

# Threatened Limestone Fynbos plant communities of Andrew's Field and Tsaba-Tsaba Nature Reserve, Western Cape

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**Keywords:** conservation area, endemic plants, Limestone Fynbos, phytosociology, plant communities, TWINSpan, Western Cape

## ABSTRACT

The vegetation of inland plains and hills of the Andrew's Field and Tsaba-Tsaba Nature Reserve, Bredasdorp District, Western Cape was classified using TWINSpan and Braun-Blanquet procedures. The resulting four plant communities and nine subcommunities were described and interpreted ecologically. The vegetation was sampled using 97 randomly stratified plots. The floristic composition, Braun-Blanquet cover-abundance of each species, and various environmental variables were recorded in each sample plot. The relationship between the vegetation units and the associated environmental gradients was confirmed by ordination, using the DECORANA computer program, applied to the floristic data set. The conservation priority of each vegetation unit was determined by taking the occurrence of Red Data List species, limestone endemic species and Cape Floristic Region endemic species into consideration. The distribution of the plant communities can mainly be ascribed to differences in the clay/sand content of the soil and the degree of exposure of the vegetation to the dominating winds (southeastern and northwestern) of the area.

## INTRODUCTION

The Andrew's Field and Tsaba-Tsaba Nature Reserve is situated in the Bredasdorp/Riversdale Centre of Endemism (Cowling 1992). This centre refers to a well-defined group of plants confined to the limestones of the Bredasdorp Formation (Moll *et al.* 1984) and associated colluvial deposits (Heydenrych 1994). Limestone Fynbos is one of the most threatened vegetation types in the Cape Floristic Region (Hilton-Taylor & Le Roux 1989). Factors threatening Limestone Fynbos vegetation include alien plants (considered to be the biggest threat to the natural environment), land clearing, resort development, incorrect fire management and over-harvesting of flowers (Heydenrych 1994).

Cowling *et al.* (1988) and Rebelo *et al.* (1991) indicated that very little is known about the vegetation ecology of Limestone Fynbos. Both these authors attempted vegetation classifications based on a combination of structural characters (Campbell 1986) and dominant species. Vegetation classification and description using total floristics were avoided due to the highly variable floristic structure and the very high number of species in Fynbos communities (Cowling *et al.* 1988). Detailed vegetation studies based on total floristics are therefore very limited or do not exist at all in Limestone Fynbos. Furthermore, 21% of all Limestone Fynbos species are not conserved in state-owned nature reserves (Heydenrych 1994). The conservation importance of Limestone Fynbos, which dominates the inland plains and hills, makes the effective management of the area all the more important, and justifies a detailed vegetation study based on total floristics.

## STUDY AREA

### Location

The study area is situated in the Bredasdorp District, Western Cape, between Struisbaai North in the south

and the De Mond State Forest in the north (Figure 1). The area is bordered in the west by the Bredasdorp/Struisbaai road, and in the south by the sea. According to the geographical division of Heydon & Tinley (1980), the study area is situated on the south coast, which is a transitional zone, between tropical and temperate waters. Offshore is the major retroflex area of Agulhas Current waters, recurving eastwards and landwards (Heydon & Tinley 1980).

The study area is  $\pm 979$  ha in extent and consists of Andrew's Field ( $\pm 129$  ha) and Tsaba-Tsaba Nature Reserve ( $\pm 850$  ha), which are adjacent areas on the same farm (Portion 7 and the remainder of Portion 8 of the Farm Zoetendalsvlei No. 280). Approximately two thirds of the study area consists of inland plains and hills of Limestone Fynbos; the rest of the area consists of coastal thickets. According to Low & Rebelo (1998), two veld types occur on the inland plains and hills: Limestone Fynbos and South- and Southwest Coast Renosterveld, whereas Mustard *et al.* (1997) also mentions Dune Asteraceous Fynbos for this coastal area. According to Mucina *et al.* (2005), the area consists of Overberg Dune Strandveld and De Hoop Limestone Fynbos.

### Geology

Two formations of the Bredasdorp Group namely the Strandveld Formation and the Waenhuiskrans Formation are found in the study area. The Bredasdorp Group is described by Malan *et al.* (1994) as Cenozoic sediments of marine and marine related origin, stretching up to 22 km inland from the current coastline. The rocks are discordantly laid down on marine-paved rocks of the Table Mountain, Bokkeveld and Uitenhage Groups (Malan *et al.* 1994).

The Strandveld Formation, found along the coast, consists of white to pale grey dune sands with a high percentage of shell fragments. Partial cementing of sands with a high calcium carbonate content took place. The lithology of this formation can be described as white dune sand with finely divided shell and alluvial stones (Malan *et al.* 1994).

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MS. received 2005-08-19.

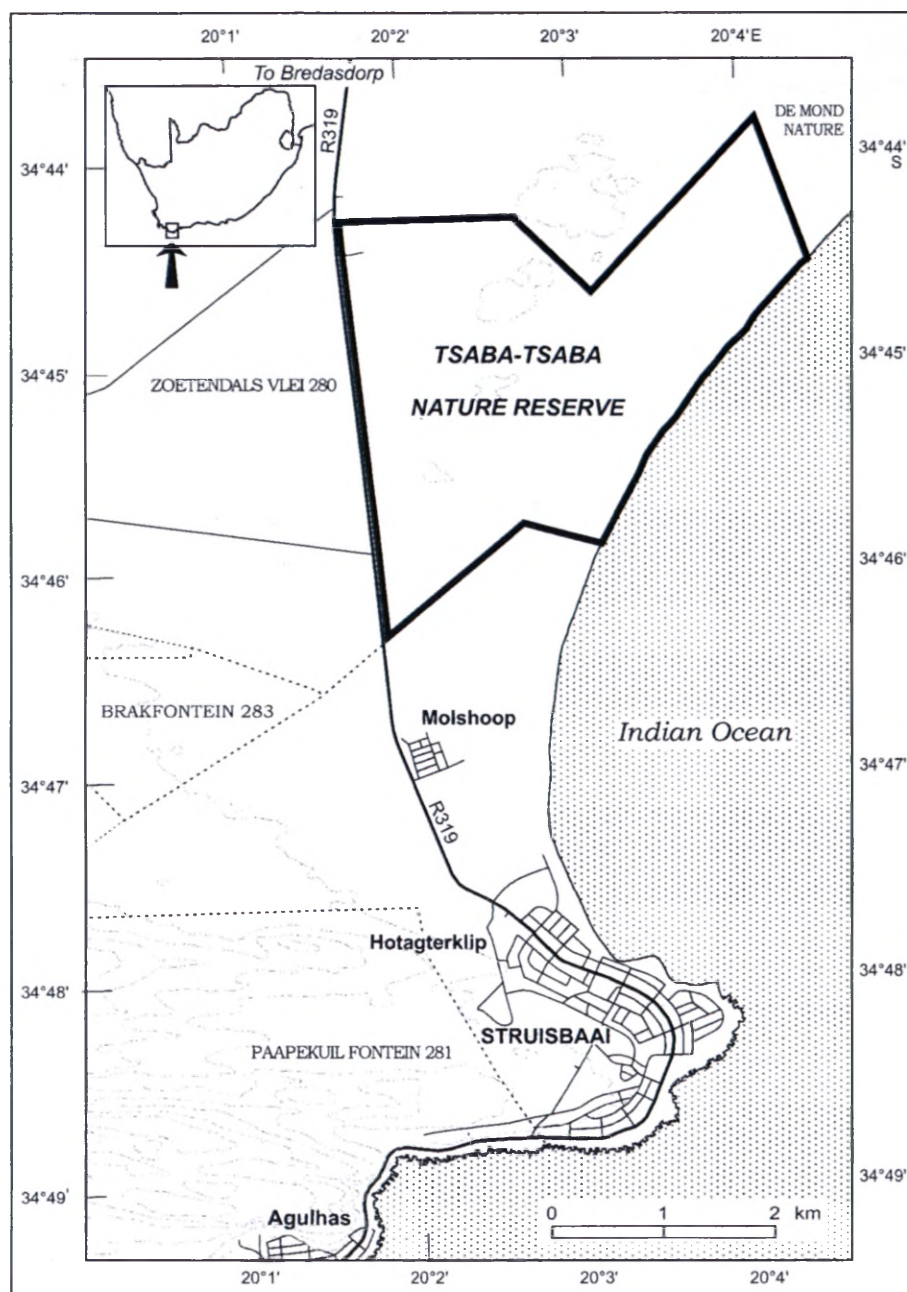


FIGURE 1.—The location of the study area.

The Waenhuiskrans Formation forms outcrops next to the current coastline. The Waenhuiskrans stratotype is 12.4 m deep, overlain with 1 m thick calcretes locally, and consists of medium granulated cross-layered calcarenite with well-rounded quartz and a few glauconite grains. Large-scale aeolic cross layers are characteristic of the unit. The lithology of this formation can be described as partially calcified dune sand (Malan *et al.* 1994).

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

#### Physiography

The study area is situated on the Agulhas Plain, which is a coastal lowland. Most of the study area falls below the 10 m contour with a ridge running roughly north-

south reaching an altitude of 31 m in places (Jeffery 1996). The area mostly consists of gradual, sloped limestone hills and flat to gradual, sloped plains.

#### Soil

The soil is shallow and sandy, overlying limestone, or deeper and sandy, overlying clay, silt and gravel. Four different soil forms have been distinguished in the area. Coega (Orthic A on hard bank carbonate horizon), family Marydale (lime containing A-horizon); Immerpan (Melanic A on hard bank carbonate horizon), family Kalkpan (lime containing A-horizon); Brandvlei (Orthic A on soft carbonate horizon), family Kolke (signs of wetness in the carbonate horizon); and Namib (Orthic A on regic sand), family Beachwood (containing lime within 1 500 mm from the soil surface) (MacVicar 1991).

The Coega soil form is found on the limestone hills and shallow-soil limestone plain. The Immerpan soil form is found on the deeper soil of a proteoid-dominated



limestone plain. The Brandvlei soil form is found in the marsh area, as well as on the renosterveld plain, whereas the Namib soil form is found on the dune plain and the deep sand found on proteoid-dominated foothills and plains.

### Climate

The main factors affecting the climate are the contrasting sea surface temperatures of the two major ocean currents and the inshore circulation (Tinley 1985). The south coast has a warm temperate climate with all seasons and bimodal equinoctial rainfall (Strydom 1992).

The study area is situated in the Southern Overberg, which is a transition between the winter rainfall region and the nonseasonal rainfall region in the east (Mustard *et al.* 1997). According to Heydorn & Tinley (1980) the study area is situated in a low rainfall region, on an arid inland tongue reaching the coast. The low rainfall regime appears to be due to the occurrence of cold inshore waters, which inhibit shoreline rains. The average annual precipitation of the area is 444 mm. Precipitation mostly takes place in the form of rain, but also occurs in the form of fog. The maximum precipitation is in June, and the minimum precipitation during February and December. A climate diagram (Figure 2) was compiled from data obtained from the Agulhas Weather Station.

The average annual minimum and maximum temperatures for the area are 6°C and 13.3°C, respectively. The maximum and minimum temperatures for the area were 36.1°C in February and 3.9°C in June respectively.

The wind along the south coast is bi-directional; southeasterly winds alternate with northwesterly and southwesterly winds (Heydorn & Tinley 1980).

### METHODS

Relevés were compiled in 97 plots, placed in a stratified random way in relatively homogeneous areas, representative of particular plant communities. A plot size of 10 × 10 m was used, which is considered as large enough to ensure that all species of regular occurrence in the stand are present in the sample plot (Rebello *et al.* 1991). Sample plots were placed to ensure that each plot adequately represented the structure of the particular vegetation (Werger 1974). A list of plant species found in each sample plot was compiled. The cover-abundance of each species in the sample plot was assessed, using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974; Werger 1974), with the modification proposed by Barkman *et al.* (1964) and Westhoff & Van der Maarel (1978). Vegetation structure, based on height and plant cover classes, is described according to the structural classification of Edwards (1983).

The Edwards (1983) height classification is as follows:

Height class	Shrubs	Grasses and herbs
High	2–5 m	> 2 m
Tall	1–2 m	1–2 m
Short	0.5–1.0 m	0.5–1.0 m
Low	< 0.5 m	< 0.5 m

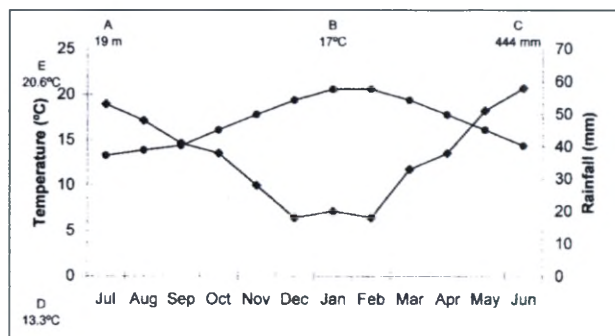


FIGURE 2.—A climate diagram for Andrew's Field and Tsaba-Tsaba Nature Reserve. A, altitude; B, mean annual temperature; C, mean annual rainfall; D, mean daily minimum (coldest month); E, mean daily maximum (hottest month).

The following habitat characteristics were recorded in each sample plot: altitude, topographical position, geomorphology, exposure to sun and wind, slope angle, slope direction, geology, soil, percentage rock cover and biotic influence.

All data were incorporated into a vegetation database created in TURBOVEG (Hennekens & Schaminee 2001). To obtain a first approximation of the plant communities of the area, relevés were extracted from TURBOVEG into MEGATAB (Hennekens 1996) and then classified using the TWINSpan algorithm (Hill 1979) contained within MEGATAB. These results were then refined by application of the classical Braun-Blanquet methodology (Behr & Bredenkamp 1988), using MEGATAB as the table editor. The results obtained from the classification are presented in a phytosociological table (Appendix 1). Plant names conform to Germishuizen & Meyer (2003).

### RESULTS

#### Classification

Six main habitat types are found in the study area, namely wetlands, limestone hills, shallow limestone plains, deep-soil limestone plains, undulating dune plains with neutral sands and Renosterveld.

The plant communities are classified as follows:

1. *Phragmites australis*–*Juncus kraussii* Tall to High Closed Reed Wetland Community
2. *Chondropetalum microcarpum*–*Metalasia pungens* Low Closed Ericoid and Restioid Fynbos Community
  - 2.1 *Adromischus caryophyllaceus*–*Chondropetalum microcarpum* Low Closed Limestone Fynbos Subcommunity
  - 2.2 *Passerina corymbosa*–*Chondropetalum microcarpum* Low to Short Closed Fynbos Subcommunity
  - 2.3 *Empodium gloriosum*–*Chondropetalum microcarpum* Low to Short Closed Limestone Fynbos Subcommunity
  - 2.4 *Eriocephalus kingesii*–*Chondropetalum microcarpum* Low to Short Closed Fynbos Subcommunity
3. *Leucadendron meridianum*–*Protea obtusifolia* Low to High Limestone Fynbos Community
  - 3.1 *Amphithalea alba*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity
  - 3.2 *Erica abietina*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity
  - 3.3 *Ehrharta calycina*–*Leucadendron meridianum* Low to Short Limestone Fynbos Subcommunity

- 3.4 *Metalasia muricata*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity  
 3.5 *Protea susannae*–*Leucadendron coniferum* High Closed Fynbos Subcommunity  
 4. *Oedera uniflora*–*Elytropappus rhinocerotis* Low Closed Renosterveld Community

A diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the plant communities is given in Figure 3. The community numbers in Figure 3 correspond with the plant community numbers used in the text.

The distribution of the communities is shown in a vegetation map (Figure 4).

#### Description of the communities

1. *Phragmites australis*–*Juncus kraussii* Tall to High Closed Reed Wetland Community

Species per relevé: 4.

Diagnostic species: the reed *Phragmites australis*, the rush *Juncus kraussii* as well as the shrub *Plecotachys serpyllifolia* (Species Group A, Appendix 1).

Dominant plants: *Phragmites australis* and *Juncus kraussii*.

Structure: high, closed grass *Phragmites australis* in the wetland, with high *Phragmites australis*, tall *Juncus kraussii* and some short shrubs in the area surrounding the dam. The surrounding marshy area contains tall, closed *Juncus kraussii*, with some short shrubs in between.

The community is situated near the corner of the northern and western borders of the Reserve. It is found in the flat wetland/marsh area close to a dam, at an altitude of 3 m. Small, irregular, white-grey limestone stones, originating from the Waenhuiskrans Formation of the Bredasdorp Group, and orange-brown ferricrete pebbles associated with Table Mountain Rocks (Malan *et al.* 1994), cover 10% of the soil surface. Soils are of the Coega Form.

2. *Chondropetalum microcarpum*–*Metalasia pungens* Low Closed Ericoid and Restioid Fynbos Community

Diagnostic species: the shrubby *Metalasia pungens*, *Indigofera meyeriana*, *Acmadenia obtusata*, *Agathosma collina*, *Muraltia satureoides* var. *satueoides*, the forb *Lobelia setacea*, the restio *Calopsis viminea*, and the grasses *Cymbopogon pospischilii* and *Setaria sphacelata* var. *sphacelata* (Species Group B, Appendix 1).

Dominant plants: the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Metalasia pungens*, *Acmadenia obtusata*, *Agathosma collina* (Species Group B), *Diosma guthriei* (Species Group C), *Disparago anomala*, *Phylica ericoides* (Species Group M), *Morella quercifolia* (Species Group N), *Passerina paleacea* (Species Group P) and *Passerina galpinii* (Species Group Q), and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: varies from predominantly low, closed ericoid and asteraceous shrubs, with low restioids in abundance and with short shrubs sparsely scattered in the area.

This widespread and diverse community, consisting of four subcommunities, is found at the western and northern borders of Tsaba-Tsaba Nature Reserve and also in a mosaic of scattered patches in the central parts of the study area. It occurs at an altitude of 3–23 m, at a gradient of 0°–45°, on various habitat types, including the shallow-soil limestone plains, undulating dune plains, sandy footslopes and southerly slopes of limestone hills.

Small, irregular, white-grey pebbles, stones and rocks from the Waenhuiskrans Formation cover 0–40% on the limestone plains and 2–60% on the limestone hills. Small limestone pebbles originating from the Strandveld Formation cover 0–5% on the dune plains.

Soils are of the Coega and Brandvlei Forms on the limestone plain, the Namib Form on the dune plain and the Coega and Immerpan Forms on the limestone hills.

This restio-dominated fynbos community is floristically different from the Restioid Fynbos recognized by Cowing *et al.* (1988) or Rebelo *et al.* (1991). It should, however, be mentioned that Rebelo *et al.* (1991) combined structural and floristic characters in their analysis, and only dominant species were surveyed. This may account for some of the floristic differences between the plant communities from the current study and those from the Riversdale Plain. Many floristically different plant communities are, however, expected to be found in Restioid Fynbos from the limestone areas, as four subcommunities are recognized in this study:

- 2.1 *Adromischus caryophyllaceus*–*Chondropetalum microcarpum* Low Closed Limestone Fynbos Subcommunity

Species per relevé: 28.

Diagnostic species: the shrubby *Diosma guthriei*, the succulent forb *Adromischus caryophyllaceus* and the sedge *Ficinia truncata* (Species Group C, Appendix 1).

Dominant plants: the shrubs *Metalasia pungens* and *Acmadenia obtusata*, (Species Group B), and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Disparago anomala*, *Phylica ericoides* (Species Group M) and *Passerina galpinii* (Species Group Q) and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: low, closed ericoid and asteraceous shrubs, with low restioids in abundance; short shrubs are also sparsely distributed.

The subcommunity is found scattered throughout the study area and is situated at an altitude of 3–10 m on a gradient of 0°–8°, on the shallow-soil limestone plain, where pebbles, stones and rocks cover 0–30% of the soil. Soils are of the Coega and Brandvlei Forms.

- 2.2 *Passerina corymbosa*–*Chondropetalum microcarpum* Low to Short Closed Fynbos Subcommunity

Species per relevé: 35.

Diagnostic species: the shrubby *Passerina corymbosa* and *Agathosma dielsiana* and the restio *Ischyrolepis triflora* (Species Group D, Appendix 1).

Dominant plants: the shrubs *Metalasia pungens*, *Acmadenia obtusata* (Species Group B), *Agathosma collina* (Species Group B), *Morella quercifolia*



**VEGETATION UNITS OF THE INLAND PLAINS AND HILLS OF ANDREW'S FIELD AND  
TSABA-TSABA NATURE RESERVE.**

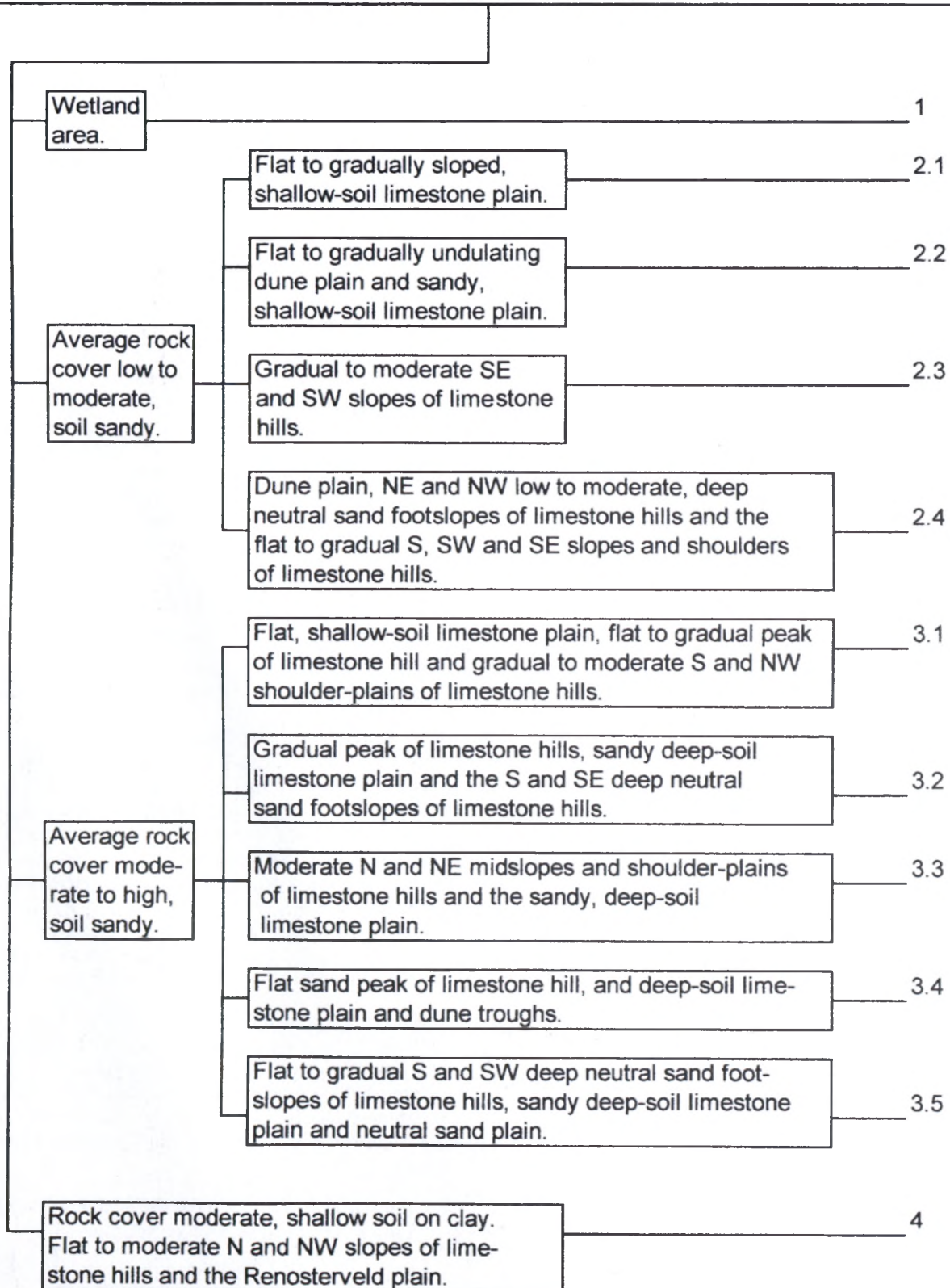


FIGURE 3.—The hierarchical classification and associated environmental characteristics of plant communities of the inland plains and hills.

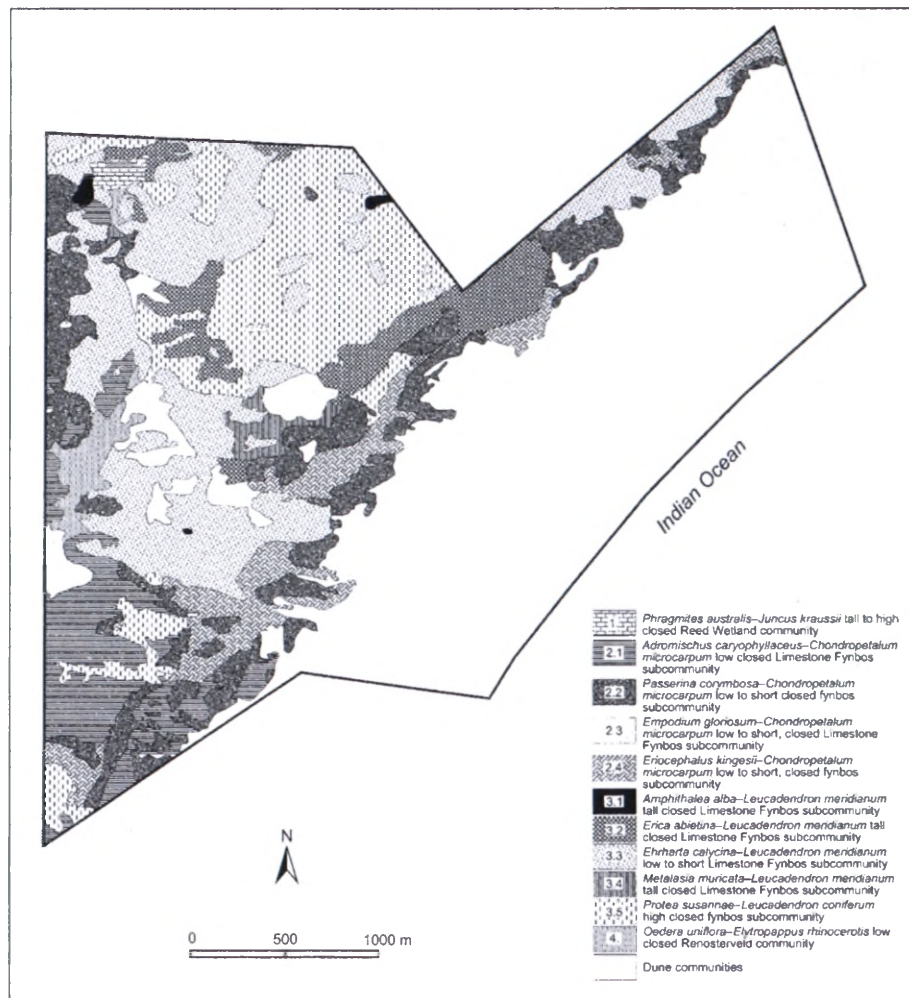


FIGURE 4.—Vegetation map of the Andrew's Field and Tsaba-Tsaba Nature Reserve.

(Species Group N) and *Passerina paleacea* (Species Group P), and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Phylica ericoides*, *Disparago anomala*, (Species Group M), *Otholobium bracteolatum* (Species Group P) and *Passerina galpinii* (Species Group Q), the restio *Thamnochortus insignis* (Species Group Q) and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: mostly low to short, closed ericoid and asteraceous shrubs; taller shrubs scattered throughout the area; some tall and short restios in abundance.

The subcommunity is found scattered over the entire study area at an altitude of 0–12 m, at a gradient of 0°–26°, on the dune plains where pebbles cover 0–5% and the sandy, shallow-soil limestone plains with pebbles covering 7–40%. Soils are of the Namib Form on the dune plains and the Brandvlei Form on the limestone plain.

### 2.3 *Empodium gloriosum*–*Chondropetalum microcarpum* Low to Short Closed Limestone Fynbos Subcommunity

Species per relevé: 26.

Diagnostic species: the forb *Empodium gloriosum*. (Species Group E, Appendix 1). Although this species group is poorly defined, with low constancy of the diagnostic species, the subcommunity is further confirmed by

the presence of Species Group B and absence of Species Groups C, D, and E.

Dominant plants: the shrub *Phylica ericoides* (Species Group M) and restioids *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Disparago anomala* (Species Group M), *Passerina paleacea* (Species Group P) the restoid *Thamnochortus insignis* (Species Group Q) and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: mostly low to short, closed ericoid and asteraceous shrubs; some taller shrubs scattered throughout the area; some tall and short restios in abundance.

This subcommunity is situated near the western border and in the eastern middle part of the Reserve. It occurs at an altitude of 3–23 m, at a gradient of 0°–45°, on the southeastern- and southwestern-facing slopes of limestone hills. Pebbles, stones and small rocks cover 2–60% of the soil. Soils are of the Coega and Immerpan Forms.

### 2.4 *Erioccephalus kingesii*–*Chondropetalum microcarpum* Low to Short Closed Fynbos Subcommunity

Species per relevé: 22.

Diagnostic species: the shrub *Erioccephalus kingesii* (Species Group F, Appendix 1).

Dominant plants: the shrubs *Acmadenia obtusata* and *Agathosma collina* (Species Group B), *Phylica ericoides* (Species Group M), *Passerina paleacea* (Species Group P),



the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Metalasia pungens* (Species Group B), *Disparago anomala* (Species Group M), *Morella quercifolia* (Species Group N) and *Passerina galpinii* (Species Group Q), the restios *Calopsis viminea* (Species Group B) and *Thamnochortus insignis* (Species Group Q) and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: mostly low to short, closed ericoid and asteraceous shrubs; taller shrubs scattered throughout the area with tall and short restios in abundance.

The subcommunity occurs scattered over the entire study area on footslopes and slopes of limestone hills and on dune plains at an altitude of 3–21 m, with gradients of 0°–16°. Pebbles cover 1–35% of the soil. Soils are of the Namib Form on the dune plain and Immerpan and Coega Forms on the limestone hills.

### 3. *Leucadendron meridianum*–*Protea obtusifolia* Low to High Limestone Fynbos Community

Diagnostic species: the shrub *Helichrysum patulum* and the trees *Leucadendron meridianum* and *Protea obtusifolia* (Species Group G, Appendix 1).

Dominant plants: the shrubs *Rhus glauca*, *Euclea racemosa* and the restio *Thamnochortus insignis* (Species Group Q).

Prominent species: the shrubs/trees *Amphithalea alba*, *Leucospermum truncatum*, *Erica longifolia*, *E. propinqua*, *Stoebe cinerea* and *Aspalathus globulosa* (Species Group I), *Protea susannae* (Species Group L), *Metalasia muricata* (Species Group N), *Passerina paleacea* (Species Group P), and *Passerina galpinii* (Species Group Q), the forbs *Dimorphotheca nudicaulis* (Species Group I), *Dorotheanthus bellidiformis*, *Gladiolus gracilis*, *Dianthus albens* (Species Group J), the grass *Eragrostis sarmentosa* (Species Group K) and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Structure: a mixture of low, open ericoid-dominated fynbos shrubland, with scattered groups of tall to high, closed proteoid-dominated shrubs. High restios are found in the community, usually more abundant in the closed proteoid-dominated shrubland areas of the community. Low restios are also found quite abundantly throughout the community.

The community occurs from the corner formed by the northern and western borders of the Reserve up to the middle of the study area, running along the western border, and on the eastern section of the northern border, at an altitude of 1–31 m, at a gradient of 0°–16°, on the shallow and deep soils of the limestone plains, along the limestone hills, on the northern and northeastern midslopes of limestone ridges, on the deep sands of footslopes as well as in the dune troughs between dunes.

Large, irregularly shaped, white-grey rocks, with some smaller stones and pebbles, as well as rock sheets, cover 3–65% of the soil on the ridge. Small, irregular white-grey pebbles and stones cover 0–7% of the limestone plains. The sand in the dune troughs have no rocks. The limestone originated from the Waenhuiskrans

Formation of the Bredasdorp Group. Soils are of the Brandvlei Form on the shallow-soil limestone plain, the Immerpan Form on the deep-soil limestone plain, the Immerpan and Coega Forms on the limestone hills, and the Namib Form in the dune through areas.

The tall-, high-, short-, and low shrub strata have an average canopy cover of 21%, 16%, 11% and 11% respectively, and an average height of 2.5 m, 1.5 m, 0.75 m and 0.4 m respectively. The forb stratum has an average canopy cover of 4% and an average height of 0.3 m. The high-, tall-, short-, and low restioid strata have an average canopy cover of 0.5%, 6%, 2%, and 14% respectively, and an average height of 2.5 m, 1.5 m, 0.75 m and 0.4 m respectively. The sedge stratum has an average canopy cover of 0.7% and an average height of 0.15 m. The short- and low grass strata have an average canopy cover of 1% and 3% respectively, and an average height of 0.5 m and 0.3 m respectively. Rebelo *et al.* (1991) emphasized the conspicuous high cover of proteoids and restioids in this type of vegetation.

Similar communities were described from the Riversdale Plain by Cowling *et al.* (1988) and Rebelo *et al.* (1991) as *Leucadendron meridianum*/*Protea obtusifolia* Mesic Proteoid Fynbos.

Five subcommunities could be distinguished. The diagnostic species groups of particularly subcommunities 3.2, 3.3 and 3.4 are rather weakly defined, though TWINSPAN delimited these subcommunities on the basis of total floristic composition, and the diagnostic species, though present with rather low constancy, are to a large extent restricted to the particular subcommunity.

#### 3.1 *Amphithalea alba*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity

Species per relevé: 42.

Diagnostic species: the shrubs *Amphithalea alba*, *Leucospermum truncatum*, *Oedera capensis* and *Erica spectabilis* (Species Group I, Appendix 1).

Dominant plants: the shrubs *Leucadendron meridianum* and *Protea obtusifolia* (Species Group G) and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Helichrysum patulum* (Species Group G), *Metalasia calcicola* (Species Group H), *Phyllica ericoides* (Species Group M), *Disparago anomala* (Species Group M), *Rhus glauca* and *Euclea racemosa* (Species Group Q).

Structure: low, open ericoid-dominated fynbos shrubland, with scattered groups of tall, closed proteoid-dominated shrubs.

The subcommunity is situated near the corner of the northern and western border of the Reserve, adjacent to the marsh area. The subcommunity is also found at the northwestern inland border, as well as near the middle of the western border of the Reserve, at an altitude of 3–31 m, at a gradient of 0°–16°, on shallow-soil limestone plains and along the limestone hill summit.

Large irregularly shaped, white-grey rocks, smaller stones and pebbles cover 3–5% of the soil on the limestone hills, while pebbles are present on the limestone



plain. The limestone originated from the Waenhuiskrans Formation of the Bredasdorp Group. Soils are of the Brandvlei Form on the limestone plain and the Coega and Immerpan Forms on the limestone hills.

### 3.2 *Erica abietina*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity

Species per relevé: 34.

Diagnostic species: the shrubs *Erica abietina* var. *abietina*, *Heterolepis peduncularis* and *Stoebe cinerea* (Species Group J, Appendix 1).

Dominant plants: the shrubs *Leucadendron meridianum* and *Protea obtusifolia* (Species Group G) and the restioids *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Helichrysum patulum* (Species Group G), *Metalasia calcicola* (Species Group H), *Phyllaea ericoides*, *Disparago anomala* (Species Group M), *Metalasia muricata* (Species Group N, Appendix 1), *Passerina paleacea* (Species Group P), *Rhus glauca* and *Euclea racemosa* (Species Group Q) and the restio *Thamnochortus insignis* (Species Group Q).

Structure: tall, closed, proteoid-dominated shrubland fynbos.

The subcommunity is found along the northern border of the Reserve, near the marsh area and at the northwestern border, as well as near the middle of the Reserve, at an altitude of 3–31 m, at a gradient of 0°–16°, on the summit of limestone hills, deep soils of the limestone plains and the deep sand on the footslopes of the limestone hills. Small, irregular, white-grey pebbles and stones on the limestone plains, and large, irregular, white-grey rocks, with some pebbles and stones, as well as sheets of rock on the limestone hills cover 0–65% of the soil. Soils are of the Immerpan Form on the limestone plains, the Immerpan and Coega Forms on the limestone hills, and the Namib Form in the sand area.

### 3.3 *Ehrharta calycina*–*Leucadendron meridianum* Low to Short Limestone Fynbos Subcommunity

Species per relevé: 33.

Diagnostic species: the shrub *Cassine peragua* and the grasses *Ehrharta calycina*, *Bromus diandrus* and *Eragrostis sarmentosa* (Species Group K, Appendix 1).

Dominant plants: the shrubs *Rhus glauca*, *Euclea racemosa* (Species Group Q) and *Passerina paleacea* (Species Group P), and the restio *Thamnochortus insignis* (Species Group Q).

Prominent species: the shrubs *Leucadendron meridianum*, *Protea obtusifolia* (Species Group G), *Helichrysum patulum* (Species Group G), *Metalasia muricata*, *Morella quercifolia* (Species Group N), *Otholobium bracteolatum* (Species Group P) and *Passerina galpinii* (Species Group Q) and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N) and the grass *Stipagrostis zeyheri* subsp. *sericans* (Species Group M).

Structure: low to short, open ericoid-dominated fynbos shrubland, with groups of tall to high, closed proteoid-dominated shrubs; high and low restios are abundant.

The subcommunity occurs in patches from the middle section of the northern border to the central part of the Reserve; it also occurs in the centre of the whole of the study area, near the western and northern borders, at an altitude of 3–21 m, at a gradient of 0°–16° on the northern and northeastern midslopes and upper slopes of limestone hills and also on the sandy, deep-soil limestone plain. Irregular white-grey limestone pebbles, stones and small rocks and rock sheets cover 1–10 % of the soil on the limestone plain. Large, irregular, white-grey rocks, with pebbles, stones and rock sheets, cover up to 60% on the limestone hills. Soils are of the Immerpan Form on the limestone plain, and the Immerpan and Coega Forms on the limestone hills.

### 3.4 *Metalasia muricata*–*Leucadendron meridianum* Tall Closed Limestone Fynbos Subcommunity

Species per relevé: 13.

Diagnostic species: Species Group G and the absence of Species Groups H–L (Appendix 1).

Dominant plants: the shrub *Metalasia muricata* and the restio *Chondropetalum microcarpum* (Species Group N).

Prominent species: the shrubs *Leucadendron meridianum*, *Protea obtusifolia*, *Helichrysum patulum* (Species Group G) and *Passerina paleacea* (Species Group P).

Structure: tall, closed, proteoid-dominated shrubland.

The subcommunity is found in patches near the central part of the whole study area and in patches near the southeastern border of the Reserve, at an altitude of 1–14 m, at a gradient of 0°–8°, on the sandy summits of limestone hills, and on the deep-soil limestone plain and on dune troughs. Small, irregular, white-grey pebbles and stones cover 3% of the soil on the limestone hill, but no rocks occur on the limestone plain and in the dune troughs. Soils are of the Namib Form in the dune area, the Immerpan Form on the limestone plain, and the Immerpan and Coega Forms on the limestone hills.

The absence of the widespread species of Species Group M is a further diagnostic feature. An obvious explanation for the lack of diagnostic species is the very low species richness of this subcommunity. The species present in this subcommunity are from Species Group G (diagnostic species of the *Leucadendron meridianum*–*Protea obtusifolia* low to high Limestone Fynbos community), and other widespread species (Species Groups N, P and Q).

### 3.5 *Protea susannae*–*Leucadendron coniferum* High Closed Fynbos Subcommunity

Species per relevé: 24.

Diagnostic and dominant species: the trees *Protea susannae* and *Leucadendron coniferum* (Species Group L, Appendix 1).

Dominant plants: the trees *Protea susannae* and *Leucadendron coniferum* (Species Group L, Appendix 1).

Prominent species: the shrubs *Helichrysum patulum* (Species Group G) and *Passerina paleacea* (Species Group P) and the restios *Ischyrolepis eleocharis* and *Chondropetalum microcarpum* (Species Group N).

Structure: high, closed, proteoid-dominated shrubland.

The subcommunity is situated in patches along the northern border of the Reserve, adjacent to the marsh area, in the corner of the northern and inland northwest-



ern border and in patches near the centre of the whole study area, at an altitude of 3–25 m, at a gradient of 3°–8°, on the southern and southwestern deep sands on the footslopes of limestone hills and on the deep-soil limestone plain. There are no rocks in this subcommunity. Soils are of the Namib Form on the sand areas and the Immerpan Form on the deep-soil limestone plain.

A further characteristic feature of this subcommunity is the absence of the widespread species of Species Groups M and N.

Rebello *et al.* (1991) also identified a community with *Protea sussanae* from the Riverdale Plain, while Cowling *et al.* (1988) described a *Protea sussanae*/*Leucadendron coniferum* Mesic Proteoid Fynbos from the Agulhas Plain.

#### 4. *Oedera uniflora*–*Elytropappus rhinocerotis* Low Closed Renosterveld Community

Species per relevé: 25.

Diagnostic and dominant species: the shrubs *Elytropappus rhinocerotis*, *Oedera uniflora* and *Euchaetis meridionalis*, the grass *Andropogon appendiculatus* and the forbs *Berkheya coriacea* and *Tritonia deusta* (Species Group O, Appendix 1).

Prominent species: the shrubs *Passerina galpinii* and *Helichrysum teretifolium* (Species Group Q).

Structure: low, closed renosterveld shrubland.

The community is found in patches near the middle of the western border of the study area, as well as adjacent to the wetland area, at an altitude of 3–18 m, at a gradient of 0°–13°, on the northern and northwestern slopes of limestone hills, and on the Renosterveld plain. Small, irregular, white-grey pebbles and stones cover 1–10%.

The tree stratum has an average canopy cover of 6% and an average height of 2.5 m. The high shrub stratum has an average canopy cover of 6% and an average height of 1.5 m, while the medium shrub stratum has an average canopy cover of 7%, and an average height of 0.75 m and the low shrub stratum has an average canopy cover of 32% and an average height of 0.4 m. The high, medium and low restio strata have an average canopy cover of 2%, 0.6% and 4% respectively, and an average height of 1.5 m, 0.75 m, and 0.20 m respectively. The medium grass stratum has an average canopy cover of 17% and an average height of 0.6 m while the low grass stratum has an average canopy cover of 2% and an average height of 0.25 m. The sedges have an average canopy cover of 0.5% and an average height of 0.10 m. The forb stratum has an average canopy cover of 3% and an average height of 0.15 m.

The absence of widespread Limestone Fynbos species listed in Species Groups M, N and P (Appendix 1) is a feature of this Renosterveld community. This community is considered to be rare and threatened by encroachment from alien *Acacia* species (Zietsman & Bredenkamp 2006). A similar community was recognized by Cowling *et al.* (1988) from the Agulhas Plain west of the study area and Rebello *et al.* (1991) from the Riversdale Plain, east of the study area.

## DISCUSSION

A large variety of plant species grouped into various plant communities occur on the Reserve. This study indicated that a total floristic approach can be successfully applied in the species-rich Limestone Fynbos communities. It is also shown that floristically derived plant communities can be mapped at the scale of nature reserves, and that this can be applied in conservation management plans. It is, however, recognized that a total floristic approach for regional studies remains difficult within the Limestone Fynbos area (Van der Merwe 1977; Cowling *et al.* 1988; Rebello *et al.* 1991). The use of TWINSpan and the application of Braun-Blanquet procedures for refinement were successful to delimit the communities and classify them in a hierarchical system. Four plant communities, with nine subcommunities, were identified. The plant communities could all be related to specific environmental conditions and are therefore floristically and ecologically distinguishable and interpretable. These plant communities are interpreted as separate ecosystems (Bredenkamp & Brown 2001), they therefore represent different management units, and can be incorporated in a veld management program.

The communities are well defined by diagnostic species, though diagnostic species for the subcommunities often have low constancy values. However, these subcommunities are retained because they were delimited by TWINSpan, based on total floristic composition, and the diagnostic species are largely restricted to the particular subcommunities.

## CONSERVATION

All the plant communities of the inland plains and hills are considered to have a high conservation value. Community 1, the *Phragmites australis*–*Juncus kraussii* tall to high closed Reed Wetland is a sensitive wetland system that could easily be disturbed and should therefore be protected (Doust & Doust 1995; Van Wyk *et al.* 2000). The conservation of wetlands is furthermore enforced by law (Environment Conservation Act, 1989: Act No. 73 of 1989 and National Water Act, 1998: Act No. 36 of 1998).

Among the terrestrial plant communities identified in the study area, nine species encountered are listed in the *Red Data List of southern African plants* (Hilton-Taylor 1996) and a further four are listed in the later *Southern African plant Red Data List* (Golding 2002), giving a total of 13 Red Data plant species. Furthermore, 23 limestone endemic species were present. From a PRECIS list (SANBI 2006), 38 from 238 species collected from the 3420CC grid, were Red Data species. The Agulhas plain, on which the study area is situated, is considered, from a botanical viewpoint, as an area of high irreplaceability and high vulnerability, being rich coastal lowland with remnant patches of coastal renosterveld and lowland fynbos, which are considered among the highest priorities for conservation in South Africa and globally (Schwegler 2003).

Heydenrych (1994) listed 110 plant species endemic to limestone outcrops. The Agulhas Plain Centre, one

of the six phytogeographic centres of the Cape flora, contains a total of 1 374 species (Goldblatt & Manning 2000). Of the 285 species recorded during the plant surveys in the Reserve, 138 species are endemic to the Cape, giving a figure of 48% endemism for the study area.

It can clearly be seen that the study area is one of exceptional species richness and conservation importance. Communities 2, 3 (Limestone Fynbos) and 4 (Renosterveld) should be protected due to the endemic and Red Data plant species present. Furthermore, large areas of renosterveld have been destroyed, mainly because of agricultural land clearing (Low & Rebelo 1998).

### CONCLUSIONS

Andrew's Field and Tsaba-Tsaba Nature Reserve are of great conservation significance. This area comprises an important part of a unique natural floral heritage found at the southern tip of Africa, with several endemic and Red Data species, and it should be protected and conserved to maintain its biodiversity for future generations.

The resulting classification could provide a useful tool, not only for the management of the plant communities of Andrew's Field and Tsaba-Tsaba Nature Reserve, but also for similar vegetation areas, e.g. the Agulhas National Park, found in the surrounding region.

### ACKNOWLEDGEMENT

Mrs F. Siebert is thanked for her assistance during data processing.

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APPENDIX 1.—Phytosociological table of inland plains and hills of Andrew's Field and Tsaba-Tsaba Nature Reserve (cont.)

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APPENDIX 1.—Phytosociological table of inland plains and hills of Andrew's Field and Tsaba-Tsaba Nature Reserve (cont.)

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APPENDIX 1.—Phytosociological table of inland plains and hills of Andrew's Field and Tsaba-Tsaba Nature Reserve (cont.)

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