

Phytosociological classes of the western Transvaal grassland, South Africa

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Bezuidenhout, H., G.J. Bredenkamp and G.K. Theron. 1994. Phytosociological classes of the western Transvaal grassland, South Africa. *Koedoe* 37(1): 1-18. Pretoria. ISSN 0075-6458.

A detailed syntaxonomical and synecological account of five newly described phytosociological classes of the western Transvaal, South Africa is given. Using a new large data set classification technique, a synoptic table was compiled from 1 025 relevés, representing 114 plant communities. An objective classification technique (TWINSPAN) was used complementary to the Braun-Blanquet methodology. An ordination algorithm (DECORANA) was also applied to the synoptic data set. This indicates the floristic relationships among the classes while the vegetation gradient can be related to the habitat gradient.

Keywords: Braun-Blanquet method, grassland, synoptic tables, synthesis, syntaxonomical classification.

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Introduction

A formal syntaxonomical classification of the vegetation of the western Transvaal grassland was not attempted in the past due to a lack of information on the western Transvaal grassland (Bredenkamp & Theron 1978). Since Mentis & Huntley (1982) stated the necessity of research work in the Grassland Biome, a phytosociological research programme on the phytosociology and syntaxonomical synthesis of this biome has been conducted (Bredenkamp *et al.* 1989; Bezuidenhout & Bredenkamp 1990; Kooij *et al.* 1990; Matthews 1991; Breytenbach *et al.* 1992; Myburgh *et al.* 1992; Bezuidenhout *et al.* 1993; Bloem *et al.* 1993; Eckhardt *et al.* 1993; Fuls *et al.* 1993; Smit *et al.* 1993). Relevant phytosociological data of the grasslands of the western Transvaal have been collected by Morris (1973), Van Wyk & Bredenkamp (1986), Bezuidenhout *et al.* (1988), Bredenkamp & Bezuidenhout (1990), Bezuidenhout & Bredenkamp (1991a, 1991b), Bredenkamp *et al.* (1994), Bezuidenhout *et al.* (1993, 1994, *in press.*, *in prep.*). These data sets and resulting classifications provide the basis for a phytosociolog-

ical and syntaxonomical synthesis of the western Transvaal grassland.

Siegfried (1989) identified the Grassland Biome as one of the most critically threatened southern African ecosystems, with approximately 2% of the area being conserved. The present conservation status of the western Transvaal grassland is very poor (0,33%) with only small areas officially conserved namely: (i) the Baberspan Nature Reserve (3 086 hectares), (ii) Abe Bailey Nature Reserve (1 888 hectares), (iii) Boskop Dam Nature Reserve (3 160 hectares) (Greyling & Huntley 1984) and the Faan Meintjes Nature Reserve (930 hectares) (Bredenkamp & Bezuidenhout 1990). The poor conservation record within the western Transvaal grassland, combined with the high exploitation thereof, emphasise the urgent need for ecologically sound conservation planning in the region.

Study area

The study area represents the western part of the Grassland Biome and is bounded by lati-

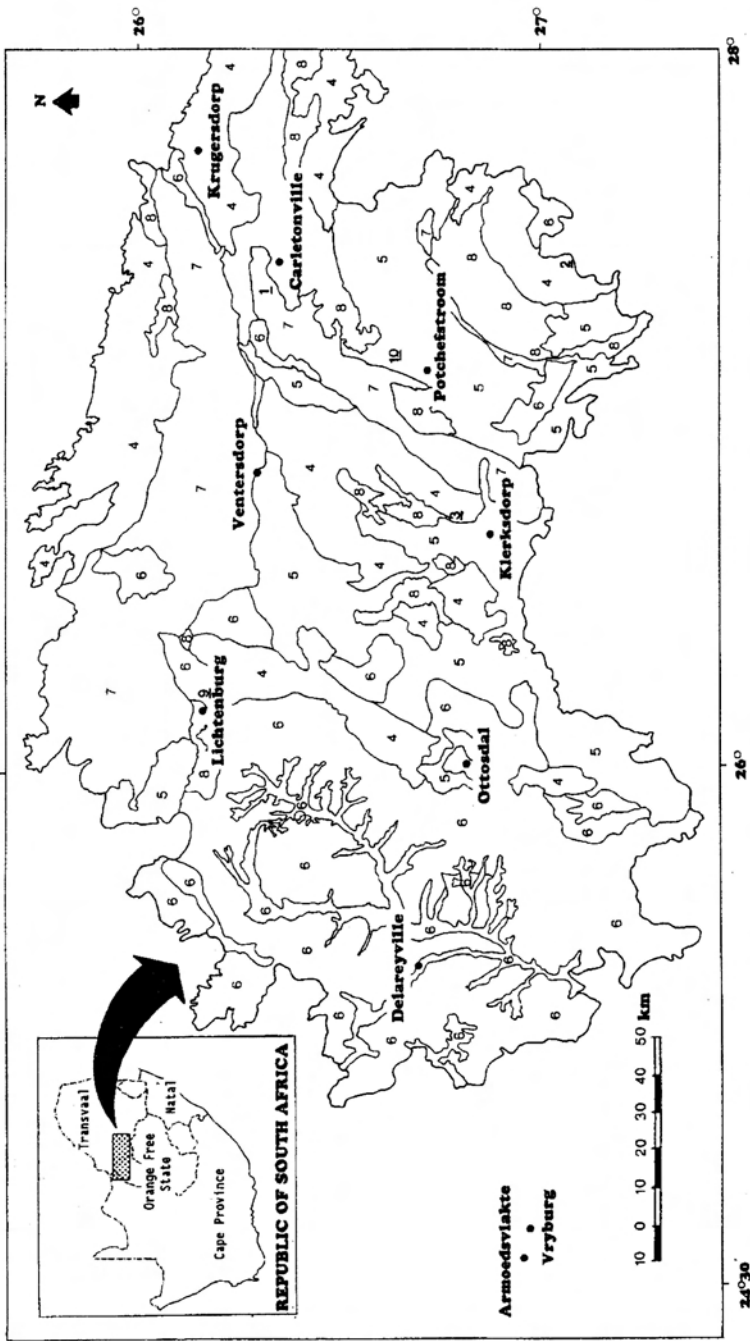


Fig. 1. The location of the study area, showing the distribution of the different studies in the western Transvaal, South Africa ((1) Abe Bailey Nature Reserve, (2) Vredefort Dome, (3) Faan Meinijes Nature Reserve, (4) Bc Land Type, (5) Ba Land Type, (6) Bd and Ea Land Types, (7) Fa Land Type, (8) Fb Land Type, (8) Lichtenburg data, (9) Lichtenburg data, (10) Boskop Dam Nature Reserve).

tudes 25° 45' and 27° 15' south and longitudes 24° 45' and 27° 45' east (Fig. 1). The study area covers approximately 2.7 million hectares.

According to Acocks (1953, 1988) three veld types are represented in the study area. In the eastern parts Acocks' (1988) western variation of the Bankenveld (Veld Type 61a) merges into the northern variation of the *Cymbopogon-Themeda* Veld (Veld Type 48b), located in the central part of the study area. In the western parts the northern variation of the Dry *Cymbopogon-Themeda* Veld (Veld Type 50a) merges north-westwards into the Sourish Mixed Bushveld (Veld Type 19) and westwards into the Kalahari Thornveld Proper (Veld Type 16a).

The rainfall is erratic, especially in the western part of the study area and increases in an easterly direction from 450 mm to 770 mm per year. The temperature decreases eastwards with an annual average of 17.9°C at Armoedsvlakte (near Vryburg), to 15.6°C at Krugersdorp (Weather Bureau 1986; Fig. 2). The landscape varies from flat to undulating plains, at an altitude of 1 200 m above sea-level, sometimes dissected by prominent ridges and hills with altitudes of up to 1 700 metres. In the western part pans occur occasionally.

The relatively heterogenous geology is represented by the Witwatersrand and Ventersdorp Supergroups and the Transvaal Sequence with isolated occurrences of old Archaic granites and Karoo Sequence sediments (SACS 1980). Soils in the study area are heterogenous and vary from sandy to clayey, due to great variation in parent rock material (Land Type Survey Staff 1984).

Methods

Eleven separate phytosociological studies had been carried out in the study area, comprising classifications of:

- the vegetation of the Abe Bailey Nature Reserve (Van Wyk & Bredenkamp 1986),

- the Vredefort Dome north-west of Parys (Bezuidenhout *et al.* 1988),
- the Faan Meintjes Nature Reserve (Bredenkamp & Bezuidenhout 1990),
- the vegetation of the Bc Land Type (formal syntaxonomy)(Bezuidenhout & Bredenkamp 1991a),
- the vegetation of the Bd and Ea Land Types (formal syntaxonomy)(Bezuidenhout *et al.* 1993),
- the vegetation of the Fa Land Type (formal syntaxonomy) (Bezuidenhout *et al. in press.*),
- the vegetation of the Ba Land Type (formal syntaxonomy)(Bezuidenhout *et al. in prep.*),
- (viii) The vegetation of the Fb Land Type (formal syntaxonomy) (Bezuidenhout *et al.* 1994),
- a Braun-Blanquet reclassification of Morris' (1973) Bankenveld data (Bezuidenhout *et al. in prep.*),
- a Braun-Blanquet reclassification of Morris' (1973) *Cymbopogon-Themeda* grassland data (Bezuidenhout *et al. in prep.*),
- the Boskop Dam Nature Reserve (Bredenkamp *et al.* 1994).

Each of these studies resulted in phytosociological tables and a vegetation classification, as well as descriptions of the plant communities identified. A total of 114 plant communities were identified and described. Using the new classification technique as described by Bredenkamp & Bezuidenhout (1993), synoptic tables were compiled for each of the phytosociological data sets and then re-entered into a combined synoptic data set. In each of the above-mentioned synoptic tables, non-diagnostic species with a constancy of less than 20% were not included. This combined synoptic data set then consisted of eleven synoptic tables. An objective statistical classification technique, TWINSPAN (Hill 1979a) was used for analysing the combined synoptic data, as a first approximation, and subsequently Braun-Blanquet procedures were used to classifying the 114 synoptic relevés, representing 114 plant communities and a total of 493 species. The major groupings of related plant communities are considered to represent the vegetation (phytosociological) classes within the area. A final synoptic table, representing the five classes, gives the essential floristic detail (Table 1). The matrix of Table 1 shows the constancy values (Mueller-Dombois & Ellenberg, 1974) of each species within each class.

An ordination algorithm, DECORANA (Hill, 1979b) was also applied to the synoptic data set (Fig. 4).

Taxon names conform to those of Arnold & De Wet (1993).

The new classes are described and formally named in accordance to the Code of Phytosociological Nomenclature (Barkman *et al.* 1986). Names of the vegetation units (plant communities and/or syntaxa of any

rank) which were classified under these classes are given in accordance with their original names.

Table 1

A synoptic table of synrelevés of the vegetation classes of the western Transvaal grasslands, South Africa

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group A

Diagnostic species of *Diplachno fuscae* - *Stipagrostidetea uniplumis*.

<i>Blepharis integrifolia</i>	5	1		1	
<i>Diplachne fusca</i>	4	1			1
<i>Chamaesyce inaequilatera</i>	4	1			
<i>Solanum supinum</i>	4	1		1	
<i>Digitaria argyrograpta</i>	3	1		1	
<i>Eragrostis stapfii</i>	3	1			
<i>Hermannia tomentosa</i>	3	1		1	
<i>Stipagrostis uniplumis</i>	3	1		1	
<i>Nolletia ciliaris</i>	3	1			
<i>Thesium magalisonianum</i>	3	1			
<i>Dicoma macrocephala</i>	3	1			
<i>Leucas capensis</i>	3	1			
<i>Hibiscus microcarpus</i>	3	1			
<i>Antheophora pubescens</i>	3	1			
<i>Blepharis squarrosa</i>	2	1			
<i>Ursinia nana</i>	2	1	1		
<i>Raphionacme burkei</i>	2	1		1	
<i>Ophrestia oblongifolia</i>	2	1			
<i>Helichrysum caespititium</i>	2	1			
<i>Eragrostis trichophora</i>	2	1			
<i>Cyperus margaritaceus</i>	2	1		1	
<i>Selago welwitschii</i>	2	1		1	
<i>Nidorella hottentotica</i>	2	1			
<i>Oropetium capense</i>	2	1		1	
<i>Indigofera daleoides</i>	2	1			
<i>Plexipus pinnatifidus</i>	2	1			
<i>Menodora africana</i>	2	1			
<i>Hermannia geniculata</i>	2				
<i>Barleria pretoriensis</i>	2				
<i>Fingerhuthia africana</i>	2				
<i>Helichrysum zeyheri</i>	2				
<i>Lightfootia fasciculata</i>	1				
<i>Rhynchosia totta</i>	1				
<i>Euphorbia pseudotuberosa</i>	1				
<i>Helichrysum cerastioides</i>	1				
<i>Convolvulus ocellatus</i>	1				
<i>Wahlenbergia undulata</i>	1				
<i>Raphionacme velutina</i>	1				
<i>Limeum viscosum</i>	1				

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group B

Diagnostic species of *Eragrostido racemosae* - *Trachypogonetea spicati*.

<i>Eragrostis racemosa</i>	1	5	1	1	1
<i>Trachypogon spicatus</i>	1	4	2	1	
<i>Diheteropogon amplexens</i>	1	4	2	1	
<i>Schizachyrium sanguineum</i>	1	3	2		
<i>Andropogon schirensis</i>		3	2	1	
<i>Trichoneura grandiglumis</i>		3	2	1	
<i>Senecio coronatus</i>	1	3		1	
<i>Bewisia biflora</i>		2			
<i>Hermannia lancifolia</i>	2	1	1	1	
<i>Digitaria tricholaenoides</i>	2				
<i>Cucumis hirsutus</i>	2		1		
<i>Chamaecrista mimosoides</i>	2	1	1		
<i>Polygala hottentotta</i>	2	1	1		
<i>Ipomoea obscura</i>	2	1	1		
<i>Oxygonum dregeana</i>	1	2	1	1	1
<i>Chaetacanthus costatus</i>	1	2		1	
<i>Sporobolus pectinatus</i>		1	1		
<i>Polygala rehmannii</i>		1			
<i>Blepharis transvaalensis</i>		1			
<i>Urelytrum agropyroides</i>		1			
<i>Cyperus zollingeri</i>		1			
<i>Walafrida saxatilis</i>		1			
<i>Scilla nervosa</i>		1			
<i>Fimbristylis hispidula</i>		1			
<i>Helichrysum chionosphaerum</i>		1			
<i>Tristachya rehmannii</i>		1			
<i>Lotononis calycina</i>		1			
<i>Senecio othonniflorus</i>		1			
<i>Clerodendrum triphyllum</i>		1			
<i>Abildgaardia hygrophila</i>		1			
<i>Pachystigma pygmaeum</i>		1			
<i>Delosperma herbeum</i>		1			
<i>Senecio erubescens</i>		1			
<i>Melinis nerviglumis</i>		1			
<i>Polygala uncinata</i>		1			
<i>Zaluzianskya elongata</i>		1			
<i>Sporobolus conrathii</i>		1			
<i>Polygala amatymbica</i>		1			
<i>Gnidia burchellii</i>		1			
<i>Chamaecrista comosa</i>		1			
<i>Indigofera setiflora</i>		1			
<i>Bulbostylis oritrephes</i>		1			
<i>Anthericum cooperi</i>		1			
<i>Tristachya leucothrix</i>		1			
<i>Alloteropsis semialata</i>		1			
<i>Pearsonia cajanifolia</i>		1			
<i>Parinari capensis</i>		1			
<i>Ipomoea omaneyi</i>		1			
<i>Graderia scabra</i>		1			
<i>Digitaria monodactyla</i>		1			

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group B (continues)

Diagnostic species of *Eragrostido racemosae* - *Trachypogonetea spicati*.

<i>Helichrysum miconiifolium</i>		1			
<i>Indigofera sanguinea</i>		1			
<i>Chaetacanthus burchellii</i>		1			
<i>Pentanisia angustifolia</i>		1			
<i>Monocymbium cerasiiforme</i>		1			
<i>Helichrysum indicum</i>		1			
<i>Gisekia pharnacioides</i>		1			
<i>Indigofera hedyantha</i>		1			
<i>Boophane disticha</i>		1			
<i>Hypoxis multiceps</i>		1			
<i>Sporobolus stapfianus</i>		1			
<i>Deverra burchellii</i>		1			
<i>Helichrysum coriaceum</i>		1			
<i>Tephrosia lupinifolia</i>		1			
<i>Hypoxis argentea</i>		1			

Species group C

diagnostic species of *Rhoo leptodictyae* - *Acacieteae caffrae*

<i>Rhus leptodictya</i>			5	1	
<i>Pavetta zeyheri</i>			5		
<i>Acacia caffra</i>			4	2	
<i>Ehretia rigida</i>			4	3	
<i>Maytenus heterophylla</i>	1		4	3	
<i>Ziziphus mucronata</i>			4	3	
<i>Vangueria infausta</i>			4	1	
<i>Tapiphyllum parvifolium</i>		1	4		
<i>Dombeya rotundifolia</i>			4		
<i>Loudetia simplex</i>		1	3	1	
<i>Indigofera comosa</i>		2	3		
<i>Phyllanthus parvulus</i>			3		
<i>Leonotis ocyimifolia</i>			3		
<i>Rhynchosia venulosa</i>		1	3	1	
<i>Rhus magalismontana</i>		1	3	1	
<i>Pappea capensis</i>			3		
<i>Combretum molle</i>			3		
<i>Maytenus tenuispina</i>			3		
<i>Setaria lindenberiana</i>			3		
<i>Zanthoxylum capense</i>			3	1	
<i>Euclea crispa</i>			3	1	
<i>Vernonia galpinii</i>		1	2		
<i>Becium angustifolium</i>			2		
<i>Cheilanthes hirta</i>		1	2	1	
<i>Grewia occidentalis</i>			2	1	
<i>Euclea undulata</i>			2		
<i>Acacia robusta</i>			2	1	
<i>Brachylaena rotundata</i>			2		
<i>Kyphocarpa angustifolia</i>		1	2	1	
<i>Olea europaea</i>			2	1	
<i>Sporobolus fimbriatus</i>		1	2	1	1

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group C (continues)

Diagnostic species of *Rhoo leptodictyae* - *Acacieteae caffrae*

<i>Hibiscus engleri</i>			2		
<i>Pellaea calamelanos</i>			2	1	
<i>Mundulea sericea</i>			2	1	
<i>Lepidium bonariense</i>			2	1	
<i>Tephrosia burchellii</i>		1	2	1	
<i>Ruellia patula</i>			2		
<i>Asclepias decipiens</i>			2		
<i>Nuxia congesta</i>			2		
<i>Melhania prostrata</i>			2		
<i>Selaginella dregei</i>			1		
<i>Protea caffra</i>			1		
<i>Helichrysum kraussii</i>			1		
<i>Rhoicissus tridentata</i>			1		
<i>Enneapogon scoparius</i>			1		
<i>Barleria obtusa</i>			1		
<i>Phyllanthus incurvus</i>			1		
<i>Cussonia paniculata</i>			1		
<i>Dalechampia kirkii</i>			1		
<i>Evolvulus alsinoides</i>			1		
<i>Berchemia zeyheri</i>			1		
<i>Enneapogon pretoriensis</i>			1		
<i>Plumbago auriculata</i>			1		
<i>Cassine aethiopica</i>			1		
<i>Diospyros whyteana</i>			1		
<i>Rhus lucida</i>			1		
<i>Scolopia zeyheri</i>			1		
<i>Sphenostylis angustifolia</i>			1		
<i>Cotyledon barbeyi</i>			1		
<i>Carissa bispinosa</i>			1		
<i>Aristida canescens</i>			1		
<i>Combretum zeyheri</i>			1		
<i>Oldenlandia herbacea</i>			1		
<i>Phyllica paniculata</i>			1		
<i>Aristida vestita</i>			1		
<i>Pachycarpus schinzianus</i>			1		
<i>Indigofera spicata</i>			1		
<i>Cryptolepis oblongifolia</i>			1		
<i>Sutera campanulata</i>			1		

Species group D

Diagnostic species of *Grewia flavae* - *Acacieteae karroo*

<i>Grewia flava</i>		1	3	5	
<i>Protasparagus laricinus</i>		1	2	5	
<i>Protasparagus suaveolens</i>		1	3	5	
<i>Acacia karroo</i>		1	2	4	1
<i>Rhus pyroides</i>		1	2	4	
<i>Teucrium trifidum</i>		1	3	4	1
<i>Diospyros lycioides</i>		1	3	4	
<i>Celtis africana</i>		1	2	3	

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group D (continues)

Diagnostic species of *Grewia flavae* - *Acacieeta* karroo

<i>Pavonia burchellii</i>			2	3	
<i>Eragrostis obtusa</i>		1		3	1
<i>Protasparagus africana</i>			1	3	
<i>Tragus berteronianus</i>	1	1	1	3	
<i>Rhus lancea</i>				2	
<i>Eragrostis capensis</i>		1	1	2	1
<i>Clematis brachiata</i>	1	1	1	2	
<i>Talinum caffrum</i>		1		2	
<i>Hibiscus calyphyllus</i>				1	
<i>Heteromorpha arborescens</i>				1	
<i>Solanum nigrum</i>				1	
<i>Setaria verticillata</i>				1	
<i>Scadoxus puniceus</i>				1	
<i>Priva meyeri</i>				1	
<i>Plectranthus madagascariensis</i>				1	
<i>Ledebouria luteola</i>				1	
<i>Kedrostis africana</i>				1	
<i>Ehrharta erecta</i>				1	
<i>Dipcadi viride</i>				1	
<i>Ceterach cordatum</i>				1	
<i>Bidens pilosa</i>				1	
<i>Anomatheca grandiflora</i>				1	
<i>Achyranthes aspera</i>				1	
<i>Gerbera piloselloides</i>				1	
<i>Hyperthelia dissoluta</i>				1	
<i>Salvia stenophylla</i>				1	
<i>Bulbine capitata</i>				1	
<i>Bonatea speciosa</i>				1	
<i>Urochloa mosambicensis</i>				1	
<i>Lepidium africanum</i>				1	
<i>Jatropha zeyheri</i>				1	
<i>Cheilanthes viridis</i>				1	
<i>Panicum maximum</i>				1	
<i>Boscia albitrunca</i>				1	
<i>Delosperma mahonii</i>				1	
<i>Acacia erioloba</i>				1	
<i>Acacia hebeclada</i>				1	
<i>Pseudognaphalium oligandrum</i>				1	
<i>Pygmaeocthamnus zeyheri</i>				1	
<i>Chloris virgata</i>				1	
<i>Rhus ciliata</i>				1	
<i>Eragrostis rigidior</i>				1	
<i>Aloe transvaalensis</i>				1	
<i>Schmidtia pappophoroides</i>				1	
<i>Crotalaria lotoides</i>				1	
<i>Terminalia sericea</i>				1	
<i>Ozoroa paniculosa</i>				1	
<i>Grewia flavescens</i>				1	
<i>Dichrostachys cinerea</i>				1	

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group D (continues)

Diagnostic species of *Grewia flavae* - *Acacieeta* karroo

<i>Dicerocaryum eriocarpum</i>					1
<i>Acacia mellifera</i>					1
<i>Eragrostis biflora</i>					1
<i>Cyperus longus</i>					1
<i>Portulaca oleracea</i>					1
<i>Artemisia afra</i>					1
<i>Senecio isatideus</i>					1

Species group E

Diagnostic species of *Eragrostido plana* - *Hyparrhenieta* hirtae

<i>Eragrostis plana</i>			1		1	5
<i>Hyparrhenia hirta</i>			1	1	1	3
<i>Berkheya radula</i>			1		1	3
<i>Conyza podocephala</i>			1	1	1	3
<i>Verbena bonariensis</i>			1	1		3
<i>Falckia oblonga</i>						2
<i>Paspalum dilatatum</i>						2
<i>Cirsium vulgare</i>						2
<i>Eragrostis chloromelas</i>			1		1	2
<i>Chamaesyce hirta</i>			1	1	1	2
<i>Chloris pycnothrix</i>						1
<i>Asclepias fruticosa</i>						1
<i>Salvia runcinata</i>						1
<i>Echinochloa holubii</i>						1
<i>Gnaphalium filagopsis</i>						1
<i>Schoenoplectus muricinus</i>						1
<i>Cyperus esculentus</i>						1
<i>Oenothera tetraptera</i>						1
<i>Amaranthus hybridus</i>						1
<i>Plantago lanceolata</i>						1
<i>Oenothera indecora</i>						1
<i>Oenothera rosea</i>						1
<i>Haplocarpha scaposa</i>						1
<i>Setaria incrassata</i>						1
<i>Andropogon eucomus</i>						1

Species group F

Common species of the western Transvaal grassland

<i>Eragrostis curvula</i>	5	5	5	5	5
<i>Themeda triandra</i>	5	5	4	5	4
<i>Aristida congesta</i>	5	5	4	5	4
<i>Elionurus muticus</i>	5	5	4	3	3
<i>Cymbopogon plurinodis</i>	5	4	2	4	3
<i>Heteropogon contortus</i>	5	5	4	2	2
<i>Cynodon dactylon</i>	3	3	2	5	5
<i>Vernonia oligocephala</i>	5	4	1	3	3
<i>Aristida diffusa</i>	4	4	2	1	1

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group F (continues)

Common species of the western Transvaal grassland

<i>Cymbopogon excavatus</i>	3	4	2	1	3
<i>Setaria flabellata</i>	5	3	2	3	2
<i>Hermannia depressa</i>	3	3	1	3	3
<i>Commelina africana</i>	3	2	5	1	1
<i>Eragrostis superba</i>	4	2	1	3	1
<i>Corchorus asplenifolius</i>	4	3	1	2	2
<i>Eragrostis gummiflua</i>	3	2	2	2	2
<i>Triraphis andropogonoides</i>	5	4	2	3	1
<i>Justicia anagaloides</i>	5	4	2	2	1
<i>Felicia muricata</i>	2	2	2	4	3
<i>Melinis repens</i>	1	3	5	2	1
<i>Crabbea angustifolia</i>	5	3	1	2	1
<i>Pogonarthria squarrosa</i>	4	3	1	2	1
<i>Turbina oblongata</i>	4	2	2	1	1
<i>Panicum coloratum</i>	1	1	1	2	3
<i>Helichrysum nudifolium</i>	1	3	1	1	2
<i>Hibiscus pusillus</i>	1	1	1	3	2
<i>Sporobolus africanus</i>	3	1	1	3	1
<i>Barleria macrostegia</i>	5	4	1	3	1
<i>Sutera atropurpurea</i>	1	1	1	1	1
<i>Eragrostis lehmanniana</i>	4	2		3	1
<i>Scabaria columbaria</i>	2	1		1	3
<i>Geigeria burkei</i>	2	2		2	2
<i>Anthospermum rigidum</i>	5	2		1	1
<i>Setaria nigrirostris</i>	1	1		1	1

Species group G

<i>Eustachys paspaloides</i>	5	3	3	3	
<i>Brachiaria serrata</i>	5	5	3	1	
<i>Senecio venosus</i>	2	4	1	1	
<i>Elephantorrhiza elephantina</i>	2	4	1	1	
<i>Lippia scaberrima</i>	2	3	2	4	
<i>Ziziphus zeyheriana</i>	2	3	2	4	
<i>Blepharis angusta</i>	1	2	1	2	
<i>Dicoma anomala</i>	3	4	1	1	
<i>Commelina benghalensis</i>	1	1	1	1	
<i>Plexipus hederaceus</i>	2	3	1	1	
<i>Raphionacme hirsuta</i>	3	2		2	
<i>Gazania krebsiana</i>	4	2		1	
<i>Berkheya onopordifolia</i>	1	1		1	
<i>Salvia radula</i>	1	1		1	
<i>Mariscus capensis</i>	1	1		1	

Species group H

<i>Sida dregei</i>		2	2	4	1
<i>Hibiscus trionum</i>		2	2	1	3
<i>Gomphrena celosiojdes</i>		1	2	2	2
<i>Dicoma zeyheri</i>		2	2	1	1
<i>Walafrida densiflora</i>		2	1	2	4
<i>Stoebe vulgaris</i>		2	1	1	2

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12

Species group H (continues)

<i>Mariscus indecorus</i>		2	2	1	1
<i>Anthospermum hispidulum</i>		3	3	2	3
<i>Helichrysum rugulosum</i>		2	1	1	3
<i>Crabbea acaulis</i>		2	2	2	3
<i>Setaria sphacelata</i>		2	2	3	4
<i>Solanum incanum</i>		2	1	2	1
<i>Digitaria eriantha</i>		4	3	5	5
<i>Monsonia angustifolia</i>		1	1	2	3
<i>Acalypha angustata</i>		4	2	1	1
<i>Becium obovatum</i>		2	2	1	1
<i>Guilleminea densa</i>		1	1	1	1
<i>Aristida stipitata</i>		1	1	1	1
<i>Lightfootia denticulata</i>		3	2	1	1
<i>Ledebouria marginata</i>		2	2	1	1
<i>Salvia disermas</i>		1	1	1	1
<i>Stachys spathulata</i>		1	1	1	1
<i>Tylosema esculentum</i>		1	1	1	1
<i>Bulbine narcissifolia</i>		1	1	1	1
<i>Nidorella resedifolia</i>		1		1	1
<i>Pentzia globosa</i>		1		1	1
<i>Senecio affinis</i>		1		1	1
<i>Schkuhria pinnata</i>		1		3	3
<i>Lactuca serriola</i>		3		2	4
<i>Tephrosia semiglabra</i>		1	1		1

Species group I

<i>Kohoutia amatymbica</i>		2	2		
<i>Chamaecrista biensis</i>		3	2		
<i>Sida chrysantha</i>		1	1		
<i>Crassula lanceolata</i>		1	1		
<i>Zornia milneana</i>		1	1		
<i>Thesium transvaalense</i>		1	1		

Species group J

<i>Bulbostylis burchellii</i>	2	3	3		
<i>Tephrosia longipes</i>		2	2		
<i>Acrotome hispida</i>		1	1		
<i>Plexipus adenostachyus</i>		1	1		
<i>Crabbea hirsuta</i>		1	1		
<i>Eriosema burkei</i>		1	1		
<i>Panicum natalensis</i>		1	1		
<i>Leucas glabrata</i>		1	1		
<i>Anthericum galpinii</i>		1	1		
<i>Indigofera filipes</i>		1	1		
<i>Pearsonia sessilifolia</i>		1	1		
<i>Thesium utile</i>		1	1		
<i>Triumfetta sonderi</i>		1	1		
<i>Eleusine coracana</i>		1	1		
<i>Pavetta gardeniifolia</i>		1	1		

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12
Species group K					
<i>Tarchonanthus camphoratus</i>			1	1	
<i>Rhus rigida</i>			1	1	
<i>Osyris lanceolata</i>			1	1	
<i>Lantana rugosa</i>			1	1	
<i>Maytenus polyacantha</i>			1	1	
<i>Ipomoea crassipes</i>			1	1	
<i>Tribulus terrestris</i>			1	1	
Species group L					
<i>Kyllinga alba</i>		1		1	
<i>Ipomoea bathycolpos</i>		1		1	
<i>Antizoma angustifolia</i>		1		1	
<i>Hypoxis rooperi</i>		1		1	
<i>Ledebouria ovatifolia</i>		1		1	
<i>Albuca setosa</i>		1		1	
<i>Euphorbia clavaroides</i>		1		1	
<i>Hypoxis rigidula</i>		1		1	
<i>Helichrysum callicomum</i>		1		1	
<i>Rhynchosia adenodes</i>		1		1	
<i>Urginea sanguinea</i>		1		1	
<i>Indigofera hiliaris</i>		1		1	
<i>Osteospermum muricatum</i>		1		1	
Species group M					
<i>Solanum capense</i>		2	3	1	
<i>Pollichia campestris</i>		2	2	3	
<i>Gnidia capitata</i>		2	2	2	
<i>Cyanotis speciosa</i>		3	1	2	
<i>Rhynchosia nervosa</i>		2	2	1	
<i>Solanum panduriforme</i>		1	2	2	
<i>Zornia glochidiata</i>		1	1	1	
<i>Lotononis foliosa</i>		1	1	1	
<i>Tephrosia elongata</i>		1	1	1	
<i>Dianthus mooiensis</i>		1	1	1	
<i>Cleome rubella</i>		1	1	1	
<i>Sporobolus discosporus</i>		1	1	1	
<i>Aloe davyana</i>		1	1	1	
<i>Zinnia peruviana</i>		1	1	1	
<i>Haemanthus humilis</i>		1	1	1	
<i>Microchloa caffra</i>		1	1	1	
Species group N					
<i>Tagetes minuta</i>				1	1
<i>Portulaca quadrifida</i>				1	1
<i>Convolvulus sagittatus</i>				1	1
<i>Chenopodium album</i>				1	1
<i>Arctotis venusta</i>				1	1
<i>Cynodon hirsutus</i>				1	1
<i>Aristida bipartita</i>				1	1
<i>Cyperus esculentus</i>				1	1

Table 1 (continued)

Class number	1	2	3	4	5
Number of communities / class	16	43	16	27	12
Species group O					
<i>Bidens bipinnata</i>			1	1	1
<i>Merremia tridentata</i>			1	1	1
<i>Salvia runcinata</i>			1	1	1
<i>Urochloa panicoides</i>			1	1	1
Species group Q					
<i>Andropogon appendiculatus</i>		1			1
<i>Kohautia cynanchica</i>		1			1
<i>Hermannia coccocarpa</i>		1			1

Results

Five phytosociological classes (Table 1) were recognised in the western Transvaal grasslands:

- 1) The *Diplachno fuscae* - *Stipagrostidetea uniplumis*, a grassland of the aeolian sandy north-western plains;
- 2) The *Eragrostido racemosae* - *Trachypogonetetea spicati*, a grassland of the shallow and rocky, relatively high-altitude regions;
- 3) The *Rhoo leptodictyae* - *Acacieteae caffrae*, a woodland of the rocky hills;
- 4) The *Grewio flavae* - *Acacieteae karroo*, a woodland of the footslopes and floodplains; and
- 5) The *Eragrostido planae* - *Hyparrhenietea hirtae* a grassland of the floodplains and dry watercourses.

All these classes are clearly associated with specific habitat conditions.

1. *Diplachno fuscae* - *Stipagrostidetea uniplumis* Class nov.

This class occurs mainly on plains in the north-western parts of the study area where the influence of strip mining and cultivation had a significant impact on the vegetation (Morris 1973). According to Harmse (1967) most of the area has aeolian sand overlying the existing rock. The area consists mainly of an undulating plain which is accentuated by the absence of topographical features (Morris 1973). The largest part of the habitat is relatively dry, with soils of a low clay content and good internal drainage. Occasionally the habitat changes into a restricted drainage pattern where the clay content is higher, resulting in a wetter habitat. This leads to a mosaic distribution pattern of habitat and associated vegetation. The presence of the perennial grass *Diplachne fusca* which, according to Gibbs Russell *et al.* (1990) favours a wet habitat, but could also occur in other variations in grassland, confirms this mosaic. The *Diplachno fuscae* - *Stipagrostidetea uniplumis* is strongly associated with the *Cymbopogon - Themeda* Veld Type 48b and Dry *Cymbopogon - Themeda* Veld Type 50a of Acocks (1988).

Diagnostic species, with a constancy higher than 40%, are *Blepharis integrifolia*, *Diplachne fusca*, *Chamaesyce inaequilatera*, *Solanum supinum*, *Digitaria argyrograpta*, *Eragrostis stapfii*, *Hermannia tomentosa*, *Stipagrostis uniplumis*, *Nolletia ciliaris*, *Thesium magalismontanum*, *Dicoma macrocephala*, *Leucas capensis*, *Hibiscus microcarpus* and *Anthephora pubescens* (species group A; Table 1). Other diagnostic and companion species are listed in Table 1.

The ordination (Fig. 4) indicates that this grassland class is associated with a dry, sandy habitat. The soils of the *Diplachno fuscae* - *Stipagrostidetea uniplumis* (Class 1) also has better internal drainage than the *Eragrostido planae* - *Hyparrhenieta hirtae* (Class 5) (Fig. 3).

A total of 156 sample plots representing 16 plant communities, all derived from Morris' (1973) data are classified under this class. The plant communities include:

- a) the three variants of the *Stipagrostis uniplumis* - *Fingerhuthia africana* Grassland, the three variants of the *Diplachne fusca* - *Cymbopogon excavatus* Grassland and the two communities, with four relevant variants, under the *Elionurus muticus* - *Heteropogon contortus* Grassland described by Bezuidenhout *et al.* (in prep.)
- b) the *Cymbopogon plurinodis* - *Eragrostis superba* Major Grassland with three communities and one variant and the *Stipagrostis uniplumis* - *Anthephora pubescens* Variant of the *Anthephora pubescens* - *Schizachyrium sanguineum* Grassland described by Bezuidenhout *et al.* (in prep.).

2. *Eragrostido racemosae* - *Trachypogonetea spicati* Class nov.

This class is the predominant and extensive grassland of the western Transvaal. It occurs on the plateaux of rocky hills or ridges, but can also be found on shallow soils of the upland convex crests in the undulating landscape, or on relatively high altitude plains (Fig. 3). The rocky soils are mostly derived from quartzite and shale (Witwatersrand Supergroup) or sometimes lava (Ventersdorp Supergroup). The clay content of these well-drained soils of this grassland varies, but is usually low.

Diagnostic species (with a constancy higher than 40%) are *Eragrostis racemosa*, *Trachypogon spicatus*, *Diheteropogon amplexens*, *Schizachyrium sanguineum*, *Andropogon schirensis*, *Trichoneura grandiglumis* and *Senecio coronatus* (species group B; Table 1). Other diagnostic and companion species are listed in Table 1. Floristically the *Eragrostido racemosae* - *Trachypogonetea*

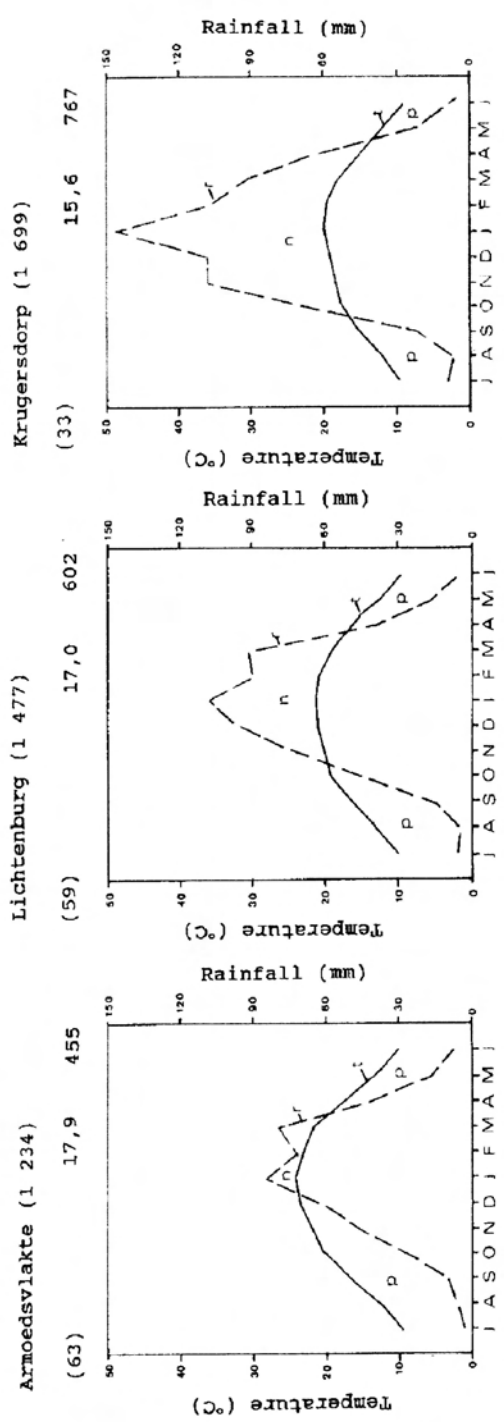
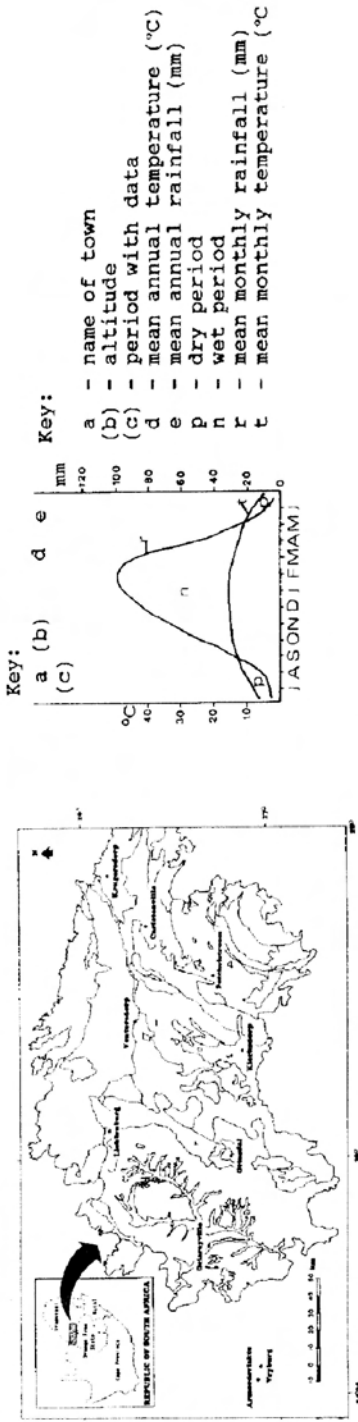


Fig. 2. Climate diagrams for selected towns in the study area.

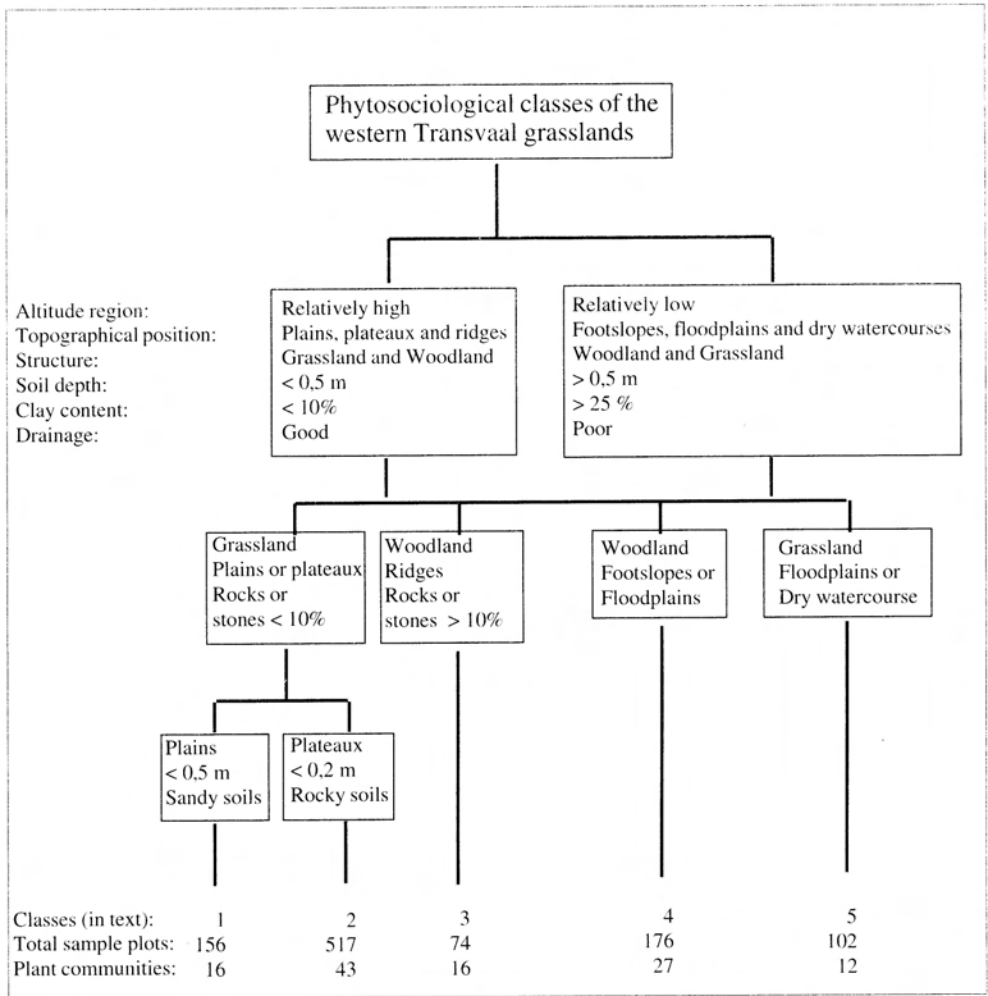


Fig. 3 A dendrogram to illustrate the habitat relationships of the phytosociological classes of the western Transvaal grassland.

spicati (Class 2) shows affinity to the *Rhoo leptodictyae* - *Acacietea caffrae* (Class 3) (species groups B, D and J; Table 1). The vegetation of both classes associate with rocky hills and ridges. The vegetation of Class 2 occurs on a more even topography to the rugged topography where the vegetation of Class 3 occurs (Fig. 3). The vegetation of the *Eragrostido racemosae* - *Trachypogonetea spicati* (Class 2) is found in all the major land types and associates well with the western variation of the Bankenveld Veld Type (61a) (Acocks 1988).

The ordination (Fig. 4) also shows an affinity between the *Eragrostido racemosae* - *Trachypogonetea spicati* (Class 2) and the *Diplachno fuscae* - *Stipagrostidetea uniplumis* (Class 3) but the two classes are separated by a more sandy habitat (*Diplachno fuscae* - *Stipagrostidetea uniplumis*) and more rocky habitat (*Eragrostido racemosae* - *Trachypogonetea spicati*).

A total of 517 plots classified into 43 plant communities are present in this class:

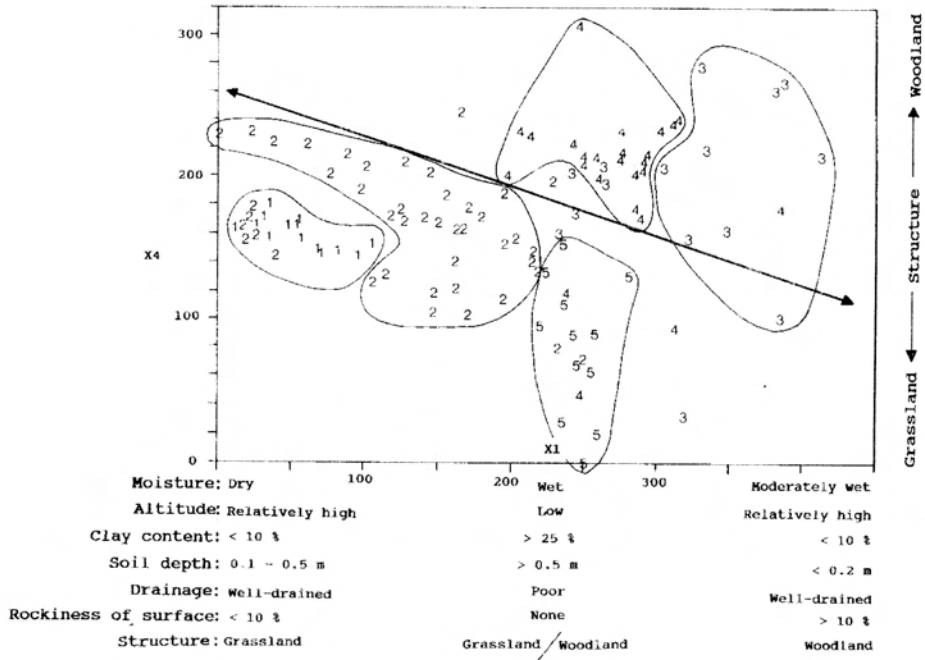


Fig. 4 The ordination of the phytosociological classes of the western Transvaal grassland, South Africa. (1) *Diplachno fuscae* - *Stipagrostidetea uniplumis*, (2) *Eragrostido racemosae* - *Trachypogonetea spicati*, (3) *Rhoo leptodictyae* -

capensis, *Combretum molle*, *Maytenus tenuispina*, *Setaria lindenberiana*, *Zanthoxylum capense* and *Euclea crispa*. Other diagnostic and companion species are listed in Table 1.

In the ordination diagram (Fig. 4) the communities of this woodland class are situated towards the right and top, indicating the moderately wet, well-drained habitat.

A total of 74 plots, representing 16 plant communities are classified under this class. The plant communities are:

- the six savanna communities described by Bezuidenhout *et al.* (1988): *Nuxia congesta* - *Rhus magalismsontana* Savanna, *Nuxia congesta* - *Combretum molle* Savanna, *Acacia caffra* - *Enneapogon scoparius* Savanna, *Diospyros lycioides* - *Sporobolus fimbriatus* Savanna, *Acacia*

caffra - *Ziziphus mucronata* Savanna and *Acacia karroo* - *Ziziphus mucronata* Savanna;

- the two communities under the *Rhus magalismsontana* - *Aristida vestita* Shrubland and the *Grewia flava* - *Acacia caffra* Woodland described by Bredenkamp & Bezuidenhout (1990);
- the *Vangueria infaustae* - *Acacietum caffrae* described by Bezuidenhout & Bredenkamp (1991a);
- the two associations under the *Schizachyrio sanguinei* - *Vangueria infaustae* (Bezuidenhout *et al. in prep.*);
- the *Rhoo rigidae* - *Acacietum caffrae*, *Dombeyo rotundifoliae* - *Acacietum caffrae* and the *Protea caffrae* - *Acacietum caffrae* described by Bezuidenhout *et al.* (1994);

f) the *Setaria lindenberiana* - *Combretum molle* Woodland Community described by Bredenkamp *et al.* (1994).

4. *Grewia flavae* - *Acacietea karroo* Class nov.

The vegetation of this class is a woodland which is mostly associated with moderately deep, often clayey alluvial or colluvial soils. This habitat is usually found at the footslopes of the quartzite ridges, chert ridges, lava hills and floodplains of the study area (Fig. 3). Although the vegetation of this class is relatively rare in the dolomite region, it occurs widely in the rest of the study area. The relatively high grazing capacity of the vegetation of this class (Bosch 1985), leads to overutilisation and subsequent degradation of the vegetation. Some of the diagnostic species (species group D; Table 1), especially *Acacia karroo*, *Protasparagus laricinus* and *P. suaveolens* may also increase or encroach into disturbed woodland and grassland units (Friedel 1987). Diagnostic species (with a constancy of higher than 40 %) include *Grewia flavae*, *Rhus pyroides*, *Teucrium trifidum*, *Diospyros lycioides*, *Celtis africana*, *Pavonia burchellii*, *Eragrostis obtusa*, *Protasparagus africana* and *Tragus berteronianus* (species group D; Table 1). Other diagnostic species and companion species are listed in Table 1.

In the scatter diagram (Fig. 4) the communities of this woodland class are situated towards the centre and top, indicating the wet, poorly drained habitat.

This class is represented by 176 plots, representing 27 plant communities. The plant communities are:

a) the three communities described by Van Wyk & Bredenkamp (1986) as the *Maytenus polyacantha* - *Celtis africana* Bush, the *Cymbopogon plurinodis* - *Tarchonanthus camphoratus* community and

the *Eustachys paspaloides* - *Acacia karroo* Bush;

b) the *Grewia flavae* - *Acacia karroo* Woodland described by Bredenkamp & Bezuidenhout (1990);

c) the three associations described by Bezuidenhout *et al.* (*in prep.*) under the *Protasparagus africana* - *Acacia karroo*;

d) the two subassociations under the *Sporobolus africana* - *Acacietum karroo* and the *Elionurus muticus* - *Acacia karroo* community described by Bezuidenhout & Bredenkamp (1991a);

e) the two associations, one with two subassociations under the *Rhus lanceae* - *Acacia karroo* and the two associations under the *Acacia eriolobae* described by Bezuidenhout *et al.* (1993);

f) the two associations and one community under the *Grewia flavae* - *Rhus pyroides* (Bezuidenhout *et al.* *in press.*);

g) the two subassociations described by Bezuidenhout *et al.* (1994) under the *Acacietum karroo* - *caffrae*;

h) the two bush communities and one subcommunity under the *Rhus pyroides* Woodland Community and the *Senecio isatideus* - *Artemisia afra* Wetland Community described by Bredenkamp *et al.* (1994);

i) the *Cynodon dactylon* - *Acacia karroo* Woodland described by Bezuidenhout *et al.* (*in prep.*).

In a syntaxonomic synthesis of the vegetation of the south-eastern Orange Free State, Du Preez & Bredenkamp (1991) identified a class named the *Acacia karroo* riparian thicket. They mention that the *Acacia karroo* communities of the Bankenveld and Western Transvaal may possibly be included under this class, but presently the riparian *Acacia karroo* communities seem to be quite different from the *Grewia flavae* - *Acacietea karroo*. Furthermore the communities with *Acacia karroo*, included in the phytosocio-

logical synthesis of Fuls (1993) are not presently considered as part of this class.

5. *Eragrostido planae - Hyparrhenietea hirtae* Class nov.

The vegetation of this class is restricted to the poorly-drained floodplains and dry water-courses within the study area (Fig. 3). The habitat is fairly unstable due to seasonal flooding and drying which, together with the frequent overgrazing of the area, have caused the advanced state of degradation of the vegetation. The soils have a higher clay content than the soils of the upland areas. The vegetation of this class occurs in all the land types and within all the veld types (Acocks 1988) in the study area.

The diagnostic species with a constancy value of 40% or more are *Eragrostis plana*, *Hyparrhenia hirta*, *Berkheya radula*, *Coryza podocephala* and *Verbena bonariensis* (species group E; Table 1). Other diagnostic and companion species are listed in Table 1.

In the ordination diagram (Fig. 4) the communities of this grassland class are situated towards the centre and bottom, indicating the wet, poorly drained habitat.

Sampling of this class were done by 102 plots representing 12 plant communities. The plant communities of this class are:

- a) the *Coryza bonariensis* - *Cynodon dactylon* community (Van Wyk & Bredenkamp 1986);
- b) the two subcommunities described by Bredenkamp & Bezuidenhout (1990) under the *Setaria sphacelata* - *Eragrostis plana* Wetland ;
- c) the two variants under the *Eragrostidetum planae* described by Bezuidenhout & Bredenkamp (1991a);
- d) the two subassociations under the *Falckio oblongae* - *Eragrostidetum planae* (Bezuidenhout *et al.* in prep.);
- e) the *Circio vulgaris* - *Eragrostidetum planae* and the *Diplachno fuscae* - *Echinochloetum holubii* described by Bezuidenhout *et al.* (1993);
- f) the *Paspalo dilatati* - *Hyparrhenietum hirtae* (Bezuidenhout *et al.* in press.);
- g) the *Hyparrhenio hirtae* - *Eragrostidetum planae* described by Bezuidenhout *et al.* (1994);
- h) the *Hyparrhenia hirta* - *Eragrostis plana* Variant (Bredenkamp *et al.* 1994).

This area is much drier, and floristically different from the *Themeda triandra* - *Eragrostis plana* moist grasslands, a class described by Du Preez & Bredenkamp (1991) from the eastern Orange Free State, and also differs from the *Aristida junciformis* - *Eragrostis plana* Grassland of the undulating plains in the northern Orange Free State (Fuls 1993).

Ordination

In the scatter diagram the distribution of the classes along the first and second axes (Fig. 4) of the ordination is given. Although no distinct discontinuity among the different classes could be made, the classes are restricted to specific spatial areas in the diagram. A clear gradient is illustrated on the first axis showing variance in moisture, drainage, altitude, clay content and percentage rocks/stones on the soil surface. The woodland class on the right of the scatter diagram associated with high altitudes, well-drained, moderately wet soils, with a low clay content of the soil. The two grassland classes on the left of the diagram are associated with high altitude, well-drained drier soils with a low clay content, while the two classes in the centre are associated with low altitude, poorly drained wetter soils with a relatively high clay content.

Discussion and Conclusion

This is the first comprehensive synecological account of the western Transvaal grassland. The vegetation of western Transvaal can be divided into two structural units, woodland and grassland. Five classes have been identified, all of which are strongly related to specific habitat conditions. A total of 1 025 plots have been used to classify the vegetation of the study area. Species from species group F (Table 1) are the common species of this study area. The other species (species groups G - O; Table 1) indicate minor floristic relationships among the different classes. The main contributing abiotic factors which influence the distribution of the classes are available moisture, topographical position in relation to altitude, soil depth, drainage, percentage stones or rocks on the soil surface and to a lesser extent percentage clay content (Figs. 3 & 4).

Although the classes are easily correlated with the habitat, a vegetation map with all the classes can not be drawn on a 1:250 000 scale which had been used in this survey, because the vegetation classes are distributed in a mosaic pattern and some classes are not limited to certain areas. Because the vegetation of the different classes sometimes occur only locally, it complicates the compilation of a vegetation map on this scale. According to the Land Type Survey Staff (1984) more than 80 % of the study area is ploughed. This makes the compilation of a vegetation map even more difficult. A more detailed description of the vegetation of the western Transvaal grassland is given by Bezuidenhout & Bredenkamp (1991a), Bezuidenhout *et al.* (1993, 1994, *in press.*, *in prep.*). These respective classifications can be used in management and conservation planning. It can not be emphasised enough that the vegetation units that occur in the western Transvaal grassland, with the exception of the *Grewia flavae* - *Acacietea karroo* (Class 4), which relates to a certain extent to Du Preez & Bredenkamp (1991), are unique and are not

found elsewhere in South Africa and therefore deserves a high conservation priority.

Regarding possible synonymy of the different plant communities within a class, all original relevés representing a specific class should be combined in a single phytosociological table in order to establish the floristic relationship and hierarchy among the communities. From these analyses a hierarchical syntaxonomy including synonyms may be compiled. This account creates the essential basis for such detailed syntaxonomic investigation.

Acknowledgement

Mrs. D. Bezuidenhout is thanked for assistance in the preparation of the manuscript. Mrs J. Schaap assisted with drawing Figure 1. Some of the data for this research were collected while H. Bezuidenhout was employed by the Department of Agricultural Development, Grassland (Roodeplaat) Research Centre, Private Bag X05, Lynn East, 0039 Republic of South Africa.

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