The vegetation of the deep sandy soils of the A land type in the north western Orange Free State, South Africa.

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Abstract. A phytosociological analysis of the vegetation of the A land type, covering 199 000 hectares in the north western Orange Free State, South Africa, is presented. More than 80% of the area has been ploughed. Relevés were compiled in 23 stratified random sample plots, representing the relics of natural vegetation. A TWINSPAN classification, refined by Braun-Blanquet procedures revealed five communities. All communities are related to specific environmental conditions. Descriptions of the communities are given.

Key words: Braun-Blanquet method; Classification; Grassland Biome; Plant communities.

Introduction

The necessity to identify and describe the major vegetation types and subtypes within the South African Grassland Biome was stated by Mentis and Huntley (1982) and Scheepers (1986). Previous phytosociological studies in the north western Orange Free State, only include those of Scheepers (1975) in the Kroonstad area and Du Preez (1987) in the Vredefort district. A comprehensive synecological and syntaxanomical investigation was therefore undertaken of the vegetation of the north western Orange Free State. Kooij *et al.* (1990b,1990c) reported on the plant communities from various land types within the area. For the completion of the phytosociological study of the vegetation of the north western Orange Free State, it is necessary to classify and describe the until now unknown vegetation of the deep sandy soils of the A land types. The A land types refer to freely drained, yellow to red apedal soils with no water table. Within the study area the A land type includes the Ae and Ai land type units. These two land types occur in the south western parts of the study area. By definition plinthic catenas do not occur in the Ae and Ai land type units and one or more of the above soil forms occupy at least 40% of the area (Land Type Survey Staff, 1984). The entire A land type is very suitable for agronomy. More than 80% of the area have been ploughed for the cultivation of mainly maize, peanuts, potatoes and sunflowers. Natural vegetation is therefore extremely restricted, and only relics, often degraded due to grazing or other land-use practices, may be found scattered throughout the area.

The identification, classification and description of the remaining grassland communities of the A land type should have high priority as a basis for efficient vegetation (grazing) management and to identify suitable areas for probable conservation.

The aim of this project was therefore to identify, characterise and describe the plant communities of the A land type in the north western Orange Free State. The results should contribute to the knowledge of this vegetation type and therefore to a phytosociological synthesis of the western Grassland Biome.

The Study Area

The study area is situated between 26°00' and 27°

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23' E longitude and 27°00' and 28°00' S latitude, in the Grassland Biome of the north western Orange Free State, South Africa. A detailed description of the physical environment of the area is given by Kooij *et al.* (1990a). Soil nomenclature follows that of MacVicar *et al.*, 1977. The A land type occurs on approximately 199 000 hectares of the study area with approximately 193 000 hectares suitable for agronomy (Land Type Survey Staff, 1984)

The soils can be classified in one of the following soil forms: Inanda, Kranskop, Magwa, Hutton, Griffin and Clovelly. In the Ae land type red soils with a high base status, deeper than 300 mm, with no visible predominating dunes, whereas yellow, high base status soils predominate in the Ai land type.

The geology of the Ae land type consists predominantly of Ecca sandstone, mudstone and shale with the sporadic occurance of intrusive dolerite sills. Aeolian sand, derived from the Ecca sandstone, overlies all rocks. In depressions, pans occupy 4% of this land type. The predominant soil forms in the Ae land type are the Hutton Form on the slightly raised upland areas, the Valsrivier, Sterkspruit, Mispah and Oakleaf Forms, in the relatively low laying plains and the Willowbrook, Katspruit, Valsrivier, Rensburg and Sterkspruit Forms in the concave bottomland sites (Land Type Survey Staff, 1984).

The geology of the Ai land type consists mainly of sandstone of the Ecca Group. Intrusive dolerite sills occur sporadic throughout this land type. Pans occupy 2% of the Ai land type (Land Type Survey Staff, 1984). The predominant soil forms in this land type are the Clovelly and Hutton Forms on the upland situations, the Oakleaf, Clovelly, Westleigh and Sterkspruit on the plains and the Oakleaf, Sterkspruit, Katspruit, Arcadia and Willowbrook Forms in depressions (Land Type Survey Staff, 1984).

Materials and Methods

Over the entire north western Orange Free State relevés were compiled in 204 stratified random sample plots. Due to the limited occurance of natural vegetation in the A land type, only 23 relevés were compiled in this land type. As geology and land type were relatively uniform, stratification was based on the five terrain units, namely 1- crests, 2- scarp, 3- midslope, 4- footslopes and 5- valley bottom or flood plain (Fig. 1) (De

Beer, 1988; Land Type Survey Staff, 1984). In accordance with Scheepers (1975), plot sizes were fixed on 16 m² for grassland vegetation, while 100 m² plots were used for woody vegetation (Bredenkamp and Theron, 1978).

In each sample plot all species were noted, using the Braun-Blanquet cover-abundance scale (Mueller-Dombois and Ellenberg, 1974). Taxa names and taxon author names usually conform to those of Gibbs-Russell *et al.* (1985, 1987), however in accordance with Bredenkamp *et al.* (1989) *Setaria flabellata* Stapf. and *S. sphacelata* (Schumach.) Moss were distinguished as two seperate taxa. Environmental information includes terrain units, soil types, aspect, slope and rockiness of the soil surface. Other soil properties were obtained from Land Type Survey Staff (1984).

Two way indicator species analysis (TWINSPAN) (Hill, 1979) was applied to the floristic data set in order to derive a first approximation of the vegetation types of the area. Refinement of this classification was done by the application of Braun-Blanquet procedures (see also Behr and Bredenkamp, 1988; Bredenkamp *et al.*, 1989; Kooij *et al.*, 1990b, 1990c). The results are presented in a phytosociological table (Table 1). In order to determine a probable vegetation gradient, an ordination algorithm, Detrended Correspondance Analysis (DECORANA) (Hill, 1979) was applied to the floristic data set.

Results

Classification

In general the vegetation of the A land type can be considered as a *Pentzia globosa - Eragrostis curvula* Grassland. *Eragrostis curvula* is mostly the dominant grass species. The grass species of species group G, (Table 1) are mostly classified as Increasers 2 and 3 (Bosch and Van Rensburg, 1987) as these species increase, and are therefore abundantly present, in overgrazed or selectively grazed, degraded grassland vegetation. The poor condition of these grasslands are emphasized by the presence of the karroid shrubs *Felicia muricata* and *Pentzia globosa*. Other pioneers such as *Walafrida densiflora* and *Cirsium vulgare* are constantly present. The number of species recorded per sample plot varies from 12 to 31 with an average of 22 species. The vegetation varies as a result of variations in habitat, for example topography, soil type, drainage

Table 1. *A Phytosociological table of the vegetation of the A land type of the north western Orange Free State*

COMMUNITIES	1	2	3.1	3.2	3.3
RELEVES	193 061	065 063 064	184 182 183 191 179 181	060 062 078 121 108	054 120 104 119 105 106
SPECIES GROUP A					
OENOTHERA INDECORA	1 +				
CONYZA SUMATRENSIS	+ +				
SCHKUHRIA PINNATA	+ +				
OENOTHERA ROSEA	+ +				
ARISTIDA DIFFUSA	+				
MONANDRUS LONGICARPUS	+ +				
CORONOPUS INTEGRIFOLIUS	+ +				
SPECIES GROUP B					
ACACIA KARROO		3 + +			
HIBISCUS TRIONUM		+ +			
HIBISCUS PUSILLUS		+ +			
SPOROBOLUS FIMBRIATUS		1 +	+		
POLLICHIA CAMPESTRIS		1 +			
LYCIUM CINEREUM		+ +			
PORTULACA KERMESINA		+ +			
ACACIA HEBECLADA	+	+ +			
PROTASPARAGUS SUAVEOLENS		+			
PROTASPARAGUS LARICINUS		+			
SPECIES GROUP C					
ERAGROSTIS SUPERBA			+ + + + + + 3 4	+ + + +	+ + 1 + + 2
THEMEDA TRIANDRA		+ +	3 + + + + +	+ + + 3 +	1 1 2 4
DIGITARIA ERIANTHA		+ +	+ +	+ +	+ + + +
OXALIS SPECIES		+ +		+	+ + + +
SPECIES GROUP D					
ERAGROSTIS LEHMANNIANA		+	3 2 3	+ + + + 4 +	2 1
COMMELINA BENEGALENSIS			+ + +	+ +	+
CUCUMIS AFRICANA			+	+ +	
SPOROBOLUS SPESCIES			+ +	+ + + +	
SETARIA NIGRIROSTRIS			+ +	+ +	
MENODORA AFRICANA		+	+ +	+	
MARISCUS REHMANNIANUS			+	+	
WAHLENBERGIA CALEDONICA			+ +	+	
BRACHIARIA SERRATA			+	+ +	
SPECIES GROUP E					
ANTHEPHORA PUBESCENS		+	+	+ + + + +	2 1 +
ARISTIDA STIPITATA				+ + + +	+
ERAGROSTIS GUMMIFLUA				+ + +	+
COMMELINA ECKLONIANA				+ +	
TEHPROSIA SPECIES		+		+ +	
CYPERUS MARGARITACEUS		+		+	
SPECIES GROUP F					

COMMUNITIES	1	2	3.1	3.2	3.3
RELEVES	193 061	065 063 064	184 182 183 191 179 181	060 062 078 121 108	054 120 104 119 105 106
ERAGROSTIS TRICOPHORA					+ + + + + 3 3 2 2
MONSONIA ATTENUATA				+	+ + + + +
TRAGUS RACEMOSUS					+ + +
STACHYS SPATULA					+ +
SALVIA RADULA					+
CYMBOPOGON EXCAVATUS		+			+
SPECIES GROUP G					
PENTZIA GLOBOSA	2 2	+ + +	+ + + + +	+ + +	+ + +
ERAGROSTIS CURVULA	1 1	4 2 4	3 3	2 3 4 1	+ 4 +
CYNODON DACTYLON		+ + +	+ + + +	2 2 + +	1 + +
BULBINE NARCISSIFOLIA		+ +	+	+ +	+ + +
FELICIA MURICATA	+	+ +			+ +
ARISTIDA CONGESTA			+ + +	+ +	+ + +
SOLANUM INCANUM				+ +	
PANICUM COLORATUM	+	+ +	+ 3	+	+ 1 +
ERAGROSTIS OBTUSA		+ +	+	+	+ +
ALBUCA SPECIES		+	+	+	+
SPECIES GROUP H					
KYLLINGA ALBA	+ +	+ +	+ + + +	+ + + +	+ + + +
COMMELINA AFRICANA	+ +	+ +	+ +	+ + + +	+ + + +
MARISCUS INDICORUS		+ +		+ + +	+ + + +
BARLERIA MACROSTEGIA			+	+	+ + + +
LEDEBOURIA MARGINATA					+
HERMANNIA TOMENTOSA			+	+	
SPECIES GROUP I					
CHLORIS VIRGATA	+ +	+ +	+ + + +		+ +
WALAFRIDA DENSIFLORA	+ +	+ +	+ + +	+	+ +
CIRSIUM VULGARE		+ +	+ +	+ +	+ + +
SETARIA SPHACELATA	+		+		
CASSIA ITALICA		+			
TURBINA OBLONGATA				+ +	+ +
CRASSULA SCHIMPARI					
CYPERUS USITATUS			+		
BLEPHARIS ANGUSTATA					
POGONARTHRIA SQUARROSA			+	+ + 1	+ +
HETEROPOGON CONTORTUS		+		+ +	+ +
CYMBOPOGON PLURINODIS	+			+	2 2
TRIRAPHIS ANDROPOGONOIDES				+	1
CHENOPODIUM ALBUM				+	+
DICOMA MACROCEPHALA			+		
CHAMAESYCE PROSTRATA					
INDIGOFERA SPECIES					
GAZANIA KREBSIANA			+		
LACTUCA SERIOLA				+	
PTERODISCUS SPECIOSUS		+		+	+

SPECIES WITH AN OCCURANCE OF 1 HAVE BEEN OMMITTED.

regime and vegetation management (grazing by animals), and consequently the various plant communities can easily be distinguished. A hierarchical classification of the distinguished plant communities is listed below:

1. The *Oenothera indecorus-Conyza sumatrensis* Secondery Grassland on severely disturbed sites.
2. *Acacia karroo-Hibiscus pusillus* Thornveld along drainage lines.
3. *Eragrostis superba-Themeda triandra* Grassland of the undulating plains.
3.1 *Eragrostis lehmanniana* Variant.
3.2 *Anthephora pubescens* Variant.
3.3 *Eragrostis trichophora* Variant.

Description of the communities

1. The *Oenothera indecorus-Conyza sumatrensis* Secondary Grassland.

This Grassland community occurs on deep yellow sandy (90% sand) soils of the Clovelly soil form, predominantly in the Ai land type. Soil properties are given in Table 2. The pH-neutral sands have extremely low exchangeable cations and water retentivety, but a high electrical resistence. The sites are extremely disturbed and the poor condition of the vegetation in this community is emphasized by the weedy diagnostic species (Species group A, Table 1). The diagnostic species are *Oenothera indecorus, Conyza sumatrensis, Schkuhria pinnata, Oenothera rosea, Aristida diffusa, Monandrus longicarpus* and *Coronopus integrifolius*. The vegetation is dominated by *Eragrostis curvula* and *Cynodon dactylon*. An average of 15 species was recorded per sample plot.

2. The *Acacia karroo - Hibiscus pusillus* Thornveld.

This Thornveld is restricted to the water courses and drainage lines (terrain units 3 & 4) (Figs. 1 and 2) in the A land type. The soils are usually deep, red to yellow sandy soils of the Hutton or Clovelly Forms. Soil properties are given in Table 2. These sandy soils tend to be alkaline especialy in the A horizon. The soils are leached and have a low water retentivity. The soil resistence is however in the medium range (Table 2). The diagnostic species for this Thornveld (Species group B, Table 1) includes the woody tree species *Acacia karroo, Acacia hebeclada,* the shrubby *Protasparagus suaveolens, Protasparagus laricinus* and *Lycium cinereum,* the grass *Sporobolus fimbriatus,* the forbs *Hibiscus pusillus, Hibiscus trionum, Pollichia campestris* and the succulent *Portulaca kermesina.* The herbaceous layer is

dominated by *Eragrostis curvula.* The vegetation is generally overgrazed and in a degraded condition. Other species constantly present are *Pentzia globosa, Cynodon dactylon, Bulbine narcissifolia, Felicia muricata, Solanum incanum, Eragrostis obtusa, Kyllinga alba, Barleria macrostegia, Ledebouria marginata* and *Walafrida densiflora.* An average of 27 species was recorded per sample plot.

3. The *Eragrostis superba-Themeda triandra* Grassland.

The greater part of the natural vegetation of the A land type is represented by the *Eragrostis superba -Themeda triandra* Grassland. The diagnostic species for this community include the grasses *Eragrostis superba, Themeda triandra* and *Digitaria eriantha* and an *Oxalis* species (Species group C, Table 1). Other species generaly present are the grasses *Eragrostis curvula, Cynodon dactylon, Aristida congesta* and *Panicum coloratum,* the forbs *Solanum incanum, Kyllinga alba* and *Commelina africana,* the geophytes *Bulbine narcissifolius, Albuca* species and *Ledebouria marginata* and the karroid dwarf shrubs *Pentzia globosa* and *Felicia muricata.* An average of 21 species was recorded per sample plot. This community can be sub-divided into three variants according to species composition and habitat differences.

3.1 The *Eragrostis lehmanniana* Variant.

The *Eragrostis lehmanniana* Variant is situated on the mid- and footslopes of the undulating plains (terrain units 3-4, Figs. 1 and 2). The soils are medium deep, predominantly red sands representing the Hutton Form. Soil properties are given in Table 2. Although sandy (86% in the A horizon), the B horizon contains up to 24% clay, and therefore have slightly higher water retentivety, more exchangeable cations and a lower electric resistence than communities 1 and 2. This variant is characterised by species group D, which includes the diagnostic species *Eragrostis lehmanniana, Commelina benegalensis, Cucumis africana, Sporobolus* species, *Setaria nigrirostris, Menodora africana* and *Brachiaria serrata.* The dominant species are the grasses *Eragrostis lehmanniana, Themeda triandra* and *Eragrostis curvula.* Other constantly present species are the grasses *Eragrostis superba, Digitaria eriantha, Cynodon dactylon* and the forbs *Cucumis africana, Menodora africana,* and *Kyllinga alba.* The presence of Species group I (Table 1) as well as *Pentzia globosa, Cynodon dactylon* and *Felicia muricata* indicates the degraded state of the vegetation. This variation seems to repre-

sent a severely overgrazed and degraded stage of the *Eragrostis superba-Themeda triandra* Grassland. *Eragrostis lehmanniana* seems to replace *Anthephora pubescens* with continuous overgrazing. Species group I indicates floristic similarities, probably caused by over-utilization, among communities 1, 2 and 3.1 (Table 1).

An average of 20 species was recorded per sample plot.
3.2 *Anthephora pubescens* Variant.

This Variant is also situated on the mid- and footslopes of the A land type, on similar but slightly deeper soils than the *Eragrostis lehmanniana* Variant. Soil properties are given in Table 2. The *Anthephora pubes-*

Table 2. *An analysis of the soil properties of the A and B horizons of the plant communities in the A land type of the north western Orange Free State (Adapted from Land Type Survey Staff, 1984)*

| Community number		1	2	3.1	3.2	3.3
Soil form		Clovelly	Hutton	Hutton	Hutton	Willowbrook
Soil serie		annandale	mangano	shorrocks	shorrocks	sarasdale
Soil depth (mm)						
	A	0–400	270–560	0–250	0–250	0–500
	B	400–800	550–920	250–400	250–750	500–>1000
% Sand	A	90	90	85	75	61
	B	90	85	75	73	61
% Silt	A	1	3	2	3	5
	B	1	2	3	4	6
% Clay	A	7	8	13	25	33
	B	10	18	24	25	35
H_2O retentivity (%)						
-33 kpa	A	4.6	5.6	9.5	12.8	21.4
	B	6.3	7.8	13.9	13.2	23.1
-1500 kpa	A	3.0	3.7	4.8	8.8	13.4
	B	4.1	5.2	8.1	8.5	13.7
Exchangeable cations (me/kg soil)						
Na	A	0	0	4	1	8
	B	0	1	1	1	13
K	A	3	4	5	3	2
	B	4	4	2	1	1
Ca	A	18	22	46	47	149
	B	8	14	64	45	131
Mg	A	6	15	5	22	53
	B	12	17	17	30	56
Total	A	27	41	60	73	212
	B	24	36	84	77	201
pH (H_2O)						
	A	7.6	8.5	8.2	7.6	7.4
	B	7.4	6.5	6.9	7.4	8.3
Resistence (ohm)						
	A	4 400	2 800	1800	2000	800
	B	4 000	2 100	430	800	340
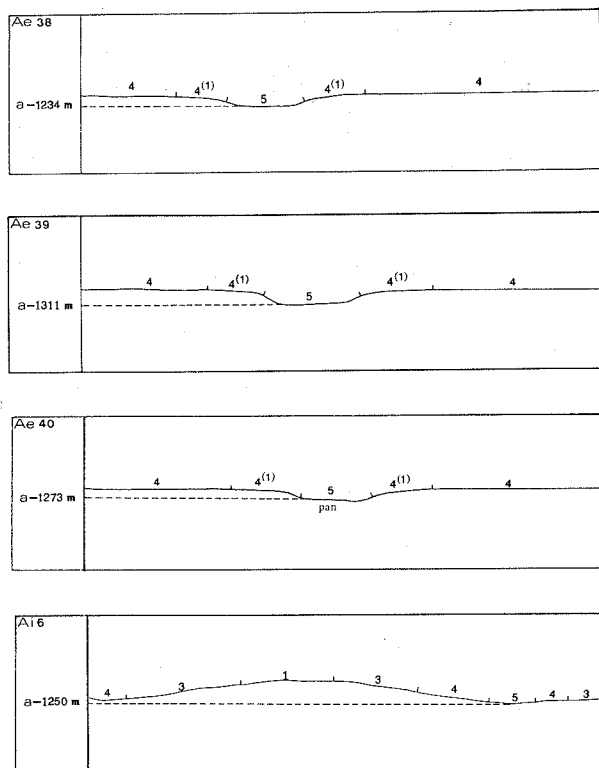
Fig. 1. A schematical representation of the different terrain
units in the A land type (Land Type Survey Staff, 1984).
Terrain unit: 1-Crest; 2-Scarp; 3-Midslope; 4-Footslope;
5-Valley Bottom or floodplain; a-Altitude.

Fig. 2. A schematical representation of the topographical gra-
dient and vegetation of the Ae and Ai land type units.
D1-Drainage line; D-Depression; 1-*Oenothera indecorus*
-*Conyza sumatrensis* Secondary Grassland on severly
disturbed sites; 2-*Acacia karroo-Hibiscus pusillus* Thorn
Veld along drainage lines; 3-*Eragrostis superba*
-*Themeda triandra* Grassland on the undulating plains;
3.1-*Eragrostis lehmanniana* Variant; 3.2-*Anthephora
pubescens* Variant; 3.3-*Eragrostis trichopora* Variant.

cens Variant is characterised by species group E
(Table 1). The diagnostic species are the grasses *Anthe-
phora pubescens, Aristida stipitata, Eragrostis gummi-
flua* and the forbs *Commelina eckloniana, Tephrosia*
species and *Cyperus margaritaceus.* Other species con-
stantly present are *Eragrostis superba, Themeda trian-
dra, Heteropogon contortus, Pentzia globosa, Kyllinga
alba, Commelina africana,* and *Mariscus indecorus.* The
presence of species group H indicates similarities
between communities 1, 2, 3.1 and 3.2 (Table 1). An
average of 20 species was recorded per sample plot.
3.3 The *Eragrostis trichophora* Variant.

This Variant is situated in relatively wet depres-
sions in the undulating landscape (terrain units 4(1) and
5, Fig. 1 and 2). Soil properties are given in Table 2.
The clayey soils have a relativeley high water
retentivity, exchangeable cations, and a relatively low
electrical resistence. The soils are usually more clayey
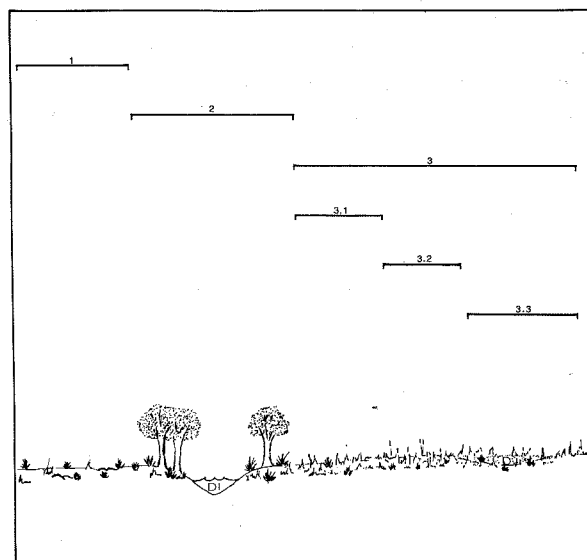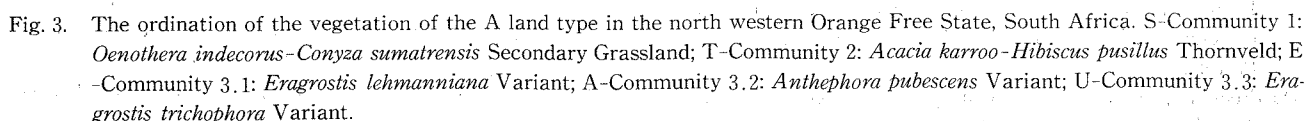(up to 35% clay) and represents the Sterkspruit, Swart-

land, Valsrivier and Willowbrook Forms. This Variant
is characterised by species group F (Table 1). The diag-
nostic species are the dominant grass *Eragrostis tricho-
phora*   as   well   as   *Monsonia   attenuata,   Tragus
racemosus, Stachys spatula* and *Salvia radula.* Other
prominent species are the grasses *Eragrostis curvula,
Themeda triandra, Heteropogon contortus, Eragrostis
superba,* the karroid shrubs *Pentzia globosa* and *Felicia
muricata* and the geophyte *Bulbine narcissifolia.* An
average of 20 species was recorded per sample plot.

Ordination

The distribution of the relevés along the first and
second axis of the ordination is given in Fig. 3. A third
axis of ordination contributes little to the interpreta-
tion of the plant communities and is therefore not in-
cluded in this result.

In the scatter diagram a distinct discontinuity can
be observed among some of the identified plant com-

Fig. 3.   The ordination of the vegetation of the A land type in the north western Orange Free State, South Africa. S-Community 1: *Oenothera indecorus-Conyza sumatrensis* Secondary Grassland; T-Community 2: *Acacia karroo-Hibiscus pusillus* Thornveld; E -Community 3.1: *Eragrostis lehmanniana* Variant; A-Community 3.2: *Anthephora pubescens* Variant; U-Community 3.3: *Eragrostis trichophora* Variant.

munities. Community 3.3 (the *Eragrostis trichophora* Variant) and 3.1 (the *Eragrostis lehmanniana* Variant) can clearly be distinguished as seperate units. Communities 1 (the *Oenothera indecorus - Conyza sumatrensis* Grassland), 2 (the *Acacia karroo - Hibiscus pusillus* Thornveld) and 3.2 (the *Anthephora pubescens* Variant) are situated to the right of the scatter diagram. The scatter diagram also illustrates the portion of the communities on a habitat gradient. A definite gradient in soil texture, water retentivety, exchangeable cations and electrical resistence of the soil is illustrated along the first axis. Communities situated to the left of the scatter diagram are associated with clayey soils with a high water retentivety and exchangeable cations and low electrical resistence, where-as the communities to the right are associated with sandy soils with a low water retentivety, exchangeable cations and a high electrical resistence.

Concluding Remarks

The results of this phytosociological survey, together with the results of other phytosociological studies in the north western Orange Free State form the basis for the synecological and syntaxonomical of this area. The application of TWINSPAN procedures refined by Braun-Blanquet procedures resulted in the succesful delimitation of the plant communities which are related to specific environmental conditions. The results of the ordination suggest that the three Variants distinguished in the *Eragrostis superba - Themeda triandra* Grassland could be interpreted as syntaxa of the higher syntaxonomical rank. This should be considerd in a synecological and syntaxonomical synthesis of the north western Orange Free State Grasslands. The dominant species in the three Variants of the *Era-*

grostis superba–Themeda triandra Grassland namely the *Eragrostis lehmanniana, Anthephora pubescens* and *Eragrostis trichophora* indicate some floristic affinity to the vegetation of the deep sandy soils of the Kalahari Gemsbok National Park (Van Rooyen *et al.*, 1988).

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南非 Orange Free 州西北部 A 土地型
深厚砂質土壤的植被

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　　本文係以植物社會學的方法來分析覆蓋南非 Orange Free 州西北部A土地型的植被。該區 80%以上的土地已被開墾過。以 23 個分層逢機樣區所收集到的樣分來表示自然植被的殘餘群落。以 TWINSPAN 的方法分類再用 Braun-Blanquet 的方法細加區分，某結果顯示有 5 個植物群落，所有的群落皆與特定的環境條件有關。文中並描述這些群落的特徵。