the western, southern and eastern Cape province.

CAPE FLORISTIC REGION:

According to Low & Rebelo (1998) the Fynbos Biome is considered by many as being synonymous with the Cape Floristic Region or Cape Floral Kingdom. The Cape Floristic Region or Cape Floral Kingdom is however a general geographical area, including Fynbos, Renosterveld, Forest, Nama Karoo, Succulent Karoo and Thicket Biomes, while the Fynbos Biome refers to only two vegetation types: Fynbos and Renosterveld (Low & Rebelo 1998).

The Cape Floristic Region is one of the world's richest regions in terms of botanical diversity (Goldblatt & Manning 2000). It is estimated that 9000 species of vascular plants are native to the Cape Floristic Region, of which almost 69% are endemic (Goldblatt & Manning 2000). The flora of the Cape Region thus comprises almost 44% of the approximately 20 500 species that occur in southern Africa (Goldblatt & Manning 2000). According to Goldblatt & Manning (2000) species richness of the Cape Region compares favourably with the species richness of areas of comparable size in the moist tropics. It is not strictly true that the Cape Floristic Region has for its size one of the richest floras in the world (Goldblatt & Manning 2000). The species richness of the Cape Floristic Region is substantially lower than some Neotropical areas like Costa Rica, Ecuador or Guatemala, but the species richness of the Cape Region is however remarkable when compared to other parts of Africa (Godblatt & Manning 2000).

Although the Cape Floristic Region or Cape Floral Kingdom contains five biomes, only the Fynbos Biome, comprising of the Fynbos and Renosterveld vegetation groups, contains most of the floral diversity (Low & Rebelo 1998).

It is distressing to realise that some three-quarters of all plant species in the South African Red Data Book occur in the Cape Floral Kingdom (Low & Rebelo 1998). According to Low & Rebelo (1998) there are 1700 plant species in the Cape Floral Kingdom threatened to some extent with extinction. Many Fynbos species are extremely localised in their distribution, with sets of such localised species organised into "centres of endemism" (Low & Rebelo 1998). According to White (1983) a

Regional Centre of Endemism is a phytochorion which has both more than 50% of its species confined to it and a total of more than 1000 endemic species.

BREDASDORP/RIVERSDALE CENTRE OF ENDEMISM

The study area is situated in the Bredasdorp/Riversdale Centre of Endemism (Cowling *et al.* 1992). According to Heydenrych (1994) the region of the Centre consists of he Agulhas Plain in the west, the Riversdale Plain in the east and the areas of Arniston/Waenhuiskrans, De Hoop, Potberg and Infanta. The Bredasdorp/Riversdale Centre of Endemism refers to a well-defined group of plants confined to the limestone of the Bredasdorp formation and associated colluvial deposits (Heydenrych 1994). Although lime-rich soils occur throughout the Bredasdorp/Riversdale Centre of endemism, limestone fynbos is not the only important and extensive vegetation type in the region (Heydenrych 1994). Small amounts of other soils (neutral and acid) supporting different vegetation types, such as acid sand proteoid fynbos, neutral sand proteoid fynbos, restioid fynbos and dune asteraceous fynbos, are also found in the region (Heydenrych 1994).

LIMESTONE FYNBOS:

According to Heydenrych (1994) Limestone Fynbos only occurs on limestone-substrates and may be seen as a rare subset of a rich, though threatened flora. According to Hilton-Taylor & Le Roux (1989) limestone fynbos is one of the most threatened vegetation types in the Cape Floristic Region.

Limestone fynbos is similar to Fynbos in consisting of an abundance of small leafed shrubs, containing Restios, Ericas and other fine leafed shrubs as well as shrubs belonging to the Protea family (Heydenrych 1994). Limestone fynbos however differs from other Fynbos by the fact that it is associated with limestone soils of the Bredasdorp Formation, which are mainly alkaline soils, in contrast with most other fynbos soils, which are acidic (Heydenrych 1994).

According to Heydenrych (1994) limestone usually protrudes as hills. These outcrops may be very small in extent or may form larger hills or plains. For the purpose of the study, conducted by Heydenrych (1994), limestone fynbos was considered to be presented by those species which are associated with exposed limestone outcrops. The study revealed that approximately 110 plant species are endemic to these limestone outcrops. Limestone fynbos also contains many species which are classified as rare (Heydenrych 1994).

According to Heydenrych (1994) the following species were found to be endemic to limestone outcrops: Letters in brackets next to species indicate the red data categories, according to Golding (2002): (CR) = Critical endangered, (EN) = Endangered, (VU) = Vulnerable, (LC) = Low concern, (DD) = Data deficient.

Limestone endemic species:

AIZOACEAE
Braunsia vanrensburgii
Ruschia calcicola

APIACEAE
Centella pottebergensis
Peucedanum sp. nov.

ASPHODELACEAE
Haworthia variegata

ASTERACEAE
Berkheya coriacea
Euryops hebecarpus
Euryops linearis
Euryops muirii (VU)
Felicia canaliculata
Felicia ebracteata (VU)
Felicia nordenstamii (VU)
Metalasia calcicola
Metalasia erectifolia
Metalasia luteola
Oedera steyniae
Osteospermum subulatum
Stoebe muirii
Syncarpha gnaphaloides

CAMPANULACEAE

Lobelia barkerae

Lobelia valida (VU)

Wahlenbergia clacarea

Wahlenbergia microphylla (VU)

Wahlenbergia squarrosa

Roella compacta (LC)

CYPERACEAE

Ficinia truncata

ERICACEAE

Acrostemon schlechteri

Acrostemon verniosus

Erica berzelioides

Erica calcareophila

Erica curtophylla

Erica excavata

Erica gracilipes

Erica oblongiflora

Erica occulta (CR)

Erica propinqua

Erica pulvinata

Erica saxicola

Erica scytophylla

Erica uysii

Platycalyx pumila

Scyphogyne calcicola

Thoracosperma muirii

FABACEAE

Amphithalia alba

Aspalathus aciloba

Aspalathus calcarea

Aspalathus candidula

Aspalathus pallescens

Aspalathus prostrata

Aspalathus repens
Aspalathus salteri
Aspalathus sanfuinea
Indigofera hamulosa
Lebeckia sessilifolia

HYACINTHACEAE
Lachenalia muirii

IRIDACEAE
Freesia elimensis
Hesperantha juncifolia
Watsonia fergusoniae

MALVACEAE
Hermannia concinnifolia
Hermannia muirii
Hermannia trifoliata
PENAEACEAE
Brachysiphon mundii (CR)

POACEA
Pentachistus calcicola var. *calcicola*
Pentaschistus calcicola var. *hirsuta*

POLYGALACEAE
Muraltia barkerae
Muraltia calycina
Muraltia depressa
Muraltia lewsiae
Muraltia pappeana
Muraltia salsolacea
Muraltea splendens
Polygala meridionalis

PROTEACEAE
Leucadendron muirii

Leucadendron meridianum
Leucospermum patersonii
Leucospermum truncatum
Mimetes saxatilis
Protea obtusifolia

RESTIONACEAE
Thamnocortus fraternus
Thamnochrotus muirii
Thamnocortus paniculatus
Thamnocortus pluristachyus

RHAMNACEAE
Phylica laevigata
Phylica selaginoides
Phylica sp. nov.

ROSACEAE
Cliffortia burgersii (EN)

RUBIACEAE
Galium bredasdorpense

RUTACEAE
Acmadenia densiflolia (LC)
Acmadenia heterophylla
Acmadenia mundiana (LC)
Adenandra rotundifolia (LC)
Agathosma abrupta (LC)
Agathosma eriantha (VU)
Agathosma florulenta (LC)
Agathosma geniculata (VU)
Agathosma riversdalensis
Agathosma sedifolia (EN)
Agathosma sp. nov. 1
Agathosma sp. nov. 2
Agathosma sp. nov. 3

Diosma demissa (LC)
Diosma echinulata
Diosma guthriei (DD)
Diosma Haelkraalensis (CR)
Euchaetis laevigata (LC)
Euchaetis intonsa (CR)
Euchaetis longibracteata
Euchaetis meridionalis (LC)

SCROPHULAREACEAE
Sutera calciphila
Sutera subspicata

Limestone fynbos is an important, unique, rich and rare vegetation type (Heydenrych 1994). There are many factors threatening limestone fynbos vegetation, of which invasive alien plants seem to be the biggest. Other threats to limestone fynbos vegetation include land clearing, resort development, bad fire management and over-harvesting of flowers (Heydenrych 1994).

According to Heydenrych (1994) 21% of all limestone fynbos species are not conserved in state-owned nature reserves. The conservation of limestone fynbos on privately owned land, like Andrew's Field and Tsaba-Tsaba nature reserve is therefore of the utmost importance.

A study on the coastal vegetation of South Africa, with specific reference to the life cycle of coastal dune species, was conducted by Knevel (2001).

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CHAPTER 3: METHODS

INTRODUCTION

A plant community can be defined as an association with a definite floristic composition, uniform physiognomy and is bound to uniform habitat conditions (Werger 1974). A plant community is not merely a random aggregate of species, but is an organised group with a typical floristic composition and combination of growth form, structure and physiognomy (Van Wyk & Smit 2001). A plant community is the result of a unique combination of certain environmental conditions and results from the interactions of species interactions through time (Van Wyk & Smit 2001). Plant communities are conceived as types of vegetation recognised by their floristic composition (Westhoff & Van der Maarel 1973). According to Van Rooyen & Theron (1995), plant communities are units with the same species composition and structure. To be defined as a plant community, homogeneity should exist within the association. Homogeneity implies that the specific species group that is considered representable of the described plant community must exist over a fairly large area, without any detailed variation within (Kent & Coker 1996).

Because each plant community has it's own floristic composition, physiognomy and habitat conditions; each plant community should be managed differently, as different plant communities react differently to environmental changes and utilisation by animals. It is therefore essential for sound management purposes to distinguish the different plant communities, as each will need a separate management plan (Bredenkamp & Brown 2001).

According to the Braun-Blanquet method, selected representative, homogenous plots of a certain minimum area, are used to sample the vegetation of a certain area (Westhoff & Van der Maarel 1973, Werger 1974, Van Rooyen 1996).

A selection of relevès is desired that will effectively represent the variation in the vegetation under study, choosing the samples in such a way that they will not represent different plant communities disproportionately and will not include mixed, incomplete, or unstable stands (Westhoff & Van der Maarel 1973).

ANALYTICAL PHASE

In the analytical phase data is gathered in the field. The following are considered during the analytical phase:

Site selection

The selection of sample sites was done in a stratified random way, within mapped units. Relatively homogeneous physiographical-physiognomical units were mapped on aerial photographs of a 1: 10 000 scale. The sample plots were placed stratified-randomly within these units (Van Rooyen 1996).

Representativeness and Homogeneity

An important prerequisite of a physiographic-physiognomic unit is that it should be homogenous in nature, concerning the floristic composition, vegetation structure and habitat (Werger 1973, Van Rooyen 1996). No obvious boundaries or variation in stratification must be visible within a stand (Westhoff & Van der Maarel 1973), to ensure that only one plant community is represented in the sample plot. Sample plots should be selected in such a way that it represents the vegetation it forms part of, giving a more or less typical description of the vegetation in terms of both floristic composition and structure (Werger 1974). Care was therefore taken in this study to place sample plots in areas that were considered to be relatively homogeneous and representative of a particular plant community, while heterogeneity within a sample plot was avoided.

Distribution and number of sample plots

Sample plots were placed randomly in each of these physiographic-physiognomic units *pro rata* on an area basis, and the exact location of each sample plot was marked with a transparency pen on a transparency, placed over the aerial photograph. Sample plots that were placed in this way in the field sometimes lie in an area that can be locally heterogeneous concerning both floristic composition, as well as habitat conditions. In exceptional cases, sample plots were therefore moved to ensure that the most important prerequisite of the Zurich-Montpellier approach is met, namely that each sample plot must be placed in a relative homogenous area. In the study area, sample plots that should have been placed near the middle of areas highly infested with mole-rats, was shifted to as near the roads running through these areas as possible, due to the inaccessibility of these areas. The aim was to place a minimum of one to two sample plots in each mapped physiographic-physiognomic unit, to ensure a fairly strong view of the vegetation of each unit. The number of sample plots will also depend on the scale of the survey and the heterogeneity of the area (Van Rooyen 1996). In this study 171 sample plots were used to sample an area of approximately 979 ha, giving an average of 0.175 per ha, or approximately one sample plots per five ha.

Minimal area and plot size, plot form

According to Westhoff & Van der Maarel (1973) the size of a sample plot largely depends on the structure of the vegetation under study, but may also be affected by the size of the stand (community). The stand may be sufficiently small to be analysed largely in one sample plot, or if this is not possible, then the plot should be large enough that all species of regular occurrence in the stand should be present in the sample plot (Westhoff & Van der Maarel 1973). In extremely uniform phytoceoenoses (communities/associations) which are very poor in species, where differences in abundance and cover are of major concern, these differences should be considered in establishing the size of the sample plot (Westhoff & Van der Maarel 1973).

According to Werger (1974) the determination of a certain minimal size of area in which the community can be represented, is important since communities can be sampled most efficiently with plots the size of minimal area or slightly larger. If a community is sampled with plots smaller than the minimal area, is difficult to extract the community type from the data, while if the plots are larger than the minimal area, much effort is wasted (Werger 1974). The minimum-area of the sample plots can be calculated using a species-area curve (Kent & Coker 1996, Van Rooyen 1996). The minimum area would then be the area where the species-area curve becomes more or less horizontal (Werger 1974).

Because of the fact that species are rated on a cover-abundance scale with relative values in the Zurich-Montpellier method, one is not bound to either a fixed plot size or fixed plot form in sampling the vegetation (Werger 1974). It is important to adapt plot size to give a more or less typical description of the phytocoenosis that is represented by the vegetation in the plot, and that the vegetation in the plot should represent an example of one vegetation type only (Werger 1974).

In this study a plot size of 10 m^2 was used. The shape of plots was mostly square (10 x 10 m). In dense, impenetrable areas, rectangular plots of (2 x 50 m), parallel to the roads were used.

Structure

When sampling, samples should be taken in such a way that each plot adequately represents the structure of the surrounding vegetation (Werger 1974). Sometimes a vegetation can be regarded as either consisting of a mosaic of two vegetation types or as consisting of one vegetation type. An important decision regarding structural homogeneity therefore needs to be taken. For vegetation to be a mosaic of two communities locally more extensive homogenous patches of either of the two communities should be found (Werger 1974). In areas where the Thicket Biome forms a mosaic with the Fynbos Biome vegetation, care was taken to ensure that thicket and fynbos patches were surveyed separately, where possible.

An important structural character is vegetation layering (Westhoff & Van der Maarel 1973). In a sample plot as many layers are distinguished as is considered appropriate or necessary (Westhoff & Van der Maarel 1997). The Braun-Blanquet approach considers the different layers as being in mutual ecological interaction, and they cannot therefore be considered as separate, independent ecological units, and has to be analysed as a whole (Westhoff & Van der Maarel 1973, Werger 1974).

At each plot, where various vegetation layers are distinguished: their ranges in height and an estimation of the aerial cover of each layer, as well as an estimation of total aerial cover of the entire vegetation of the sample plot, including all strata, are recorded (Werger 1974).

In the study the average height and percentage cover of the following were recorded separately, but analyzed as a whole: trees/shrubs, grasses/reeds, restioids/rushes, forbs and sedges.

Floristic observations

A complete list of plant species found in each sample plot must be drawn up (Werger 1974). Correct identification of the species is essential (Van Rooyen 1996).

The relative importance of each species in the sample plot is assessed, using the cover-abundance scale, used by the Zurich-Montpellier School (Werger 1974). The scale is partly based on cover and partly on abundance (Werger 1974). Abundance relates to the density of the individuals of a given species in a plot, while cover degree is measured as the vertical projection of all aerial parts of plants of a given species as a percentage of the total plot area (Westhoff & Van der Maarel 1973).

The most commonly used cover-abundance scale used in Braun-Blanquet type surveys reads as follows:

r - Very rare, with negligible cover (usually a single individual).

\+ - Present but not abundant, small cover value (less than 1 % of plot
area)

1 - Numerous but covering less than 1% of quadrate area, or not so abundant, but covering 1 - 5% of quadrate.

2a - Very numerous, covering less than 5% or covering 5 - 12% of quadrate, independent of abundance.

2b - Covering 12 - 25% of quadrate area, independent of abundance.

3 - Covering 25 - 50% of quadrate area, independent of abundance.

4 - Covering 50 - 75% of quadrate area, independent of abundance.

5 - Covering more than 75% of quadrate area, independent of abundance.

(Werger 1974, Van Rooyen 1996).

In this study a relevé was compiled in every sample plot by recording all species present in the sample plot and giving a cover-abundance value to each species according to the above mentioned scale.

<u>Habitat characteristics</u>

The distribution of plants is directly determined by the physical factors of the environment (Van Rooyen 1996). It is therefore necessary to measure or observe and note the more obvious environmental factors, which might influence the distribution of plants (Van Rooyen 1996). The more precisely habitat observations are, the more clearly associations extracted from the data can be characterized ecologically later (Werger 1974). The usual identifying information such as locality, date of sampling and size of plot is noted for each sample plot. The following can also be noted for each sample plot: altitude, topographical position, slope angle and slope direction, geology, soil, erosion, rockiness of the soil, geomorphology, soil characteristics, climatic information and biotic influence (Van Rooyen 1996, Werger 1974).

In this study locality, date of sampling, altitude, topographical position, geomorphology, exposure to sun and wind, slope angle, slope direction, geology, soil, percentage rock cover and biotic influence were noted.

SYNTHETIC PHASE

Analyzing the stands is only the first step in the description of vegetation units. After collecting the relevés, they must be compared. This is the beginning of the synthetic phase, which leads to the distinction of plant communities (Westhoff & Van der Maarel 1973). Many different mathematical and statistical algorithms exist in various computer programs to classify the relevés into plant communities (Whittaker 1978)

According to Coetzee (1974a) using the Braun-Blanquet-method leads to a better understanding of the vegetation, than using normal Association Analysis processing (Coetzee & Werger 1975). The more modern TWINSPAN (Hill 1979a), a divisive, polythetic classification algorithms, is presently the most widely used numerical technique used to obtain a first approximation of the plant communities of an area, and these results are then refined by application of the classical Braun-Blanquet methodology (Behr & Bredenkamp 1988)

Relevés were classified using TWINSPAN (Hill 1979a) and refined using Braun-Blanquet procedures.

Comparison and rearrangement of relevés

In the classical Braun-Blanquet method, the field data are tabulated in a matrix, in which rows represent species and the columns relevés (Werger 1974, Westhoff & Van der Maarel 1973). The completed matrix is called a raw table (Werger 1974). The association between species is then visually studied, and the matrix rearranged so that positively associated species are grouped together, apart from the general and most infrequent species that do not show clear discriminant floristic associations, and are listed in the lower part of the table (Werger 1974). The matrix of the table is the cover-abundance values of the species found in the sample plots (Van Rooyen 1996).

The successive rearrangement of rows (species) and columns (relevés) in the matrix should be continued until a clear pattern of mutually discriminant noda of species-relevé groups is obtained (Werger 1974).

More recently the rearrangement of the raw table has been done with the aid of a numerical cluster analysis (e.g. Bredenkamp 1982).
TWINSPAN is a computer program in FORTRAN that has primarily been designed for ecologists and phytosociologists who have collected data on the occurrence of a set of species, in a set of samples (Hill 1979a).

TWINSPAN first constructs classification of samples, and then uses this classification to obtain a classification of the species according to their ecological preferences (Hill 1979a). Both classifications are then used together to obtain an ordered two-way table that expresses the species' synecological relations as succinctly as possible (Hill 1979a).

The uniform phytocoena are then distinguished and characterized in the structured table (Westhoff & Van der Maarel 1973).

A fixed pattern of groups of relevés, with a characteristic floristic composition is obtained. In this way the table is divided into nodums, where every nodum represents relevés with a similar characteristic species composition (Van Rooyen 1996). Individual relevés are commonly placed within a nodum in a specific sequence. The sequence can be according to any environmental gradient observed, or another varying character of the vegetation or habitat observed (Werger 1974). Species are usually placed in order of their presence in each nodum (Werger 1974).

The nodums obtained are tested and confirmed through correlation between the plant community represented by the nodum, to find the specific physical habitat characteristics, noted during the survey (Van Rooyen 1996). A probable vegetation gradient is determined by using a computerized ordination algorithm DECORANA (Detrended Correspondence Analysis) (Kent & Coker 1996). According to Hill (1979b) the main purpose of DECORANA is to make ordinations by the method of detrended correspondence analysis. Detrended correspondence analysis is derived from a simpler method of ordination called reciprocal averaging. The main problem of reciprocal averaging is that the second axis tends to be strongly related to the first axis, leading to the arch effect (Hill 1979b). The arch effect is avoided in Detrended correspondence analysis by demanding that there shall be no systematic relation of any kind between the higher axes and the first (Hill 1979b).

The reality of the ecological interpretation of the plant communities is checked in the veld (Van Rooyen 1996).

An ecologically meaningful vegetation type should be based on a group of relevés which at least share some sets of unifying attributes, which allow a positive definition in terms of floristics, and which are related to a coherent complex of environmental conditions (Coetzee & Werger 1975).

In this study the vegetation and habitat data were captured in the TURBOVEG database (Hennekens 1996a, Hennekens & Schaminee 2001). The floristic data were extracted to the tabular editor MEGATAB (Hennekens 1996b) and a first approximation of the plant communities of the area was obtained by applying the TWINSPAN algorithm (Hill 1979a) that is built into MEGATAB, to the data. Refinement of this result was done within MEGATAB, and this resulted in the compilation of two separate phytosociological tables.

To indicate gradients within and between plant communities, the floristic data was subjected to the DECORANA ordination (Hill 1979b), and the results are presented in ordination diagrams.

Nomenclature

Plant communities are named binomial according to the method described by Barkman *et al.* (1986).

The name-giving taxon must be present in the syntaxon concerned (Werger 1974). Species with a high degree of restriction, which are restricted to one or a few nodums, are called diagnostic species. Diagnostic species found in only one nodum are called character species, while diagnostic species in a particular table, which may be widespread in other tables are called differential species (Westhoff & Van der Maarel 1973).

It is common practice that syntaxa are named after one or two of the diagnostic species. Sometimes a prominent or constantly abundant species is used in combination with a diagnostic species (Werger 1974).

The community can also be named by combining a certain species name with the most outstanding physiognomic characteristic of that particular community and/or with the most prominent habitat characteristic of the community (Van Rooyen 1996). Edwards' structure classification is used to supply an applicable physiognomic term, which is attached to the species name, to form the final name of the community (Edwards 1983). The characteristics that are used are four growth forms (trees, shrubs, grasses and herbs), four canopy cover classes (closed, open, sparse and spread out), and four height classes (high, long, short and low) determined separately for trees, shrubs and grasses & herbs) (Van Rooyen 1996). Poaceae, Cyperaceae and Restionaceae are all included under grasses in Edwards' structural growth forms (Van Rooyen 1996).

The syntaxa were named using a dominant plant species in the vegetation unit, in combination with a diagnostic or prominent species, and adding a physiognomic term, according to the classification of Edwards (1983). In appropriate cases, like the beach vegetation syntaxon, the names of the plant species were combined with the prominent habitat characteristic.

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