The phytosociology of the northern section of the Borakalalo Nature Reserve

L.R. BROWN, G.J. BREDENKAMP and N. VAN ROOYEN

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After classifications and descriptions of the southern and western sections of the Borakalalo Nature Reserve were published, a study on the phytosociology of the northern part was initiated. The study is aimed at providing an ecological basis for establishing an efficient wildlife management programme for the reserve. From a TWINSPAN classification, refined by Braun-Blanquet procedures, 15 plant communities, which can be grouped into six major plant communities, were identified. Descriptions of the various plant communities, include diagnostic species, prominent species and less conspicuous species of the tree, shrub, forb and grass strata. A hierarchical classification, description of the plant communities and a vegetation map are presented.

Keywords: Borakalalo, conservation, floristic composition, plant communities, vegetation classification.

L.R. Brown, Applied Natural Sciences, Technikon SA, Private Bag X6, Florida, 1710, Republic of South Africa; G.J. Bredenkamp (to whom correspondence should be addressed) *and N. van Rooyen, Department of Botany, University of Pretoria, Pretoria, 0002 Republic of South Africa.*

Introduction

The Borakalalo Nature Reserve, which covers approximately 12 000 hectares, falls under the jurisdiction of North West Environmental Conservation. The reserve lies approximately 60 km north of Brits between 27°45'E–27°55'E longitude and 25°04'S–25°15'S latitude (Fig. 1). It is situated around the Klipvoor Dam, which is approximately 10 km long and up to 1 km wide (Greyling & Huntley 1984). The dam is mainly used for irrigation purposes (Greyling & Huntley 1984) and divides the reserve into three sections, namely the northern, southern and western sections. The phytosociology of the southern section was described by Brown & Bredenkamp (1994) and that of the western section by Brown *et al.* (1995).

Nature reserves provide reservoirs of a country's fauna and flora (Greyling & Huntley 1984). It is therefore important to investigate their natural resources, in order to compile scientifically sound management programmes and conservation policies (Bredenkamp & Theron 1978; Bredenkamp *et al.* 1993). Furthermore, vegetation and ecological inventory surveys of conservation areas are considered to have high priority (NACOR 1979).

Little is known about the vegetation of this area and the aim of this study was to classify, describe and map the vegetation of the northern section of the Borakalalo Nature Reserve. This can then serve as an inventory of the ecosystems and their biota and should form the basis for the compilation of vegetation, wildlife and ecotourism management plans.

The study area

The study area covers approximately 6 000 ha and lies on the north and north-eastern side

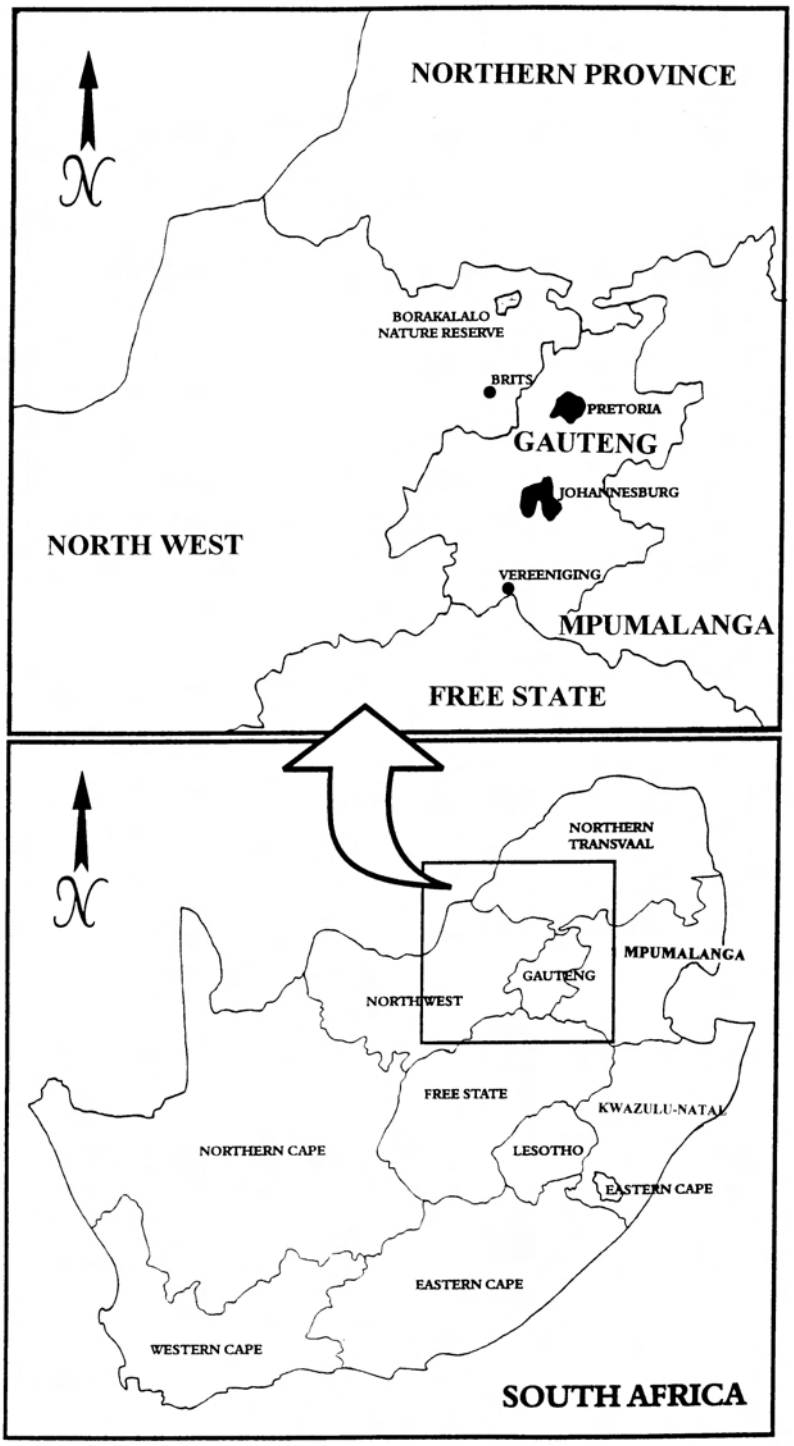

Fig. 1. The location of the study area in South Africa.

of the Klipvoor Dam. According to Acocks (1988) the area can be classified as Mixed Bushveld (veld type 18), while Van der Meulen (1979) described this area as Microphyllous Thorny Woodland. The landscape varies from flat to gentle undulating plains and is situated at an altitude of 944–1 082 m. Small patches of rocky outcrops are found in the north-eastern side of the area. The entire area slopes gradually towards the Klipvoor Dam in the south-west and numerous drainage lines dissect the area. The climate of this area was described by Brown *et al.* (1995).

Geology and soil

Geologically the study area is classified as Lebowa Granite Suite, Nebo Granite within the Bushveld Complex (Geological Survey 1981). The soils of the upland areas in the undulating terrain are coarse-grained sandy soils with large granite boulders, while those of the lower-lying areas and drainage lines are coarse and leached sandy soils. At the edge of the dam and on the banks of the Moretele River which flows into the dam, the soil is more clayey.

Methods

Stratification of the area into physiographic-physiognomic units was done using 1:50 000 stereo aerial photographs. To ensure that all variations in the vegetation were considered and sampled, a total of 132 sample plots were randomly located within these units. The sample plot size was fixed at approximately 200 m^2 in accordance with the size used by North West Environmental Conservation in their vegetation surveys (Brown & Bredenkamp 1994). The number of sample plots per unit was determined *pro rata* on the basis of the size of the unit area. The cover-abundance for every species present in each sample plot was assessed according to the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). The taxon names conform to those of Arnold & De Wet (1993). In accordance with the procedures used by North West Environmental Conservation, the woody stratum was divided into three height classes namely Lower (0-1 m), Middle (>1-3 m) and Upper classes (>3 m). Additionally, the percentage cover of the herbaceous layer, shrubs and trees was estimated. Environmental data include soil type, erosion, an estimation of aspect, slope and rockiness of the soil surface as well as the degree of grazing or trampling.

A first approximation of the main plant communities was derived by applying the TWINSPAN classification algorithm (Hill 1979) to the floristic data, and subsequently further refinement of the classification was achieved by Braun-Blanquet procedures (Bredenkamp *et al.* 1989; Kooij *et al.* 1990; Fuls *et al.* 1993).

The syntaxonomic nomenclature of Barkman *et al.* (1986) was not applied to the different plant communities, in spite of a regional syntaxonomic study by Van der Meulen (1979), as too little is presently known about the surrounding vegetation at the detailed level of this study. Therefore, the diagnostic species in this study are used in accordance with Westhoff & Van der Maarel (1978), but no distinction is made between character and differential species.

Results

Classification

The results of the classification procedure are presented in a phytosociological table (Table 1). In Fig. 2, the identified plant communities are mapped on a scale of 1:50 000. The analysis resulted in the following sixteen plant communities, which may be grouped into six major community types (Fig. 2):

1. *Combretum zeyheri-Combretum apiculatum* woodland of shallow, rocky granitic soils.
   - 1.1 *Chrysopogon serrulatus-Combretum apiculatum* woodland.
     - 1.1.1 *Chrysopogon serrulatus-Combretum apiculatum-Croton gratissimus* variant.
     - 1.1.2 *Chrysopogon serrulatus-Combretum apiculatum-Pterocarpus rotundi-folius* variant.
   - 1.2 *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum* woodland.
     - 1.2.1 *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum-Combretum molle* variant.

1.2.2 *Typicum* variant
1.2.3 *Dinebra retroflexa-Acacia nilotica - Combretum apiculatum - Peltophorum africanum* variant.
1.3 *Schizachyrium sanguineum - Combretum apiculatum* woodland.

2. *Perotis patens-Terminalia sericea* woodland of deep sandy, leached soils.
2.1 *Agathisanthemum bojeri - Terminalia sericea* woodland
2.1.1 *Eragrostis pallens* variant
2.1.2 *Protea welwitschii* variant.
2.1.3 *Agathisanthemum bojeri-Terminalia sericea-Pogonarthria squarrosa* variant.
2.2 *Digitaria eriantha-Terminalia sericea* woodland.

3. *Dichrostachys cinerea-Acacia tortilis* woodland of old cultivated fields on course-grained and loamy soils.

4. *Eragrostis trichophora-Acacia luederitzii* woodland of sandy and clayey soils on seasonally dry riverbeds.
4.1 *Eragrostis rigidior-Acacia luederitzii* woodland.
4.2 *Sporobolus ioclados-Acacia luederitzii* woodland.
4.2.1 *Sporobolus ioclados-Acacia luederitzii-Euclea undulata* variant.
4.2.2 *Sporobolus ioclados-Acacia luederitzii-Xerophyta humilis* variant.

5. *Cynodon dactylon* grassland of clayey and marshy soils on the edge of the dam.

6. *Panicum maximum-Acacia karroo* woodland of loam and clayey riverbank soils.

Description of the plant communities

The general vegetation of the study area is characterised by the presence of species group W (Table 1) in all the plant communities except the *Panicum maximum-Acacia karroo* woodland (community 6), while species of species group U are present in most plant communities. The most prominent species which therefore occur in almost all the communities, include the shrublike tree *Dichrostachys cinerea*, the grasses *Eragrostis rigidior*, *Aristida congesta* subsp. *barbicollis*, *Aristida stipitata* and *Tragus berteronianus* and the forbs *Waltheria indica*, *Monsonia angustifolia*, *Chamaecrista absus*, *Kyphocarpa angustifolia*, *Tephrosia capensis*, *Schkuhria pinnata* and *Sida cordifolia*. These species will therefore not necessarily be mentioned in the description of all the communities.

According to Van Oudtshoorn (1991), all the abovementioned grasses are pioneer grasses, and most of them are classified as Increaser IIc species, which occur abundantly in disturbed or overgrazed veld. Most of the forb species are also indicative of disturbed areas (Van Wyk & Malan 1988).

The presence of the bush encroacher *Dichrostachys cinerea* (Bredenkamp 1986; Bothma 1995), also indicates a poor veld condition which may be the result of drought and/or previous mismanagement. The vegetation is thus considered to be in a degraded condition.

1. *Combretum zeyheri-Combretum apiculatum* woodland of shallow, rocky granitic soils

This woodland plant community covers approximately 40 % of the study area and comprises a diverse habitat consisting of large, rocky granite outcrops scattered in low-lying areas where sandy and loamy soils as well as granite in various stages of deterioration are found. This woodland is situated in the central and north-western section of the study area. Due to floristic variation it can be divided into three sub-communities and five variants. The various sub-communities and variants form a mosaic distribution pattern and are, except for two variants, not indicated on the vegetation map (Fig. 2).

Diagnostic species include the trees *Combretum apiculatum*, *C. zeyheri*,

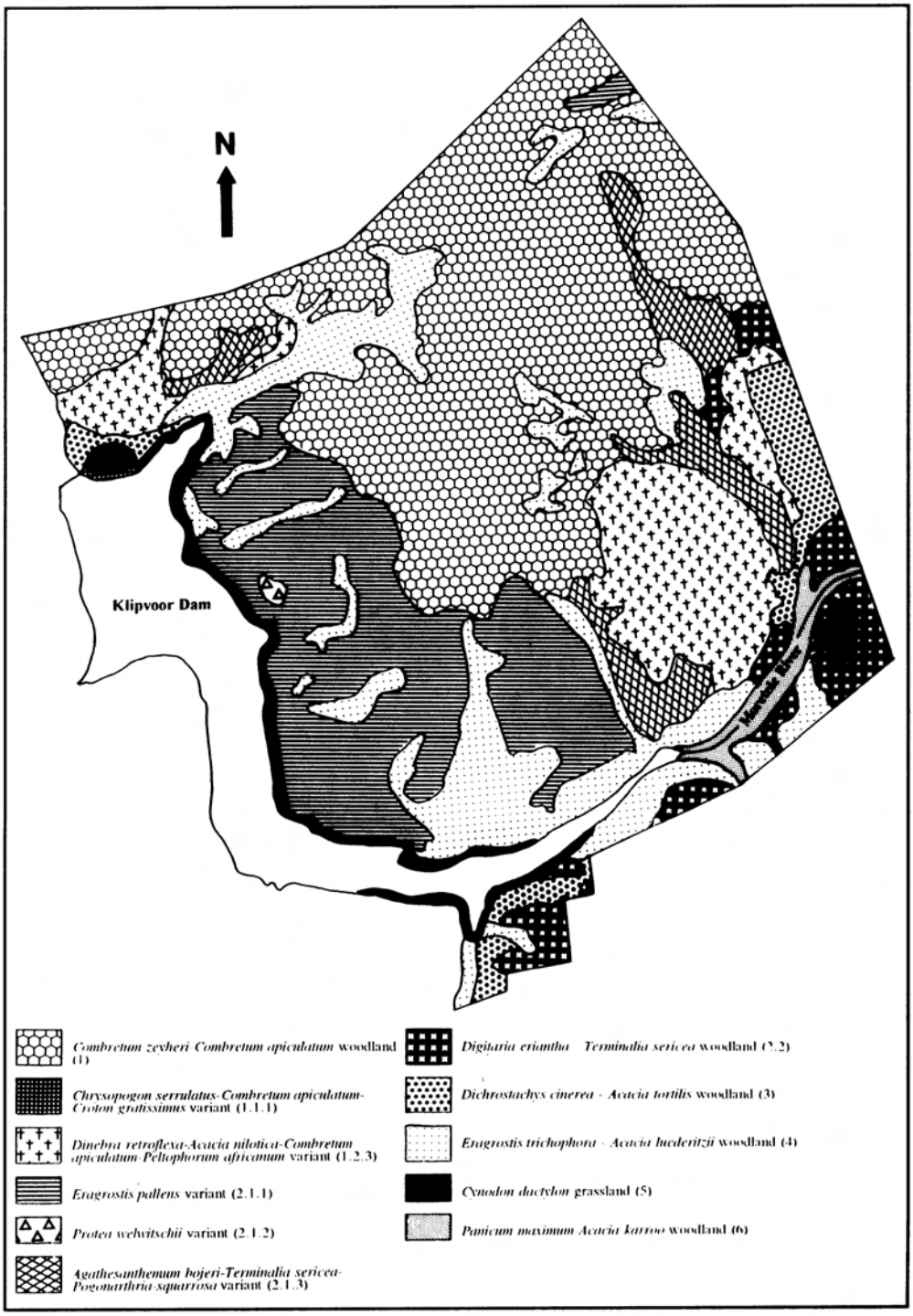

Fig. 2. A vegetation map of the northern section of the Borakalalo Nature Reserve (scale 1:50 000).

Pterocarpus rotundifolia, the grasses *Enneapogon scoparius* and *Aristida canescens* subsp. *canescens* and the forbs *Clerodendrum ternatum* and *Vernonia poskeana* (species group G - Table 1).

Although the tree *Terminalia sericea* is present in this community, it is seldom dominant and the woody layer is dominated by the trees *Combretum apiculatum* and *C. zeyheri*. It seems as though *Terminalia sericea* is slowly encroaching into this woodland, especially where the soil is sandy as a result of weathering of the granite. The shrub layer is dominated by the shrub *Vitex rehmannii*, while *Digitaria eriantha*, *Pogonarthria squarrosa*, *Melinis repens*, *Brachiaria nigropedata* and *Eragrostis rigidior* dominate the grass layer. Other grasses also present, include *Schmidtia pappophoroides*, *Trichoneura grandiglumis*, *Cymbopogon plurinodis*, *Tricholaena monachne*, *Aristida congesta* subsp. *congesta* and *Heteropogon contortus*. The most prominent forbs include *Cleome maculata*, *Tephrosia capensis*, *Monsonia angustifolia*, *Chamaecrista absus* and sometimes *Commelina africana*.

A similar woodland, the *Combretum apiculatum* woodland, was described by Van der Meulen (1979) on rocky hillsides in the Western Transvaal Bushveld (now known as the North-West province).

1.1 *Chrysopogon serrulatus-Combretum apiculatum* woodland

This sub-community is found on rocky outcrops which occur in a mosaic distribution pattern within the *Combretum zeyheri-Combretum apiculatum* woodland. Between 60-70 % of the soil surface are covered with large rocks.

Diagnostic species include the trees *Diplorhynchus condylocarpon* and *Sclerocarya birrea*, the grass *Chrysopogon serrulatus* and the xerophytic fern *Pellaea calomelanos* (species group B - Table 1). The absence of species groups C, E and F together with the absence of the tree *Combretum hereroense* (species group N - Table 1) is also characteristic of this sub-community.

The woody and shrub layer cover 30-60 %, while the herbaceous layer covers 40-60 % of the sampled areas. The woody and shrub layer are dominated by the tree *Combretum apiculatum* while other prominent trees include *Pterocarpus rotundifolia*, *Diplorhynchus condylocarpon* and sometimes *Sclerocarya birrea*.

The grass layer is dominated by the grasses *Chrysopogon serrulatus* and *Enneapogon scoparius*. Other grasses also found include *Melinis repens*, *Cymbopogon plurinodis*, *Digitaria eriantha* and *Tricholaena monachne*. The most prominent forbs include *Schkuhria pinnata* and *Pellaea calomelanos* and sometimes *Tephrosia capensis* and *Sida cordifolia*.

Two variants are recognised:

1.1.1 *Chrysopogon serrulatus-Combretum apiculatum-Croton gratissimus* variant

This variant is restricted to a small granite hill adjacent to the Klipvoor Dam wall. Approximately 70 % of the hill's surface is covered with large granite boulders. The highest point on the hill is 1 058 m above sea level. This variant can easily be distinguished from the other variants of the *Combretum zeyheri-Combretum apiculatum* woodland and is therefore indicated on the vegetation map (Fig. 2).

Diagnostic species include the trees *Croton gratissimus* and *Bridelia mollis* together with the forb *Achyranthes aspera* (species group A - Table 1). The absence of *Combretum zeyheri* from this variant, is also characteristic while the normally widespread species of species groups M, N and U are also absent (Table 1).

The woody layer covers 40-50 % and is dominated by the tree *Croton gratissimus* with *Combretum apiculatum* also prominent. Both are characteristic for rocky areas (Van Wyk & Malan 1988). *Bridelia mollis* and

Sclerocarya birrea may also be present in certain localities. Grass species present, include *Chrysopogon serrulatus*, *Enneapogon scoparius*, *Tricholaena monachne* and sometimes *Melinis repens* and *Digitaria eriantha*. The herbaceous layer, which covers 50-60 % and is dominated by the forbs *Schkuhria pinnata* and *Achyranthes aspera*, is typical of disturbed areas (Van Wyk & Malan 1988), but may also be a result of the low potential of the harsh habitat which excludes the presence of many late succession species.

1.1.2 *Chrysopogon serrulatus-Combretum apiculatum-Pterocarpus rotundifolius* variant

Granite boulders which cover 60-70 % of the soil surface, form the habitat of this variant. It is found in the central and north-western parts of the study area and is restricted to rocky outcrops. Because it forms a mosaic distribution pattern with the other variants and sub-communities of the *Combretum zeyheri-Combretum apiculatum* woodland, this variant is therefore not indicated on the vegetation map (Fig. 2).

This variant can be distinguished from the *Chrysopogon serrulatus-Combretum apiculatum-Croton gratissimus* variant (1.1.1) by the absence of species group A, while species groups M, N and U, which are absent in 1.1.1, are present in this variant (Table 1).

The woody layer covers 30-60 %, and is dominated by *Combretum apiculatum* and *Pterocarpus rotundifolius* while *Diplorhynchus condylocarpon* and *Combretum zeyheri* are also prominent. The *Combretum apiculatum* trees vary in height but most of them are in the lower and middle height classes, while most of the *Pterocarpus rotundifolius* trees reach the upper height class. The shrub layer includes *Maytenus tenuispina* and *Vitex rehmannii* which are present locally. *Chrysopogon serrulatus*, *Melinis repens*, *Eragrostis rigidior* and *Enneapogon scoparius* dominate the grass layer, while *Trichoneura grandiglumis*, *Cymbopogon plurinodis*, *Digitaria eriantha* and *Brachiaria nigropedata* are also present. The herbaceous layer, which covers 40-60 %, also includes the forbs *Pellaea calomelanos*, *Clerodendrum ternatum*, *Vernonia poskeana*, *Hermannia glanduligera*, *Commelina africana*, *Heliotropium ciliatum* and *Chamaecrista absus*.

1.2 *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum* woodland

This sub-community represents approximately 90 % of the *Combretum zeyheri-Combretum apiculatum* woodland and it is strongly associated with coarse-grained granitic soils and granite boulders. In some areas the soil texture may vary from sandy to loamy. This variation in soil type and depth, results in considerable floristic variation in the vegetation, which occurs in a mosaic distribution pattern.

Diagnostic species include the trees *Acacia nilotica* and *Combretum imberbe*, the grasses *Dinebra retroflexa*, *Eragrostis superba* and the fibrous perennial *Xerophyta retinervis* (species group E - Table 1).

The woody layer, which covers 40 %, is dominated by the trees *Combretum apiculatum* and *C. zeyheri*, while *Pterocarpus rotundifolia*, *Burkea africana*, *Terminalia sericea*, *Combretum hereroense* and *Dichrostachys cinerea* are also prominent. The shrub layer, dominated by *Vitex rehmannii*, covers approximately 5-15 %. The herbaceous layer, up to one meter tall, covers 60-100 % of the sample plots. Prominent grasses include *Melinis repens*, *Digitaria eriantha* and *Pogonarthria squarrosa* with *Trichoneura grandiglumis*, *Schmidtia pappophoroides*, *Tricholaena monachne*, *Aristida congesta* subsp. *congesta*, *Heteropogon contortus* and *Brachiaria nigropedata* also present locally. Palatable grasses such as *Digitaria eriantha*, *Schmidtia pappophoroides*, *Tricholaena monachne* and *Brachiaria nigropedata* show signs of being utilised by grazers. The most prominent forbs include *Clerodendrum ternatum*, *Chamaecrista mimosoides*, *Hermannia glanduligera*, *Lophiocarpus tenuissimus* and *Cleome maculata*.

This sub-community can be divided into three variants which occur in a scattered pattern throughout the *Combretum zeyheri-Combretum apiculatum* woodland. Except for the 1.2.3 variant, which can be mapped, they are therefore not indicated on the vegetation map (Fig. 2).

1.2.1 *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum-Combretum molle* variant

This variant occurs mainly in the central area of the reserve although they are also found in a mosaic distribution pattern in the northern and north-eastern parts of the study area. It is found on coarsely-grained granitic soil, with rocks covering between 1-10 % of the soil surface. Little to no erosion is present and the area is fairly flat with a slight gradient of 1-20 towards the south-east (Fig. 2).

Diagnostic species include the trees *Combretum molle*, *Ziziphus zeyheriana*, *Gardenia volkensii*, *Acacia caffra* and *Ozoroa paniculosa*, the grass *Eustachys paspaloides* and the forb *Zornea linearis* (species group C - Table 1). The simultaneous presence of species group D (Table 1) is also characteristic.

The trees *Combretum apiculatum* and *C. zeyheri* dominate the woody layer, while *Combretum molle*, *Lannea discolor*, *Dombeya rotundifolia*, *Pterocarpus rotundifolius*, *Burkea africana*, *Dichrostachys cinerea*, *Terminalia sericea* and the shrub *Vitex rehmannii* are also present. About 70-80 % of the woody plants fall in the middle and upper height classes (>1 m), while the woody layer has a 10-35 % canopy coverage. The herbaceous layer covers 60-80 % of the area. The grass layer is dominated by *Digitaria eriantha* and *Brachiaria nigropedata* while other prominent grasses include *Dinebra retroflexa*, *Melinis repens*, *Schmidtia pappophoroides*, *Pogonarthria squarrosa*, *Heteropogon contortus*, *Aristida congesta* subsp *barbicollis* and *Aristida stipitata*. Forbs present include *Chamaecrista mimosoides*, *Phyllanthus incurvus*, *Hermannia glanduligera*, *Lophiocarpus tenuissimus* and *Cleome maculata*.

1.2.2 *Typicum* variant

This variant is typical of the *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum* sub-community and is mainly found on sandy and loamy soils with 10-30 % of the soil surface being covered by large granite boulders. This variant is distinguished from the *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum-Combretum molle* variant (1.2.1) by the absence of species groups C and D (Table 1), and from the *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum-Peltophorum africanum* variant (1.2.3), by the absence of species groups F and J (Table 1).

Although the woody layer is dominated by *Combretum apiculatum* and *Combretum zeyheri*, it is important to note that *Burkea africana* and *Terminalia sericea* (species groups K and M respectively - Table 1) are co-dominant in certain parts of this variant, especially in relevés 28, 58, 67 and 68, where they are adjacent to the *Perotis patens-Terminalia sericea* woodland.

1.2.3 *Dinebra retroflexa-Acacia nilotica-Combretum apiculatum-Peltophorum africanum* variant

This variant is found on coarsely-grained, sandy granitic soils. It's major distribution in the north and south-east of the study area is indicated on the vegetation map (Fig. 2), while patches occur in a mosaic distribution pattern in the *Combretum zeyheri-Combretum apiculatum* woodland. The area is flat with a 0-10° gradient towards the east.

Diagnostic species include the tree *Acacia erioloba*, the grass *Loudetia simplex* and the forbs *Sida dregei*, *Bulbostylis hispidula* and *Crabbea angustifolia* (species group F - Table 1). This variant is also characterised by the simultaneous presence of species groups E and J (Table 1).

The woody layer, which covers 10-30 %, is dominated by *Combretum apiculatum* and *Peltophorum africanum* while *Combretum zeyheri*, *Pterocarpus rotundifolius*, *Burkea africana*, *Terminalia sericea* and *Combretum hereroense*, are also prominent. The shrub layer, covering 10-15 %, is dominated by *Vitex rehmannii*. The herbaceous layer covers 70-90 % of the area. The grass layer is dominated by *Schizachyrium sanguineum*, *Melinis repens*, *Digitaria eriantha*, *Tricholaena monachne* and *Pogonarthria squarrosa* while *Schmidtia pappophoroides*, *Heteropogon contortus* and *Brachiaria nigropedata* are also present. According to Van Oudtshoorn (1991) most of these grasses are indicators of sandy soils. The most prominent forbs include *Clerodendrum ternatum*, *Dicoma anomala*, *Chamaecrista mimosoides*, *Hermannia glanduligera* and *Waltheria indica*.

This variant is mainly found on deeper sandy soils than the other variants, which may have resulted from the weathering of the granite that is characteristic of the *Combretum zeyheri-Combretum apiculatum* woodland. The tree *Peltophorum africanum* as well as many grass species found in this variant, are indicative of deep sandy soils (Van Wyk & Malan 1988).

1.3 *Schizachyrium sanguineum-Combretum apiculatum* woodland

This sub-community is found on sandy to loamy soils in the north-eastern part of the study area. Because it has a mosaic distribution pattern within the *Combretum zeyheri-Combretum apiculatum* woodland (community 1), it is therefore not indicated on the vegetation map (Fig. 2).

The simultaneous absence of species groups A, B, C, D, E and F (Table 1) together with the presence of species group J (Table 1) is characteristic. The woody layer, which covers 5-30 % of the area, include the trees *Terminalia sericea*, *Combretum apiculatum*, *Combretum zeyheri* and *Peltophorum africanum*. The herbaceous layer, which covers 60-90 % is dominated by the grasses *Schizachyrium sanguineum*, *Eragrostis gummiflua*, *Digitaria eriantha* and *Pogonarthria squarrosa*, while *Melinis repens*, *Schmidtia pappophoroides*, *Tricholaena monachne*, *Aristida congesta* subsp. *congesta* and *Brachiaria nigropedata* are also present. Forbs present include *Hermannia glanduligera*, *Lophiocarpus tenuissimus* and *Waltheria indica*.

2. *Perotis patens-Terminalia sericea* woodland of deep sandy, leached soils

This woodland community comprises approximately 40 % of the study area and is associated with deep sandy soils. It is mainly found in the eastern, southern and western parts of the study area where it occurs along the edge of the Klipvoor Dam and also northward to merge with the *Combretum zeyheri-Combretum apiculatum* woodland (Fig. 2). Some parts of this community are also found close to seasonal riverbeds. Characteristic is the absence of species group G, while species group K is present (Table 1).

High cover-abundance values of the tree *Terminalia sericea* (species group M - Table 1), which dominates the woody layer and covers between 5-75 % of the area, are characteristic of this woodland. *Burkea africana* is locally prominent and may even be dominant in parts. Other trees such as *Peltophorum africanum* and *Combretum hereroense* are also present.

The grass layer is often dominated by the grasses *Perotis patens* and *Melinis repens* while *Trichoneura grandiglumis*, *Schmidtia pappophoroides*, *Digitaria eriantha*, *Tricholaena monachne*, *Pogonarthria squarrosa*, *Aristida congesta* subsp. *congesta* and sometimes *Diheteropogon amplectens* may also be present. The most prominent forbs include *Chamaecrista mimosoides*, *Agathisanthemum bojeri*, *Indigofera filipes*, *Lophiocarpus tenuissimus* and *Cleome maculata*.

This woodland can be divided into two subcommunities, with variants. Although they

form a mosaic distribution pattern throughout the study area, the major distribution centres are indicated on the vegetation map (Fig. 2).

2.1 *Agathisanthemum bojeri-Terminalia sericea* woodland

This sub-community, which can be subdivided into three variants, occurs throughout the reserve, but is mainly concentrated in the eastern, southern and western parts of the study area. It is found in sandy, coarsely-grained soils. The slope varies from 1-50°, facing south and south-west. The presence of species group J with the simultaneous absence of species group G (Table 1), is characteristic for this community.

The woody layer is dominated by *Terminalia sericea* with *Burkea africana* and *Dichrostachys cinerea* also present. Conspicuous grasses include *Melinis repens*, *Perotis patens*, *Digitaria eriantha*, *Pogonarthria squarrosa* and sometimes *Eragrostis gummiflua*. The forb layer is dominated by *Agathisanthemum bojeri* while other forbs present include *Dicoma anomala*, *Crabbea hirsuta*, *Chamaecrista mimosoides*, *Lophiocarpus tenuissimus* and *Cleome maculata*.

2.1.1 *Eragrostis pallens* variant

This variant is found in the southern and western parts of the study area, where it occurs along the edge of the Klipvoor Dam (Fig. 2). The soil is very sandy and the terrain is flat with a slight slope of 1-20° towards the dam. Little to no erosion is present.

Diagnostic species include the grass *Eragrostis pallens* and the forbs *Convolvulus sagittatus* and *Rhynchosia totta* (species group H - Table 1).

The woody layer, which has a 20-50 % coverage, is dominated by *Terminalia sericea* while *Burkea africana* is also prominent in some sample plots. Most of these trees are between five to ten meters tall, and they are therefore classified in the upper height class. The shrub layer covers 15-40 % while the forbs and the grasses, cover 30-80 %. The most prominent grass species is *Eragrostis pallens* together with those mentioned in the description of the *Perotis patens-Terminalia sericea* woodland. Prominent forbs include *Convolvulus sagittatus*, *Chamaecrista mimosoides*, *Agathisanthemum bojeri*, *Phyllanthus incurvus*, *Lophiocarpus tenuissimus* and *Cleome maculata*.

2.1.2 *Protea welwitschii* variant

This variant is found in only one small locality within the *Eragrostis pallens* variant (2.1.1) in the western part of the study area, close to the edge of the Klipvoor Dam (Fig. 2). The soil is coarsely-grained and sandy, and medium-sized granite rocks (20-200 mm in diameter) cover approximately 20 % of the soil surface.

Diagnostic species include the shrub *Protea welwitschii* and the forb *Triumfetta sonderi* (species group I - Table 1).

The woody layer is dominated by the 0.5-2 m tall *Protea welwitschii* while scattered *Terminalia sericea* trees are also prominent. The grass layer includes *Melinis repens*, *Trichoneura grandiglumis*, *Perotis patens* and *Tricholaena monachne* while prominent forbs include *Triumfetta sonderi*, *Merremia tridentata* and *Dicoma anomala*. The woody and shrub layer covers 15-20 % while the herbaceous layer covers 80-85 %.

It seems as though *Terminalia sericea* is encroaching into this area. This can be substantiated by the fact that most of the *Terminalia sericea* trees are classified within the lower and middle height classes (0.1-3 m), which indicates that these trees are still young. Most of the older *Terminalia sericea* trees found in the *Perotis patens-Terminalia sericea* woodland are taller than five meters.

2.1.3 *Agathisanthemum bojeri-Terminalia sericea-Pogonarthria squarrosa* variant

Situated mainly in the eastern and southern parts of the study area, this variant is also

found on sandy, coarsely-grained soil. The slope varies from 1-50° facing south or south-west. This variant can be distinguished from the previous two variants (2.1.1 and 2.1.2) by the absence of species groups H and I (Table 1) and the presence of species group J (Table 1).

Terminalia sericea, which is very prominent in the previous variants (2.1.1 and 2.1.2), dominates the woody layer, and covers 20-80 %, while *Peltophorum africanum* and *Dichrostachys cinerea* are also present. The herbaceous layer (grasses and forbs) covers 40-80 % and includes all the grasses and forbs listed in the *Perotis patens-Terminalia sericea* woodland.

2.2 *Digitaria eriantha-Terminalia sericea* woodland

This sub-community can be distinguished from 2.1 by the absence of species group J (Table 1) and the presence of the shrub *Grewia flava*, the grasses *Urochloa mosambicensis* and *Panicum maximum* and the forb *Portulaca kermesina* (species group S - Table 1). This sub-community is situated in the south-eastern part of the study area on sandy, coarsely-grained soils. In some areas of the reserve it is distributed in a mosaic pattern with the *Eragrostis pallens* (2.1.1) variant as well as with the *Agathisanthemum bojeri - Terminalia sericea - Pogonarthria squarrosa* variant (2.1.3) of the *Agathisanthemum bojeri-Terminalia sericea* woodland.

Prominent species include the trees *Terminalia sericea*, *Burkea africana* and *Dichrostachys cinerea* and sometimes *Peltophorum africanum*, the shrub *Grewia flava*, the grasses *Digitaria eriantha* (which is very prominent locally), *Melinis repens*, *Schmidtia pappophoroides*, *Tricholaena monachne* and the forb *Lophiocarpus tenuissimus*. The woody layer has a 20-50 % coverage, the shrub layer 10-30 % and the herbaceous layer 30-60 %.

3. *Dichrostachys cinerea-Acacia tortilis* woodland of old cultivated fields on course-grained and loamy soils

This woodland is found on old cultivated fields on the eastern and southern borders of this section of the reserve. The area is flat with coarsely-grained and loamy soil present. Little to no trampling and erosion is present. Characteristic for this community is the simultaneous presence of species groups L and R (Table 1) and the absence of species groups A-K (Table 1).

The woody layer covers 10-30 %, the shrub layer 20-50 % and the herbaceous layer 50-80 %, which indicates that this is an open woodland.

The woody layer is dominated by the trees *Acacia tortilis* and *Dichrostachys cinerea*, although *Peltophorum africanum* is also present in some areas of this community. The absence of *Terminalia sericea*, which is prominent in most parts of the study area, is also noticeable. Other prominent species include the grasses *Eragrostis rigidior* and *Digitaria eriantha* while *Melinis repens*, *Trichoneura grandiglumis*, *Tricholaena monachne*, *Heteropogon contortus*, *Panicum maximum* and *Aristida congesta* subsp *barbicollis* may also be present. Conspicuous forbs include *Evolvulus alsinoides* and *Waltheria indica*.

It seems as though *Acacia tortilis* and *Dichrostachys cinerea* are re-establishing onto these old cultivated fields. According to Van Wyk & Malan (1988), encroaching by *Acacia tortilis* and *Dichrostachys cinerea* is common for these areas and care should therefore be taken that this woodland is not over-utilised by antelope since the presence of *Acacia tortilis* and *Dichrostachys cinerea* usually indicates sweetveld (Bothma 1995).

4. *Eragrostis trichophora-Acacia luederitzii* woodland of sandy and clayey soils on seasonally dry riverbeds

This woodland is found throughout the reserve in old and seasonal riverbeds where brackish soils are found. The vegetation is

preferred by grazing animals and has been prone to a high degree of grazing, where an estimated 85 % of the area has been overgrazed. The presence of species group Q (Table 1) is characteristic, and diagnostic species include the trees *Acacia luederitzii* and *A. mellifera*, the grass *Eragrostis trichophora* and the forbs *Oxygonum sinuatum*, *Ruellia patula* and *Commelina erecta*.

The woody layer is dominated by the microphyllous thorn trees *Acacia luederitzii* and *A. mellifera*, although *A. tortilis* is also prominent locally along with the shrub *Grewia flava*. Most of the trees in the woody layer fall within the middle and upper height classes. The grass layer is dominated by *Eragrostis trichophora* and also includes other grasses such as *Panicum maximum*, *Urochloa mosambicensis*, *Eragrostis rigidior*, *Aristida congesta* subsp. *barbicollis* and *Tragus berteronianus*.

The most prominent forb species other than the diagnostic species include *Plectranthus madagascariensis*, *Solanum panduriforme*, *Portulaca kermesina* and *Evolvulus alsinoides*.

Two sub-communities and variants were recognised, but because they are distributed in a mosaic pattern throughout the study area, they are not indicated separately on the vegetation map (Fig. 2).

4.1 *Eragrostis rigidior-Acacia luederitzii* woodland

This sub-community is characterised by the presence of species groups M, N and Q together with the absence of species group P (Table 1).

The tree layer, which covers 30-80 %, is dominated by *Acacia luederitzii* and *Dichrostachys cinerea* while *A. mellifera*, *Terminalia sericea* and *Combretum hereroense* are also prominent. The shrub layer is dominated by *Grewia flava* and has a 10-15 % coverage. The grass layer is dominated by *Eragrostis trichophora*, with *Digitaria eriantha*, *Tricholaena monachne*, *Eragrostis rigidior*, *Aristida congesta* subsp. *barbicollis*, *Aristida congesta* subsp. *congesta*, *Pogonarthria squarrosa* and *Panicum maximum* also conspicuous, and has a 40-80 % coverage.

Forbs, other than those in species groups U and W, include *Evolvulus alsinoides*, *Cleome rubella*, *Lophiocarpus tenuissimus* and *Cleome maculata* (Table 1).

This sub-community also includes an old airstrip that is not used anymore and which is gradually being taken over by *Acacia mellifera*, *A. luederitzii* and *A. tortilis*. *Panicum maximum* was found to occur only in the shade amongst dense bushes, where it is protected against grazing by antelopes. Although this species is normally found underneath trees and along rivers (Van Oudtshoorn 1991), and is usually classified as a decreaser, it seems that it also occurs in the area as a result of over-utilization of the vegetation by animals, since there is a high degree of trampling and grazing present in this area. This role as an increaser (pioneer) species by *Panicum maximum* was also found by Friedel & Blackmore (1988) and Smit & Rethman (1989).

4.2 *Sporobolus ioclados-Acacia luederitzii* woodland

This sub-community can be distinguished by the presence of species group P (Table 1). Diagnostic species include the shrub *Euclea undulata*, the grasses *Sporobolus ioclados*, *Dactyloctenium aegyptium* and *Chloris virgata* and the forbs *Justicia flava* and *Abutilon austro-africanum* (species group P - Table 1).

The woody layer which covers 10-50 %, is dominated by *Acacia luederitzii* and *A. mellifera* while *A. tortilis* and the shrub *Grewia flava* are also present. The herbaceous layer covers 50-90 % and is dominated by the grasses *Sporobolus ioclados* and *Eragrostis trichophora*, while *Dactyloctenium aegyptium*, *Chloris virgata* and *Tragus berteronianus* are also conspicuous. Prominent forbs other than those of the diagnostic species, include *Portulaca quadrifida* and *Gomphrena celosioides*.

Two variants were recognised:

4.2.1 *Sporobolus ioclados-Acacia luederitzii-Euclea undulata* variant

This variant can be distinguished from the *Sporobolus ioclados-Acacia luederitzii-Xerophyta humilis* variant (4.2.2) by the absence of species group O (Table 1).

The woody layer covers 20-50 %, while the shrub layer covers 10-40 % of the area. Prominent trees include the dominant *Acacia luederitzii* and *A. mellifera* as well as the shrubs *Euclea undulata* and *Grewia flava*. The herbaceous layer covers 40-80 %, and is dominated by *Eragrostis trichophora*, with *Digitaria eriantha*, *Tragus berteronianus* and *Urochloa mosambicensis* also present.

4.2.2 *Sporobolus ioclados-Acacia luederitzii-Xerophyta humilis* variant

This variant is characterised by species group O (Table 1). Diagnostic species include the forbs *Xerophyta humilis*, *Delosperma* spp., *Justicia anagalloides*, *Corchorus asplenifolius* and *Protasparagus suaveolens*.

The woody layer, which has a 25-60 % coverage, is dominated by the trees *Acacia luederitzii* and *A. mellifera* which may form impenetrable thickets in certain areas, while *Acacia tortilis* is also present locally. The near absence of *Dichrostachys cinerea* (species group U - Table 1) is also characteristic. The shrubs *Euclea undulata* and *Grewia flava* are present and have a 1-10 % coverage, while the grass layer is dominated by *Eragrostis trichophora* and *Sporobolus ioclados*. Other grasses present include *Chloris virgata*, *Panicum maximum* and *Tragus berteronianus*. *Eragrostis rigidior* which is prominent in most of the study area (species group U - Table 1) is nearly absent in this variant. The most dominant forbs are *Xerophyta humilis*, *Justicia flava* and *Abutilon austro-africanum*, while *Oxygonum sinuatum*, *Solanum supinum*, *Schkuhria pinnata* and *Portulaca quadrifida* are also locally present. The herbaceous layer covers 60-80 % of the area.

5. *Cynodon dactylon* grassland of clayey and marshy soils on the edge of the dam

This community is restricted to the marshy to dry banks of the Klipvoor Dam and is associated with clayey soil. Diagnostic species include the grass *Cynodon dactylon* and the forbs *Tribulus terrestris*, *Chenopodium album* and *Schoenoplectus corymbosus* (species group V - Table 1).

The only grass species, *Cynodon dactylon*, together with the pioneer annual weedy forbs *Schkuhria pinnata* and *Portulaca quadrifida*, totally dominate the vegetation and covers 80-95 %. Other forbs also present include *Schoenoplectus corymbosus*, which is found on wet marshy areas closer to the water and *Tephrosia capensis* and *Gomphrena celosioides*.

This grassland is similar to the *Schoenoplectus corymbosus-Cynodon dactylon* grassland found on the edge of the dam in the southern side of the reserve (Brown & Bredenkamp 1994).

According to Dannhauser (1985) and Van Oudtshoorn (1991) *Cynodon dactylon* is characteristic of disturbed areas, which in this case is caused by periodic flooding after rains, as well as the fact that game flock to the water during droughts to graze the short, palatable grass.

6. *Panicum maximum-Acacia karroo* woodland of loam and clayey riverbank soils

This woodland is found in a narrow belt along the banks of the Moretele River and its tributaries on loamy and clayey soils (Fig. 2). The trees usually form a closed canopy and covers 60 % of the area. The plants occasionally suffer from floods, the resulting strong currents and damming after heavy rainfall.

Diagnostic species include the dominant trees *Acacia karroo*, *Rhus lancea* and *Combretum erythrophyllum* which covers

40-70 % of the area, together with the reed *Phragmites australis* (species group X - Table 1). The herbaceous layer, which has a 40 % coverage, is dominated by *Panicum maximum*, *Phragmites australis* and *Urochloa mosambicensis*. Forbs include *Bidens bipinnata*, *Justicia flava* and sometimes *Schkuhria pinnata*, *Portulaca quadrifida* and *Tephrosia capensis*.

Discussion and Conclusion

When surveying the area, it seemed that the vegetation of the northern section differs from that of the western section whereas there seemed to be similarities between the vegetation of the northern and southern sections. As in both the southern and western sections of the reserve, the northern section also has an abundance of *Dichrostachys cinerea* and *Terminalia sericea* (Brown & Bredenkamp 1994; Brown *et al.* 1995). In many areas these trees are still young and therefore seems to be encroaching into other communities. The presence of *Terminalia sericea* in the *Combretum zeyheri-Combretum apiculatum* woodland, may be as a result of the weathering of the granitic soils in which the latter community is found. Bredenkamp (1986) found that *Terminalia sericea*, *Combretum apiculatum* and *C. zeyheri* occur abundantly on granitic soils in the Manyeleti Game Reserve, although *Terminalia sericea* was found to be more dominant in deep sandy soils and *Combretum apiculatum* on the shallow sandy soils. Since the same was found in the study area, it serves as an explanation why *Terminalia sericea* was found to be present in many parts of the *Combretum zeyheri-Combretum apiculatum* woodland.

Both *Dichrostachys cinerea* and *Terminalia sericea* are declared invaders (Henderson *et al.* 1987), therefore monitoring measures should be taken to ensure the early detection of undesirable increase of these species.

The presence of many pioneer grasses such as *Eragrostis rigidior* and *Melinis repens* and the forbs *Waltheria indica*, *Monsonia angustifolia*, *Cleome maculata* and *Chamaesyce inaequilatera*, indicates disturbed or degraded veld, which may be as a result of drought and/or previous mismanagement.

Obvious similarities also exist between the *Panicum maximum-Acacia karroo* woodland (6) and the *Ziziphus mucronata-Acacia karroo* riverine woodland described in the western section of the reserve (Brown *et al.* 1995). This vegetation seems to fit the *Panicum maximum-Acacia karroo* veld described by Acocks (1988) in the Arid Sweet Bushveld (veld type 14) of the Matlabas Valley in the north-western Transvaal as well as the *Combretum erythrophyllum-Celtis africana* forest alliance found along the river banks in the Western Transvaal (now known as North-West Province) (Van der Meulen 1979). All these communities represent riverine vegetation types. According to Acocks (1988) they are not restricted to the Savanna biome only, but they can also be found along the east and south coast of South Africa as well as in the drier parts of the Nama Karoo biome (Werger 1980), Northern Cape (Bezuidenhout 1994) and the grassland biome (Du Preez & Bredenkamp 1991; Bezuidenhout 1993).

There is a clear distinction among the six communities identified and it is recommended that they be managed as separate ecological units. The classification resulted in vegetation units that can be related to environmental factors. Since very little is known about the phytosociology of the reserve, this classification of the plant communities, contributes to the present knowledge of the reserve and adjacent similar areas. The vegetation map and the description of the various communities can be used to improve the vegetation management plan for this section of the reserve.

It appears that there is a floristic relationship between some of the plant communities described here and those of the Microphyllous Thorny Woodland of the western Transvaal (now North-West province) as described by Van der Meulen (1979).

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Table 1.

A phytosociological table of the northern section of the Borakalalo Nature Reserve