

Plant communities of the western part of the Bloemfontein district: the Ca land type

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An analysis of the plant communities of the Ca land type of the Bloemfontein West District is presented. The Braun-Blanquet technique, supplemented by TWINSpan, was used for phytosociological classification of the vegetation of the study area. Eleven distinct vegetation units were recognized and described. An hierarchical classification is suggested and each vegetation unit is related to its particular environmental characteristics. Relevés were compiled in 76 sample plots.

'n Ontleding van die plantgemeenskappe van die Ca-landtipe van die Bloemfontein-Wes-distrik word aangebied. Die Braun-Blanquet-tegniek, ondersteun deur TWINSpan, is gebruik vir die fitososiologiese klassifikasie van die plantegroei van die studiegebied. Elf plantegroei-eenhede is geïdentifiseer en beskryf. 'n Hiërargiese klassifikasie word voorgestel en elke plantegroei-eenheid word aan die hand van toepaslike omgewingsfaktore verklaar. Relevés is in 76 monsterpersele saamgestel.

Keywords: Braun-Blanquet vegetation classification, habitat related, TWINSpan, western Free State.

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Introduction

In this study the classification of the vegetation was achieved by way of the floristic-sociological approach with the essential viewpoint that plant communities are units of classification based primarily on species composition (Mueller-Dombois & Ellenberg 1974). The fact that Acocks' (1988) broad analysis and description of South African vegetation types is one of the most cited botanical publications indicates the importance and need for such vegetation classifications. The necessity to identify and describe the Grassland and Nama Karoo Biomes was stated by Mentis & Huntley (1982), Scheepers (1986) and Hilton-Taylor (1987).

Relatively little is known about the vegetation of the western Free State. These data sets and resulting classifications provide the basis for a phytosociological synthesis of the vegetation of the western Free State which is currently under study by the authors.

Acocks (1988) recognized two veld types in this region: Dry *Cymbopogon-Themeda* veld (veld type 50) in the eastern parts of the study area and False Upper Karoo (veld type 36) in the central and western parts of the study area. The vegetation within this area shows similarities with the classification of Werger (1978), namely the Dry Cold-Temperate Grassland. The aim of this study is, therefore, to classify, describe and ecologically interpret the different plant communities within the Ca land type in the Bloemfontein West District.

Study area

The study area is situated between 25°40' and 26°10'E longitude and 29°00' and 29°25'S latitude and covers an area of approximately 132 700 ha. The Ca land type is situated in the central and eastern parts of the Bloemfontein West District (Figure 1) with an average rainfall of 564 mm per annum (Rossouw 1983).

Soils

The Ca land type qualifies as a plinthic catena, which is represented by Hutton, Bainsvlei, Avalon and Longlands soil forms (Land Type Survey Staff, in press).

Dolerite outcrops are conspicuous in the general topography of the study area. Loose scree, as well as the Sterkspruit and

Valsrivier soil forms are prominent on slopes. The Valsrivier, Milkwood and Dundee soil forms are dominant on the low-lying plains.

In the low-lying areas the soils are deep (> 1 000 mm) and clayey (Alfisol, Soil Survey Staff 1992). On the slopes the soils are shallow and mainly of the Mispah form (Land Type Survey Staff, in press). These soils are classified as Lithic Quartzipsaments (Soil Survey Staff 1992) and Lithosols (FAO UNESCO 1987).

Methods

Relevés were compiled in 76 stratified sample plots. Stratification was based on land type, and within land type on terrain units (Land Type Survey Staff, in press). Care was taken to avoid sampling of severely degraded vegetation and excessively disturbed areas. Species-area curves were used to determine plot sizes, which were fixed at 100 m² for tree and shrub communities and 25 m² for grassland. These are in accordance with plot sizes used by Rossouw (1983) and Müller (1986).

In each sample plot the floristic composition was recorded and a cover-abundance value, according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974), was allocated to each species. Taxon and author names conform to those of Arnold & de Wet (1993). The environmental information which was recorded includes land type, geology, terrain unit, aspect, rockiness of the soil surface, erosion and degree of utilization by herbivores.

Soil forms were noted according to the classification systems of the Soil Classification Working Group (1991), the Soil Survey Staff (1992) and FAO UNESCO (1987).

Two-way indicator species analysis (TWINSpan) (Hill 1979b) was applied to the floristic data set followed by Braun-Blanquet procedures to derive the plant communities of the area.

The floristic data set was further subjected to an ordination algorithm, detrended correspondence analysis (DECORANA) (Hill 1979a), to determine vegetation gradients and the relationship with environmental variables.

Results and Discussion

The vegetation of the Ca land type in the Bloemfontein West District is divided into seven distinct plant communities. Some of

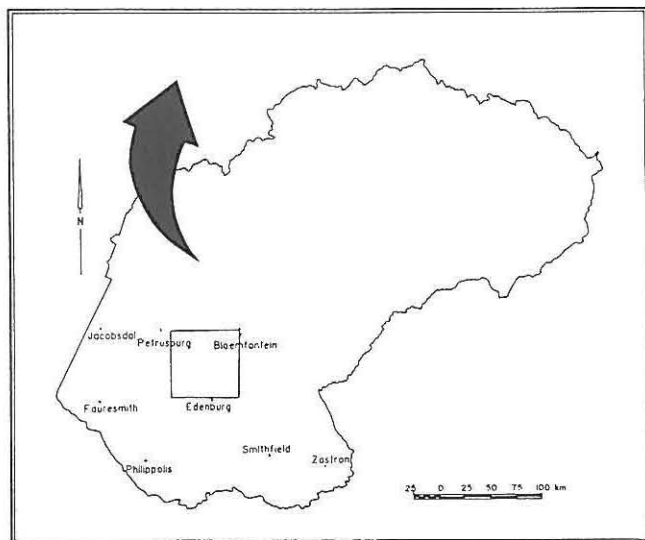
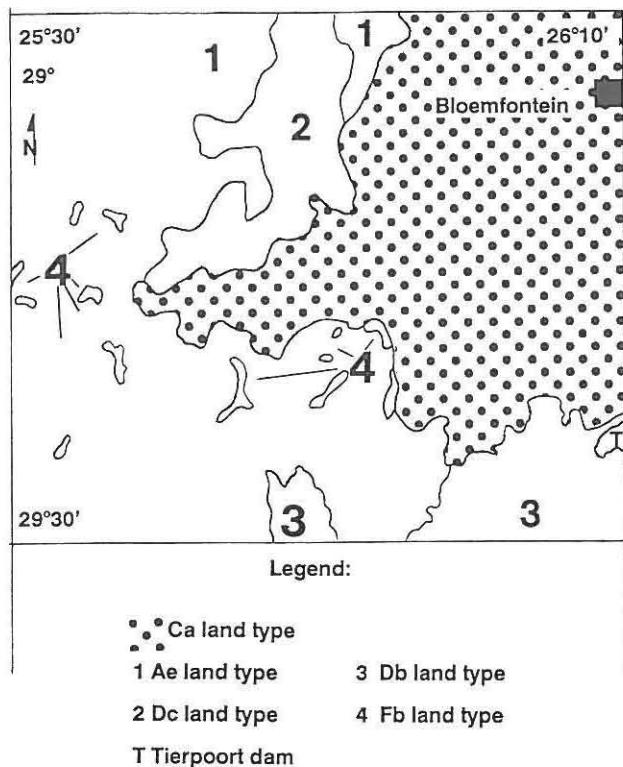


Figure 1 Map indicating the Ca land type in the Bloemfontein West District.

these communities are further divided into distinct sub-communities. The phytosociological classification is presented in Table 1.

The tree and shrub communities are restricted to the rocky outcrops, whereas the grassland communities occur mainly on the low-lying rocky areas.

The hierarchical classification of the plant communities is as follows:

1. *Olea europaea*–*Protasparagus laricinus* Woodland
 - 1.1 *Olea europaea*–*Acacia karroo* Woodland
 - 1.2 *Olea europaea*–*Grewia occidentalis* Woodland
 - 1.2.1 *Olea europaea*–*Heteromorpha trifoliata* Woodland
 - 1.2.2 *Olea europaea*–*Pavonia burchellii* Woodland
2. *Buddleja saligna*–*Themeda triandra* Woodland
3. *Rhigozum obovatum*–*Themeda triandra* Shrubland
4. *Setaria sphacelata*–*Rhus ciliata* Karroid Grassland

5. *Cymbopogon plurinodis*–*Elionurus muticus* Karroid Grassland
 - 5.1 *Cymbopogon plurinodis*–*Euryops multifidus* Grassland
 - 5.2 *Cymbopogon plurinodis*–*Nidorella resedifolia* Grassland
6. *Aristida congesta*–*Aristida diffusa* Grassland
7. *Chrysocoma ciliata* Karroid Grassland
 - 7.1 *Chrysocoma ciliata*–*Rumex lanceolatus* Karroid Grassland
 - 7.2 *Chrysocoma ciliata*–*Eberlanzia spinosa* Karroid Grassland

1. The *Olea europaea*–*Protasparagus laricinus* Woodland

This woodland is characterized by plants occurring in species groups A and F, with species group A diagnostic (Table 1), and is restricted to slopes of dolerite outcrops and ravines with a relatively high species diversity.

The soil is shallow representing the Swartland, Sterkspruit (Luvisols, FAO UNESCO 1987), Hutton and Bainsvlei soil forms (Land Type Survey Staff, in press). Hutton and Bainsvlei soils (Regosols, FAO UNESCO 1987) characterize the low-lying ravines (Land Type Survey Staff, in press). The soil taxonomy equivalent of these soils is Typic Quartzipsamments (Soil Survey Staff 1992).

Olea europaea, *Ziziphus mucronata*, *Osyris lanceolata*, *Diospyros lycioides* (species group A), and *Buddleja saligna* (species group F) are the most conspicuous tree species. Diagnostic shrubs encountered in this major community are *Protasparagus laricinus* and *Rhus burchellii*. *Protasparagus laricinus* and the dwarf shrub *Solanum coccineum* (species group F) occur in the semi-shade of the above-mentioned species in ravine areas. *Rhus ciliata*, *Euclea crispa* and *Felicia filifolia* (species group M) were also frequently encountered on rocky outcrops.

Themeda triandra (species group Q) is the most common grass species in southern Africa (van Oudtshoorn 1991) and it is also well represented in this woodland. Other grass species present include *Triraphis andropogonoides*, *Eragrostis lehmanniana* (species group M) and *Heteropogon contortus* (species group R).

The *Olea europaea*–*Protasparagus laricinus* Woodland can be divided into two distinct sub-communities.

1.1. The *Olea europaea*–*Acacia karroo* Woodland

This woodland is associated with medium high, less steep slopes which receive moisture from upslope.

The soil is shallow (< 50 mm) and contains a much higher clay content than the *Olea europaea*–*Grewia occidentalis* Woodland (sub-community 1.2). Soils of the Valsrivier, Sterkspruit (Hapludalf, Soil Survey Staff 1992) and Dundee (Fluvent, Soil Survey Staff 1992) forms are the most prominent. These soil forms are also classified respectively as Luvisols and Fluvisols (FAO UNESCO 1987).

This is a typical tree community, dominated by *Acacia karroo* (species group B), which is the only diagnostic tree species present. *Acacia karroo* has a very deep root system and according to Carr (1976), these trees can reach heights of up to 20 m.

Other abundant tree species include *Olea europaea*, *Ziziphus mucronata*, *Diospyros lycioides* (species group A) and *Buddleja saligna* (species group F).

Protasparagus laricinus, *Rhus burchellii* (species group A), *Rhus ciliata* and *Euclea crispa* (species group M) are the most prominent shrubs (Table 1). *Nenax microphylla* and the exotic *Xanthium spinosum* (species group B) are the only diagnostic forbs. *Themeda triandra* (species group Q), *Triraphis andropogonoides* and *Eragrostis lehmanniana* (species group M) are the prominent grass species.

Table 1 Phytosociological table of the Ca land type

PLANT COMMUNITY NUMBER	1.1	1.2.1	1.2	1.2.2	2	3	4	5.1	5.2	6	7.1	7.2
RELEVÉ NUMBER	101101 717717 856977	00000110000 14111664147 67238438964	11100101001001 07066097640907 00243191253882		0001 0771 7107	00100 12725 00320	0110 0221 9761	112202 721171 415657	0100000 6216666 7045698	11111111110 16117666614 99855867569	2222 3333 5476	1111 2222 3542
NUMBER OF SPECIES/RELEVÉ	110111 219153	10111110010 09653718827	1111111110101 30212012138391		0001 9750	01100 92096	1010 0709	010000 816968	0000000 6778687	11011100010 02811178709	0000 5644	0000 8647
SPECIES GROUP A												
<i>Olea europaea</i>	1 3 1	3223R1	25	253333334343 2					1	2 3		
<i>Protasparagus laricinus</i>	R1R R	1 1R2221		1RR 111R R1RR				1		1		
<i>Rhus burchellii</i>	2 222	4 23	1	23 23 21 3 3		2					R	
<i>Ziziphus mucronata</i>	2 1R	322		12 13 2	1		1				R	
<i>Osyris lanceolata</i>		2		2 2 1	2							
<i>Diospyros lycioides</i>	1 1		2	2 1								
SPECIES GROUP B												
<i>Acacia karroo</i>	4234R4	2 21										
<i>Xanthium spinosum</i>	R R R											
<i>Nenax microphylla</i>	R R						R					
SPECIES GROUP C												
<i>Grewia occidentalis</i>	1	222 2 22	221R11 1133				1		1			
<i>Viscum rotundifolium</i>		R RR	R11RRR R R									
<i>Cussonia paniculata</i>		R	R 2RR2 R									1
<i>Rhus lancea</i>		R2	1 1 3	R								
SPECIES GROUP D												
<i>Eragrostis obtusa</i>	R	R 1 2R										
<i>Commelina eckloniana</i>		RR1 R				R				1		
<i>Heteromorpha trifoliata</i>		3 34										
<i>Walafrida saxatilis</i>		1 12										
<i>Crassula lanceolata</i>		11	3		1					R		
<i>Salsola kali</i>	R	1 R									1	
SPECIES GROUP E												
<i>Pavonia burchellii</i>		R	1 RRRR R R									
<i>Celtis africana</i>			R2 R 2									
<i>Cotoneaster sp.</i>			2 RR R									
<i>Lantana rugosa</i>		R	1 R			R				1		
<i>Sutherlandia microphylla</i>			RR				3					
<i>Ehretia rigida</i>			1 2		2	1	2					
SPECIES GROUP F												
<i>Buddleja saligna</i>	3	334353	34	533434333 54	+442	2 22		R12				
<i>Solanum coccineum</i>	R R	1 1 1		R R	R R	R				1	R	
<i>Opuntia ficus-indica</i>	R	1 R	R	1	R 1 1	R						1
<i>Tagetes minuta</i>	2	11 11			3 2	1			R			R R
SPECIES GROUP G												
<i>Rhigozum obovatum</i>				1		23322						111
SPECIES GROUP H												
<i>Setaria sphacelata</i>						11	1333					1
<i>Kleinia longifolia</i>	R			R R		1	11					
<i>Trachyandra asperata</i>				R R1			R R					
<i>Melinis repens</i>		R		R			R R					
SPECIES GROUP I												
<i>Cymbopogon plurinodis</i>							R111	2123233				1
<i>Elionurus muticus</i>						11	11 R	1 2				
SPECIES GROUP J												
<i>Euryops multifidus</i>							54 3					
<i>Rhus erosa</i>							2 2					1
<i>Enneapogon scoparius</i>					5		3		2 1			
SPECIES GROUP K												
<i>Nidorella resedifolia</i>	1	111					1		1 1311		R	
<i>Pennisetum sphacelatum</i>									311			
SPECIES GROUP L												
<i>Aristida congesta</i>	2			3 R						21 3 1 2221		
<i>Aristida diffusa</i>						1		1 2		2 1122 212		
<i>Elephantorrhiza elephantina</i>							1 2			1 12 R		
<i>Pellaea calomelanos</i>										1 111		
<i>Eragrostis superba</i>	1					1			1	1 1 R		
<i>Digitaria eriantha</i>										1 2	2	
SPECIES GROUP M												
<i>Rhus ciliata</i>	R4 12	3 1 131451		1112 4R	2 33	211	1232	4R2 1	31 2	1433 34434		3
<i>Euclea crispa</i>	23	2		R1 12 R 2 1	22		211	3311	1 21	32 4 1RR		1
<i>Felicia filifolia</i>	1	R	2	1 R1 1 R 11	222			1	1R 312	11 1 31		
<i>Protasparagus striatus</i>	2	1 R	2				1 12	2 3	11 R 1			
<i>Melolobium candicans</i>	R RR1	1		R R RRR					1	1 11	R 1 1R3	
<i>Euphorbia mauritanica</i>	R		1	R R			R R	1			1 1 1	1
<i>Felicia muricata</i>	1 111	2	2		1		21			112213 2		
<i>Triraphis andropogonoides</i>	1 3	22 2 2					2	211		1 1		2
<i>Eragrostis lehmanniana</i>	2 R 1	221	1						31	1 R 2		
<i>Eustachys paspaloides</i>		1				2		1	R	1		
<i>Hermannia bryoniifolia</i>	R	1		R		R				R 2		
SPECIES GROUP N												
<i>Chrysocoma ciliata</i>	1										342	211

Table 1 Continued

SPECIES GROUP O																									
Rumex lanceolatus														RR 1											
Hermannia comosa														1 R											
SPECIES GROUP P																									
Eberlanzia spinosa												3		1232											
SPECIES GROUP Q																									
Themeda triandra		32	32	2	2	231	1	42323	3	3	2521	3	53	43	1	1	4R	3354433	5R532	3	2145	1			
SPECIES GROUP R																									
Cheilanthes eckloniana			R	RR2	11	2	1	R	RR	R	12	2	R	22	22	2	1	12		12	2	R	RR2	4434	
Heteropogon contortus																				1	12R	1		1	2

1.2 The *Olea europaea*–*Grewia occidentalis* Woodland

This woodland is restricted predominantly to the relatively humid areas such as ravines and moist south-facing slopes where the vegetation is often very dense (terrain units 3 and 4, Land Type Survey Staff, in press). Only two relevés (relevés 8 and 45) were located on north-facing slopes (Table 1).

The diagnostic trees are *Grewia occidentalis*, *Cussonia paniculata* and *Rhus lancea* (species group C, Table 1). Other abundant tree species include *Olea europaea* (species group A) and *Buddleja saligna* (species group F). Diagnostic grasses and shrubs are absent and only the semi-parasite *Viscum rotundifolium* (species group C) further characterizes this community.

The *Olea europaea*–*Grewia occidentalis* Woodland can be divided into two distinct variants.

1.2.1 The *Olea europaea*–*Heteromorpha trifoliata* Woodland

This woodland occurs mainly on rocky slopes and in ravines. Only relevé 19 was situated on a hill crest (Table 1).

The most important soils are the Swartland and Hutton soil forms (Land Type Survey Staff, in press).

Heteromorpha trifoliata is the only diagnostic shrub and *Eragrostis obtusa* the only diagnostic grass species (species group D, Table 1).

Species of species groups C, A, F, M and R are also present in this sub-community. The most conspicuous are *Grewia occidentalis* (species group C), *Olea europaea*, *Protasparagus laricinus*, *Rhus burchellii*, *Ziziphus mucronata* (species group A), *Buddleja saligna*, *Solanum coccineum*, *Tagetes minuta* (species group F), *Rhus ciliata*, *Triraphis andropogonoides* and *Eragrostis lehmanniana* (species group M), *Themeda triandra* (species group Q) and *Cheilanthes eckloniana* (species group R).

1.2.2 The *Olea europaea*–*Pavonia burchellii* Woodland

This woodland (species group E) is associated with relatively favourable conditions such as moist and protected ravine areas. The most important soils are the Hutton and Swartland forms (Land Type Survey Staff, in press).

Celtis africana (species group E) is the only diagnostic tree species, while *Ehretia rigida* and an exotic, *Cotoneaster* sp., are the only diagnostic shrubs.

Other species present are those listed in species groups C, A, F, M and Q (Table 1). Species with the highest cover-abundance values are *Grewia occidentalis* (species group C), *Olea europaea*, *Protasparagus laricinus*, *Rhus burchellii* (species group A), *Buddleja saligna* (species group F), *Rhus ciliata*, *Euclea crispa*, *Felicia filifolia* (species group M) and *Themeda triandra* (species group Q).

2. The *Buddleja saligna*–*Themeda triandra* Woodland

The *Buddleja saligna*–*Themeda triandra* Woodland is restricted mainly to the hot and drier north- and west-facing slopes. Only relevé 117 was surveyed on an east-facing slope (Table 1). The

extremely rocky soils are mostly of the Valsrivier form (Hapludalf, (Soil Survey Staff 1992).

This plant community has no diagnostic species and also lacks any from species groups B, C, G, I, K, N or P (Table 1). Species of species groups F, M, and Q are well represented with *Buddleja saligna* (species group F), *Rhus ciliata*, *Euclea crispa*, *Felicia filifolia* (species group M) and *Themeda triandra* (species group Q) the most important.

The most conspicuous tree species is *Buddleja saligna* (species group F). *Rhus ciliata*, *Euclea crispa* and *Felicia filifolia* (species group M) are important representatives of the shrub stratum. *Themeda triandra* (species group Q) is the most dominant grass species (Table 1).

3. The *Rhizozum obovatum*–*Themeda triandra* Shrubland

This entity is associated with low-lying, rocky slopes (terrain unit 3, Land Type Survey Staff, in press). Only five relevés were surveyed in this study (Table 1).

Soils of the Hutton, Valsrivier and Westleigh forms commonly occur (Land Type Survey Staff, in press).

A tree stratum is almost absent. Only *Buddleja saligna* (species group F) is present. *Rhizozum obovatum* (species group G) is conspicuous and occurs commonly on rocky slopes. These slopes are covered by loose scree.

The most prominent shrubs are *Rhus ciliata* and *Protasparagus striatus* (species group M). *Themeda triandra* (species group Q) is the only dominant grass species.

4. The *Setaria sphacelata*–*Rhus ciliata* Karroid Grassland

The *Setaria sphacelata*–*Rhus ciliata* Karroid Grassland is restricted to the north-facing hillsides and plateaux of low hills (terrain units 3 and 1, Land Type Survey Staff, in press). The habitat is disturbed and only a few species occur.

The soil is very shallow and its surface is strewn with numerous loose rocks. The Valsrivier soil form is prominent on plateaux, whereas the Hutton form is prominent on the steeper hillslopes (Land Type Survey Staff, in press). The soil taxonomy equivalents of these soils are Hapludalf and Typic Quartzsamsments (Soil Survey Staff 1992) respectively, while FAO UNESCO (1987) refers to them as Luvisols and Regosols, respectively.

Setaria sphacelata (species group H), *Triraphis andropogonoides* (species group M) and *Heteropogon contortus* (species group R) are the most important grass species. According to van Oudtshoorn (1991) *S. sphacelata* often occurs in disturbed and overgrazed pasture. *Elionurus muticus* (species group I) and *Themeda triandra* (species group Q) are among the most abundant grass species (Table 1).

Rhus ciliata, *Euclea crispa* and *Protasparagus striatus* (species group M) are the most important shrubs present.

5. The *Cymbopogon plurinodis*–*Elionurus muticus* Karroid Grassland

This grassland is associated with west-facing slopes but also occurs on a few plateaux. The soil is shallow and more clayey than in the previous communities. The most important soil forms are the Valsrivier and Westleigh forms (Land Type Survey Staff, in press).

The most prominent grass species are the diagnostic species *Cymbopogon plurinodis* and *Elionurus muticus* (species group I), *Eragrostis lehmanniana*, *Eustachys paspaloides* (species group M) and *Themeda triandra* (species group Q) also occur (Table 1).

Trees are virtually absent and only *Buddleja saligna* (species group F) was noted in a few sample plots. *Rhus ciliata* and *Euclea crispa* are the most conspicuous among the shrubs.

The grassland vegetation of the west-facing slopes and plateaux can be subdivided into two sub-communities.

5.1 The *Cymbopogon plurinodis*–*Euryops multifidus* Grassland

This grassland occurs on the low, mostly undisturbed west-facing slopes (terrain unit 3, Land Type Survey Staff, in press) on deep clayey soil.

The *Cymbopogon plurinodis*–*Euryops multifidus* Grassland is characterized by the diagnostic species *Euryops multifidus*, *Rhus erosa* and the grass *Enneapogon scoparius* (species group J). *Euryops multifidus* is an example of a karroo encroacher species because of its ability to grow on deep and shallow soil (Anonymous 1968).

Diagnostic shrubs are absent. *Rhus ciliata*, *Euclea crispa* and *Protasparagus striatus* (species group M) are common.

Themeda triandra (species group Q) and *Heteropogon contortus* (species group R), although not abundant, are the most important grasses.

5.2 The *Cymbopogon plurinodis*–*Nidorella resedifolia* Grassland

The *Cymbopogon plurinodis*–*Nidorella resedifolia* Grassland is restricted to the higher elevated areas and plateaux of low hills (terrain unit 1, Land Type Survey Staff, in press). The soil is extremely shallow and more rocky than the *Cymbopogon plurinodis*–*Euryops multifidus* Grassland.

This community is characterized by the presence of the diagnostic species *Nidorella resedifolia* and *Pennisetum sphacelatum* (species group K, Table 1). A prominent tree and shrub stratum is absent.

Themeda triandra (species group Q) is very abundant. Other important species are *Euclea crispa*, *Felicia filifolia*, *Melolobium candicans* and *Rhus ciliata* (species group M).

6. The *Aristida congesta*–*Aristida diffusa* Grassland

The *Aristida congesta*–*Aristida diffusa* Grassland occurs within disturbed and overgrazed pastures on dry slopes (terrain unit 3, Land Type Survey Staff, in press). The soils are sandy and of the Shortlands, Valsrivier and Sterkspruit forms (Land Type Survey Staff, in press).

This community is a typical example of a heavily overgrazed pasture. *Aristida congesta* (species group L), especially, is characteristic of overgrazed pastures (van Oudtshoorn 1991). *Elephantorrhiza elephantina* (species group L) readily grows in sandy soil, but also occurs sporadically high up on the drier areas of hillsides and on plateaux.

A tree stratum is absent, probably due to the shallow soil (< 50 mm, Land Type Survey Staff, in press). This community is further characterized by the fern *Pellaea calomelanos* (species group L) which is restricted to rocky areas.

Species of species groups M and Q are also well represented in this community (Table 1). The most conspicuous shrubs are *Rhus ciliata*, *Euclea crispa*, *Felicia filifolia*, *F. muricata* and *Melolobium candicans* (species group M) while *Aristida congesta*, *A. diffusa* (species group L), *Eragrostis lehmanniana* (species group M), *Themeda triandra* (species group Q) and *Heteropogon contortus* (species group R) are the most prominent grasses.

7. The *Chrysocoma ciliata* Karroid Grassland

This Karroid Grassland is typically found in shallow depressions on flat rock slabs and on shallow, rocky soils of the lowlands (terrain unit 4, Land Type Survey Staff, in press). The soil is mainly lithosols (FAO UNESCO 1987). A low species diversity is encountered here compared with that of the previous communities. The soil is easily trampled. The most important soil type present is the Hutton form (Land Type Survey Staff, in press).

A tree stratum is absent and the shrub stratum is inconspicuous. *Chrysocoma ciliata* (species group N) is the only diagnostic species and is extremely unpalatable and a definite sign of pasture degradation (Anonymous 1968).

This Karroid Grassland includes two distinct sub-communities.

7.1 The *Chrysocoma ciliata*–*Rumex lanceolatus* Karroid Grassland

This vegetation unit is represented by four relevés (Table 1), and it occurs in much-disturbed and rocky habitats with considerable loose scree. The *Chrysocoma ciliata*–*Rumex lanceolatus* Karroid Grassland is more disturbed than the *Chrysocoma ciliata*–*Eberlanzia spinosa* Karroid Grassland where grasses are scarce. Soils of the Westleigh and Hutton forms are common (Land Type Survey Staff, in press).

A tree and shrub stratum is absent. *Chrysocoma ciliata* has high cover-abundance values (species group N, Table 1). *Rumex lanceolatus* and *Hermannia comosa* (species group O) are the only diagnostic species. *Themeda triandra* (species group Q) is the only grass species which is dominant in this vegetation unit.

7.2 The *Chrysocoma ciliata*–*Eberlanzia spinosa* Karroid Grassland

This sub-community is characterized by *Eberlanzia spinosa* (species group P) and is prominent in the rocky habitats of the lowlands (terrain unit 4, Land Type Survey Staff, in press). Large boulders cover the soil surface.

The soil is shallow (< 50 mm). Surface rock and soil of the Valsrivier form occurs commonly (Land Type Survey Staff, in press).

The *Chrysocoma ciliata*–*Eberlanzia spinosa* Karroid Grassland has only a few species and is characterized by the diagnostic species *Eberlanzia spinosa* (species group P) and the fern *Cheilanthes eckloniana* (species group R). *Cheilanthes eckloniana* occurs commonly and grows very well in rocky habitats. *Themeda triandra* (species group Q), in contrast to the *Chrysocoma ciliata*–*Rumex lanceolatus* Karroid Grassland, is inconspicuous.

Ordination

The distribution of relevés along the first and second axes of the ordination is presented (Figure 2). Three vegetation groups representing the seven plant communities of the Ca land type were distinguished. Definite environmental gradients are illustrated along the axes on the scatter diagram (Figure 2). Vegetation units situated towards the left of the diagram, indicated by 1, are mostly related to high-lying areas and ravines with a high percentage of surface rock. These vegetation units also have a high species diversity. Plant communities of the lowlands with a lower percentage of surface rock and a lower species diversity are situ-

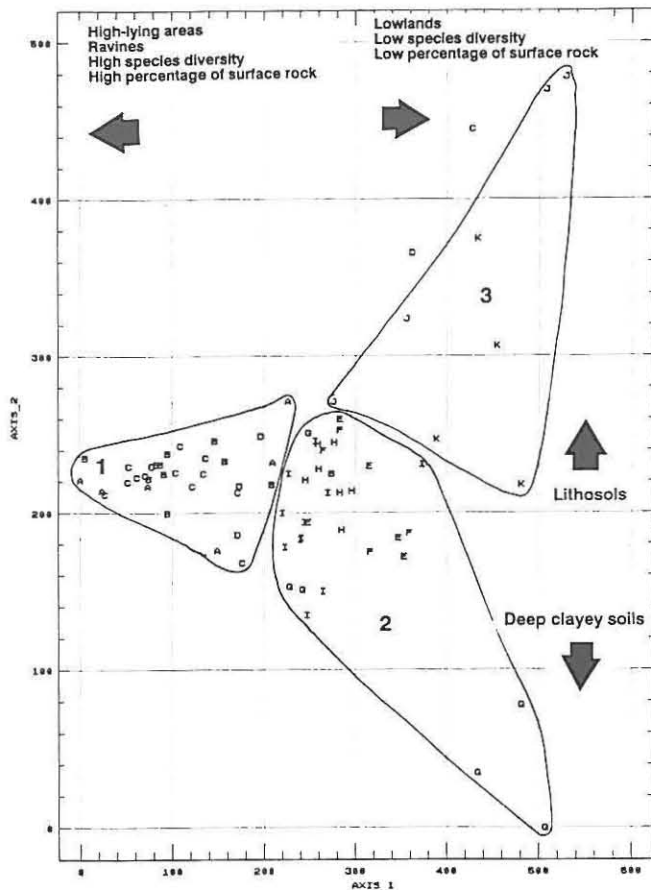


Figure 2 An ordination (DECORANA) of the relevés of the Ca land type of the Bloemfontein West District. A = *Olea europaea*-*Acacia karroo* Woodland; B = *Olea europaea*-*Heteromorpha trifoliata* Woodland; C = *Olea europaea*-*Pavonia burchellii* Woodland; D = *Buddleja saligna*-*Themeda triandra* Woodland; E = *Rhigozum obovatum*-*Themeda triandra* Shrubland; F = *Setaria sphacelata*-*Rhus ciliata* Karroid Grassland; G = *Cymbopogon plurinodis*-*Elionurus muticus* Karroid Grassland; H = *Cymbopogon plurinodis*-*Nidorella resedifolia* Grassland; I = *Aristida congesta*-*Aristida diffusa* Grassland; J = *Chrysocoma ciliata*-*Rumex lanceolatus* Karroid Grassland; K = *Chrysocoma ciliata*-*Eberlanzia spinosa* Karroid grassland and karroid grassland communities (E, F, G, H); 2 = shrubland, grassland and karroid grassland communities (E, F, G, H); 3 = karroid grassland communities on lithosols (J, K).

ated towards the bottom right and are indicated by 2. Plant communities on lithosols (3) are situated towards the top of the diagram, whereas plant communities on deep clayey soils are found towards the bottom (2).

Conclusion

The aim of this study was to identify, characterize, and interpret, ecologically, the communities of the Ca land type in the Bloemfontein West District.

The Ca land type offers a wide variety of habitats and microclimates in a limited area. All vegetation units in this study can be related to specific environmental conditions and can therefore

be distinguished and interpreted ecologically.

No attempt was made to formally fix names or ranks of syntaxa.

The presentation of these plant communities contributes to the present scanty knowledge of the phytosociology of the vegetation west of Bloemfontein.

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