The vegetation types and management units of Goedverwacht farm in the mixed bushveld of the Northern Province, South Africa

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An analysis of the vegetation of Goedverwacht farm in the mixed bushveld of the Northern Province is presented. Relevés were compiled in 33 stratified random sample plots. Eight distinct plant communities were identified by means of Braun-Blanquet procedures. Detrended correspondence analysis (DCA) was applied to the floristic data set using the computer programme DECORANA (Detrended Correspondence Analysis) to determine a probable environmental gradient and to facilitate in the identification of management units. The computer programme CANOCO (Canonical Correspondence Analysis) was used to apply canonical correspondence analysis (CCA) to the floristic data set. Two management units were determined by means of vegetation ordinations and soil data. A classification, description and ecological interpretation of the plant communities as well as a description of the management units are presented.

Keywords: Braun-Blanquet classification, CANOCO, DECORANA, management units, mixed bushveld, ordination, plant communities.

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Introduction

The farm Goedverwacht is trust land owned by the people of Masemola and forms part of the Olifants River Irrigation Project. The ideal of the Masemola people is to establish a nature reserve which will be managed on sound ecological and economic principles. The project is of value since it is aimed at upgrading the living standards of the Masemola people by creating employment opportunities, education, recreational facilities and financial benefits from eco-tourism. The main aims of the Masemola is to teach their people about the environment and the importance of conserving it and to encourage traditional craft work. This should be looked at not only as a financial benefit and upliftment of the people but also as a form of spiritual growth. Allowing local people participation in decision making and management instills a sense of ownership of that conservation area within the community (Fourie 1991). The experience of control over one's own destiny satisfies the need for self-esteem and personal growth (Viljoen *et al.* 1987). The nature reserve will also provide a haven for fauna and flora typical to the region.

To formulate a management and conservation policy for a nature reserve the emphasis must fall on optimal habitat utilisation (Van Rooyen & Theron 1990). Optimal resource utilisation in general, and assessing the conservation status of the vegetation in particular, necessitates a detailed identification, classification and mapping of the vegetation of a region (Fuls *et al.* 1992). In semi-arid regions there is usually a good correlation between geological formations, soil types and plant communities (Van Rooyen & Theron 1990). This implies that the soil and

the parent rock from which it is formed have a strong influence on the species composition and structure of vegetation (Schmidt 1992).

The classification and description of homogeneous vegetation units form the primary basis for delineation of homogeneous physiographic units for management purposes (Shackleton *et al.* 1991). Within each homogeneous unit, the vegetation should react uniformly to use and management (Teague & Danckwerts 1989). A sound knowledge of the ecology of an area is an essential prerequisite for the establishment of sound wildlife management programmes (Bredenkamp & Theron 1991). The aim of this study was therefore to identify, describe and map the plant communities of Goedverwacht farm, to correlate these with selected environmental factors, and to delineate management units.

Study area

Goedverwacht has been, and is presently being, used as a cattle farm. Government funds were made available to establish a centre pivot irrigation system of approximately 60 ha to develop this farm as an independent and economically viable entity. The Masemola people have decided that the centre pivot irrigation system should remain since the crops supply the people with food and finance through selling the produce. The property comprises 689 ha in total. Of this total area the centre pivot is 59 ha in size and the showgrounds 3 ha. The effective area available for the reserve is thus 627 hectares.

Goedverwacht is situated between 24°31´–24°33´S and 29°32´–29°35´E. The farm is approximately 100 km south of Pietersburg and 80 km north-north-east of Marble Hall, just off the road (R579) to Lebowakgomo. The altitude ranges from 780–810 m above sea level. The topography comprises a predominantly flat terrain, with a slope of less than 3°. The Ngwaritzi River drains into the Olifants River which forms the northern border of Goedverwacht.

Goedverwacht is underlain by Lebowa Granite of the Bushveld Complex. The soils on Goedverwacht are predominantly sandy and shallow (no deeper than 1.2 m) with illuviation of the lower lying regions giving rise to duplex soils (National Working Group for Vegetation Ecology 1986).

The study area is characterised by warm summers and mild winters. The mean annual air temperature for the ten year period 1985 to 1994 at Marble Hall (Station number: 05915383; 24°58'S, 29°18'E; 915 m) is 20 °C. Frost is seldom recorded, but when it occurs it is usually light (Weather Bureau, undated). The amplitude between the mean daily maximum temperature (28 °C) and the mean daily minimum temperature (13 °C) is 15 °C for this ten year period. The lowest and highest temperatures recorded during this period are 2 °C and 38 °C respectively. The mean annual rainfall for Arabie (Station number: 0591797; 24°47'S, 29°27'E; 914 m) is 460 mm for the period 1979 to 1991 (Weather Bureau undated). Seventy-four percent of the annual rainfall in the study area occurs between October and March. The peak in the wet season occurs in November, with a mean monthly rainfall of 83 mm. Rainfall is erratic and usually occurs in the form of thunderstorms. The dry season stretches from April to September. July is the driest month.

Methods

Vegetation

In order to obtain a complete check list of plants and to classify the vegetation of Goedverwacht farm into structural-floristic units, the Braun-Blanquet sampling approach was used. Relevés were compiled in 33 random sample plots. The stratification units were structural-floristic homogeneous units semi-

subjectively identified with the aid of stereo-aerial photographs. The sample plot size was fixed at 200 m² (10 m x 20 m). This plot size has been found to be adequate for studies in the bushveld (Pauw 1988). In each sample plot all species were recorded and Braun-Blanquet cover-abundance values were accorded to each species (Werger 1974; Mueller-Dombois & Ellenberg 1974). Environmental data recorded include aspect, slope angle, exposure, geomorphology (flat, concave, convex), topography, percentage rock cover, drainage and biotic influence.

To classify the field data the computer programme TWINSPAN (Two Way Indicator Species Analysis) (Hill 1979a) was used, together with Braun-Blanquet procedures (Mueller-Dombois & Ellenberg 1974), to obtain an ordered two-way table that expresses the species' synecological relations as succinctly as possible (Hill 1979a). TWINSPAN emphasises the indicator species and produces an arranged matrix similar to the Braun-Blanquet approach (Kent & Coker 1992). Braun-Blanquet procedures were used to refine the TWINSPAN classification. The homogeneous vegetation units were named according to the binomial naming method (Barkman *et al.* 1986). Where possible, the first species name was that of a diagnostic species and the second species name was that of a dominant species. Following the species names, a relevant structural physiognomic term was given, following the classification of Edwards (1983).

Detrended correspondence analysis (DCA) was applied to the floristic data set using the computer programme DECORANA (Detrended Correspondence Analysis) (Hill 1979b) to determine a probable environmental gradient and to facilitate in the identification of management units. The computer programme CANOCO (Canonical Correspondence Analysis) (Ter Braak 1991) was used to apply canonical correspondence analysis (CCA) to the floristic data set. The principal aims of this particular set of analysis were to define environmental gradients within the floristic data of the vegetation of Goedverwacht, to assess the relative importance of the environmental variables and to recognise management units.

Soil survey

Fifteen soil profile pits were dug, examined, and the soil classified according to the taxonomic classification system of the Soil Classification Working Group (1991). Clay content was determined using the sausage method (National Working Group for Vegetation Ecology 1986). The same plots identified for the Braun-Blanquet studies were used to conduct the soil surveys. The objective of the soil survey was to classify the soils in order to facilitate the interpretation of results from the vegetation studies and to define management units.

Results and discussion

Classification

The vegetation on Goedverwacht farm can be broadly classified as an *Acacia karroo - Panicum maximum* open woodland. The graminoids with a high constancy in the communities are *Panicum maximum* and *Digitaria velutina* (Species group Q, Table 1). The numerous forb species often encountered may be the result of disturbance caused by grazing and trampling. The most conspicuous tree species found on Goedverwacht farm are *Acacia karroo* (species group Q, Table 1), *Dichrostachys cinerea* (Species group G, Table 1) and *Rhus pyroides* (Species group O, Table 1). *Dichrostachys cinerea* often invades disturbed places presenting a serious bush encroachment problem (Grossman 1988). Shrub species often encountered include *Grewia flava* (Species group P, Table 1). A total of 111 species were recorded in the 33 sample plots. The vegetation was divided into eight distinct plant communities. The phytosociological classification of the vegetation on Goedverwacht is summarised in Table 1 and the boundaries of the vegetation units are indicated on a map (Fig. 1).

The vegetation units recognised are:

1. *Portulaca quadrifida–Sporobolus stapfianus* Low Open Grassland
2. *Acacia tortilis–Schmidtia pappophoroides* Low Open Woodland
3. *Ximenia caffra–Heteropogon contortus* Low Open Woodland
4. *Aristida diffusa–Enneapogon scoparius* Low Open Woodland
5. *Euclea undulata – Setaria verticillata* Short Closed Woodland

6. *Dactyloctenium aegyptium – Urochloa mosambicensis* Low Closed Grassland
7. *Bothriochloa insculpta – Maytenus heterophylla* Short Closed Woodland
8. *Combretum erythrophyllum – Rhus pyroides* Short Closed Woodland

Description of plant communities

1. *Portulaca quadrifida – Sporobolus stapfianus* Low Open Grassland

This plant community comprises a small seasonal pan (Fig. 1) and occurs on very poorly-drained, deep clay soils of the Valsrivier soil form with a clay content of 55 % (Table 2). This soil form has a high water-holding capacity but a low infiltration rate. Surface rocks are absent in this community.

The succulent, *Portulaca quadrifida* (Species group A, Table 1), is the diagnostic species of this community. *Sporobolus stapfianus* (Species group I, Table 1) and *Enneapogon scoparius* (Species group L, Table 1) are the dominant graminoids. Other species found include *Aristida adscensionis*, *Ipomoea* species (Species group H, Table 1) and *Sporobolus ioclados* (Species group O, Table 1). This community differs from communities 2, 3, 4, 5, 6, 7 and 8 by the absence of species groups B to G as well as species groups I to K and M to Q (Table 1).

Aristida adscensionis, *S. ioclados* and *S. stapfianus* give an indication of the moist habitat occupied by this community (Gibbs-Russell *et al.* 1990) and serve also as an indicator of disturbance and overgrazing (Van Oudtshoorn 1992).

2. *Acacia tortilis – Schmidtia pappophoroides* Low Open Woodland

This plant community is found on the plain (Fig. 1). The community occurs on well-drained, sandy soils (clay content, 6–15 percent) with a low water-holding capacity (Hutton and Glenrosa soil forms)(Table 2). Rock cover ranges from 0–25 percent, with an average of three percent. The surface is predominantly flat with a slope of between 0° and 3°.

This community is characterised by the diagnostic species in species group B (Table 1). Diagnostic forbs include *Tribulus terrestris*, *Senna italica*, *Ocimum canum*, *Phyllanthus burchellii*, *Crotalaria sphaerocarpa* and *Lotononis laxa*. The diagnostic graminoid species is *Echinochloa colona* while *Acacia tortilis* is the diagnostic tree species. The dominant woody and forb species include *Acacia senegal* var. *rostrata*, *Boscia albitrunca*, *Mundulea sericea*, *Ceratotheca triloba* and *Indigofera cryptantha* (Species groups G, J, L and Q, Table 1). *Eragrostis rigidior* and *Schmidtia pappophoroides* (Species group J, Table 1) are the dominant graminoids.

Echinochloa colona and *Eragrostis rigidior* are often associated with disturbed areas such as overgrazed or trampled veld (Van Oudtshoorn 1992) and prefer sandy soils (Gibbs Russell *et al.* 1990). *Schmidtia pappophoroides* is found in open veld on a variety of soils (Gibbs Russell *et al.* 1990) but prefers sandy to stoney soils (Van Oudtshoorn 1992).

3. *Ximenia caffra–Heteropogon contortus* Low Open Woodland

This community occurs along the upper riverbanks of the Ngwaritzi River and along the ridges (Fig. 1). The community is restricted to well-drained, sandy, very shallow soils of the Glenrosa soil form, with a low water-holding capacity and a clay percentage of ten (Table 2). The rock cover ranges from six to 55 % with an average of 24 % which is the highest rock cover recorded for all the communities. The slope is north-east facing and gradual (8°) compared

Table 1

Phytosociological table of the vegetation of Goedverwacht, Northern Province

Community Number	1	2	3	4	5	6	7	8
Releve Number	20	0000100221	01011	01	111122	22	3322	133
	25	6147223018	49015	85	695672	36	8027	931
Species Group A								
Portulaca quadrifida	A							
Species Group B								
Acacia tortilis		++RRR1B						
Tribulus terrestris		11++R +		R				
Senna italica		++R+ R		R				
Ocimum canum		+A++ 1	+					
Phyllanthus burchellii		+ 11 1 R	R					
Lotononis laxa multiflora		1 R+						
Monsonia burkeana		1RR						
Crotolaria sphaerocarpa		1 +						
Echinochloa colona		A R						
Species Group C								
Ximenia caffra			R1RRR	1 R				
Grewia flavescens		R	R +R1					
Holmskioldia speciosa			+R +					
Polygonum lapathifolium			R R1					
Grewia bicolor			RR R					
Diheteropogon amplectens			R R					
Carissa bispinosa			RR	B				
Rhus zeyeri			A	R				
Species Group D								
Panicum natalense		R +RRR+	AAARA	R				
Melinis repens repens		R R3B	A A+R					
Aloe dabenorisana		R+	1+R1	+				
Aloe marlothi		R +	RR +					
Combretum apiculatum		+ R	A 3	R				
Hemizygia canescens	+		+1					
Species Group E								
Aristida diffusa burkei			+R					
Species Group F								
Heteropogon contortus		+ A	BBA+3	+B				
Fingerhuthia africana		B	BRABA	AA				
Commelina africana africana		+	R RR	R R				
Combretum hereroense			R	1				
Species Group G								
Commiphora africana		RRRRBBRR	R RR+	RR	R			
Dichrostachys cinerea		B+RR+RR++	AR R	R			R	

Table 1 (continued)

Hermannia modesta		RR+11 1++	1+1	++				
Aristida canescens canescens		A B+AAA	+AA A	RA	R			
Melhania species		1 +RR + R	1RR 1	RR				
Opuntia ficus-indica		+1+1	111R1	R1				
Limeum species		+ R+11 R	1 ++1	1	R			
Sarcostemma viminale		1 +13+11	R	R+				
Ceratotheca triloba		+ 52B R R	+	R1	R			
Acacia senegal rostrata		+ 52B R R	+	R1	R			
Kyphocarpa angustifolia		+3 AB	45 15	3B				
Pavetta gardeniifolia		A +	++1+1	R+				
Indigofera species		R +R	+1+R	1+				
Dicoma anomala		B 1RA R	+	R1				
Aptosimum lineare		+R1 +	R	R+				
Species Group H								
Aristida adscensionis	A	AR+AABRRR	RRRRA	RA			+	
Ipomoea species	A	R 3A+BB +	+ +A+					
Species Group I								
Euclea undulata			R+		R RA			
Ehretia rigida			R		R R			
Abutilon austro-africanum					RR			
Sporobolus stapfianus	B				A R	+		
Species Group J								
Eragrostis rigidior		43A3BBB33	BBAAA	AA	BA A			
Boscia albitrunca		RBRRR11RR	R RR	R	+ R			
Schmidtia pappophoroides		ABAABAA3B	+RR	+A	B			
Acacia burkei		+ + R	RRAAA	R	AR4R			R
Peltophorum africanum		R1	RR++R		R			
Mundulea sericea		3 +1 +3	1		R			
Ledebouria floribunda		R R	+R		1			
Species Group K								
Bidens pilosa					+1+	+R	++	
Tagetes minuta					++ 11	A	R+	
Solanum species					+R+ +		1 +	
Dactyloctenium aegyptium	+				A B+	33	B	
Hibiscus trionum					+	+		
Species Group L								
Enneapogon scoparius	B	R33+ +A+A	+BR	33	AA	R	+A	
Urochloa mosambicensis	R	RR R RA		R	BB	33	3333	
Indigofera cryptantha		14 1A A+1	+++		1	R+	+ R	
Species Group M								
Bothriochloa insculpta		+				A	AA++	
Cleome maculata							RR	

Table 1 (continued)

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Species Group N

Combterum erythrophylum      | |         |     |  |      |  |  RR|B33|
Themeda triandra             | |        R|     |  |      |  |+  +|  A|
Acacia erioloba              | |         |     |  |      |  |  R | R |

Species Group O

Achyranthes aspera           | |         |     |  | +54A5|  |++R |31+|
Diospyros lycioides          | |         |     |  |13R1 R|  |R+RA|AA |
Rhus pyroides                | |         |     |  | RAARB|  |B3  |B33|
Maytenus heterophyla         | |         |     |  |1+ R1+|  |1 43| 1A|
Setaria verticillata         | |         |     |  |RA32BA|  |   R|R  |
Sporobolus ioclados          |A|       + |     |  |3   + | R|AARR| +A|
Cynodon dactylon             | |         |     |  | 333  |  |  AA| AA|

Species Group P

Grewia flava                 | |  R R    |RRRRR| R|+RR+RR|  |R+  |RRR|
Asparagus species            | |  R  RRRR|RRR R|  |RRA1RR|  |   R|+  |
Ziziphus mucronata           | |      R  |R    | R|  RBR+|  |R+AR|RR |
Commelina erecta             | |    1    | R   |  |      |  |+R  |  R|

Species Group Q

Panicum maximum              | |+ R A+AAA|BBA3B|BA|3333B4|+B|B333|A44|
Digitaria velutina           | |A  A  R++|R+AR+|+R|AAR+B+| +|R RR|+AA|
Acacia karroo                | |   R   R+|BBR R|BR|44B555|R1|B33A|3RB|

Species Group R

Leonotis dysophylla          | |    +    |     |  |  +   |  |    |  R|
Eragrostis nindensis         | |       R |     |  |    ++|  |R   |   |
Aristida stipitata           | |        R|     |  |      |  |    |   |
Justicia flava               | |         |1    |  |      |  |    |   |
Tephrosia polystachya        | |         |    1|  |      |  |    |   |
Pogonarthria squarrosa       | |     +   |     |  |      |  |    |   |
Evolvulus alsinoides         | | R  .    |     |  |      |  |    |   |
Stipagrostis uniplumis       | |         |     |B |      |  |    |   |
Sida alba                    | |         |     |  |  +   |  |    |   |
Amaranthus thunbergii        | |         |     |  |      |  |   R|   |
Melia azedarach              | |         |     |  |      |  |   3|   |
Dichapetalum cymosum         | |         |     |  |      |  |   R|   |
Schizachyrium jeffreysii     | |         |     |  |      | R|    |   |
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to the other communities which are more or less flat (0–3°).

This community is characterised by the diagnostic species in species group C (Table 1). Diagnostic woody species include *Ximenia caffra*, *Grewia bicolor*, *Holmskioldia speciosa*, *Rhus zeyheri* and *Carissa bispinosa*. *Diheteropogon amplectens* is the diagnostic graminoid and *Polygonum lapathifolium* is the diagnostic forb. The vegetation is dominated by the grass species *Heteropogon contortus*, *Fingerhuthia africana* (Species group F, Table 1), *Panicum natalense* (Species group D, Table 1), *Aristida canescens* (Species group G, Table 1), *Eragrostis rigidior* (Species group J, Table 1) and *Panicum maximum* (Species group Q, Table 1).

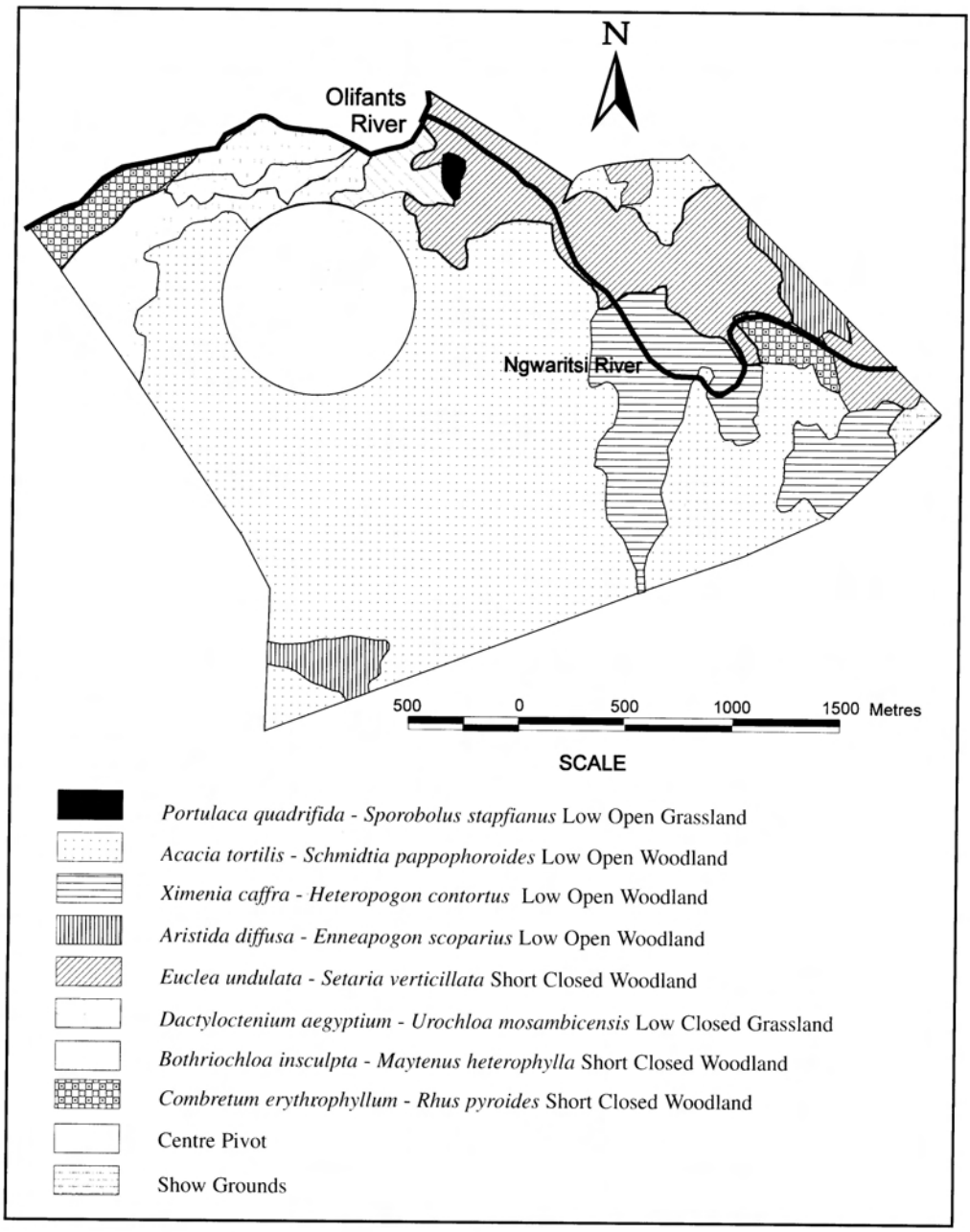


Fig. 1. A vegetation map of Goedverwacht, Northern Province.

Pavetta gardeniifolia (Species group G, Table 1), *Combretum apiculatum* (Species group D, Table 1) and *Acacia burkei* (Species group J, Table 1) are the dominant woody species.

Aristida canescens, *Diheteropogon amplectens* and *Panicum natalense* are indicators of poor shallow soils on stoney slopes (Gibbs-Russell *et al.* 1990). *Heteropogon contortus* is common on well-drained, stoney soils and is generally found on stoney slopes (Van Oudtshoorn 1992).

4. *The Aristida diffusa–Enneapogon scoparius* Low Open Woodland

This community is found in seepage lines of the plain where the surface is flat (0–3°) (Fig. 1). This low open woodland is encountered on shallow, well-drained sandy soils of the Hutton and Glenrosa soil forms (Table 2). The average rock cover and clay content is 12.5 percent.

The only diagnostic species is the grass *Aristida diffusa* (Species group E, Table 1). Dominant species include the shrub *Pavetta gardeniifolia* (Species group G, Table 1) and the graminoid *Enneapogon scoparius* (Species group L, Table 1). Other species generally present are the graminoids *Heteropogon contortus* and *Fingerhuthia africana* (Species group F, Table 1), indicating a relationship with the *Ximenia caffra* - *Heteropogon contortus* Low Open Woodland community.

Aristida diffusa occurs on dry, sandy, gravelly soils (Gibbs-Russell *et al.* 1990) and can be regarded as an indicator of overgrazed veld (Van Oudtshoorn 1992). *Enneapogon scoparius* prefers shallow soils (Van Oudtshoorn 1992). *Fingerhuthia africana* grows on well drained sandy or gravelly soils (Gibbs-Russell *et al.* 1990) and is often found on disturbed sites (Van Oudtshoorn 1992).

5. *The Euclea undulata–Setaria verticillata* Short Closed Woodland

This short closed woodland community occurs along the riverbanks of the Ngwaritzi River (Fig. 1). The community is restricted to poorly-drained, deep soils of the Oakleaf soil form with a clay percentage of 35 (Table 2) and no rock cover.

This community is characterised by the diagnostic species of species group I (Table 1). *Euclea undulata* and *Ehretia rigida* are the diagnostic shrub species and *Sporobolus stapfianus* the diagnostic grass. The diagnostic forb is *Abutilon austro-africanum.* Dominant woody species include *Rhus pyroides*, *Diospyros lycioides* (Species group O, Table 1) and *Acacia karroo* (Species group Q, Table 1), graminoid species *Setaria verticillata*, *Cynodon dactylon* (Species group O, Table 1), *Panicum maximum* and *Digitaria velutina* (Species group Q, Table 1), and the forb *Achyranthes aspera* (Species group O, Table 1).

Cynodon dactylon and *Setaria verticillata* often occur in damp, shady places under trees (Gibbs-Russell *et al.* 1990) and generally on nitrogen-rich disturbed soils. *Digitaria velutina* generally occurs in disturbed areas, often in moist places and in the shade (Van Oudtshoorn 1992). Although regarded as a pioneer species, *Cynodon dactylon* is one of the most valuable grasses because it protects the soil and provides some grazing in areas that suffer from overstocking (Gibbs-Russell *et al.* 1990).

6. *Dactyloctenium aegyptium – Urochloa mosambicensis* Low Closed Grassland

This plant community occurs within the floodplain of the Olifants River (Fig. 1). The community is confined to deep, fertile, alluvial soils of the Dundee soil form. The clay content is 55 % (Table 2) and rocks are

Table 2

The physical properties of the soils in the plant communities on Goedverwacht, Northern Province

Community	Soil			
	Form	Clay %	Texture [a]	Colour
Portulaca quadrifida - Sporobolus stapfianus Low Open Woodland	Valsrivier	55+	Clay	Red-brown
Acacia tortilis - Schmidtia pappophoroides Low Open Woodland	Hutton	5-10	Sand	Red
	Glenrosa	10-15	Loamy sand	Red
	Bainsvlei	10-15	Loamy sand	Red
Ximenia caffra - Heteropogan contortus Low Open Woodland	Glenrosa	10-15	Loamy sand	Red
Aristida diffusa -Enneapogon scoparius Low Open Woodland	Hutton	20-30	Sandy clay loam	Red-brown
	Glenrosa	< 10	Sand	Red
Euclea undulata - Setaria verticillata Short Closed Woodland	Oakleaf	35-40	Sandy clay	Red
Dactyloctenium aegyptium - Urochloa mosambicensis Short Closed Grassland	Dundee	55+	Clay	Brown
Bothriochloa insculpta - Maytenus heterophylla Low Closed Woodland	Valsrivier	55+	Clay	Red-brown
	Oakleaf	35-40	Sandy clay	Red
Combretum erythrophyllum - Rhus pyroides Short Closed Woodland	Valsrivier	55+	Clay	Red-brown

[a] - Soil texture classes according to clay content (National Working Group for Vegetation Ecology 1986).

absent. The soils are poorly-drained with a high water-holding capacity.

This community has no diagnostic species but is differentiated from communities 1, 5, 7 and 8 by the absence of species groups I, J, N, O and P (Table 1). *Dactyloctenium aegyptium* (Species group K, Table 1) and *Urochloa mosambicensis* (Species group L, Table 1) are the dominant grass species. Other species that occur in the community are the forb *Indigofera cryptantha* (Species group L, Table 1), the graminoid *Panicum maximum* and the tree *Acacia karroo* (Species group Q, Table 1).

Dactyloctenium aegyptium is found on all soil types and occurs in disturbed areas near water (Gibbs-Russell *et al.* 1990). *Urochloa mosambicensis* grows on most fertile soil types and usually occurs in disturbed areas such as overgrazed and trampled veld along drainage lines and flood plains (Van Oudtshoorn 1992).

7. *Bothriochloa insculpta–Maytenus heterophylla* Short Closed Woodland

This community is found along the banks and within the floodplain of the Olifants River (Fig. 1). This short closed woodland is encountered on deep, poorly-drained soils of the Valsrivier soil form with a clay percentage of 55 (Table 2). The rock cover is zero.

This community has no diagnostic species but is characterised by the presence of species groups K, L and M (Table 1), which differentiates it from community 8. The presence of species groups N, O and P distinguishes this community from community 6. The absence of species from species groups A, H, I and J differentiates the community from communities 1 and 5. The dominant graminoid species include *Urochloa mosambicensis* (Species group L, Table 1), *Bothriochloa insculpta* (Species group M, Table 1) and *Panicum maximum* (Species group Q, Table 1). *Maytenus heterophylla*, *Rhus pyroides* (Species group O, Table 1) and *Acacia karroo* (Species group Q, Table 1) are the dominant woody species.

Bothriochloa insculpta is usually dominant when it colonises disturbed sites (Van Oudtshoorn 1992).

8. *Combretum erythrophylum–Rhus pyroides* Short Closed Woodland

This plant community is encountered on the riverbanks of the Ngwaritzi and Olifants rivers (Fig. 1). The community occurs on soils of the Valsrivier soil form. The soils are deep, poorly-drained with a high water-holding capacity and a clay content of 55 % (Table 2). Rocks are absent in this community.

This plant community has no diagnostic species but is characterised by the presence of species group N which differentiates it from communities 1, 5 and 6. It is distinguished from community 7 by the absence of species groups K, L and M. Dominant tree species include *Combretum erythrophyllum* (Species group N, Table 1), *Rhus pyroides* (Species group O, Table 1) and *Acacia karroo* (Species group Q, Table 1). The dominant forb is *Achyranthes aspera* (Species group O, Table 1) while *Panicum maximum* (Species group Q, Table 1) is the dominant grass species. Other species that occur in this community are the woody species *Diospyros lycioides* and *Maytenus heterophylla* (Species group O, Table 1) and graminoids *Themeda triandra* (Species group N, Table 1), *Cynodon dactylon* (Species group O, Table 1) and *Digitaria velutina* (Species group Q, Table 1).

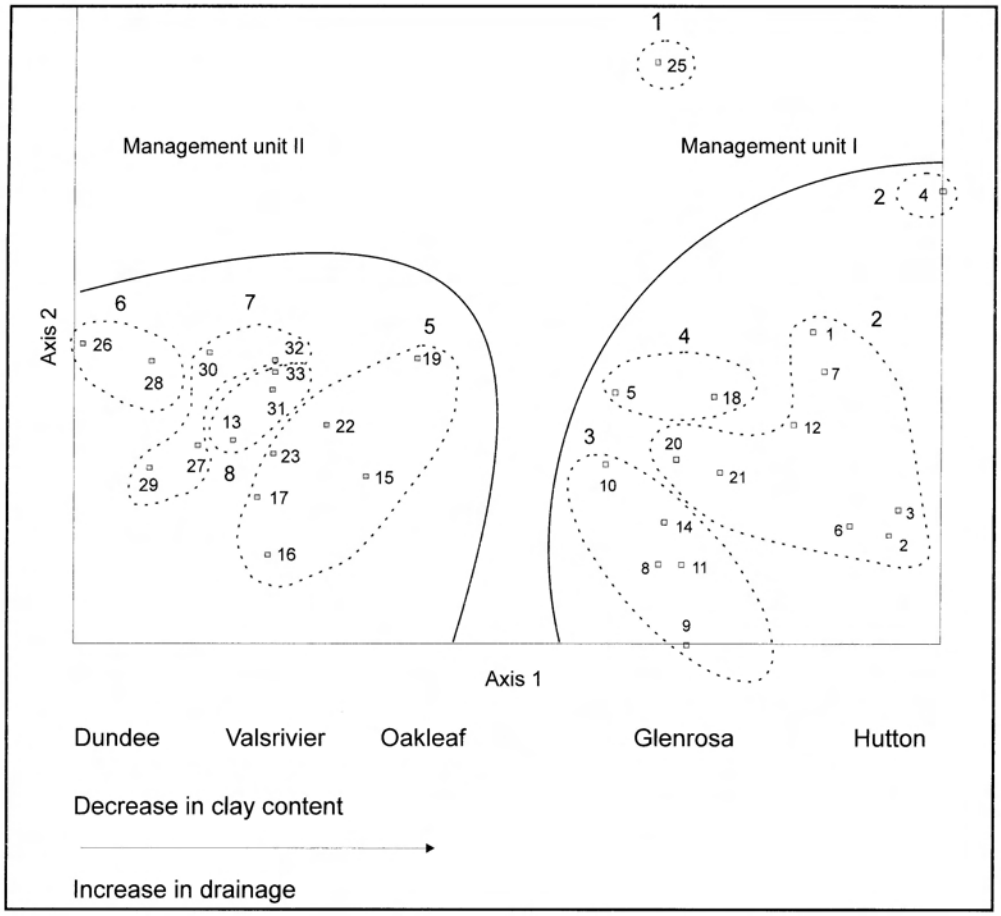
Panicum maximum prefers damp places with fertile soil, such as in the shade of trees and shrubs and along riverbanks (Gibbs-Russell *et al.* 1990).

Ordination

DCA

The distribution of the relevés along the first and second axes of a detrended correspondence analysis scatter diagram is presented in Fig. 2. A definite gradient in soil type, and hence soil properties, is illustrated along the first axis (Eigen value = 0.81). Communities situated to the left of the diagram are associated with clayey soils with an average clay content of 35–55 % and poor drainage, while communities to the right are associated with well-drained, sandy soils with an average clay content of six to 25 percent. No environmental gradient (Eigen value = 0.38) could be identified along the second axis.

Relevé 25 is considered an outlier (Fig. 2). An outlier is a quadrat/relevé which is very different from the others in a data set in terms of species composition (Kent & Coker 1992). The reason for this is that the quadrat, which is a pan, contains species (e.g. *Portulaca quadrifida*) that only occur in this



Community:

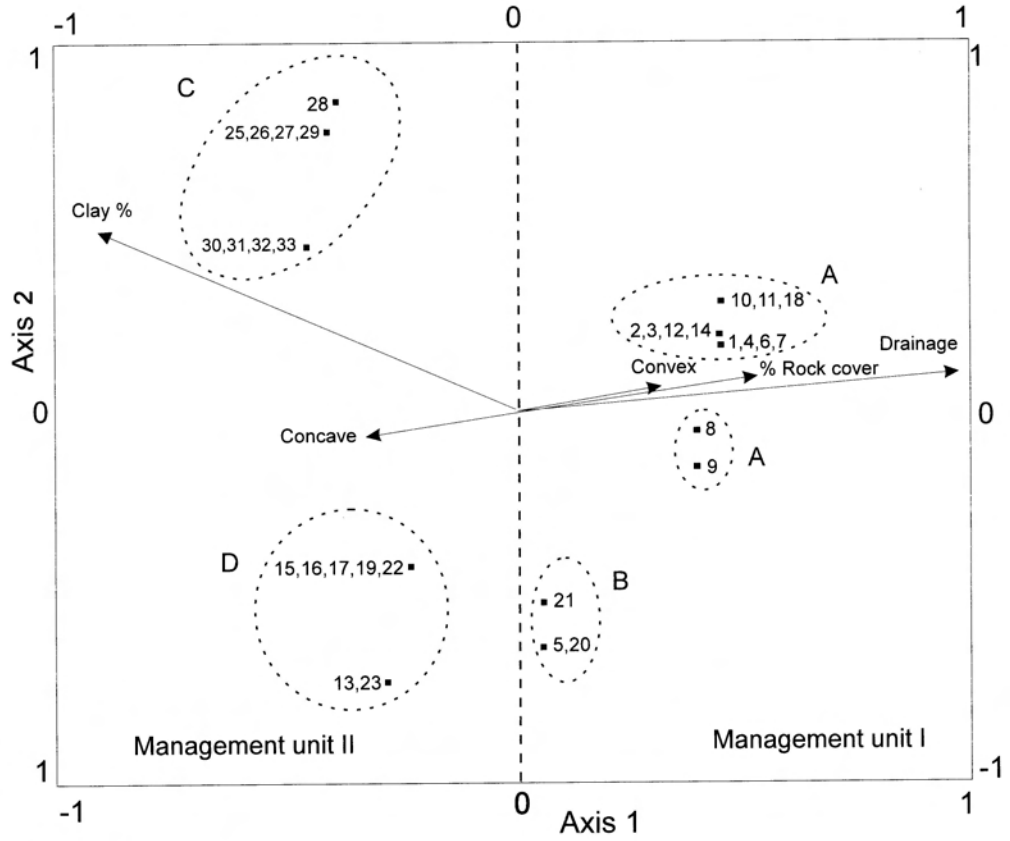
1. The *Portulaca quadrifida - Sporobolus stapfianus* Low Open Grassland
2. The *Acacia tortilis - Schmidtia pappophoroides* Low Open Woodland
3. The *Ximenia caffra - Heteropogon contortus* Low Open Woodland
4. The *Aristida diffusa - Enneapogon scoparius* Low Open Woodland
5. The *Euclea undulata - Setaria verticillata* Short Closed Woodland
6. The *Dactyloctenium aegyptium - Urochloa mosambicensis* Low Closed Grassland
7. The *Bothriochloa insculpta - Maytenus heterophylla* Short Closed Woodland
8. The *Combretum erythrophyllum - Rhus pyroides* Short Closed Woodland

Management unit:

I. The *Commiphora africana - Aristida canescens* management unit

II. The *Diospyros lycioides - Cynodon dactylon* management unit.

Fig. 2. Scatter diagram of a detrended correspondence analysis of the floristic data of 33 relevés of the vegetation of Goedverwacht, Northern Province (Eigen values: Axis 1 = 0.81; Axis 2 = 0.38).



A - D: Vegetation units

Management unit I. *Commiphora africana - Aristida canescens* Management Unit

II. *Diospyros lycioides - Cynodon dactylon* Management Unit

Fig. 3. Canonical correspondence ordination of the vegetation of Goedverwacht, Northern Province, showing correlation between relevés (■) and environmental variables (→) (Eigen values: Axis 1 = 0.72; Axis 2 = 0.31).

relevé and does not contain species (e.g. *Acacia karroo*, *Panicum maximum*, *Digitaria velutina*) which occur in the other communities. Relevé 4 is also an outlier (Fig. 2) due to the abundance and dominance of *Acacia senegal* var. *rostrata.*

In the scatter diagram (Fig. 2) a distinct discontinuity can be observed between communities 2, 3 and 4 on the right and communities 5, 6, 7 and 8 on the left and were identified as management units I and II respectively.

CCA

For the canonical correspondence analysis (Ter Braak 1991) the data set consisted of the cover-abundance values for the plant species at each relevé plus a matrix of environmental variables such as clay content (%), drainage, percentage rock cover and geomorphology i.e. if the surface is concave, flat

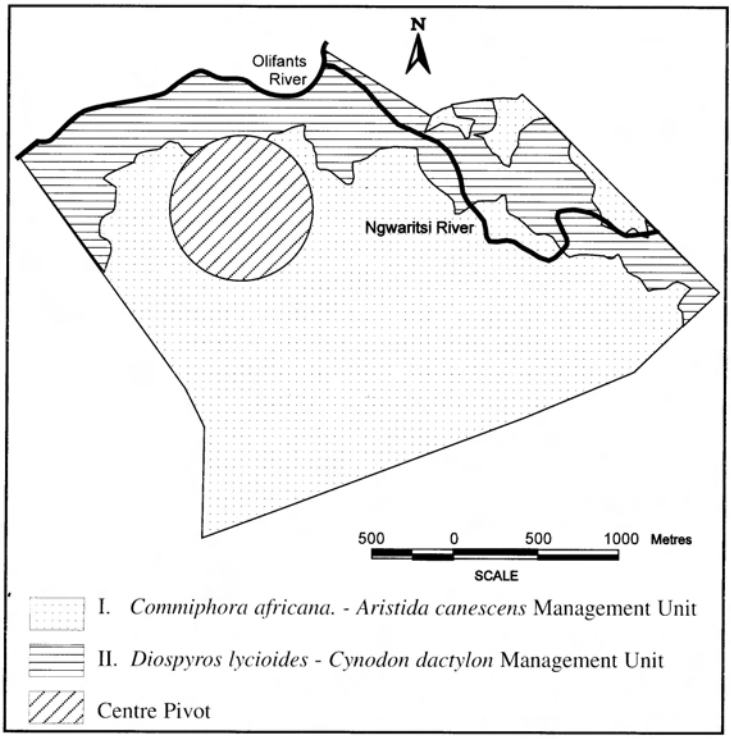


Fig. 4. The management units of Goedverwacht, Northern Province.

or convex. Figure 3 shows the sample - environment variable biplot. Two distinct management units (I and II) and four vegetation units (A, B, C, D) were identified.

The environmental gradients and the relative importance and inter-relations of the environmental variables are shown by the arrows (Fig. 3). The length of the arrow is proportional to its importance and the angles between the arrows reflect the inter-relation between the variables. The angle between an arrow and each axis is a representation of its degree of correlation with the axis. Thus on axis 1 drainage is the most significant variable determining the variation between relevés and hence in species composition, followed by clay percentage and the percentage rock cover.

There is no significant gradient on the second axis. Geomorphology is shown to be of little significance in explaining the variation. Axis 1 explains 73 % of the variation shown, and axis 2 accounts for only 31 % of the variation shown between the relevés.

Two management units emerge clearly in the scatter diagram of CANOCO (Fig. 3). The same management units were identified using DECORANA (Fig. 2). Management unit I is to the right of the diagram and is associated with good to fair drainage, low clay content and a relatively high percentage rock cover. Vegetation unit A is strongly associated with both high rock cover and

good drainage (Fig. 3). The soils associated with this unit are of the Hutton and Glenrosa soil forms with a clay content of between six and 10 percent. These soils have a low water-holding capacity and hence good drainage. Relevés 5, 20 and 21 of vegetation unit B are less strongly associated with the environmental variables drainage and percentage rock cover. This unit has a higher weighted average with respect to clay content than vegetation unit A, i.e. it is associated with soils of a higher clay content. An unmeasured environmental factor could account for the distribution of this vegetation unit in the ordination diagram. Soils associated with this unit are of the Glenrosa, Hutton and Bainsvlei soil forms. The clay content ranges from 10–30 percent.

Management unit II is to the left of the ordination diagram (Fig. 3) and is associated with a high clay percentage and poor drainage and the absence of rocks. Vegetation unit C has a higher weighted average with respect to clay content than unit D, i.e. it is associated with a higher clay content. The soils of this unit are of the Valsrivier and Dundee soil forms, with a clay percentage of approximately 55. Vegetation unit D is associated with a high clay content and poor drainage. The soils of this unit are of the Oakleaf soil form. The average clay content is 35 percent. It is possible that an unmeasured environmental variable could account for the position of this vegetation unit in the ordination diagram. Vegetation unit D is representative of the *Euclea undulata–Setaria verticillata* Short Closed Woodland plant community.

Management units

Two management units that were identified (Figs. 2 & 3) on the basis of discontinuity and floristic and ecological affinity are mapped (Fig. 4) and described according to floristic composition and soil characteristics, such as soil depth, clay content and drainage.

1. *Commiphora africana – Aristida canescens* Management Unit

This management unit is comprised of the *Acacia tortilis - Schmidtia pappophoroides* Low Open Woodland, the *Aristida diffusa - Enneapogon scoparius* Low Open Woodland and the *Ximenia caffra - Heteropogon contortus* Low Open Woodland. The species characterising this unit are species group G (Table 1). *Acacia senegal* var. *rostrata* and *Dichrostachys cinerea* are dominant trees. The succulent, *Opuntia ficus-indica*, is widespread in this management unit. *Opuntia ficus-indica* is an exotic problem plant and will have to be removed from the farm.

Soils in the higher lying areas (management unit I) are primarily of the Glenrosa (Orthic A over lithocutanic B) and Hutton (Orthic A over red apedal B) soil forms. The Glenrosa soils on Goedverwacht are relatively shallow with an average depth below 0.2 m and a clay content of ten percent (Table 2). In the study area, soils of the Hutton form have a relatively low clay content averaging approximately 15 % (Table 2) and a maximum depth of 1 m.

2. *Diospyros lycioides – Cynodon dactylon* Management Unit

This management unit includes the *Portulaca quadrifida - Sporobolus stapfianus* Low Open Grassland, the *Euclea undulata - Setaria verticillata* Short Closed Woodland, the *Dactyloctenium aegyptium - Urochloa mosambicensis* Low Closed Grassland, the *Bothriochloa insculpta - Maytenus heterophylla* Short Closed Woodland and the *Combretum erythrophyllum - Rhus pyroides* Short Closed Woodland. This management unit is characterised by species groups K and O (Table 1) with *Rhus*

pyroides and *Maytenus heterophylla* being conspicuous tree and shrub species.

In management unit II (the lower lying regions) soils are of the Oakleaf (Orthic A over neocutanic B), Dundee (Stratified alluvium) and Valsrivier (Orthic A over pedocutanic B - unconsolidated material with no signs of wetness) soil forms. Along the banks of the Ngwaritzi River, soils of the Oakleaf form have an average clay content of 35 % (Table 2). Neocutanic horizons are young sub-soils that develop from unconsolidated material and typically occur on river terraces. Neocutanic horizons tend to be nutrient rich (Laker 1992). The Dundee soils on Goedverwacht have a relatively high clay content of more than 55 % (Table 2) and a depth of approximately 1 m. The Valsrivier soil form, with a clay content greater than 55 % (Table 2) and a depth below 1 m is encountered along the Olifants River. Pedocutanic B-horizons are formed through illuviation. These are B-horizons that have typically become enriched in clay (Soil Classification Working Group 1991).

Conclusions

Eight plant communities were identified and classified on the basis of floristic and structural similarities using TWINSPAN (Hill 1979a) refined by Braun-Blanquet procedures (Mueller-Dombois & Ellenberg 1974). Two management units were identified with the aid of detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA). A definite gradient in soil type, and hence soil properties, was identified. Drainage was the most significant variable determining the variation between relevés and hence in species composition, followed by clay percentage and the percentage rock cover.

Management unit I comprises communities 2, 3 and 4 and is associated with good to fair drainage, low clay content and relatively high percentage rock cover. Management unit II includes communities 1, 5, 6, 7 and 8 and is associated with high clay percentage and poor drainage and zero rock cover.

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