

The major vegetation communities of the Augrabies Falls National Park, Northern Cape. 1. The southern section

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Bezuidenhout, H. 1996. The major vegetation communities of the Augrabies Falls National Park, Northern Cape. 1. The southern section. *Koedoe* 39(2): 7-24. Pretoria. ISSN 0075-6458.

Classification, description and mapping of the vegetation of the Augrabies Falls National Park, Northern Cape, were initiated. The classification is intended to serve as a basis for the establishment of an efficient wildlife management programme as well as conservation policies for the Augrabies Falls National Park. Using the BBPC suite, according to Braun-Blanquet procedures to classify the vegetation of the southern section of the Augrabies Falls National Park, six major plant communities are recognised. A hierarchical plant community classification, description, ecological interpretation and a vegetation map are presented.

Keywords: conservation, management units, Northern Cape, Augrabies Falls National Park, vegetation classification.

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Introduction

The Augrabies Falls National Park (AFNP) is a popular tourist attraction, particularly because of the spectacular Augrabies Falls and Orange River Gorge. The landscape scenery and the associated vegetation are also spectacular but unfortunately is largely unknown to the visitor.

The necessity for an ecological classification, description and mapping of the vegetation of a conservation area was stated by Bredenkamp & Theron (1978). A sound knowledge of the ecology will contribute considerably to the compilation of an efficient wildlife management programme and conservation policy for the AFNP (Van Rooyen *et al.* 1981). Being a national park, it should also serve as a permanent reference area for wider reconnaissance surveys in the Northern Cape region.

The AFNP is the largest conservation area (18 200 ha) within the Orange River Nama Karoo vegetation type (Hoffman 1996). Apart from Werger & Coetzee's (1977),

detailed vegetation classification of parts of the AFNP, Acocks' (1953) description of the veld types of South Africa and Hoffman's (1996) description of the Orange River Nama Karoo, little is known about the vegetation of the area. Therefore, the main aim of this study was to map the major vegetation units of the AFNP. In order to achieve this goal, my own field work and the classification of Werger & Coetzee (1977) were used to classify, describe, interpret and map the vegetation of the southern section of the park. The study by Werger & Coetzee (1977) did not cover the entire area of this national park.

This project also forms part of a broader inventory of the diversity of plant species and plant communities conserved in the different national parks, as already conducted for the Mountain Zebra National Park (Van der Walt 1980), Zuurberg National Park (Van Wyk *et al.* 1988), Golden Gate Highlands National Park (Kay *et al.* 1993) and the Vaalbos National Park (Bezuidenhout 1994, 1995).

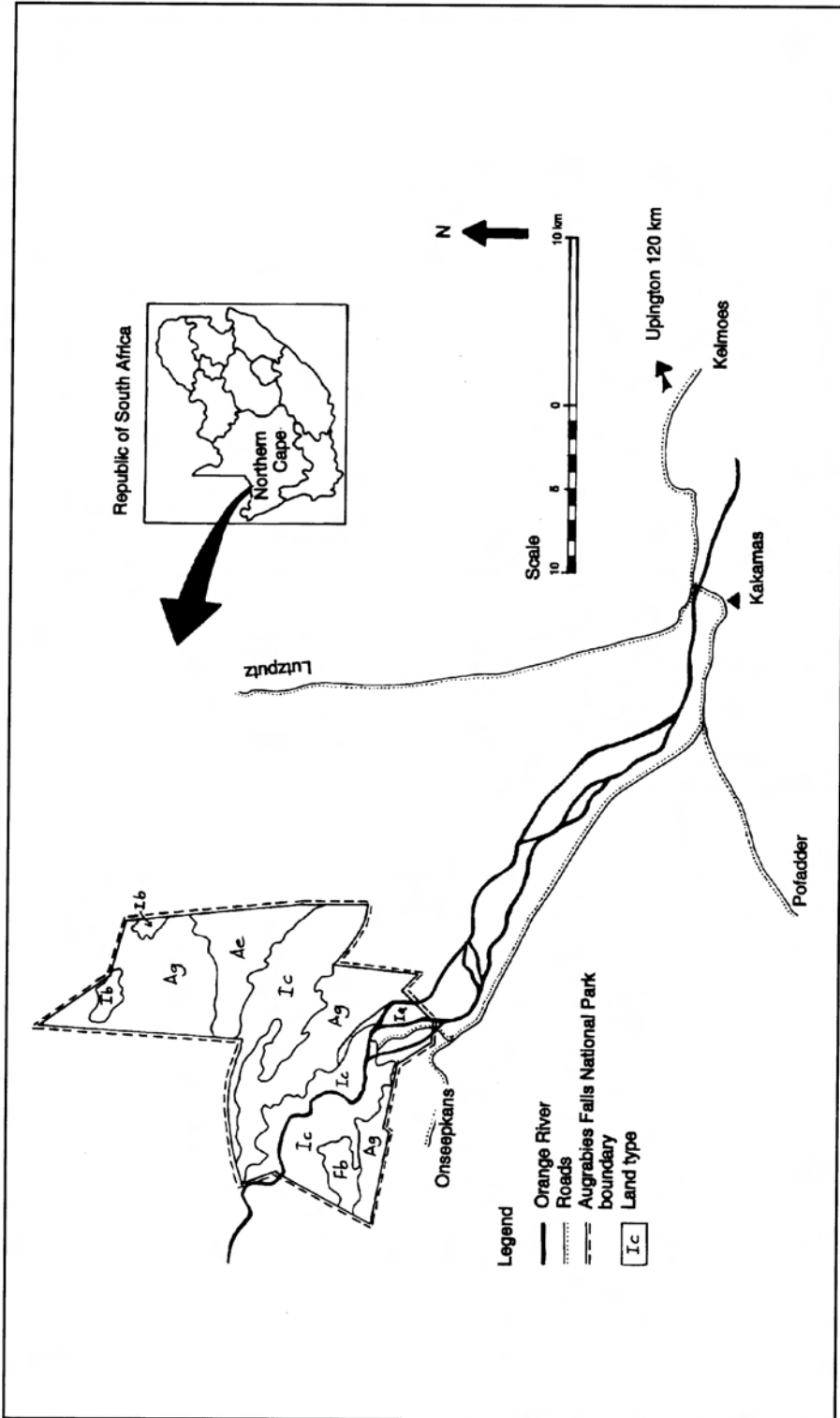


Fig. 1. The location of the Augrabies Falls National Park in relation to towns, Orange River, land types and main roads.

Study area

The Orange River divides the AFNP into a northern (13 700 ha) and southern (4 500 ha) section. The river flows through the extensive arid plains of Bushmanland. The AFNP (18 200 ha) is located approximately 120 km west of Upington (Fig. 1). The national park is situated at latitude 28°25'–28°38'S and longitude 20°15'–20°20'E. This report deals with the vegetation of the southern section of the AFNP only.

Land types with references to the physiography, geology and soil

Four land types, namely Ag, Ia, Ic and Fb, occur in the southern section of the park. According to the Land Type Survey Staff (1986) "A land type denotes an area that can be shown at 1:250 000 scale and that displays a marked degree of uniformity with respect to terrain form, soil pattern and climate". A remarkable association between the major plant communities and the different land types have been observed. The land type concept has frequently provided a useful basis for description of vegetation (Bezuidenhout 1988, 1993; Kooij 1990; Breytenbach 1991; Smit 1992; Coetzee 1993; Myburgh 1993).

The land type Ag refers to red apedal, freely drained, high base status soil which is shallower than 300 mm. The predominant geology of this land type is migmatite, gneiss and granite. Dorbank outcrops occur at many places and a very dense subdendritic drainage and dissection pattern occur in this land type. The slightly undulating plains are dominated by the midslopes (3 - Fig. 2) with the dominant soil form Hutton (Soil Classification Working Group 1991). This soil is shallow (100 - 300 mm) and rocky while the sand grade is coarse (Land Type Survey Staff 1986).

According to the Land Type Survey Staff (1986) the Ia land type refers to a soil pattern comprising at least 60 % pedologically youthful, deep unconsolidated deposits. The dominant soil forms are Dundee and Oakleaf. These plains are dominated by the floodplains (5 - Fig. 2). Intrusive rocks (mainly granite) of the Namaqualand Metamorphic Complex and alluvium of Tertiary to Recent age are the dominant geological substrate of this land type (Land Type Survey Staff 1986).

The Ic land type refers to exposed rocks which covers more than 80 % of the area. The midslopes (3 - Fig. 2) is the most prominent topographical position in this hilly landscape and the dominant soil-rock complex consists of rocky outcrops while the Hutton

soil form is subdominant. The geology consists of garnet-sillimanite-cordierite-biotite gneiss, granulite and garnet bearing quartz-felspargneiss with amphibolite of the Toeslaan Formation (Korannaland Sequence) while red to flesh-coloured wind-blown sand of Tertiary to Recent age also occur (Land Type Survey Staff 1986).

The Fb land type refers to pedologically young landscapes which are predominantly rocky and not alluvial or aeolian. Lime occurs regularly in one or more of the valley bottom soils. Soil forms that epitomise this land type are Glenrosa and Mispah. The geology consists of gneissic granite and other ultrametamorphic rocks of the Namaqualand Metamorphic Complex. Two topographical positions are prominent in this rolling landscape namely the midslopes (3) and footslopes (4) (Fig. 2).

Climate

The predominantly summer rainfall is erratic, ranging from < 40 mm p.a. to 391 mm p.a. The average annual rainfall (July to June) for the AFNP is based on data collected within the rest camp of the park, by the Weather Bureau, over the past thirty years (1946 - 1996), and is just more than 211 mm (Weather Bureau 1996). The past ten years (1986–1996) were dry years, well below the average annual rainfall (Fig. 3), with the months December, January and February 1996, representing the rainy period (Fig. 4).

The temperature is less erratic than the rainfall with cold winter temperatures (coldest months June - July) as low as -2,9 °C while the summer temperatures (warmest months December, January and February) are as high as 42,9 °C (Land Type Survey Staff 1986).

Methods

The stratification of the area into relatively homogeneous physiographic-physiognomic units was done on 1:40 000 aerial photographs. Sample plots were allocated *pro rata* to these units on the basis of the sizes of the areas. Relevés were compiled in 59 sample plots. Plot sizes were fixed on 900 m² (30 m x 30 m) according to Bezuidenhout (1994). Fieldwork was done during February 1996. The cover-abundance for each species present in the sample plot was estimated according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). The frequency for each species in the community was calculated according to the method described by Mueller-Dombois & Ellenberg (1974). Average estimated

height and average canopy cover for the tree, shrub and herbaceous layers are given for each individual community (Bezuidenhout 1988). Environmental data include rock, terrain and soil types, as well as soil depth and soil texture. The floristic data was analysed according to Braun-Blanquet procedures using the BBPC suite (Bezuidenhout *et al.* 1996). The final result of the classification procedure is a phytosociological table (Table 1). This approach has proved to produce ecologically reliable results in many phytosociological studies in South Africa (Bredenkamp & Bezuidenhout 1990; Kooij 1990; Du Preez 1991; Bezuidenhout 1993; Eckhardt 1993; McDonald 1993; Mustart *et al.* 1993). No attempt was made to formally fix syntaxa names as this is normally avoided in detailed local studies (Coetzee 1983).

Taxa names conform to those of Arnold & De Wet (1993). In Table 1, as well as in the community names, the taxa names do not include the subspecies and variant of that taxa but it is mentioned in the

description. Soil nomenclature follows the classification of the Soil Classification Working Group (1991). The broad-scale structural classification of Edwards (1983) was used for describing the structure of the vegetation.

Results

Classification

Nine plant communities (Fig. 5) are described for the complex geology and broken, rocky terrain of the AFNP. In the phytosociological table, six distinct major vegetation communities are recognised (Table 1). The hierarchical classification and a brief habitat interpretation of these communities are summarised as follows:

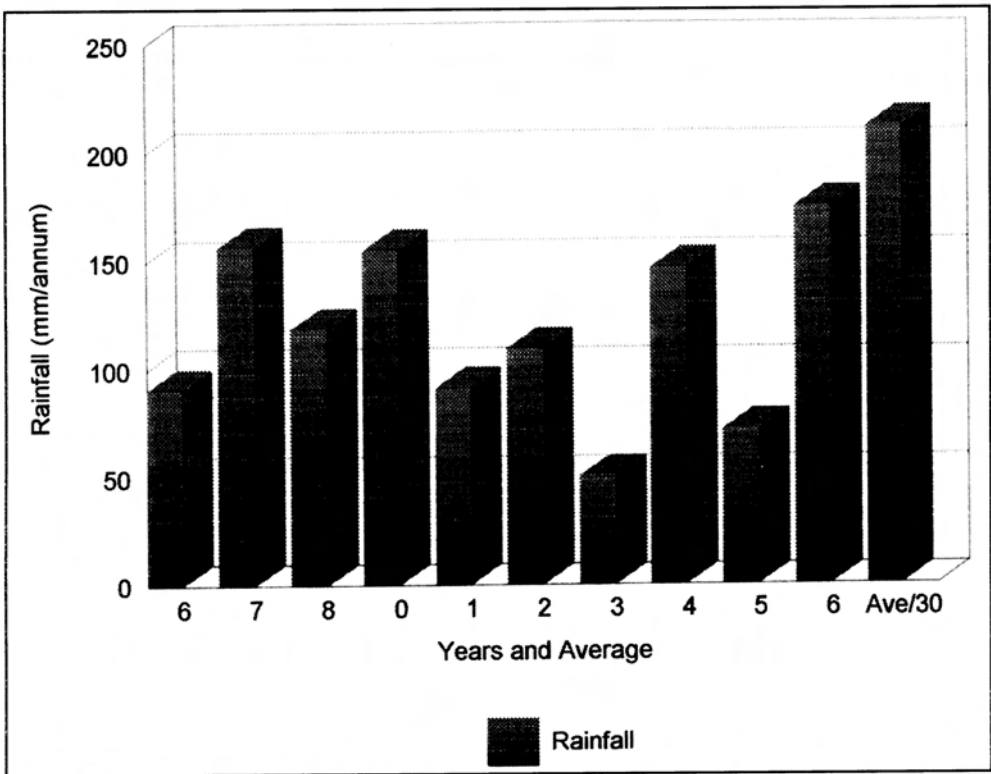


Fig. 3. The rainfall (mm/July-June) statistics for the past ten years of the Augrabies Falls National Park (6 - 1985/1986; 7 - 1986/1987; 8 - 1987/1988; 9 - 1988/1989; 0 - 1989/1990; 1 - 1990/1991; 2 - 1991/1992; 3 - 1992/1993; 4 - 1993/1994; 5 - 1994/1995; 6 - 1995/1996; Ave/30 - average of 30 years).

1. The *Aloe dichotoma* Sparse Woodland is strongly associated with the black hills situated in the middle of the southern section of the AFNP.
2. The *Schotia afra* Open Woodland
 - 2.1 The *Rhus populifolia* - *Schotia afra* Open Woodland is associated with the hilly, rocky parts closer to the river to the north of the southern section of the AFNP.
 - 2.2 The *Sisyndite spartea* - *Schotia afra* Open Woodland is mainly found in the drainage lines of these hills.
3. The *Ceraria namaquensis* Open Shrubland is associated with rocky outcrops of mainly rather strongly weathered gneiss.
4. The *Acacia mellifera* Open Shrubland.
 - 4.1 The *Euphorbia rectirama* - *Acacia mellifera* Open Shrubland is strongly associated with the slightly undulating, rocky plains of the southern parts of the study area.
 - 4.2 The *Sarcostemma viminale* - *Acacia mellifera* open Shrubland is found on Klaas Island which is associated with a slightly undulating, rocky plain.

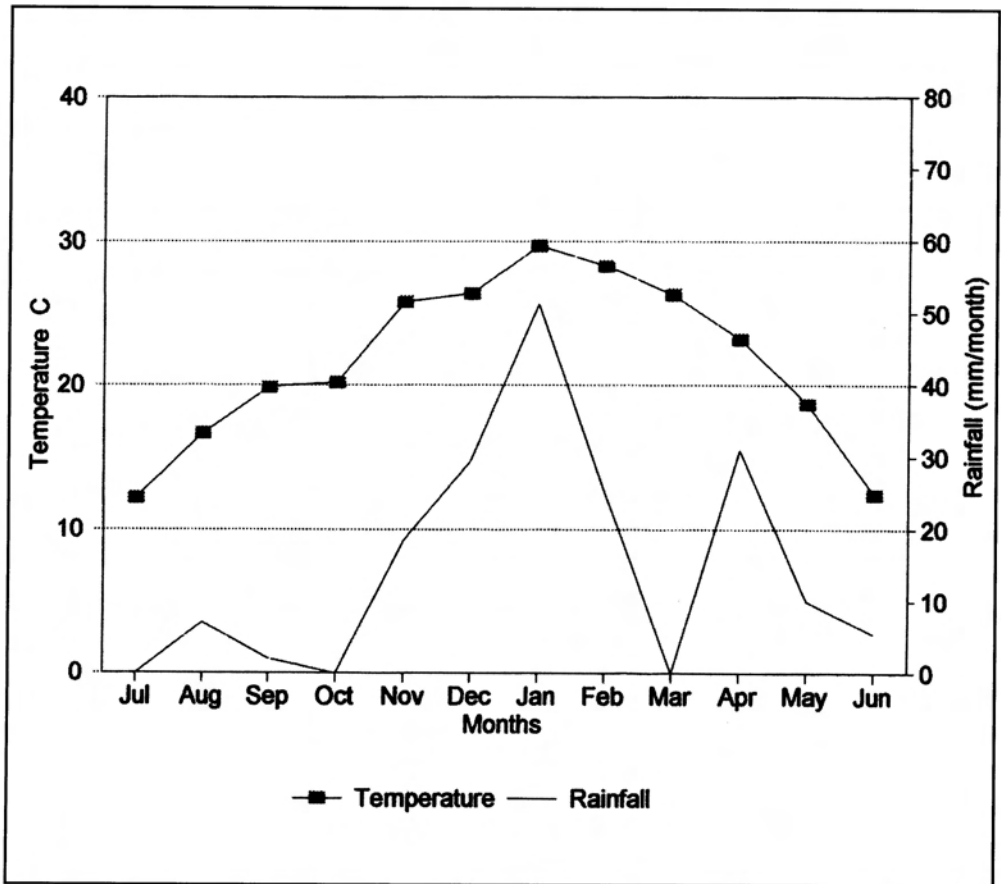


Fig. 4. A climate diagram for Augrabies Falls National Park (July 1995 - June 1996).

5. The *Stipagrostis hochstetteriana* Open Grassland is restricted to the sandy plain north of the black hills.
6. The *Ziziphus mucronata* Closed Woodland
 - 6.1 The *Tamarix usneoides* - *Ziziphus mucronata* Closed Woodland is associated with the alluvial deposits and rocky outcrops of the Orange River as well as of the larger sandy drainage lines.
 - 6.2 The *Diospyros lycioides* - *Ziziphus mucronata* Closed Woodland is strongly associated with the numerous islands formed by the braided stream of the Orange River above the main waterfall as well as small floodplains along the Orange River.

Description of the vegetation

The vegetation is strongly related to land types. Four land types-cum-plant communities can be recognised: the *Schottia afra* Open Woodland (2), *Ceraria namaquensis* Open Shrubland (3) and the *Stipagrostis hochstetteriana* Open Grassland (5) of the undulating rocky hills (Land type Ic), the *Aloe dichotoma* Sparse Woodland (1) of the rolling black hills (Land type Fb), the *Acacia mellifera* Open Shrubland (4) of the slightly undulating plains (Land type Ag) and the *Ziziphus mucronata* Closed Woodland (6) of the drainage lines and plains along the Orange River (Land type Ia)(Figs. 1, 2 & 5).

1. The *Aloe dichotoma* Sparse Woodland

This Sparse Woodland is strongly associated with the rolling black hills of the Fb land type situated in the middle of the southern section of the AFNP (Figs. 1, 2 & 5). The geology of this community consists of ultrametamorphic rocks of the Namaqualand Metamorphic Complex. Surface limestone occurs sporadically. Two topographical positions are prominent in this rolling landscape

namely the midslopes (3) and footslopes (4) (Fig. 2). The soil forms of the Fb land type that epitomise this woodland habitat are the very shallow (<0.1 m) Glenrosa and Mispah forms.

The diagnostic species are the conspicuous tree-*Aloe dichotoma*, the conspicuous forbs *Berkheya spinosissima* subsp. *spinosissima*, *Cleome angustifolia* subsp. *diandra*, *Barleria rigida*, *Sutera ramosissima*, *Rhigozum trichotomum* and *Abutilon pycnodon* (species group A; Table 1). The tree stratum has a frequency of 50 % in this community, with a canopy cover of 2 % and a height of 5 m (Table 2).

The most prominent trees are *Aloe dichotoma* (species group A) and *Adenolobus garipensis* (species group O; Table 1). The shrub layer (100 % frequency) has a canopy cover of 3.5 % and is 1.6 m tall (Table 2). The most prominent shrub species are *Commiphora gracilifronsosa* (species group E), *Rhus populifolia* (species group H) and *Boscia foetida* subsp. *foetida* (species group R; Table 1). The herbaceous layer, with a frequency of 100 %, is 0.6 m tall and has a canopy cover of 12.5 % (Table 2).

Prominent grasses are *Triraphis ramosissima* (species group F), *Antheophora pubescens* (species group M), *Enneapogon scaber* (species group O) and *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1). Forbs that are constantly present are the diagnostic forbs (species group A), *Forsskaolea candida* (species group E), *Trichodesma africanum* (species group F), *Codon schenckii* (species group M) and *Monechma spartioides* (species group R; Table 1). Other species that are present in this subcommunity are species of species groups E, F, H, M, O, R and W (Table 1).

This community is similar to the *Commiphora gracilifronsosa* Community described by Werger & Coetzee (1977). It was found that *Commiphora gracilifronsosa* (species group E; Table 1) also occurs prominently in the *Rhus populifolia* - *Schottia afra* Open Woodland (4.1).

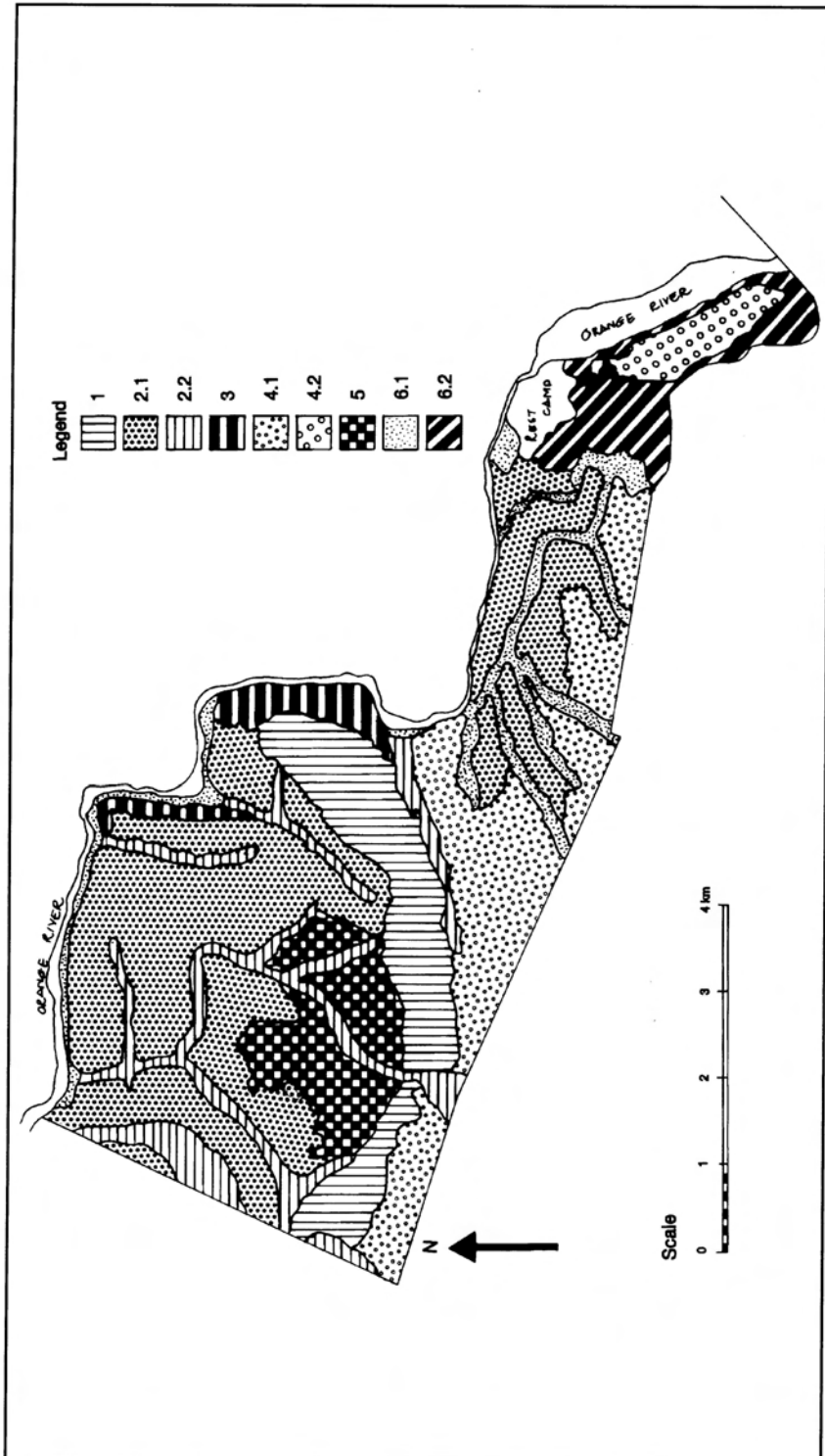


Fig. 5. A vegetation map of the southern section of Augrabies Falls National Park (1. *Aloe dichotoma* Sparse Woodland; 2.1 The *Rhus populifolia* - *Schottia afra* Open Woodland; 2.2 The *Sisyndite spartea* - *Schottia afra* Open Woodland; 3. The *Ceraria namaquensis* Open Shrubland; 4.1 The *Euphorbia rectirama* - *Acacia mellifera* Open Shrubland; 4.2 The *Sarcostemma viminalis* - *Acacia mellifera* Open Shrubland; 5. The *Stipagrostis hochstetteriana* Open Grassland; 6.1 The *Tamarix usneoides* - *Ziziphus mucronata* Closed Woodland; 6.2 The *Diospyros lycioides* - *Ziziphus mucronata* Closed Woodland).

2. The *Schotia afra* Open Woodland.

The *Schotia afra* Open Woodland occurs in the undulating rocky hills of the Ic land type (Figs. 1 & 2), mainly in the north western part of the study area (Fig. 5). It is strongly associated with exposed rocks which cover more than 80 % of the area. The geology consists of garnet-sillimanite-cordierite-biotite gneiss, granulite and garnet bearing quartz-felspargneiss with amphibolite of the Toeslaan Formation (Korannaland Sequence). The crests (1) and midslopes (3) are the most prominent topographical positions in this hilly landscape and the dominant soil-rock complex consists mainly of rocks while the shallow (< 0.1 m deep) Hutton soil form is subdominant (Fig. 2). Twenty eight percent of this land type is associated with the drainage lines (4 - footslopes and 5 - valley bottoms) of this hilly landscapes (Fig. 2) (Land Type Survey Staff 1986).

This community is characterised by species group B (Table 1). The diagnostic species are the conspicuous tree *Schotia afra* var. *angustifolia*, the conspicuous shrub *Sisyndite spartea* as well as the conspicuous forbs *Hibiscus engleri* and *Cleome foliosa* var. *lutea*.

Two subcommunities of this Woodland have been distinguished.

2.1 The *Rhus populifolia* - *Schotia afra* Open Woodland

This subcommunity is associated with the hilly, rocky parts closer to the river to the north of this southern section of the AFNP (Fig. 5). The crests (1) and midslopes (3) are the most prominent topographical positions in this landscape and the dominant soil-rock complex is rock outcrops while the shallow (< 0.1 m deep) Hutton soil form is subdominant (Fig. 2).

The non-conspicuous forb *Indigofera pechuelii* and the non-conspicuous succulent *Euphorbia* cf. *peplus* are the diagnostic species of this subcommunity (species group C; Table 1). The tree stratum with a frequency of 85 % is 3.8 m tall and the canopy cover

is 6.5 % (Table 2). The tree *Schotia afra* var. *angustifolia* (species group B) is prominent in the tree stratum while the shrubs *Commiphora gracilifrons* (species group E), *Boscia albitrunca* (species group W), *Rhus populifolia* (species group H), *Cadaba aphylla* (species group W) and *Adenolobus garipensis* (species group O) are very prominent in this subcommunity (Table 1). The shrub stratum is 1.5 m tall with the canopy cover 5.6 % and has a frequency of 100 %. The herbaceous layer with a frequency of 100 %, has a canopy cover of 15 % and is 0.4 m tall (Table 2). Forbs such as *Indigofera pechuelii* (species group C), *Euphorbia* cf. *peplus* (species group C), *Hibiscus engleri* (species group B), *Cleome foliosa* var. *lutea* (species group B), *Forsskaolea candida* (species group E), *Trichodesma africanum* (species group F), *Codon schenckii* (species group M) and *Indigofera pungens* (species group H) are present in this poorly developed herbaceous layer (Table 1). The prominent grass species are *Triraphis ramosissima* (species group F), *Panicum coloratum* (species group H), *Enneapogon scaber* (species group O) and *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1). Other species that are present in this subcommunity include species of species groups H, L, M, O, R and W (Table 1).

A similar *Schotia afra* community was described by Werger & Coetzee (1977).

2.2 The *Sisyndite spartea* - *Schotia afra* Open Woodland

This woodland subcommunity is strongly associated with the drainage lines (4 - footslopes and 5 - valley bottoms) of this hilly landscape (Fig. 2). It contributes to 28 percent of the Ic land type (Land Type Survey Staff 1986). The dominant soil-rock complex is the Dundee soil form while rocky outcrops are subdominant.

The diagnostic species are the conspicuous tree *Ficus cordata* subsp. *cordata* (mainly associated with the rocky outcrops) and the non-conspicuous shrub *Euclea undulata* var.

Table 1 (continued)

Species Group I

<i>Zygophyllum suffruticosum</i>	+2	+			2 21 2 112			
<i>Phaeoptilium spinosum</i>					+ + +++ 1++	1		
<i>Hermannia stricta</i>		+			++ + +++ ++	+		

Species Group J

<i>Euphorbia rectirama</i>					+ 1 11+			
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Species Group K

<i>Sarcostemma viminale</i>					322			
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Species Group L

<i>Hibiscus elliotiae</i>		12		+	+++	+++	+++	
<i>Protasparagus species</i>		+	+	++	+++	++	++	+
<i>Indigofera heterotricha</i>		+1+	+	++	+++	+	+++21++	

Species Group M

<i>Codon schenckii</i>	+++	+++++	1 + ++	++ 2+	+1			
<i>Anthepha pubescens</i>	++22	+	+ 1	1 1	+			

Species Group N

<i>Lineum sulcatum</i>			+	+	+++	+++++++	+++	
<i>Plexipus garipensis</i>					++1	++	++	

Species Group O

<i>Enneapogon scaber</i>	2212	2222221222212	R21++11 3	+22+2	1+ ++1++1	+++		3
<i>Adenolobus garipensis</i>	+3	23 +	+ +R 12	2		111		
<i>Dyerophytum africanum</i>	+	+ ++	2 +	++ +	+++ +	+++	+	
<i>Osteospermum microcarpum</i>	+++			+++	+ +	+++		

Species Group P

<i>Stipagrostis hochstetteriana</i>		1	++ +	2		33324		
<i>Parkinsonia africana</i>				+	+	1 +++		
<i>Stipagrostis ciliata</i>			++			++ +1	+	
<i>Monechma genistifolium</i>						+ +		

Species group Q

<i>Euphorbia gregaria</i>					3 +12	2 +2++	2112	
<i>Zygophyllum microcarpum</i>	+				++1	++2111++	+22	+

Species group R

<i>Monechma spartioides</i>	11++	+	+	+	++ ++	++11++221	+++ + +1	
<i>Boscia foetida</i>	1 +	+	R +	1 +	+++1+ +	+ +	+++ +	+

Table 1 (continued)

Species group S

<i>Lycium bosciifolium</i>				+		+	+	+	3212+	2322
<i>Acacia karroo</i>									+1+	3+22
<i>Ziziphus mucronata</i>									+++2	1+2+
<i>Rhus pendulina</i>									+ 1+2	21++
<i>Maerua gilgii</i>									1112	+ +
<i>Euclea pseudebenus</i>									121 3	+ +
<i>Cenchrus ciliaris</i>	+			+	1	+	+		+1+2	+ +

Species group T

<i>Tamarix usneoides</i>				+					1+2113	
<i>Stipagrostis namaquensis</i>		+		2					+ 12+	
<i>Maytenus linearis</i>									++ ++	+
<i>Zygophyllum simplex</i>									1	+
<i>Prosopis glandulosa</i>									++	

Species group U

<i>Diospyros lycioides</i>										+33+
<i>Phragmites australis</i>									+	2+ 1
<i>Protaspargus retrofractus</i>										2+
<i>Mesembryanthemum crystallinum</i>										+ +

Species group V

<i>Acacia erioloba</i>						+R			R	+1+ + 1 22+
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Species group W

<i>Stipagrostis uniplumis</i>	1+++	+++33++1	+ +21+++1	+++112	31+++++2	+++1+2++	+ +			
<i>Boscia albitrunca</i>	++	1++ + +R+1+1	+ + 2+2	+ +	+++ ++ +	++ + ++	++ +			R
<i>Acacia mellifera</i>		+R 3 +	+3+	+ 22	323333343	333 3223+	23 1 1			1
<i>Cadaba aphylla</i>		1 + 1+ 1 +	++R +	+++ +		++ +	+			+
<i>Tribulus species</i>	++	+ +	+++ +	++	1	++ ++	++++ +			
<i>Pappia capensis</i>	+ +	+ 1	R + 1+2+	1	+++	R +	+			R
<i>Stipagrostis obtusa</i>		R+			+	+	1			
<i>Kyphocarpa angustifolia</i>			+	+	+++	+				
<i>Cleome oxyphylla</i>	+	+ + +		+						
<i>Gisekia africana</i>				++	+	++				
<i>Salvia species</i>	+ + +		++							
<i>Ehretia rigida</i>			++	++						+
<i>Schmidtia kalahariensis</i>			+ +							
<i>Hermannia minutiflora</i>	++	+	+							

* Non-diagnostic species with a frequency of less than 7% (< 4) are omitted from the table.

myrtina (species group D; Table 1). The prominent tree stratum with a frequency of 100 % is 5.2 m tall and has a canopy cover of 11.7 %. In the drainage lines of this hilly landscape three tree species, which are very

prominent, are *Ficus cordata* (diagnostic for this subcommunity - species group D), *Schotia afra* var. *angustifolia* (diagnostic for the community - species group B) and *Pappia capensis* (species group W; Table 1).

The well-developed shrub stratum has a frequency of 100 % and has a canopy cover of 12 %, and is 2 m tall (Table 2). The most prominent shrub in this mixed shrub stratum is the conspicuous *Sisyndite spartea* (species group B; Table 1). The herbaceous layer is 0.6 m tall and has a frequency of 100 %, with a canopy cover of 12.5 % (Table 2). Apart from the grasses *Enneapogon scaber* (species group O; Table 1) and *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1), the forb *Hibiscus engleri* (species group B; Table 1) is also prominent in this mixed herbaceous layer. Species from species groups B, D, F, H, L, M, O, R and W (Table 1) are also present in this subcommunity.

Werger & Coetzee (1977) described a similar community namely the *Sisyndite spartea* Community.

3. The *Ceraria namaquensis* Open Shrubland

The *Ceraria namaquensis* Open Shrubland is associated with the rocky outcrops of mainly rather strongly weathered gneiss as well as small sparsely scattered quartzitic outcrops (Fig. 5). This community is strongly associated with the crests (1) of the Ic land type and rocks are the dominant soil rock complex in this habitat (Figs. 1 & 2).

The *Ceraria namaquensis* Open Shrubland is characterised by the diagnostic conspicuous, portulacaceous shrub *Ceraria namaquensis* and the non-conspicuous forb *Salsola* species (species group G; Table 1). The tree stratum with a low frequency of 40 %, is 4 m tall and has a canopy cover of 2 %. The tree *Pappea capensis* (species group W) and tree/shrub *Adenolobus garipensis* (species group O) are sometimes present in this shrub dominated community (Table 1). Apart from the diagnostic succulent shrub *Ceraria namaquensis* (species group G), the conspicuous shrub *Acacia mellifera* subsp. *detinens* (species group W) is also prominent in this shrub stratum (Table 1). It has a canopy cover of 8.4 % and is 1.7 m tall with a fre-

quency of 100 %. The herbaceous layer is poorly developed with a frequency of 100 % and is 0.5 m tall and has a canopy cover of 8 % (Table 2). The grasses *Enneapogon scaber* (species group O; Table 1) and *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1) as well as the succulent forbs *Euphorbia gregaria* and *Zygophyllum microphyllum* (species group Q; Table 1) and the non-conspicuous forbs *Limeum sulcatum* var. *robustum* and *Plexipus garipensis* (species group N; Table 1) are prominent in this community. Other species that are also present include species of species groups L, M, O, R and W (Table 1).

This community is similar to the *Ceraria namaquensis* Community as described by Werger & Coetzee (1977).

4. The *Acacia mellifera* Open Shrubland

This open shrubland is strongly associated with the slightly undulating, rocky plains of the Ag land type (Figs. 1 & 2). It is situated in the southern parts of the study area (Fig. 5). The predominant geology of this Ag land type is migmatite, gneiss and granite. The habitat of this shrubland consists of dorbank outcrops at many places and a very dense subdendritic drainage and dissection pattern. The slightly undulating plains are dominated by the midslopes (3) with the dominant soil forms Hutton and Mispah (Fig. 5). The coarse sandy soil is shallow (0.1–0.3 m deep) and rocky (Land Type Survey Staff 1986).

The diagnostic succulent *Zygophyllum suffruticosum*, the diagnostic conspicuous shrubs *Phaeoptilum spinosum* and *Hermannia stricta* characterise this shrubland (species group I; Table 1).

Two subcommunities have been identified (Table 1). No different obvious topographic or soil factors were noted for these two subcommunities except that the *Sarcostemma viminale* - *Acacia mellifera* Subcommunity is restricted to Klaas Island.

A similar community was described by Werger & Coetzee (1977) namely the

Table 2

The average height (H), average canopy cover (C) and frequency (F) of the different strata of the plant communities found in the southern section of the AFNP

Stratum Plant community ^a	Tree			Shrub			Herbaceous		
	H (m)	C (%)	F (%)	H (m)	C (%)	F (%)	H (m)	C (%)	F (%)
1	5	2	50	1.6	3.5	100	0.6	12.5	100
2.1	3.8	6.5	85	1.5	5.6	100	0.4	15	100
2.2	5.2	11.7	100	2	12	100	0.6	12.5	100
3	4	2	40	1.7	8.4	100	0.5	8	100
4.1	3.9	2	56	2.4	10	100	0.6	14	100
4.2	6	2	34	2.6	7.6	100	1	18	100
5	4.8	2.6	100	1.6	6.6	100	0.5	18	100
6.1	7	9	100	2.3	15	100	0.4	9	100
6.2	10	12.5	100	3.6	34	100	0.8	5	100

Indigofera heterotricha-Zygophyllum suffruticosum Community.

4.1 *Euphorbia rectirama* - *Acacia mellifera* Open Shrubland

This subcommunity is strongly associated with the slightly undulating, rocky plains of the southern parts of the study area (Figs. 2 & 5).

Floristic differences were detected in the presence of species from species groups J (diagnostic species), L, M and N while the absence of species of species group K is also significant (Table 1). The diagnostic species which characterise this subcommunity is the conspicuous *Euphorbia rectirama* (species group J; Table 1).

The tree stratum is 3.9 m tall and has a canopy cover of 2 %. The poorly represented tree stratum has a frequency of 56 % (Table 2). The most prominent tree is the conspicuous *Pappea capensis* (species group W; Table 1), which is mainly associated with the drainage lines of this plains. The shrub stratum has a frequency of 100 % and is 2.4 m tall. It has a canopy cover of 10 %. The prominent as well as dominant conspicuous shrub is *Acacia mellifera* subsp. *detinens* (species group W; Table 1). The herbaceous

layer is 0.6 m tall and has a frequency of 100 % as well as a canopy cover of 14 % (Table 2). Prominent grasses are *Enneapogon scaber* (species group O; Table 1) and *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1). Prominent forbs are *Zygophyllum microphyllum* (species group Q; Table 1) and *Monechma spartioides* (species group R; Table 1). Other species of species groups I, L, M, O, Q, R and W are also present in this subcommunity (Table 1).

Two small isolated patches of the *Ceraria namaquensis* Open Shrubland occur in this subcommunity. It is associated with quartzitic outcrops in this subcommunity.

The described *Antherothamnus pearsonii* Community by Werger & Coetzee (1977) is also similar to this subcommunity.

4.2 *Sarcostemma viminale* - *Acacia mellifera* Open Shrubland

The *Sarcostemma viminale* - *Acacia mellifera* Open Shrubland Subcommunity is found on Klaas Island, which is associated with a slightly undulating, rocky plain (Figs. 2 & 5).

The presence of species from species groups K (diagnostic species), N and O and the absence of species of species groups J, L and M (Table 1) indicate a floristic difference between the subcommunities. This subcommunity is characterised by the diagnostic succulent creeper *Sarcostemma viminalis* (species group K; Table 1).

The poorly developed tree stratum, with a frequency of 34 %, is 6 m tall and has a canopy cover of 2 % (Table 2). Only one tree, an *Acacia erioloba* (species group V; Table 1), was noted. The two dominant shrub species *Acacia mellifera* subsp. *detinens* (species group W; Table 1) and *Adenolobus garipensis* (species group O; Table 1) are conspicuous in this subcommunity. The shrub stratum is 2.6 m tall and has a canopy cover of 7.6 % with a frequency of 100 % (Table 2). The herbaceous layer has a canopy cover of 18 % and is 1 m tall with a frequency of 100 %. Apart from the diagnostic species the two succulents *Zygophyllum suffruticosum* (species group I) and *Zygophyllum microphyllum* (species group Q) are very prominent in the herbaceous layer (Table 1). The most prominent grass species is *Stipagrostis uniplumis* var. *uniplumis* (species group W; Table 1). Other species of species groups I, N, Q, R and W (Table 1) are also present in this subcommunity.

5. The *Stipagrostis hochstetteriana* Open Grassland

This community is restricted to the sandy plain north of the black hills (Fig. 5). The geology consists of red to flesh-coloured wind-blown sand of Tertiary to Recent age (Land Type Survey Staff 1986). The foot-slopes (4) of the Ic land type are dominated by the Hutton soil form as well as scattered rock outcrops (Figs. 1 & 2). The soil depth varies from 0.3 to 1.2 m.

The species of species group P (Table 1) are diagnostic for the *Stipagrostis hochstetteriana* Open Grassland. It includes the grasses *Stipagrostis hochstetteriana* var. *secalina* and *S. ciliata* var. *capensis*, the non-conspicuous

but interesting tree *Parkinsonia africana* and the non-conspicuous forb *Monechma genistifolium* subsp. *genistifolium*. Three tree species are prominent in the tree stratum, which is 4.8 m tall and has a frequency of 100 % and a canopy cover of 2.6 %. The trees are *Acacia erioloba* (species group V), *A. mellifera* subsp. *detinens* (species group W) and *Parkinsonia africana* (species group P; Table 1). The shrub stratum is 1.6 m tall and has a canopy cover of 6.6 % with a frequency of 100 % (Table 2). The most prominent shrubs are the succulent *Euphorbia gregaria* (species group Q), the shrub *Acacia mellifera* subsp. *detinens* (species group W) and the conspicuous shrub *Boscia foetida* subsp. *foetida* (species group R; Table 1). The herbaceous layer with the diagnostic grasses (species group P) and *Stipagrostis uniplumis* var. *uniplumis* (species group P) is 0.5 m tall with a canopy cover of 18 % and has a frequency of 100 %. No prominent forbs for this community were noted during the survey.

Werger & Coetzee (1977) described a similar plant community namely the *Stipagrostis hochstetteriana* var. *secalina* Community.

6. The *Ziziphus mucronata* Closed Woodland

The *Ziziphus mucronata* Closed Woodland is strongly associated with the relatively wetter drainage lines as well as with the floodplains and islands of the Orange River (Fig. 5). It is associated with the floodplain (5) of the Ia land type with a soil pattern of at least 60 % pedologically youthful, deep unconsolidated deposits/alluvium (Figs. 1 & 2). The dominant soil forms are Dundee and Oakleaf. Also occurring is the intrusive rock (mainly granite) of the Namaqualand Metamorphic Complex (Land Type Survey Staff 1986).

This community is characterised by the diagnostic conspicuous woody component *Lycium bosciifolium*, *Acacia karroo*, *Ziziphus mucronata* subsp. *mucronata*, *Rhus pendulina*, *Maerua gilgii*, *Euclea pseudebenus* and the diagnostic conspicuous grass species *Cenchrus ciliaris* (species group S; Table 1).

Two subcommunities are identified (Table 1).

6.1 The *Tamarix usneoides* - *Ziziphus mucronata* Closed Woodland

This woodland is associated with the alluvial deposits as well as intrusive outcrops (granite) of the Orange River and of the larger sandy drainage lines (Fig. 5). This community's habitat is drier and more rocky than that of the *Diospyros lycioides* - *Ziziphus mucronata* Closed Woodland (6.2).

The diagnostic species of species group T (Table 1) are the conspicuous tree *Tamarix usneoides*, the conspicuous shrub *Maytenus linearis*, the invader shrub/tree *Prosopis glandulosa* var. *torreyana*, the grass *Stipagrostis namaquensis* and the succulent *Zygophyllum simplex*. The tree stratum is 7 m tall and has a canopy cover of 9 % and a frequency of 100 % (Table 2). Apart from the diagnostic trees (species groups S (community), T (subcommunity)) the only other tree which is prominent in this subcommunity is *Acacia erioloba* (species group V) (Table 1). The shrub stratum is 2.3 m tall and has a frequency of 100 % and a canopy cover of 15 % (Table 2). The shrubs *Acacia mellifera* (species group W) and *Sisymbrium sparteae* (species group B; Table 1) are the only other shrubs apart from the above-mentioned diagnostic shrubs that are prominent. The poorly developed herbaceous layer has a canopy cover of 9 %, a frequency of 100 % and is 0.4 m tall (Table 2). Only the diagnostic grass and forb species (species groups S (community), T (subcommunity)) are prominent in this subcommunity (Table 1).

The described *Stipagrostis namaquensis*-*Leucophrys mesocoma* Community and *Lycium prunus-spinosa*-*Lycium oxycarpum* Community by Werger & Coetsee (1977) are similar to this subcommunity.

6.2 The *Diospyros lycioides* - *Ziziphus mucronata* Closed Woodland

The *Diospyros lycioides* - *Ziziphus mucronata* Closed Woodland is strongly associated

with the numerous islands formed by the perennial braided stream of the Orange River above and along the main waterfall as well as small floodplains along the Orange River (Figs. 2 & 5). The dominant soil form is the Dundee form which is mostly deeper than 1.2 m.

The tree/shrub *Diospyros lycioides* subsp. *lycioides*, the robust reed *Phragmites australis*, the creeper *Protasparagus retrofractus* and the succulent *Mesembryanthemum crystallinum* are the diagnostic species for this subcommunity (species group U; Table 1). At some places the creeper *Protasparagus retrofractus* forms an impenetrable clump. The tree stratum, as well as the shrub stratum are the best developed of all the plant communities (Table 2). The tree stratum has a frequency of 100 % and is 10 m tall with a canopy cover of 12.5 % while the shrub stratum is 3.6 m tall with a frequency of 100 % and has a canopy cover of 34 % (Table 2). Apart from the woody species of the diagnostic species for the community and subcommunity (species groups S and U; Table 1), no other woody species are prominent in this subcommunity. The herbaceous layer, which is poorly developed, is 0.8 m tall and has a canopy cover of 5 %, with a frequency of 100 %. Apart from the diagnostic grass and forb species (species groups S and U; Table 1) no other species are prominent in the herbaceous layer.

The *Ziziphus mucronata*-*Euclea pseudebe-nus* Community described by Werger & Coetsee (1977) is similar to this subcommunity.

Concluding remarks

The *Ziziphus mucronata* Closed Woodland is very threatened and if this plant community is not properly conserved and cared for, it could become extinct. Between the AFNP and Groblershoop, all along the Orange River, the habitat of this woodland is irrigated with water from the Orange River after the natural vegetation was cleared. Now it produces vegetables, fruit and lucerne. The

building of dams further upstream in the Orange River also threatens this plant community because tributaries dry up and the water-level of the Orange River falls. Monitoring of this plant community is therefore of the utmost importance. Also, according to Werger & Coetzee (1977) the occurrence of *Rhus lancea* in the *Ziziphus mucronata* Closed Woodland is of phytogeographical interest. This species is absent and very rare along the Upper Orange River (Werger 1973), but occurs commonly in the riverine forest along the Vaal River.

An interesting observation is that the woody component of the study area is more strongly associated with the drainage lines and Orange River than with the rest of the landscapes (Table 2). In Table 2, the frequency of the trees of the sample plots in the communities of the drainage lines and Orange River (subcommunities 2.2, 6.1 and 6.2) is given as 100 %. The average canopy cover of the shrub stratum for the communities of the drainage lines and Orange River (subcommunities 2.2, 6.1 and 6.2) is higher than that of the rest of the plant communities.

One other disturbing fact noted during the survey, was the absence of young *Aloe dichotoma* plants. This tree is very characteristic of this landscape and it would be a pity if this tree should disappear. A detailed, autecological study of *Aloe dichotoma* is necessary.

The description of the plant communities, together with the vegetation map, can serve as a basis to formulate a management programme for the southern section of the Augrabies Falls National Park. An understanding of the plant communities and their associated habitats are of fundamental importance for devising sound management and conservation strategies. The vegetation description and map were used to initiate a monitoring project for vegetation and animal-habitat relationships.

The classification of Werger & Coetzee (1977) of parts of the AFNP was of great help and if more detailed information is

required about some of the plant communities or background information this paper should be consulted.

Acknowledgements

Mrs Thea Bezuidenhout is thanked for comments on the manuscript and for drawing the figures. The National Museum Bloemfontein: Herbarium is thanked for identification of plant species.

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