The phytosociology of the western section of Borakalalo Nature Reserve

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As part of a vegetation survey programme for conservation areas in South Africa, the plant communities of the western section of the Borakalalo Nature Reserve were investigated. From a TWINSpan classification, refined by Braun-Blanquet procedures, 19 plant communities, which can be grouped into eleven major groups, were identified. A classification and description of these communities, some of which have a karoo affinity, are presented. The diagnostic species, as well as the prominent and less conspicuous species of the tree, shrub, herb and grass strata are outlined. A vegetation map is included.

Keywords: Borakalalo, Braun-Blanquet procedures, conservation area, plant communities, TWINSpan, vegetation classification.

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Introduction

The Borakalalo Nature Reserve, which falls under the jurisdiction of North-West Environmental Conservation (former Bophuthatswana Parks Board), lies approximately 60 km north of the town Brits, between 25°04'–25°15'S latitude and 27°45'–27°55'E longitude (Fig. 1). The reserve is situated around the Klipvoor Dam and is divided into three sections namely the northern, southern and western sections. Due to big differences in geology and vegetation between these areas, it was decided to study and describe the sections separately. The phytosociology of the southern section was described by Brown & Bredenkamp (1994).

This reserve has considerable potential to serve as an education centre for

environmental education and wildlife management, since it is visited by many people and there are many rural communities close to it. Therefore it is essential that an inventory of natural resources be undertaken and scientifically sound management programmes and conservation policies be established. To compile these programmes and policies a sound knowledge of the ecology of the area is essential (Bredenkamp & Theron 1978; Bredenkamp *et al.* 1993).

This project was undertaken for the above reasons and because vegetation and ecological surveys of conservation areas are considered to have a high priority (NACOR 1979).

The aim of this study was to classify, describe and map the vegetation of the western section of the reserve, to serve as an

inventory of the representative ecosystems and their biota. These relatively homogeneous plant communities should form the basis for the compilation of wildlife and ecotourism management plans.

The study area

According to Acocks (1988), the area can be classified as Mixed and Sourish Mixed Bushveld (veld types 18 and 19). The study area covers approximately 3 500 ha. The Mogosane Mountains are in the south, 1 172 m above sea level, and slopes down towards the Moretele River in the north at 960 m above sea level (Geological Survey 1981). The Mogosane Mountains, which are incised by a number of ravines, some with seasonal streams, stretch from east to west with the Klipvoor Dam in the east. In the north-western part of the study area, there is a small area north of the Moretele River that is comparatively flat and gradually slopes down from the north at 1 000 m above sea level, towards the Moretele River in the south. In this area there is a dry tributary, Blokspruit, flowing southward and joining with the Moretele River. A small section south-east of the mountains gradually slopes from 1 080 m to 1 000 m above sea level towards the Klipvoor Dam in the east.

Climate

The climate of the reserve is summarised in the climate diagram (Fig. 2), which is based on data from the Weather Bureau (1995). Since 1987 the annual rainfall for the reserve varied from 284.2 mm to 594.4 mm, with the average annual rainfall being 540.8 mm. Annual rainfall for 1992, 1993 and 1994 were 409.8 mm, 440.7 mm and 316.4 mm respectively, which were below average. The average maximum temperature is 32.4 °C in January (summer) and 23 °C in July (winter), while the average minimum

temperature is 18.3 °C in summer and 1.6 °C in winter.

Geology

Geologically the study area is classified within the Transvaal Sequence, Pretoria Group, the Rayton Formation. The Mogosane Mountains consist of ferruginous quartzite while the low-lying areas consist of feldspathic quartzite and shale (Geological Survey 1981).

Methods

By using 1:50 000 stereo aerial photographs, the study area was stratified into physiognomic - physiographic units. A total of 135 sample plots were randomly located within these units to ensure that all variations in the vegetation were considered and sampled. The sample plot size was fixed at approximately 200 m², in accordance with the size used by North-West Environmental Conservation in their vegetation surveys (Brown & Bredenkamp 1994). In each sample plot all species were recorded and the cover-abundance of each species 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). Structural terminology is according to Edwards (1983). The woody vegetation was divided into three height classes namely Lower (0-1 m), Middle (>1-3 m) and Upper (>3 m) in accordance with the woody vegetation surveys conducted by North-West Environmental Conservation. The percentage open veld (grasses and herbaceous plants), shrub veld (woody species varying in height from 0-3 m) and tree veld (woody species higher than 3 m) were also estimated.

Environmental data included soil type, erosion, an estimation of aspect, slope and rockiness of the soil surface and degree of grazing or trampling. By applying the Two-way indicator species analysis (TWINSPAN) (Hill 1979) to the floristic data, a first approximation of the main plant communities was derived. Further refinement of the classification was achieved by Braun-Blanquet procedures (Bredenkamp *et al.* 1989; Kooij *et al.* 1990; Fuls *et al.* 1993). The results are presented in a phytosocio-

logical table (Table 1) and the identified plant communities are mapped on a scale of 1:50 000 in Fig. 3.

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

Results

Classification

The analysis resulted in the following nineteen plant communities, which may be grouped into eleven major community types, being identified (Table 1):

1. *Kirkia wilmsii*-*Croton gratissimus* mountain woodland.
2. *Mimusops zeyheri*-*Pappea capensis* ravine woodland.
3. *Pappea capensis*-*Spirostachys africana* mountain woodland.
4. *Combretum apiculatum*-*Combretum zeyheri* mountain woodland.
 - 4.1 *Bridelia mollis*-*Dombeya rotundifolia*-*Combretum zeyheri* woodland.
 - 4.2 *Diplorhynchus condylocarpon*-*Combretum zeyheri* woodland.
 - 4.2.1 *Diplorhynchus condylocarpon*-*Combretum zeyheri*-*Elionurus muticus* variant.
 - 4.2.2 *Diplorhynchus condylocarpon*-*Combretum zeyheri*-*Brachiaria serrata* variant.
 - 4.2.3 *Diplorhynchus condylocarpon*-*Combretum zeyheri*-*Acacia caffra* variant.
 - 4.2.4 *Diplorhynchus condylocarpon*-*Combretum zeyheri*-

Brachiaria nigropedata variant.

- 4.3 *Schkuhria pinnata*-*Combretum zeyheri* woodland.
5. *Enneapogon scoparius*-*Pterocarpus rotundifolia* midslope woodland.
6. *Perotis patens*-*Terminalia sericea* plains woodland.
 - 6.1 *Eragrostis pallens*-*Terminalia sericea* woodland.
 - 6.2 *Dichrostachys cinerea*-*Terminalia sericea* woodland.
7. *Euclea undulata*-*Acacia tortilis* plains woodland.
 - 7.1 *Portulaca quadrifida*-*Acacia tortilis* woodland.
 - 7.2 *Aristida congesta*-*Acacia tortilis* woodland.
8. *Acacia erubescens* disturbed woodland.
9. *Eragrostis rigidior*-*Acacia luederitzii* dry riverine woodland.
10. *Eragrostis rigidior*-*Acacia permixta* plains woodland.
11. *Ziziphus mucronata*-*Acacia karroo* riverine woodland.
 - 11.1 *Urochloa mosambicensis*-*Eragrostis rigidior*-*Acacia karroo* riverine woodland.
 - 11.2 *Panicum maximum*-*Combretum erythrophyllum*-*Acacia karroo* riverine woodland.

Description of the plant communities

The vegetation of this area is characterised by the presence of species group CC (Table 1) in all the plant communities. The most prominent woody species which occur in almost all the communities are the shrub *Grewia subspatulata*, the grasses *Panicum maximum*, *Aristida canescens* subsp. *canescens* and the forbs *Commelina erecta* and *Bidens bipinnata*. These species (group CC) will therefore not be repeatedly mentioned in the description of the communities.

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

1. *Kirkia wilmsii*-*Croton gratissimus*
mountain woodland

This woodland is exclusively found on the steep north-eastern slopes of the rocky quartzite Mogosane Mountains close to the dam wall and opposite the Moretele River, where it occurs under hot, dry conditions (Fig. 3). The gradient of the slope varies from 21-30° with the trees growing between rocky outcrops. The substratum which has a rock cover varying from 60-70%, consists of rocks and stones of various sizes.

Diagnostic species include the woody species *Croton gratissimus*, *Combretum engleri*, *Urera tenax*, *Rhoicissus revoilii* and the forbs *Plumbago zeylanica* and *Acalypha indica* (species group A, Table 1).

The woody layer is taller than three metres and has a canopy cover of 50%. The most prominent species present include the trees *Croton gratissimus*, *Urera tenax*, *Kirkia wilmsii* and the shrubs *Combretum engleri* and *Rhoicissus revoilii*. The trees *Sclerocarya birrea*, *Lannea discolor* and the shrub *Grewia subspatulata* may also be present in some localities. The grass layer is dominated by *Panicum maximum*, *Brachiaria deflexa*, *Melinis repens* and *Aristida canescens* subsp. *canescens* which grow between the rocks. Prominent forbs other than the diagnostic species include *Pellaea calomelanos* and *Solanum panduriforme*.

According to Coates Palgrave (1991) the trees *Croton gratissimus*, *Urera tenax* and *Kirkia wilmsii* are normally found on mountain slopes and rocky hills. This habitat is characteristic for this community. Van der Meulen (1979) also found *Croton gratissimus* to be characteristic on dry, warm and steep northern slopes.

2. *Mimusops zeyheri*-*Pappea capensis*
ravine woodland.

This community is found in rocky ravines on the north and north-eastern slopes of the

Mogosane Mountains (relevés 79 and 81) while relevé 89 is located in a wide ravine that lies on an eastern slope of the southern part of the mountain (Fig. 3). The latter ravine is drained by a small perennial stream. In all of these ravines the rocks are moist and covered with lichens. The rock cover varies from 70-80%.

Diagnostic species include the trees *Mimusops zeyheri*, *Berchemia zeyheri* and *Acacia robusta* (species group B, Table 1) which together with the tree *Pappea capensis*, dominate the woody layer. According to Coates Palgrave (1991) most of these species are typical for rocky areas and riverine fringes where adequate water is available. Other species also present include the grasses *Brachiaria deflexa* and *Panicum maximum* and the prominent forb *Achyranthes aspera*.

3. *Pappea capensis*-*Spirostachys africana*
mountain woodland

This community covers a small area restricted to the rocky north-eastern midslope of the Mogosane Mountains, opposite the Moretele River (Fig. 3). A steep man-made cliff (on the western side of this community), forms the boundary to the adjacent *Schkuhria pinnata*-*Combretum zeyheri* woodland. The northern border of this community is formed by the *Kirkia wilmsii*-*Croton gratissimus* mountain woodland. The slope is steep with a gradient of 21°. The woody layer is higher than three metres (most of them 5 m and higher) and has a 70% canopy coverage.

The tree *Spirostachys africana* (species group D, Table 1), is diagnostic for this community and, together with the trees *Pappea capensis* and *Croton gratissimus*, it dominates the woody layer. Other species also found include the trees *Combretum apiculatum*, *Combretum molle*, *Acacia erubescens*, the shrub *Grewia subspatulata* and the very prominent grass *Panicum*

Fig. 2. Climate diagram for Borakalalo Nature Reserve (diagrams according to Walther & Lieth (1960)).

maximum. Forbs other than those of species group CC, include *Justicia flava*.

forbs *Phyllanthus parvulus* and *Fimbristylis hispidula* (species group K, Table 1).

4. *Combretum apiculatum*-*Combretum zeyheri* mountain woodland

This community, which constitutes more than half of the study area, is found on the warm, dry hillsides, and can be divided into three sub-communities. It is found in the southern part of the study area and includes most of the ravines, slopes and mountain tops of the Mogosane Mountains. The geology is mainly quartzite.

Diagnostic species include the trees *Combretum zeyheri*, *Combretum apiculatum*, *Combretum molle*, *Dombeya rotundifolia*, *Sclerocarya birrea*, the grasses *Eustachys paspaloides*, *Setaria pallide-fusca* and the

4.1 *Bridelia mollis*-*Dombeya rotundifolia*-*Combretum zeyheri* woodland

This sub-community is found in wide, warm and dry valleys that extend through the Mogosane Mountains from north to south (Fig. 3). Similar to the *Mimusops zeyheri*-*Pappea capensis* ravine woodland, these valleys also have a high rock cover that varies from 50-70%. Diagnostic species include the tree *Bridelia mollis*, the grass *Sporobolus africanus* and the forbs *Lantana rugosa*, *Chamaesyce inaequilatera* and *Hibiscus cannabinis* (species group E, Table 1).

The woody layer, consisting of trees taller than three metres, has a canopy cover of 70-80% and are dominated by the trees *Combretum zeyheri*, *Combretum apiculatum*, *Dombeya rotundifolia*, *Bridelia mollis* and sometimes *Combretum molle*. The shrub layer (1-3 m tall) includes *Grewia subspathulata* and has a 10% canopy cover. The most prominent grasses found are *Sporobolus africanus*, *Chrysopogon serrulatus*, *Brachiaria deflexa*, *Aristida canescens* subsp. *canescens* and the locally present *Panicum maximum*. The occurrence of the grasses *Sporobolus africanus* and *Aristida canescens* subsp. *canescens*, which are indicators of disturbed veld (Van Oudtshoorn 1991), can be explained by the low natural potential of the habitat to support vegetation. Forbs include *Lantana rugosa*, *Chamaesyce inaequilatera* the very prominent *Achyranthes aspera*, *Solanum panduriforme*, *Commelina erecta* and *Bidens bipinnata*.

Together with the grasses, the forbs form the lower stratum which varies in height from 0-1 m and covers 10% of the area.

4.2 *Diplorhynchus condylocarpon-Combretum zeyheri* woodland

This sub-community, within which four variants are recognised, is found on the mountain tops and rocky hillsides. Except for relevés 14 and 15, where little rocks were found, the rock cover varies from 50-90%, with sandy to loamy soil.

The woody layer is higher than three metres and covers 20-70% of the sample plots, the shrub layer covers 10-20%, and the herbaceous layer (which includes the grasses and forbs) 10-50%. Diagnostic species include the tree *Diplorhynchus condylocarpon*, and the more shrub-like *Ozoroa paniculosa*, *Maytenus tenuispina* and *Vitex rehmannii*, the grasses *Chrysopogon serrulatus*, *Loudetia flavida*, *Schizachyrium sanguineum*, *Eragrostis superba* and *Enneapogon cenchroides* and

the forbs *Limeum viscosum*, *Chaetacanthus setiger*, and *Tephrosia longipes* (species group J, Table 1).

This type of vegetation is typical of the Mountains of the Sour Bushveld (Van den Berg 1993; Van Staden 1991; Westfall 1981).

4.2.1 The *Diplorhynchus condylocarpon-Combretum zeyheri-Elionurus muticus* variant

This variant is found on slightly undulating eastern, south and north-eastern slopes in the southern part of the study area (Fig. 3). The slopes are gentle and varies from 5-15°. Rock cover varies from 70-90% but may be as low as 40% in some areas.

Diagnostic species include the trees *Acacia hereroensis* and *Faurea saligna*, the shrub-like *Vitex zeyheri*, the grass *Elionurus muticus* and the forbs *Clerodendrum triphyllum* and *Vernonia oligocephala* (species group G, Table 1). The woody layer is taller than three metres and has a canopy cover that varies from 30-70%. The most dominant species include the trees *Acacia hereroensis*, *Combretum zeyheri*, *Combretum apiculatum*, *Combretum molle*, *Dombeya rotundifolia*, *Lannea discolor*, *Burkea africana*, *Dichrostachys cinerea*, the grasses *Elionurus muticus*, *Brachiaria serrata*, *Chrysopogon serrulatus*, *Eustachys paspaloides*, *Heteropogon contortus* and the very prominent *Melinis repens*. The forbs are dominated by *Clerodendrum triphyllum*, *Phyllanthus parvulus*, *Pellaea calomelanos* and *Waltheria indica*.

4.2.2 The *Diplorhynchus condylocarpon-Combretum zeyheri-Brachiaria serrata* variant

This variant occurs on top of the Mogosane Mountains on dry rocky quartzitic soil and lies in the south and south-western part of the study area (Fig. 3). The soil varies from sand to loam and little to no erosion occurs.

Fig. 3. A vegetation map of the western section of the Borakalalo Nature Reserve (scale 1:50 000).

The grass layer covers an estimated 65% of the area where this variant is found.

The presence of species group H and the absence of species group G (Table 1) from this variant, is characteristic.

The woody layer is dominated by the trees *Diplorhynchus condylocarpon*, *Combretum zeyheri*, *Combretum molle*, *Burkea africana* and the shrub-like *Maytenus tenuispina*, while the grass layer is dominated by the grasses *Brachiaria serrata*, *Enneapogon scoparius* and *Digitaria eriantha*. Other grasses also found include *Eustachys paspaloides*, *Aristida diffusa*, *Heteropogon contortus*, *Aristida congesta* subsp. *congesta* and *Schmidtia pappophoroides*. Forbs found in this variant include *Cleome maculata*, *Chamaecrista mimosoides*, *Schkuhria pinnata* and *Mariscus* spp. The absence of the shrub *Grewia subspathulata* and the grass *Panicum maximum*, which are found in almost all the communities, is also characteristic.

4.2.3 The *Diplorhynchus condylocarpon*-*Combretum zeyheri*-*Ochna inermis* variant

This variant is situated on the steep south-eastern slopes of the Mogosane Mountains (Fig. 3). The gradient varies from 25-30° and the soil, which varies from sandy to loam, has an 60-70% rock cover.

Diagnostic species include the trees *Acacia caffra*, *Aloe marlothii*, *Ochna inermis* and the forbs *Thesium utile* and *Berkheya* spp. (species group I, Table 1).

The woody layer, which is dominated by the trees *Combretum molle* and *Pterocarpus rotundifolius*, covers 30-50%, resulting in an open woodland with various grasses and forbs. Other woody species also found include *Acacia caffra*, *Ochna inermis*, *Diplorhynchus condylocarpon*, *Combretum zeyheri* and *Combretum apiculatum*. The grass layer is dominated by the grasses *Loudetia flavida* and *Enneapogon scoparius*.

Other grasses include *Schizachyrium sanguineum*, *Eustachys paspaloides*, *Brachiaria deflexa*, *Melinis repens* and *Digitaria eriantha*. The forb layer includes *Fimbristylis hispidula*, *Achyranthes aspera*, *Pellaea calomelanos*, *Solanum panduriforme* and *Commelina africana*.

4.2.4 The *Diplorhynchus condylocarpon*-*Combretum zeyheri*-*Brachiaria nigropedata* variant

The variant is found mainly on the northern slopes and mountain top of the Mogosane Mountains (Fig. 3). The soil is sandy to loamy and the rock cover varies from 20%-70%. Little to no erosion and trampling is present. The presence of species group J and the simultaneous absence of species groups G, H and I (Table 1) is characteristic for this variant. Species group J includes the trees *Diplorhynchus condylocarpon*, *Vitex rehmanni* the more shrub-like *Maytenus tenuispina* and *Ozoroa paniculosa*, the grasses *Chrysopogon serrulatus*, *Loudetia flavida*, *Schizachyrium sanguineum*, *Eragrostis superba*, *Enneapogon cenchroides* and the forbs *Limeum viscosum*, *Chaetacanthus setiger* and *Tephrosia longipes*. Also characteristic is the absence of species groups G, H and I (Table 1).

The woody layer, which is higher than three metres and covers 30-50%, is dominated by the trees *Diplorhynchus condylocarpon*, *Combretum zeyheri*, *Combretum apiculatum*, *Combretum molle*, *Pterocarpus rotundifolius* and *Lannea discolor*, while *Burkea africana* may also be dominant in some localities. The herbaceous layer, which includes the grasses and the forbs, covers 50-70% of the area. The grass layer is dominated by *Chrysopogon serrulatus* and *Brachiaria nigropedata*, both classified as decreaser species (Van Oudtshoorn 1991), as well as *Loudetia flavida*, *Enneapogon scoparius* and *Melinis repens*. Other grasses also present include the very palatable *Eustachys paspaloides*, *Digitaria eriantha* and *Brachiaria deflexa* together with the

unpalatable *Tragus berteronianus*. This species composition indicates the high grazing potential and good condition of the veld. The forb layer is dominated by the species *Achyranthes aspera*, *Melhania prostrata*, *Pellaea calomelanos*, *Schkuhria pinnata* and *Tephrosia capensis*. The presence of the forb *Ceratotheca triloba*, only found in a few other localities, is also characteristic.

The absence of *Dichrostachys cinerea* (species group X, Table 1) which is found in most places of the study area is characteristic for this variant as well as the *Diplorhynchus condylocarpon-Combretum zeyheri-Ochna inermis* variant.

4.3 *Schkuhria pinnata-Combretum zeyheri* woodland

The northern midslopes of the Mountains with sandy to loamy soils represent the habitat of this woodland (Fig. 3). The rock cover varies from 10-50%. This sub-community is not differentiated from the other *Combretum apiculatum-Combretum zeyheri* sub-communities by the presence of diagnostic species, but rather by the absence of species groups G, H, I and J (Table 1).

Prominent species include the trees *Combretum zeyheri*, *Combretum apiculatum* and *Dombeya rotundifolia*, while *Pterocarpus rotundifolius*, *Sclerocarya birrea*, *Burkea africana* and *Peltophorum africana* are also present in some localities. The grass layer includes the grasses *Setaria pallide-fusca*, *Melinis repens*, *Pogonarthria squarrosa*, *Digitaria eriantha*, *Tragus berteronianus*, *Eragrostis rigidior*, *Aristida canescens* subsp. *canescens* and *Aristida congesta* subsp. *congesta*. Other less prominent grasses that are also present, include *Eustachys paspaloides*, *Brachiaria deflexa*, *Enneapogon scoparius* and *Cymbopogon plurinodis*. The herbaceous layer is dominated by the forbs *Schkuhria pinnata* and *Waltheria indica*, while *Achyranthes*

aspera, *Clerodendrum ternatum*, *Elephantorrhiza elephantina*, *Indigofera filipes*, *Chamaecrista absus*, *Lophiocarpus tenuissimus*, *Solanum panduriforme* and *Kyphocarpa angustifolia* may also be prominent in some localities.

5. *Enneapogon scoparius-Pterocarpus rotundifolia* midslope woodland.

This woodland may be distinguished from the other communities by the presence of species groups M and N and the absence of species groups K and L (Table 1). It is only found on a warm, dry and gentle northern midslope opposite the Moretele River with the gradient varying from 8-14° (Fig. 3). The rock cover varies from 60-70 % and the soil texture is sandy. Little erosion is present.

Prominent species include the tree *Pterocarpus rotundifolius* and the grass *Enneapogon scoparius*. The grasses *Brachiaria nigropedata* and *Heteropogon contortus* and the forbs *Hermannia glanduligera* and *Ceratotheca triloba* (species group M and N, Table 1) are also present.

The average height of the woody layer varies from one to three metres, with a few individuals taller than three metres. This layer covers approximately 30% of the area with the herbaceous layer (which includes grasses and forbs) 70%. This part of the study area is totally dominated by the tree *Pterocarpus rotundifolius*. Other prominent species include the grass *Enneapogon scoparius* with the grasses *Brachiaria nigropedata*, *Melinis repens* and *Eragrostis rigidior* also present. The forbs *Schkuhria pinnata*, *Waltheria indica* and *Indigofera comosa* are prominent while *Hermannia glanduligera*, *Ceratotheca triloba* and *Chamaecrista absus* are also found in this woodland.

6. *Perotis patens*-*Terminalia sericea* plains woodland.

This woodland, which can be divided into two sub-communities, is spread throughout the study area on the low lying areas closer to the river (Fig. 3). The gentle slopes have a slight gradient that varies from 1-4°. The soil is sandy with little or no rocks present.

The diagnostic species are the tree *Terminalia sericea* the grass *Perotis patens* and the forb *Agathisanthemum bojeri* (species group P, Table 1). The woody layer is totally dominated by *Terminalia sericea* which has an average cover of 80%. Approximately 50% of these trees is classified in the middle height class (1-3 m tall) which indicates that the woody layer may still increase in height and cover (Palmer 1981; Van Wyk 1984; Coates Palgrave 1991).

Vegetation of a similar habitat, described by Van der Meulen (1979), also has *Terminalia sericea*, *Burkea africana* and *Perotis patens* as prominent species. According to Theron (1973) and Van der Meulen (1979) a high cover of *Terminalia sericea* and *Burkea africana* is characteristic for deeper, sandy, infertile soils. These soils usually have a low fertility as a result of leaching (Van der Meulen 1979).

6.1 *Eragrostis pallens*-*Terminalia sericea* woodland

This sub-community is found throughout the study area (Fig. 3) and is characterised by the presence of species group O (Table 1). Soil texture is sandy and course-grained.

The diagnostic species include the grasses *Eragrostis pallens* and *Stipagrostis uniplumis* (species group O, Table 1) which are usually found in dry sandy soils (Gibbs Russell *et al.* 1991; Van Oudtshoorn 1991; Van Rooyen *et al.* 1988; Coetzee *et al.* 1976). The woody layer is dominated by the tree *Terminalia sericea* with *Burkea africana* and *Dichrostachys cinerea* prominent in

some localities. Other prominent species include the grasses *Perotis patens*, *Pogonarthria squarrosa*, *Melinis repens*, *Digitaria eriantha*, *Schmidtia pappophoroides* and the forbs *Agathisanthemum bojeri*, *Cleome maculata*, *Indigofera filipes*, *Chamaecrista absus*, *Lophiocarpus tenuissimus* and *Waltheria indica*. With the exception of *Digitaria eriantha* and *Schmidtia pappophoroides* the grasses have a low grazing capacity and are indicative of poor soil condition (Van Oudtshoorn 1991).

6.2 *Dichrostachys cinerea*-*Terminalia sericea* woodland

This sub-community usually forms a mosaic distribution with the *Eragrostis pallens* - *Terminalia sericea* woodland, but can be distinguished by the absence of species group O (Table 1). Little erosion is present and the area is flat with a gradient of 2°. The soil is sandy and course-grained. Prominent species other than those already mentioned in community 6, include the tree *Dichrostachys cinerea* which, together with *Terminalia sericea*, dominates the woody layer. Also characteristic for this community is the presence of the grass *Urochloa mosambicensis* and the forbs *Zornea glochidiata*, *Schkuhria pinnata*, *Solanum panduriforme* and *Portulaca quadrifida* which are not found in sub-community 6.1.

The encroacher *Dichrostachys cinerea*, which is a co-dominant in this community, may become invasive as a result of overgrazing (Bothma 1988). The presence of pioneer grasses *Tragus berteronianus* and *Eragrostis rigidior* (Van Oudtshoorn 1991) indicates that this area have been disturbed in the past either as a result of drought and/or previous management.

7. *Euclea undulata*-*Acacia tortilis* plains woodland

Lying in the lowlands north of the Mogosane Mountains (Fig. 3), this community is characterised by the presence of the tree

Acacia tortilis, the shrub *Euclea undulata* and the forb *Justicia flava* (species group S, Table 1). The gradient varies from 0-2° and the soil is sandy to loamy. Grass patches that alternate with bare ground are found in some localities, especially north of the Moretele River.

The woody layer is dominated by the tree *Acacia tortilis*, which can become invasive (Van Wyk & Malan 1988) and also includes *Dichrostachys cinerea* together with the shrubs *Euclea undulata* and *Grewia flava*. The most prominent grass is *Eragrostis rigidior* while *Digitaria eriantha*, *Schmidtia pappophoroides*, *Aristida congesta* subsp. *barbicollis* and *Urochloa mosambicensis* are also present in some localities. Forbs present in this community include *Waltheria indica*, *Solanum panduriforme* and *Evolvulus alsinoides*.

Two sub-communities which form a mosaic distribution pattern, can be recognised:

7.1 The *Portulaca quadrifida*-*Acacia tortilis* woodland

The woodland is characterised by the presence of species group R and the simultaneous absence of species group Q (Table 1). Species group R includes the tree *Peltophorum africanum*, the grass *Eragrostis lehmanniana* and the forbs *Monsonia angustifolia*, *Chamaecrista absus*, *Limeum fenestratum*, *Lophiocarpus tenuissimus*, *Zornea glochidiata* and *Leucas glabrata*. Slight erosion estimated at 5-10% is present in some sample plots. Rock cover varies from 0-30% with sandy to loamy soil.

The woody layer is taller than three metres and covers 20-40% while the shrub layer (0-3 m) covers 10-20% and the open/herbaceous layer 40-80% of the area. The dominant species include the trees *Acacia tortilis*, *Acacia karroo*, *Dichrostachys cinerea*, the grass *Tragus berteronianus* and the forbs *Schkuhria pinnata*, *Waltheria indica* and *Portulaca quadrifida*, while *Solanum panduriforme* and *Evolvulus*

alsinoides are also found. All of these forbs are indicative of disturbed areas and the dominance of *Acacia tortilis* and *Dichrostachys cinerea*, which are both declared invaders (Henderson *et al.* 1987), indicates that this area was previously disturbed as a result of drought or mismanagement.

7.2 *Aristida congesta*-*Acacia tortilis* woodland

Although this sub-community forms a mosaic distribution in some areas with the previous community, it is mainly found north of the Moretele River in the northern section of the study area (Fig. 3). It is situated close to, or in, dry riverbeds and the soil has sodic properties. Diagnostic species include the forbs *Anthericum transvaalense*, *Portulaca kermesina* and *Ruellia patula* (species group T, Table 1).

The woody layer is dominated by *Acacia tortilis* which seems to have become invasive in certain areas of this community. The tree *Ziziphus mucronata* is also present in some localities. Relevé 31, which is situated south of the Moretele River represents a grassland dominated by the grass *Cynodon dactylon*, but is gradually being invaded by *Acacia tortilis*. All the *Acacia tortilis* individuals found here are between 1-3 m high indicating that they are still young and therefore spreading. The same applies to relevés 47, 120 and 121, which are old farmlands gradually being invaded by *Acacia tortilis*.

Other species also found in this community that do not occur in sub-community 7.1, include the grasses *Aristida congesta* subsp. *congesta*, *Aristida stipitata* and *Cynodon dactylon*.

8. *Acacia erubescens* disturbed woodland

This community is found at low altitudes of 900-1 000 m in the south-eastern part of the study area with only one small area in the

north-western section (Fig. 3). The sandy soil shows a high degree of trampling, estimated at 70%, but no erosion is present. There are no rocks present and the slight gradient varies from 1-2°. Diagnostic species include only the tree *Acacia erubescens* which dominates in all the height classes (species group U, Table 1), although *Dichrostachys cinerea*, *Peltophorum africanum*, *Combretum hereroense* and the shrubs *Grewia flava* and *Euclea undulata* are also prominent. Other prominent species include the grasses *Eragrostis trichophora*, *Schmidtia pappophoroides*, *Digitaria eriantha*, *Eragrostis rigidior* and the forbs *Anthericum transvaalense* and *Portulaca kermesina*. In some localities the forbs *Ruellia patula*, *Waltheria indica*, *Solanum panduriforme*, *Kyphocarpa angustifolia* and *Commelina africana* are also present. A similar disturbed community was described by Van der Meulen (1979) in the western Transvaal (currently known as North-West Province).

9. *Eragrostis rigidior*-*Acacia luederitzii* dry riverine woodland

Mainly found in low-lying areas around old or dry riverbeds in the north-western and southern part of the study area (Fig. 3), this woodland has also been prone to a high degree of grazing and trampling estimated at up to 70% on certain localities. The soil has a sandy texture.

Diagnostic species include *Acacia luederitzii*, *Acacia mellifera*, *Diospyros lycioides*, *Eragrostis trichophora*, *Sporobolus ioclados*, *Dactyloctenium aegyptium*, *Chloris virgata*, *Abutilon austro-africanum* and *Plectranthus madagascariensis* (species group V, Table 1).

The woody and shrub layer has a 30-60% coverage and are dominated by *Acacia luederitzii* and *Acacia tortilis*, while *Acacia mellifera* and *Dichrostachys cinerea* are also abundant in some areas. The shrub layer includes species such as *Grewia flava*,

Euclea undulata and sometimes *Diospyros lycioides*, while the most dominant grasses are *Eragrostis rigidior*, *Eragrostis trichophora* and *Urochloa mosambicensis*, the latter being found underneath the trees and shrubs. Other grasses include *Digitaria eriantha*, *Tragus berteronianus*, *Schmidtia pappophoroides*, *Aristida congesta* subsp. *congesta* and *Aristida congesta* subsp. *barbicollis*. The forb layer is dominated by *Portulaca quadrifida*, *Schkuhria pinnata* and *Plectranthus madagascariensis*, while *Kyphocarpa angustifolia*, *Mariscus* spp. and *Justicia flava* are constantly present.

This community has many similarities with the *Acacia luederitzii*-*Boscia albitrunca* woodland that was found on sandy karoo deposits by Van der Meulen (1979). Except for the species *Boscia albitrunca* and *Tarchonanthus camphoratus*, the woody layer of the *Acacia luederitzii*-*Boscia albitrunca* community has the same dominant species as this community. It therefore seems that this community has an affinity with the Kalahari Thornveld (Acocks 1988; Van Rooyen *et al.* 1988).

10. *Eragrostis rigidior*-*Acacia permixta* plains woodland

This community is found in the northern and western part of the study area (Fig. 3). The soil varies from sandy to gravelly.

Diagnostic species include only *Acacia permixta* (species group W, Table 1) which appears shrub-like. The woody layer which varies in height from 1-3 m covers 50-70% and is dominated by *Acacia permixta*. Other woody species include *Acacia tortilis*, *Acacia luederitzii* and *Dichrostachys cinerea*. The grass layer include the grasses *Digitaria eriantha*, *Schmidtia pappophoroides* and *Eragrostis rigidior*. The most prominent forbs are *Indigofera commosa*, *Kyphocarpa angustifolia* and *Waltheria indica*.

11. *Ziziphus mucronata*-*Acacia karroo* riverine woodland

This riverine community can be divided into two sub-communities and is situated all along the banks of the Moretele and Blokspruit Rivers (Fig. 3). The alluvial soil is loamy to clayey with a high degree of grazing and trampling, estimated at up to 80% in certain localities.

Diagnostic species include the trees *Acacia karroo*, *Rhus lancea*, the shrub *Maytenus heterophylla* and the forb *Aerva leucura* (species group Z, Table 1). Other prominent species include the tree *Ziziphus mucronata*, the shrub *Grewia flava*, the grasses *Urochloa mosambicensis*, *Cynodon dactylon*, *Panicum maximum* and the forbs *Commelina erecta* and *Bidens bipinnata*.

The high degree of grazing and trampling as well as the presence of many pioneer species which are indicative of disturbed veld, is explained by the fact that many animals frequent the river to drink water and to graze the sweet grasses on the banks thereof.

The two sub-communities occur in a mosaic distribution pattern and are therefore not indicated on the vegetation map (Fig. 3).

11.1 *Urochloa mosambicensis*-*Eragrostis rigidior*-*Acacia karroo* riverine woodland

The absence of species group AA (Table 1) is characteristic for this sub-community.

Prominent species include the trees *Acacia tortilis*, *Acacia karroo*, *Maytenus heterophylla*, *Rhus lancea* and the shrub *Grewia flava*, the grasses *Eragrostis rigidior*, *Digitaria eriantha*, *Tragus berteronianus*, *Chloris virgata*, *Aristida congesta* subsp. *congesta* and *Aristida congesta* subsp. *barbicollis* and the forbs *Aerva leucura*, *Schkuhria pinnata*, *Commelina africana*, *C. erecta*, *Portulaca quadrifida*, *Justicia flava*, *Phyllanthus incurvus* and *Bidens bipinnata*.

11.2 *Panicum maximum*-*Combretum erythrophyllum*-*Acacia karroo* riverine woodland

Characteristic species of this sub-community include *Combretum erythrophyllum*, *Phragmites australis* and *Protasparagus* spp. (species group AA, Table 1).

Other prominent species include the trees *Acacia karroo*, *Maytenus heterophylla*, *Rhus lancea*, *Ziziphus mucronata*, the shrub *Grewia flava*, the grasses *Urochloa mosambicensis*, *Cynodon dactylon*, *Phragmites australis* and the very prominent *Panicum maximum*. Prominent forbs include *Commelina erecta* and *Bidens bipinnata*. The absence of the grass *Aristida canescens* subsp. *canescens* is also characteristic for this community.

Discussion

With the exception of a few cases, there is a clear distinction between the different communities identified and it is therefore recommended that each of the eleven main communities be managed as separate ecological units.

As was found in the southern section of the reserve, the western section also has an abundance of *Dichrostachys cinerea* and *Terminalia sericea* (Brown & Bredenkamp 1994). In some areas these plants are still young and it therefore seems that they are encroaching into the other communities. Since both species are declared invaders (Henderson *et al.* 1987) and it appears to have become invasive in the reserve, measures should be taken to control these plants. It also appears that *Acacia tortilis* is becoming invasive in certain areas and is gradually invading open areas and especially old farmlands. Little is known of the fire history of the area and therefore no comments are made on the possible effects of fire on the woody species.

Many of the species present in the different communities indicate disturbed veld and the

many pioneer grasses such as *Eragrostis rigidior* and *Melinis repens*, reiterate this point. Increaser II species are relatively abundant in relation to decreaseers. This may be the result of drought and previous mismanagement. Further assessment of the grazing potential of the different communities should be done in order to determine the stocking rate of the reserve.

Conclusion

As already mentioned in the description of the various communities, it appears that there is a floristic relationship between some of the plant communities described here and those of the Kalahari Thornveld and Microphyllous Thorny Woodland of the western Transvaal (currently the North-West Province) as described by Van der Meulen (1979) and Acocks (1988). On the other hand, the mountain vegetation shows affinity to Sour Bushveld (Acocks 1988). The important location of the reserve is indicated by the presence of the various veld types (ecosystems) found here. This section is the most important conservation area within the reserve because of its habitat and biodiversity which makes it imperative that it be conserved. Since very little is known about the phytosociology of the reserve, the description and classification of the plant communities identified contribute significantly to the present knowledge about the reserve as well as adjacent areas. The vegetation map together with the description of the communities can be used to formulate a vegetation management plan for the reserve.

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North-West Environmental Conservation is thanked for allowing and encouraging the research in the reserve as well as the arrangements made for the first author while doing the surveys in the veld. This research was supported financially by the Foundation for Research Development, CSIR.

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Table 1

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