PHYTOSOCIOLOGY, VEGETATION STRUCTURE AND LANDSCAPES OF THE CENTRAL DISTRICT, KRUGER NATIONAL PARK

by

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PRETORIA

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Co-promotor: PROF. DR. M.J.A. WERGER

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Preface

"The song of a river ordinarily means the tune that waters play on rock, root, and rapid ..... This song of the waters is audible to every ear, but there is other music in these hills, by no means audible to all. To hear even a few notes of it you must live here for a long time, and you must know the speech of hills and rivers. Then on a still night, when the campfire is low and the Pleiades have climbed over rimrocks, sit quietly and listen for a wolf to howl, and think hard of everything you have seen and tried to understand. Then you may hear it - a vast pulsing harmony - its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rythms spanning the seconds and the centuries .... Parks are made to bring the music to the many, but by the time many are attuned to hear it there is little left but noise."

- Aldo Leopold (1949)

We are conserving, studying, managing and enjoying not only various components of nature but also their natural relationships. It is the task of the research ecologist in nature conservation to help create sensitivity towards natural harmony, inventorizing it for himself as a guide to further research; for conservation management personnel to whom the care of the precious commodity is entrusted; and also for the connoisseur who must satisfy his inherent need for harmony, joy and inspiration that virgin landscapes and the arts offer.

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ABSTRACT

Variation within the Kruger National Park Vegetation, at the broadest level, is essentially four dimensional. Twenty principal vegetation regions may be delimited by superimposing these four major types of variation. A Braun-Blanquet Type phytosociological classification identified: 15 differential species groups that are each shared by more than one association; a group of species that are essentially exclusive to individual associations; two groups that occur either too generally or too sporadically to form differential groups; and 12 associations. A new approach to classifying Bushveld physiognomic structure is offered. This system is based simply on canopy cover regime at three levels, using Braun-Blanquet cover classes. Emphasis and detail may be varied and an accompanying terminology, suited to casual and formal use, is provided. A hierarchical system for classifying vegetation-delineated ecosystems and their entire abiotic and vegetation components is offered. This system integrates several ecologically important climatic, physiographic and vegetation classifications currently in use. Twelve landscapes are accordingly identified and their climates, physiographic and vegetation patterns and medium to large herbivore faunas described. The inventory is offered as an information base and as a means of within and between group communication to scientists, conservation managers, information officers and public.

UITTREKSEL

Op die breedste vlak is die plantegroeivariasie in die Nasionale Krugerwildtuin basies vierdimensioneel. Saam het hierdie hooftipes variasie twintig breë plantegroeistreke tot gevolg. 'n Braun-Blanquet-tipe plantsosiologiese klassifikasie toon: 15 differensiërende spesiesgroepe wat elk in meer as een assosiasie voorkom; 'n groep spesies wat elk nagenoeg eie is aan individeule assosiasies; twee groepe wat òf te algemeen òf te sporadies voorkom om tussen assosiasies te onderskei; en 12 assosiasies. Fisionomiese struktuur in die Bosveld word met behulp van 'n nuwe benadering geklassifiseer. Die stelsel berus op kroonbedekkingsregime op drie vlakke en die gebruik van Braun-Blanquet-bedekkingsklasse. Klem en detail kan gevarieer word met 'n gepaardgaande terminologie wat geskik is vir formele en informele gebruik. 'n Hierargiese klassifikasiestelsel vir plantegroeigedefinieerde ekosisteme en hul abiotiese en plantegroeikomponente, word voorsien. Hierdie stelsel integreer 'n aantal ekologies nuttige klimaat-, fisiografiese- en plantegroeiklassifikasies wat tans in gebruik is. Twaalf landskappe is dienooreenkomstig geïdentifiseer en hulle klimaat, fisiografiese- en plantegroeipatroon, en medium tot groot plantvreterfauna, beskryf. Die inventaris word aangebied as 'n inligtingsbron en as 'n medium tot intra- en intergroepkommunikasie vir wetenskaplikes, natuurbestuurders, inligtingspersoneel en die publiek.

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6.3 *Sclerocarya caffra* - *Acacia nigrescens* - *Themeda triandra* - *Bothriochloa radicans* - dominated treeveld of lightly grazed gently undulating basaltic terrain with comparatively high pH and - high conductivity soils and A horizon clay content exceeding 20 per cent, in the relatively low rainfall region north of Tshokwane

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6.5 *Sclerocarya caffra* - *Dichrostachys cinerea* - dominated shrubby, brushy treeveld, and grassveld with scattered *Dichrostachys cinerea* - dominated shrub and brush; with *Themeda triandra* - *Panicum coloratum* - *Bothriochloa radicans* - *Digitaria eriantha* - dominated field layers; and with relatively xeric indicator species (e.g. *Acacia nigrescens, A. tortilis, Securinega virosa, Chloris virgata, Heliotropium steudneri* and *Boerhavia bracteosa*); of lightly grazed, gently undulating terrain with moderate sandstone influence and 15-20 per cent clay in A horizon

6.6 *Sclerocarya caffra* - *Acacia nigrescens* - *Combretum apiculatum* or *Acacia exuvialis* - *Bothriochloa radicans* - *Themeda triandra* - dominated treeveld of relatively strongly undulating, non-rocky, basaltic terrain

6.7 *Acacia nigrescens* - *Grewia bicolor* - *Terminalia prunioides* - *Combretum apiculatum* - dominated brushveld associated with extremely shallow soils where sheet outcrop is common and with strongly undulating terrain

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6.11 _Themeda triandra_ - _Panicum coloratum_ - dominated grassveld with scattered _Albizia harveyi_ shrubs, and _Albizia harveyi_ - _Dichrostachys cinerea_ - _Themeda triandra_ - dominated shrubveld and brushveld of lightly grazed, non-vertic non-sodic bottomlands that are mesic with relatively low soil conductivity and relatively high pH

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TABLE 2. SYNOPSIS OF CENTRAL DISTRICT VEGETATION, KRUGER NATIONAL PARK.

ASSOCIATION NUMBERS, E.G. 2=2.1			1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	5.3	5.4	6.1	6.2	6.3	6.4	7.1	7.2	7.3	8.1	8.2	8.3	9.1	9.2	9.3	9.4	10.1	10.2	11.1	11.2	12.1	12.2	
NUMBER OF RELEVES			008	006	006	009	005	004	005	008	006	014	007	020	006	004	009	017	032	017	008	005	032	009	006	007	016	016	017	009	004	011	003	004	00000000
GROWTH FORM PREFIX: F=FORB, G=GRASS, W=WOODY SU=SUCCULENT																																			
INDICATOR SPECIES GROUPS (SPP. NAMES, PRESENCE VALUES)																																			
DEFLOCCULATED SOILS-																																			
1-SODIC AND PUDDLED SOILS																																			
F	RUELLIA PATULA	58	5	3	3	3	3	3	2	2	2	*		2				+	2					+			+	*	*		2	+			
F	JUSTICIA FLAVA	53	4	5	4	3	+	4	4	+	+		+	2				*	*			+	*		4		*	+	+					2	
F	CYPHOCARPA ANGUSTIFOLIA	45	5	3	2	2	2	2	3	2				3	3				*					+					2						
F	PUPALIA LAPPACEA	36	4	5	2	3	4	3						2		2			*						2			+	*						
F	TEPHROSIA SEMIGLABRA	24	2	3	+	+	4	2	3	+				*			+		*				*					*							
W	RHUS GUEINZII	22	2	2	2	+	+		3					*	+		+	+		*			*		+		*								
2-SODIC SOILS																																			
W	EUCLEA DIVINORUM	45	5	4	+	3			4	2				*				2	2	*			*		2		*								
F	IPOMOEA COPTICA	33		5	3	2			4	4	+		+	*					2		+														
G	DACTYLOCTENIUM AEGYPTEUM	25	3	4	3	2			5	4									*		+														
W	CASSINE TRANSVAALENSIS	7	+	+		+			+	+				*					*																
W	SCHOTIA CAPITATA	6	2						2	+																									
SOIL TEXTURE-																																			
3-SAND, LOAMY SAND & SANDY LOAM SOIL PROFILES RAINFALL > 550MM																																			
G	TRICHONEURA GRANDIGLUMIS	60		+	+							4	5	5	4	3	3	3	*								*	*	*						
F	MELHANIA DIDYMA	58			3						2	2	3	4	3	3	2	3	+				*		3			*	2					2	
G	TRICHOLAENA MONACHNE	35			2							2	4	3	+		+	+	*						+				2						
G	RHYNCHELYTRUM VILLOSUM	31									+	2	2	+	4	5	3	2	*										*						
F	ECBOLIUM REVOLUTUM	9										2	+	+			+																		
4-SAND TO SANDY CLAY LOAM TOPSOILS, RAINFALL > 550MM																																			
G	POGONARTHRIA SQUARROSA	100		2	5	3			+	3	3	5	5	5	5		3	4	2	*							*	+	2						
G	ERAGROSTIS RIGIDIOR	95		4	5	4	+	4	3	2	3	4	5	4	3		2	+	4	+	+		*	+			+		*						
F	AGATHISANTHEMUM BOJERI	80		+	4	2			+	2	4	5	5	4	4	2	3	2	3	*		+	*												
G	BRACHIARIA NIGROPEDATA	79			5	2		2		+	4	4	5	3	5		5	4	+	+			*					+	+						
W	COMBRETUM ZEYHERI	74			3				+		4	5	5	4		3	5	3	3						+										
F	WALTHERIA INDICA	72	+	5	4	3		2		2	3	3	5	4	2			*	+									+	3			*			
F	KOHAUTIA VIRGATA	67		2	3	2			4	4	2	4	3	3	4			+	+	+			*	2		+		+	+	+		+			
G	SPOROBOLUS FIMBRIATUS	63	+	2	3	3		2	2	+	3	3	5	5			2	*	+	*							+	+	*						
F	POLYGALA SPHENOPTERA	59		+	3	+				2	+	3	3	4	4	3	2	*	2	*			*				*	+	+					2	
F	PHYLLANTHUS INCURVUS	52	2	+	3				+	+		4	3	2		4	2	+	2						2				+	+				2	
F	THUNBERGIA DREGEANA	48			3	+					3	3	4	3		5	+	+	2	*	+														
F	FIMBRISTYLIS HISPIDULA	45		2	3	2			2	+		4	2	2	5		2	2	*								*	*							
F	KOHAUTIA LASIOCARPA	30		+	2	+				3		2	3	+	+			*	+									+		+					

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9.6 *Combretum apiculatum* - *Digitaria eriantha* - *Panicum maximum* - *P. deustum* - dominated moderate to dense brushveld and shrubby, brushy sparse treeveld of moderate to steep middleslopes with scattered, low broken outcrop

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I. INTRODUCTION

Historical perspective

Col. James Stevenson-Hamilton had an epic statutory and administrative struggle as first Warden, to restore and safeguard the Kruger National Park wildlife for posterity (Tattersall, 1972; Stevenson-Hamilton, 1974; Hey, 1977). He knew and loved this heritage, devoting diligent attention to the natural and cultural histories of the area. These he documented, thoroughly covering the general character of the Lowveld, climate, geology, geomorphology, vegetation, the whole spectrum of animal life and the history of human occupation (Stevenson-Hamilton, 1929). His vegetation descriptions are lucid and synoptic with purposeful attention to prominent plants, medicinal lore, culinary uses, plant growth forms, vegetation physiognomic structure and seasonal vegetation changes, per community type. He stressed ecological interactions of vegetation with abiotic environment and animals. He identified fire as a major management problem and in his motivation of a proposed burning policy, a holistic ecosystem-orientated approach is quite clear (Stevenson-Hamilton, 1929). Despite his many and diverse responsibilities Col. Stevenson-Hamilton was substantially productive in every field of botanical enquiry subsequently persued, even after a research section was formally established with the appointment of a biologist on the 1st October, 1950.

"It does not require any very intimate or technical knowledge of trees to recognise them as living creatures, each species, if not each individual, possessed of likes and dislikes, sympathies and antipathies, love of solitude or love of company. As in the case of animals, it is the wild ones whose habits are the more interesting to study. Tame trees, like tame animals, have had their natural tastes cribbed, cabined and confined by man, and it is only in the remote wilderness that tree life, like animal life, may be studied as

Nature intended each to be" (Stevenson-Hamilton, 1929). This fact that "Over the land surface of the world there extends a mantle of vegetation, a living fabric of plant communities that is diverse and subtle in its response to environment, ..." (Whittaker, 1973) and that species evolved towards niche and habitat differentiation (Whittaker, 1970) is basic to vegetation science. It seems reasonable, therefore, to start vegetation studies in an area with a comprehensive inventory of plant species and, where the area is as large and varied as the Kruger National Park, to do a general or reconnaissance survey (<u>sensu</u> Edwards, 1972) of the major vegetation types. These were the lines persued by H.P. van der Schijff, who was the first botanist to be appointed in the Kruger National Park, and by the earlier contributors H. Lang and L.E.W. Codd.

Lang's first small published collection (Obermeijer, 1937) is referred to by Codd, who produced a successful guide to 333 of the tree and shrub species of the Kruger National Park (Codd, 1951). His guide also includes a general reconnaissance map. Van der Schijff's 4 000 specimen plant collection forms the core of the Kruger National Park herbarium at Skukuza, representing 1814 of the 1937 presently known flowering plants in the Park. Also eminating from his appointment, June 1951 to February 1955, are his floristic and phytogeographic accounts and a reconnaissance ecological survey of all major plant communities in the Park (Van der Schijff 1957a, 1958, 1959, 1964, 1968, 1969a & b). Further published contributions in these fields include supplementary check lists by botanist successors, Brynard (1961) and Van Wyk (1971a); and improved reconnaissance vegetation maps by Pienaar (1963), and by Van Wyk (1972, 1974) in his comprehensive description of the approximately 200 known tree species in the Kruger National Park.

The significance of man's inevitable control over fire in the Kruger National Park led to the National Parks Board of Trustees' decision to conduct its own fire research. In 1954 Van der Schijff designed and implemented a series of long term burning experiments, which have been re-examined and commented upon subsequently by: himself (Van der Schijff, 1958); and by A.M. Brynard (Anonymous, 1960); Davidson, Brynard, Gillard, Lecatsas & Leigh (1961); Van Wyk (1971a & b); Van Wyk & Wager (1968); Sarnak, Shapiro & Starfield (1977); Gertenbach & Potgieter (1979); and Webber (1979). The problems of fire in the Park were also discussed by Brynard (1964, 1971) and Van Wyk & Wager (1968).

Vegetation description to study the interaction between vegetation and animals, periodically received attention; e.g. by Van der Schijff (1959), Pienaar (1963, 1974), Van Wyk & Fairall (1969), Joubert (1976), Coetzee & Gertenbach (1977), Dayton (1978), Coetzee, Engelbrecht, Joubert & Retief (1979) and Engelbrecht (1979). Such descriptions have since 1977 also been included in comprehensive aerial surveys to monitor ecosystems (Joubert, unpubl.)

General vegetation monitoring was introduced into the Park in 1971 by P. van Wyk, then Chief Research Officer, who described the vegetation in parmanent quadrats. Some of these have been re-examined by Coetzee, Gertenbach & Nel (1977), who concluded (and I translate): "Before results obtained from monitor plots (and experimental plots generally) can be interpreted and generalized more successfully, it is essential that plant communities be described and mapped at semi-detailed level and on total species composition; also that communities be related to habitat and that the hierachical and reticulate relationships between communities be described, floristically as well as ecologically. This means, among other things, that the plant sociological, ecological and geographic indicator value of each plant species be determined. Any species, including subordinate forbs could conceivably relate to experimental results. Its indicator values, if known, may have value in interpreting experimental results and determining the level at which results may be extrapolated". These comments are applicable also to the burning experiments and any observation regarding vegetation composition, structure and functioning in the Kruger National Park.

Edwards (1972), referring to "agriculture and land use", remarked that "The lack of a formal classificatory system of vegetation has undoubtedly hindered the extrapolation of experimental results done upon a particular ecological system to similar examples of that system". The Braun-Blanquet School of phytosociologists regard it as largely a waste of time to undertake extensive ecological work on habitat factors controlling vegetation unless the particular composition of the vegetation is known and classified in wider context (Moore, 1962). Whittaker (1962) noted as "significant that some major developments in intensive ecological application have occurred in the [Braun-Blanquet School] and not among ecologists".

The need for a semi-detailed vegetation classsification system in the Kruger National Park was expressed when two such surveys were initiated in early 1974 by the Chief Research Officer at the time, P. van Wyk.[1] Such surveys have since been completed by Gertenbach (1978) and van Rooyen (1978). Another is reported in this thesis and others are in progress (Gertenbach, in prep. a & b).

- - - - - -

1. Mr. P. van Wyk, National Parks Board, P.O. Box 787, Pretoria 0001, South Africa.

Scope

The present treatise concerns assemblages of plants in the Central Ditrict of the Kruger National Park. Of particular interest are the species present, the amount of plant canopy at different heights, and the climates, geological formations, terrain forms soils and animals that sustain, and are sustained by, these plant assemblages. Three systems are proposed here as an inventory of such aspects of the vegetation and as an aid to uniform communication about them.

Communication about the vegetation often calls for an inventory of different types of species combinations, vegetation structure and vegetation-delineated ecosystems. It may be necessary to know where such types occur and to explain these occurrences. Consistent communication about the vegetation is also necessary when the manner in which animals and vegetation function, effects of fires, or changing climate, soils and land utilization, are referred to types of vegetation and types of ecosystem.

The three systems provided here are the following:-

1. Phytosociological classification system

The Braun-Blanquet Approach was followed to produce a classification system based on plant species assemblages. "Indicative explanations" establish an association between some characteristics of the environment on the one hand and the resulting species combinations on the other hand (cf. Bakuzis, 1959). The methods used are discussed in Chapter III and the results are presented in Chapter IV.

Once an assemblage of species has been classified, the classification system provides much additional information regarding that assemblage. However, users may find such identification cumbersome, because class definitions are based on numerous species, including inconspicuous and poorly known forbs and grasses. Easier access to the correct class is therefore provided through a cross reference in Chapter VII, which is about landscapes and landscape units. Identification is then mainly through dominant woody species.

Westhoff and van der Maarel (1973) use the term "floristic -sociological approach" to characterize the essential ideas in the Braun-Blanquet Approach. The sociological aspects of these ideas could readily apply also to classification systems based on attributes other than species and include the following (cf. Werger, 1974a):-

(a) Class members have many distinctive attributes in common because these, being influenced by powerful factors, are highly correlated. This principle is characteristic of general-purpose classifications (Gilmour & Walters, 1964).

(b) Class members need not necessarily possess one particular attribute or set of attributes for inclusion in a class, but rather show a "family resemblance", possessing any one of numerous sufficient subsets from a given set of attributes. Such "disjunctive" class definitions are appropriate where classification characters do not universally covary (Gilmour & Walters, 1964; Hull, 1964, 1965, 1970).

(c) The classification system is hierarchical including detailed and general levels. Where vegetation-habitat relationships are multi-dimensional, only detailed and therefore homogeneous classes have no alternative classificatory possibilities; for broader, more heterogeneous classes, several possibilities may exist; and a hierarchical arrangement merely draws attention to one such possibility. The Braun-Blanquet System displays one optimal hierarchy as well as alternative multi-dimensional relationships (Coetzee, 1974a).

(d) A nomenclatural system indicates hierarchical ranks in the names of species communities. This principle helps to integrate *ad hoc* classifications into a universal classification system and illuminates species communities at required levels of abstraction (Westhoff & van der Maarel, 1973; Mueller-Dombois & Ellenberg, 1974; Barkman, Moravec & Rauschert, 1976; Werger 1977).

(e) Correlated characters are grouped and categorized according to their indicator value (*sensu* Goodall, 1953) for the various classes and environmental attributes associated with these classes (Goodall, 1953; Westhoff & van der Maarel, 1973; Mueller-Dombois & Ellenberg, 1974; Werger, 1974a; Van der Meulen, 1979).

(f) Classes are constructed on the basis of sampling units representing the vegetation to be accommodated.

According to Westhoff and van der Maarel (1973): the floristic-sociological approach, classifying plant communities on species composition, may be traced back to several studies in the 1840's and 1850's; much of the development leading to what is known today as the Braun-Blanquet Approach, Zürich-Montpellier Approach and French-Swiss Approach took place in Zürich and Montpellier around the turn of the century; Braun-Blanquet later became its chief exponent and gave the Approach its final character between 1913 and 1932, whereafter it spread first through Western Europe and hence worldwide, including central, western, southern and eastern Africa in 1947, 1952, 1962 and 1968 respectively (Werger, 1977). The approach was thoroughly established in southern Africa by M.J.A. Werger when coming to South Africa in 1968 (cf. Werger, 1974a & b and Taylor, 1969; also Van Zinderen Bakker, 1971, 1973; Werger, 1972, 1973a & b, 1977; Werger, Kruger & Taylor, 1972a & b; Coetzee, 1972, 1974a & b, 1975; Müller, Werger, Coetzee, Edwards & Jarman, 1972; Coetzee & Werger, 1973; Leistner & Werger, 1973; Edwards & Werger, 1974; Van Zinderen Bakker & Werger, 1974; Bredenkamp, 1975 a & b; Bredenkamp & Theron, 1976, 1978;

Coetzee, van der Meulen, Zwanziger, Gonsalves & Weisser, 1976; Boucher, 1977, 1978; Bredenkamp & van Vuuren, 1977; Werger & Coetzee, 1977; Coetzee & Nel, 1978; Gertenbach, 1978; Gertenbach & Potgieter, 1978; van Rooyen, 1978; Weisser, 1978; Van der Meulen, 1979).

Throughout all but its most recent development, much of the Braun-Blanquet sampling and classification procedures were largely intuitive (Becking, 1957; Moore, 1962; Whittaker, 1962), vaguely explained in the literature and consequently, despite its success, opposed or ignored by statistical and other numerical ecologists (cf. Werger, 1974b, 1977). The traditional sampling procedures have since been clarified, e.g. by Moore (1962) and rationalized, e.g. by Coetzee & Nel (1978), and modern exponents of the Braun-Blanquet Method, such as Werger (1974a) are less dogmatic about the traditional sampling procedures, conceding that there is no fundamental objection to generally accepted sampling considerations. However, despite some recent contributions reviewed by Westhoff & van der Maarel (1973) and Werger (1974b), the "theoretical significance" (sensu Hull, 1970) of the classification procedure still requires considerable clarification. A contribution towards such clarification is offered in Chapter III.

On the other hand, the fidelity concept, wich was painstakingly developed in earlier years (Becking, 1957), proved to be inflated and is much less emphasized in modern application of the Braun-Blanquet Method (Moore, 1962, Mueller-Dombois & Ellenberg, 1974).

The well-developed nomenclatural system is still much in use, having just reached maturity (Barkman et al., 1976).

Despite theoretical difficulties, the Braun-Blanquet Approach has survived because of its usefulness (Whittaker, 1962) and holds much promise in applied vegetation science (cf. Werger, 1977), including nature conservation. Moreover, in addition to the *ad hoc* applications mentioned, any Braun-Blanquet Type survey is a contribution towards a uniform regional or national inventory of plant communities (cf. Werger, 1973a). The Botanical Research Institute of South Africa has adopted the Method for a National inventory of indigenous vegetation (Werger & Edwards, 1976).

2. Structural classification system

A new structural classification system was designed despite the many available. The system is presented in Chapter III. Gross structure is described and classified as it is thought to be most relevant to large mammals and to perception by man. Canopy regime at various height levels was chosen, in the first instance, as the best common denominator of browse, visibility, cover, obstruction and physiognomy and, in the second instance, for its simplicity. Application is flexible. While permitting formal communication, the system is readily manageable in compatable casual conversation. Descriptions may be brief or detailed and the parameters may be conveniently estimated or measured. The design also allows for selective emphasis on canopy regine at chosen height levels, according to purpose.

None of the systems reviewed by Beard (1973), Mueller-Dombois & Ellenberg (1974) and Barkman (1979), nor those presented by Boughey (1957), Tinley (1969), Greenway (1973), Edwards (unpublished), Walker (unpublished) and Walker & Edwards (unpublished) treat the specially selected characters in the chosen manner. In particular they neglect the importance of total canopy regime at each level: the contribution of tall growth forms to total canopy regime at lower levels is obscured or complicated. This factor cannot be ignored in Bushveld, where low-branching growth forms are characteristically common.

A technique was designed for measuring the parameters used in the classification presented here. This technique has been published (Coetzee & Gertenbach, 1977) and provides "for calculating per species, stem growth form and height class: (a) canopy regime at different height levels; (b) total projected canopy cover regime; and (c) density. Quadrat size is determined independently at each site for each height class to suit the density and distribution of plants."

3. A classification of landscapes

Chapters V-VII examine landscapes as vegetation-delineated ecosystems. Three categories of vegetation-delineated ecosystems are proposed, i.e.: (i) Landscape Units, wich combine to form (ii) Landscapes, which at a broader level form (iii) Ecological Provinces.

A landscape, in this context, has a characteristic mosaic of phytosociologically determined plant communities. Within one geomorphological province, such as the Lowveld, the nature of this mosaic depends largely on macro-climate and on climatically and geologically determined terrain form and soil pattern. Accordingly, the system presented provides for describing and naming the various ecosystem categories and their abiotic and vegetation components in a manner that integrates King's (1963) classification of Geomorphologic Provinces, Thornthwaite's classification of Thermal and Moisture regions (cf. Schulze & McGee, 1978), the "classification of land (climate, terrain form, soil)" by Mac Vicar, Scotney, Skinner, Niehaus & Loubser (1974), the phytosociological concept of the Association as the basic vegetation community (cf. Barkman et al., 1976) and Acocks' (1953) classification of Veld Types.

Joubert (unpubl.) does regular ecological aerial surveys to record and explain the distribution and densities of medium and large herbivores in the Kruger National Park. Chapter V explains how Joubert's (op. sit.) data and Correspondence Analysis (cf. Greenacre, 1978) was used to describe the medium and large herbivore communities of the various landscapes. The results of this analysis are presented in Chapter VI. Chapter VII then discusses each of the Central District Landscapes in turn, dealing with the climate, the physiographic and vegetation patterns and the medium and large herbivore fauna.

There have been major shifts in emphasis in South African vegetation descriptions towards Braun-Blanquet Type phytosociological surveys or various numerical classification and ordination studies (cf. Killick, 1968; Werger & Edwards, 1976). Studies in the earlier tradition emphasized the typical range and pattern of plant communities pertaining to each of a number of distinct major areas, such as "vegetation belts" (Killick, 1963; Scheepers, 1977) and "ecological regions" (Edwards, 1967). Van der Schijff (1957) described the patterns within similar major regions and called these major regions "plant communities". Edwards (1967) stated that such "regions correspond closely to the physiographic landforms of Fair (1955), who pointed out the close relationship between physiography, climate and vegetation...". Successional theories stimulated studies in this earlier tradition. These theories provided a useful framework within which to examine vegetation-habitat relationships. The successional theories also stimulated emphasis on the manner in which different communities contribute to the distinct pattern of their shared "ecological region".

The more recent trends in vegetation description free the study of vegetation-habitat relationships from the encumbrance of successional theory, allowing the "straightforward factual description of what the observer sees with less theorizing about possible courses of succession", referred to by Killick (1968). These recent trends also thoroughly investigate the phytosociological similarities and differences between communities, and correlate these with habitat features regardless of how the various communities may be geographically related. However, there seems to be a tendency now towards pre-occupation with these later benefits at the expense of clear descriptions of the manner in which phytosociologically different communities are geographically interdependent.

The present attempt to formalize the description of ecological regions and their internal patterns, is an acknowledgement of the necessity to integrate purely phytosociological ecology and landscape ecology.

II. VEGETATION OF THE KRUGER NATIONAL PARK AND ITS CENTRAL DISTRICT IN BROAD ECOLOGICAL PERSPECTIVE

The Kruger National Park occupies 19 500km^2 in the north-eastern corner of the Republic of South Africa. The Kruger National Park is situated along the boundaries with Zimbabwe and Mocambique. The climate, according to the Thornthwaite System, is Subhumid to Arid, Subtropical and Tropical (Schulze & McGee, 1978) and the vegetation is deciduous Bushveld (Werger & Coetzee, 1978). Variation in vegetation within the Kruger National Park is largely related to rainfall and to soils as influenced strongly by rainfall, geology and geomorphology.

Climate

The dry-tropical climate influences and controls all wildlife and agriculture and thus also most human endeavour in the Eastern Transvaal Lowveld, which is the name given to the low hot country in which the Kruger National Park is situated.

Average annual total radiation for the Lowveld is between 400 and 450 cal/cm^2/day. Of this, between 150 and 175 cal/cm^2/day is diffuse (Schulze, 1965). The average duration of bright sunshine is between 40 and 60 per cent of the astronomically possible during midspring to early autumn (October to March) and 70-90 per cent from late autumn to late winter, i.e. May to August (Weather Bureau, 1950).

The following temperature data for the Lowveld were taken from Schulze (1965):- Average daily maximum temperatures are of the order of 30°C in January and 23°C in July. Daily maximum temperatures exceed 30°C on an average of more than 120 days per year. Extremes can reach 43°C in January and 35°C in July. Average daily minimum temperatures are about 18°C in summer and 8°C in midwinter, whilst extremes drop to 7°C in summer and -2°C in winter. Frost is virtually confined to river valleys.

Monthly mean relative humidity at 14h00 S.A.S.T., for the Kruger National Park area, varies from 30-40 per cent during midwinter to early spring (July-September), to between 40 and 60 per cent during the other nine months (Schulze, 1965).

According to rainfall data supplied by Schulze (1965) and the Weather Bureau(1957), normal annual rainfall within the Park ranges between 400mm and 700mm (cf. also Webber, 1979; Gertenbach, 1980). The rainfall is lowest toward the Limpopo and Olifants Rivers, particularly in the area between them towards their confluence. These two rivers have cut hot dry valleys through the coastal escarpment into the interior of South Africa. Rainfall within the Park increases with altitude towards the mountains of the Drakensberg Escarpment in the south-west and the Soutpansberg in the north-west. The rainy season lasts from late spring to early autumn (November-March) and 80-90 per cent of the annual rainfall is received during the six month period October-March. The rainfall is variable and in only 65-70 per cent of all years does the annual rainfall exceed 85 per cent of the normal. Data ranging over more than 60 years show marked wet-dry oscillations with full wave lengths of the order of 20 years each (Dyer, 1976; Tyson & Dyer, 1978).

The bulk of the rainfall in the Kruger National Park results from thunderstorms and instability showers (Schulze, 1965). At the start of the rainy season, dry electric storms accompanied by strong winds commonly cause vegetation fires (Van der Schijff, 1957a). Several such natural fires may occur in one early season (Gertenbach*, unpubl.data). [1]

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Physiography

The following brief summary of the geological history, geomorphological history and soils of the Kruger National Park has been compiled from Dept. of Mines (1970), Hamilton & Cooke (1965), Harmse (1978), Haughton (1969), King (1963, 1978), MacVicar (1973), Mountain (1968) and Schutte (1974a & b):-

The Kruger National Park is situated on gently rolling plains, 200-400 m in altitude, below the eastern escarpment of a high temperate plateau. In restricted areas in the Park, eroding remnants of the retreating escarpment reach up to 840m altitude. The low plains are undulating and sandy, with occasional inselberge, in the west; and flat and clayey, terminated by a range of hills, in the east. This scenery was produced by cycles of erosion operating over the vast, flat, mid-Tertiary "African", plains and later surfaces, following periods of continental uplift with steepening coastal areas. The last major rock formation of the Lowveld had been formed long before in Jurassic times.

Sediments of the Karoo System, which in most of the Lowveld rest on Basement Granite, were deposited in broad subsiding basins of the Gondwanaland super-continent. This deposition started with glacial conditions in the late-Paleozoic and continued through desert conditions in the Triassic, possibly as the land mass drifted across the South Pole towards the tropics. The result was a flat Gondwanaland, worn down to the plains of the deposition areas and their eroded sides. A ring of coastal mountains encircled the continent.

Extensive outpouring of early Jurassic lavas over the Karoo sediments, foreshadowed the breaking up of Gondwanaland. When this happened, early Cretaceous drainage toward the newly created African coastline initiated the first "post-Gondwana" erosion cycle of pediplanation by river incision and scarp retreat. During a subsequent cycle, lasting uninterruptedly for 80 million years from mid-Cretaceous to mid-Tertiary times, southern Africa was worn down to a single vast peneplain. This destroyed virtually all Mesozoic surfaces.

Then, a mid-Tertiary continental uplift started the first of a series of similar erosion cycles that produced the presentday Great Escarpment and Lowveld. Differential uplift of the coastal areas led to the formation of a slight interior basin with internal drainage. This, coupled with steep monoclinal flexing of the continental margin owing to the uplift, favoured escarpment formation on the coastal side of the divide. Such flexing also tilted the Mesozoic sediment and lavas, which now dip towards the east coast at 10-30°. Subsequent erosion exposed from east to west the following layers in the Kruger National Park:-

(1) Cretaceous Deposits, comprising sandstone, shale, limestone and marl and known as the Malvernia Beds, being an extension of the Mocambique coastal plain, occur in the low-lying north-eastern corner of the Park. Most of this plain is covered by a Quarternary sand deposit.

(2) Rhyolite of the Lebombo Stage of the Stormberg Series, Karoo System of Jurassic age, forms a low rocky range of hills on the eastern boundary of the Kruger National Park. Other ridges occur in the basaltic area (see Par. 3). The Lebombo Mountains and the ridges rise above the adjacent basaltic lowlands entirely as a result of the superior resistance of rhyolite to erosion. The rhyolitic lavas were bevelled by an earlier erosion plane,

which, owing to repeated uplift and tilting now slopes eastward at 2-3°. Several east-flowing rivers cut directly across the protruding rhyolite without deviating, indicating that this superimposed drainage dates from the late-Tertiary landscape, before the summit bevel was uplifted and tilted.

(3) Jurassic basalt of the Drakensberg Stage of the Stormberg Series, Karoo System, underlies a flat landscape with black and red montmorillonite clays and weakly developed, shallow, calcareous clays.

(4) A narrow zone of late-Palaeozoic to mid-Mesozoic sediments of the Karoo System occurs over much of the length of the middle eastern parts of the Kruger National Park. This includes sandstone, shale, mudstone, grit and good quality coal, of the Ecca and Stormberg Series. The landscape is generally low and flat and the soils mainly solonetzic and planozolic. Cave Sandstone of the Stormberg Series forms a rocky plateau in the northern end of the Kruger National Park.

(5) Pre-Karoo lavas and sediments of the Waterberg System remain in the extreme north-west of the Park, extending into the Kruger National Park as the eastern end of the Soutpansberg Range. The Range and its hills in the Kruger National Park are formed of Waterberg Sandstone. The associated andesitic lava formed a flat plain south of the sandstone whereas interstratified quartzite forms prominent hills. Soils on the plain are red and loamy.

(6) Isolated syenitic intrusions of the Phalaborwa Igneous Complex also form hills in the Archaean Granite-Gneiss area.

(7) An olivine-gabbro intrusion, distributed throughout the Swaziland System and Archaean Granite-Gneiss, formed flat clayey plains as well as occasional hills and ridges, in the western region.

(8) Xenoliths of schist, banded ironstone, sediments, amphibolite and undifferentiated metamorphic rocks of the Swaziland System, occur throughout the Kruger National Park in Archaean Granite-Gneiss. The Swaziland System comprises the most ancient rocks of the Archaean Complex in southern Africa. In the Kruger National Park these rocks have eroded to flat plains with red loamy soils.

(9) Archaean Granite-Gneiss forms local mountains and occasional inselberge and underlies a gently undulating landscape with mainly weakly developed sands and loams. These are commonly calcareous in bottomland sites. Red fersiallitic soils occur in the higher rainfall parts and solonetzic and planozolic soils are common throughout in bottomlands.

Bushveld

Bushveld, in a broad sense, is a region characterized by an inseparable admixture of climate, landscape, fauna and culture; particularly culture that is intimately linked with the natural environment. Examples are the lifestyles of its primitive societies and more recent occupants, attuned to Bushveld rhythms (cf. Malan, 1962; White, 1954), its history of adventurous European pioneering days (cf. Bulpin, 1974; Fitzpatrick, 1953) and its agriculture (cf. Bonsma, 1976; Dept. Landbou-tegniese Dienste 1964; Oosgrense Boere-adviesraad, undated; West, 1955). The full flavour of this "Bushveld" not only lends itself to romantic expression but also demands such treatment.

However, the term "Bushveld" is derived from - and used, as here also for the region's vegetation consisting of trees and/or shrubs and a layer of grasses and forbs (cf. Acocks, 1953, 1975; West, 1955; Van Wyk, 1971b; Werger & Coetzee, 1978; Van der Meulen, 1979). Although a wide range of structural variation is included, much of the woody component is distinctively low-branching and of medium to small height (cf. Van Wyk, 1971b).

Bushveld belongs to the Zambezian Domain of the Sudano-Zambezian Region, which is one of the major sub-divisions of the African Paleotropis (Werger, 1978; Werger & Coetzee, 1978). This Domain has a seasonal summer rainfall that varies mainly from Arid to Dry subhumid in Tropical parts and from Semi-arid to Moist subhumid in Temperate areas (cf. Schulze & McGee, 1978). The Domain is climatically distinct from adjoining regions, i.e. the:

Arid-temperate Karoo-Namib Region;
Afromontane Region, which is more humid at more equable temperatures than the Zambezian Domain;
Humid Tropical Guineo-Congolian Region; and
Indian Ocean Coastal Belt (cf. Werger, 1978).

The Zambezian Domain may be divided into three major zonal vegetation provinces, related to distinct moisture and temperature regimes (cf. Schulze & McGee, 1978; Werger & Coetzee, 1978):-

(1) Woodland, which is usually distinctly moist-tropical is typically a dense stand of trees with long straight boles. Such vegetation predominates over southern Africa north of the Limpopo-Shashi, Makarikari and Okavango drainage systems. Climates here vary from Subhumid to Humid; and from Tropical and Subtropical to lightly frosty Warm-temperate.

(2) Bushveld grows in drier and/or somewhat cooler conditions, found mainly to the south of the former province and as enclaves in dry, hot river valleys within the predominantly woodland province. This is presumably why Bushveld is low and why, through early and regular damage to sensitive growing points, woody plants branch closer to the ground. These effects are enhanced by regular fires, which prune the slowgrowing woody plants, at the same time stimulating profuse coppicing. Bushveld climates range from Dry subhumid to Arid and include Tropical as well as moderately frosty Temperate regimes.

(3) Grassland clothes the uncultivated areas on the high Cool-temperate, Humid to Subhumid South African plateau. Summers here are hot and rainy and winters dry and moderately to severely frostly with regular natural and man-made fires. This combination precludes woody species of the nearby Bushveld, while a specially adapted "Highveld" woody flora is largely lacking. Summers produce tall dense grassland, which provides much fuel. Whatever woody plants might become established in summer, would be quick-growing and slender and thus highly susceptible to the harsh winter combination of drought, severe frost and fire.

Werger & Coetzee (1978) distinguish four major physiognomic types of Bushveld. These occupy different positions on a moisture gradient determined by rainfall and soils:-

(a) Broad-orthophyll Mesophytic Bushveld occurs in Semi-arid to high rainfall areas on loose sandy soils. Such soils promote well-aerated moist conditions, favourable to broad-leaved mesophytic tree and shrub growth (Grunow, 1965).

(b) Microphyllous Thorny Bushveld (Thornveld) woody plants, have compound pinnate leaves with small sclerophyllous leaflets and with thorns that are mostly modified stipules. The vegetation is adapted to the relatively dry, clayey, soils (Grunow, 1965) of Semi-arid to Subhumid climates and in Arid climates occurs also on sandier soils.

(c) Spiny Arid Bushveld has woody plants with small leaves and conspicuous, short, hard, stubby or thorny branchlets on long drooping or profusely branched stems. This bushveld grows on skeletal and shallow calcareous or otherwise arid soils in Semi-arid and Arid climates.

(d) Broad-Sclerophyll Arid Bushveld is dominated by Colophospermum mopane which has broad leathery leaves and other xerophytic characters such as resins, volatile oils and adaptive movements (cf. Coates-Palgrave, 1977). This vegetation occurs in the most arid parts of the Sudano-Zambezian Bushveld, such as the hot and dry Limpopo-Shashi River valley (cf. Werger & Coetzee, 1978).

Based on these, as well as floristic differences, Werger & Coetzee (1978) distinguish eight main classes of Bushveld. The floristic differences are largely related to further moisture gradients and differences in temperature regime. All except the first major type, occur in the Kruger National Park:-

(1) Temperate Subhumid Mountain Bushveld occurs on the mountains of the low interior South African plateau and includes a range of Bushveld types from cool and moist to warm and dry.

(2) Subtropical Subhumid Mountain Bushveld occupies the rolling foothills of the eastern continental escarpment where the normal annual rainfall approximates or exceeds 700mm.

(3) Broad-orthophyll Plains Bushveld is typical of the Semi-arid to Dry Subhumid Bushveld plains with 500-700mm annual rainfall. Outliers also occur in drier climates on deep, extremely sandy soils. Variations range from various *Terminalia sericea* - dominated communities to communities dominated by *Combretum* spp. *Terminalia sericea* - dominated communities include: (a) Temperate Subhumid; (b) Temperate Semi-arid; (c) Subtropical, Subhumid; and (d) Tropical Subhumid and Arid variations. *Combretum* spp. - dominated communities are grouped into: (a) a Semi-arid Tropical type of the Eastern Transvaal Lowveld; and (b) a Subhumid, Warm temperate type of the low interior plateau.

(4) Microphyllous Thorny Plains Bushveld includes:

(a) *Acacia nigrescens* Tropical Plains Thornveld, on Semi-arid Tropical Plains below the eastern continental escarpment and in low-lying areas of the interior;

(b) *Acacia tortilis* - *Acacia karroo* Subhumid Temperate Plains Thornveld, of the interior;

(c) *Acacia mellifera* Dry Warm temperate Plains Thornveld, also of the interior;

(d) Acacia erubescens Thornveld, occurring in dry sandy and stony areas and in clayey ferruginous areas, both tropical and temperate (cf. Scheepers, pers. com.); and[2]

(e) various Brackish Lowland Thornveld communities on sodic clayey soils.

(5) Dry Mountain Bushveld has variations that are closely related to Broad-orthophyll and Microphyllous Thorny Plains Bushveld, as well as more distinct variations amongst broken outcrop in Semi-arid and Arid regions.

(6) Arid Mountain Bushveld is an Arid, Tropical type dominated by broad-sclerophyll Androstachys johnsonii.

(7) Spiny Arid Bushveld occurs in Arid areas.

(8) Broad-sclerophyll Arid Bushveld dominated by Colophospernum mopane, occurs in the driest Bushveld regions.

Floristic composition and various multi-dimensional relationships between these major Bushveld Types are discussed in some detail by Werger and Coetzee (1978) and will be referred to or elaborated upon here, where applicable, in subsequent sections.

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Kruger National Park Vegetation

Variation within the Kruger National Park Vegetation, at the broadest level, is essentially four-dimensional. Twenty principal vegetation regions may be delimited by superimposing these four major types of variation.

Four major dimensions of variation

1. Rainfall

A rainfall gradient is responsible for three broad bushveld zones:-

(a) Subhumid regions

The normal annual rainfall is between 700mm and 800mm where the Kruger National Park touches the foothills of the Soutpansberg Range in the north-west and the Drakensberg Escarpment in the south-west. These two extremities of the Kruger National Park belong to a continuous zone of Subtropical Subhumid Mountain Bushveld, which runs outside the Kruger National Park along the Drakensberg and Soutpansberg foothills (Fig. 1). This zone has been mapped as Acocks' (1953) Lowveld Sour Bushveld. Subtropical Subhumid Mountain Bushveld species shared by the fractions of this zone in the Kruger National Park, include the woody plants *Annona senegalensis*, *Parinari curatellifolia* subsp. *mobola*, *Albizia versicolor*, *Piliostigma thonningii*, *Pterocarpus angolensis*, *Antidesma venosum*, *Combretum collinum* subsp. *gazense* and *Pavetta schumanniana* (cf. Coates Palgrave, 1977; Van Wyk, 1972, 1974). Woody species that are common to Temperate and Subtropical Subhumid Mountain Bushveld also occur in these two areas (cf. Coates Palgrave, 1977; Van Wyk, 1972, 1974). Examples are *Ficus sonderi*, *Zanthoxylum capense*, *Heteropyxis natalensis*, *Dombeya rotundifolia*, *Combretum molle*, *Bequaertiodendron magalismontanum* and *Vangueria infausta*. Additional exclusive affinities of the northern Subhumid Region with Temperate Subhumid Mountain Bushveld include the presence of *Burkea africana*, *Pseudolachnostylis maprouneifolia*, *Ozoroa paniculosa*, *Ochna pulchra* and *Diplorhynchus condylocarpon*.

The southern Subhumid region is linked to Temperate Subhumid Mountain Bushveld by, e.g. Celtis africana, Faurea saligna, Acacia caffra and Olea africana.

(b & c) Arid and Semi-arid regions

The normal annual rainfall decreases from 700mm and higher in the Subhumid regions to between 500mm and 400mm in the low-lying Arid Region between the Limpopo and Olifants rivers. This rainfall gradient is steep in the north where the Arid Region is separated by a relatively narrow Semi-arid zone from the northern Subhumid Region. The transition from the Arid Region to the Southern Subhumid Region is much more gradual and includes a broad Semi-arid Region with 500-700mm annual rainfall.

The Arid Region differs from the Semi-arid Region in the pattern of substrate-vegetation relationships, which is dealt with more fully in the following section. The major species involved is Colophospermum mopane, which is the dominant woody species in all landscapes of the Arid Region and entirely absent from the Semi-arid Region (cf. Van Wyk, 1972). In its wider distribution C. mopane characterizes one of the most arid tropical Bushveld types. The other such type, Spiny Arid Bushveld, is also present in the Arid regions of the Park and a typical species combination may include one or more of the following: Boscia albitrunca, Commiphora glandulosa, Sterculia rogersii, Terminalia prunioides, Rhigozum zambesiacum, Sesamothamnus lugardii and Gardenia resiniflua, which in the Semi-arid Region occur only in special dry habitats such as on brackish clayey soils.

Adansonia digitata is also associated with the arid parts of the Kruger National Park. The species occurs on granitic plains, in the northern sandy areas and on the rhyolitic Lebombo Mountain Range, but in all three instances only in the Arid Region.

A number of species distinguish Dry Mountain Bushveld of the Arid Region from Dry Mountain Bushveld in the Semi-arid Region. These include Ficus tettensis, Hexalobus monopetalus, Albizia brevifolia, Kirkia acuminata Entandophragma caudatum, Bridelia mollis, Sterculia rogersii, Strychnos decussata, Hymenodictyon parvifolium and Brachylaena huillensis. To these may be added Androstachys johnsonii, which characterizes Arid Mountain Bushveld.

Riparian species typical of the Arid Region include Hyphaene natalensis found mainly in the basaltic area, Acacia albida and Croton megalobotrys.

Sclerocarya caffra is common in the Subhumid and Semi-arid regions and relatively scarce in the Arid Region.

2. The phytogeographical importance of temperature

Another major dimension of variation is phytogeographical and related to temperature. Although two phytogeographic units may be related to a temperature difference, the exact position of boundaries may be influenced over some distance by secondary factors such as the soil and moisture preferences of the species involved. Thus a number of distinctly tropical species occur on sand and amongst sandstone outcrops in the northernmost region of the Kruger National Park; and several temperate species may be found in the two Subhumid mountainous areas in the north-west and south-west.

River banks, sandy outcrops, sand and termitaria are all favourable to mesophytic tree and shrub growth and in the Bushveld region quite a number of woody species characteristically occur in two or more of these related habitats. Common examples from the Kruger National Park include (cf. Van der Schijff, 1957a; Van Wyk, 1972, 1974): Schotia brachyptala, Zanthoxylum capense, Phyllanthus reticulatus, Bridelia micrantha, Berchemia discolor, Ochna natalitia, Euclea natalensis, Diospyros mespiliformis, Ehretia rigida and Kraussia floribunda.

Such habitat similarity might explain why a distinct tropical flora, which migrated along the Limpopo River (Codd, 1951; Van der Schijff, 1964, 1969a & b, 1971), is found mainly on adjoining sandstone areas and sand deposits in the north of the Kruger Nationa Park. Examples of this tropical element are provided by the latter authors as well as by Van Wyk (1972, 1974) and Van Rooyen (1978):- It seems, from the distribution maps and habitat information provided by Coates Palgrave (1977) that Baphia massaiensis subsp. obovata, Xylopia odoratissima and Pterocarpus lucens subsp. antunesii came down the Limpopo Valley from the West. B. massaiensis is dominant on - and also largely restricted to an Arid Quaternary Sand plateau in the north-eastern corner of the Park. Commiphora edulis occurs to the west along the Limpopo River as well as in the adjoining upper Save Valley. The following examples probably came upstream from the east and commonly grow on sand and along rivers in tropical regions: Guibourtia conjugata, Cleistanthus schlechteri and Pteleopsis myrtifolia. Species that extend from adjacent tropical regions in the north onto this sandy and rocky area include: Ostryoderris stuhlmanni, Crossopteryx febrifuga, Boscia angustifolia var. corymbosa, Stadmania oppositifolia subsp. rhodesica and Hymenocardia ulmoides.

Both the northern and southern Subhumid Mountain Bushveld regions are linked by moist Temperate mountain ranges with Temperate Subhumid Mountain Bushveld of the interior pleateau. The species shared with the interior Bushveld and listed in the previous section as examples of Subhumid affinities, also illustrate temperate relationships.

An altitudinal gradient from Subtropical to Temperate exists up the granitic mountains in the south-western Subhumid corner of the Kruger National Park. The Subtropical Subhumid Mountain Bushveld here is unique for the Park and is characterized by a group of woody species with an extremely restricted far-southern African distribution (cf. Coates Palgrave, 1977; VanWyk, 1972, 1974). The following are illustrative: Acacia davyi, Kirkia wilmsii, Sterculia murex, Galpinia transvaalica, Combretum kraussii, *Terminalia phanerophlebia* and *Manilkara concolor*. Near summits the Subtropical Bushveld grades into Moist Cool-temperate Grassland, characterized by *Tristachya hispida*.

3. Geologically controlled topography and substrate

Substrata, as determined by geology and associated topography, contributes another major dimension of variation.

(a) Outcrop

The Kruger National Park has a distinct outcrop flora occurring on hills and ridges of various geological formations. Included are the sandstone uplands and quartzite hills in the north; the rhyolitic Lebombo Mountain Range and granophyric ridges in the east; granite inselberge and gabbro and syenite hills and ridges throughout the western half of the Kruger National Park; and the granite mountains in the far south. Distributions within the hilly regions are in many instances affected also by climate so that hilly species form four distinct groups:-

(i) One group has a wide distribution over hilly areas and include *Ficus ingens*, *F. soldanella*, *Olax dissitiflora*, *Acacia erubescens*, *Croton gratissimus* var. *gratissimus*, *Euphorbia confinalis*, *E. cooperi*, *E. tirucalli*, *Cussonia spicata*, *Steganotaenia araliacea* and *Strychnos spinosa*.

(ii) A second group is partial to hilly terrain in the Arid Region as mentioned in discussing vegetation responses to rainfall.

(iii) The third group occurs in hilly sandy terrain in the northernmost corner of the Kruger National Park, where it contributes also to the distinctly tropical character of this area. A species list is given in the section on phytogeographic variation in relation to temperature.

(iv) Fourthly, the granite mountains in the south-western extremity of the Kruger National Park have a Subtropical combination of hilly species that is unique in the Kruger National Park. These species are also listed in the section on phytogeographic variation.

(b) Sandstone and sand deposits

The distinct vegetation types occurring in the northernmost region of the Park are on sandstone of the Waterberg and Karoo Systems and on Quaternary sand deposits. Some of this geological influence is through orographic high rainfall towards the hills, as mentioned in discussing the role of rainfall. However, the geologically determined sandy substrate is also of prime importance, in conjunction with a tropical influence. The influence of sand and the species involved are treated in the section of phytogeographic variation. Sandy soils are prerequisites for, or conductive to, the occurrence of *Burkea africana*, *Afzelia quanzensis*, and more so, *Monodora junodii*, *Xylopia odoratissima*, *Xylia torreana*, *Guibourtia conjugata*, *Baphia massaiensis*, *Ostryoderris stuhlmannii*, *Hugonia orientalis*, *Hymenocardia ulmoides*, *Cleistanthus schlechteri*, *Pteleopsis myrtifolia* and others.

(c) Differences on the plains

Geological differences also underlie major patterns of variation in Bushveld of the plains. As in the case of the hills, these patterns are also affected by climate.

(i) Semi-arid plains

Broad-orthophyll Plains Bushveld and Microphyllous Thorny Plains Bushveld prevail in the Semi-arid Region. Broad-orthophyll Plains Bushveld, dominated by *Combretum zeyheri*, *C. apiculatum* and *Terminalia sericea*, occurs on sandy upland sites of granitic undulations and rhyolitic and granophyric hills. Brackish Thornveld occurs on solonetzic clayey soils of granitic bottomland sites and of Karoo sediments. Sandy soils on Karoo sediments carry Terminalia sericea, Combretum zeyheri, Dichrostachys cinerea and Albizia petersiana communities. Acacia nigrescens Tropical Plains Thornveld occurs in granitic bottomlands, on clayey pediment slopes below rhyolitic summits and on flat clayey doloritic and basaltic peneplains.

(ii) Arid plains

Combretum - dominated Broad orthophyll Plains Bushveld occurs on sandy granitic upland sites in the Arid Region, but broad-sclerophyll Colophospermum mopane is often prominent in this vegetation. Clayey granitic bottomlands, clayey soils on Karoo sediments and flat clayey doloritic and basaltic plains have Broad-sclerophyll Arid Bushveld dominated by Colophospermum mopane.

4. Rivers and streams

The fourth major dimension of variation in the Kruger National Park concerns the marked difference between zonal vegetation (sensu Walter, 1970) and the azonal riparian vegetation of streams and rivers. Distinct herbaceous and woody azonal communities occur (cf. Van der Schijff, 1957a). The woody vegetation is tall and dense Riparian Bush. Some riparian species are influenced also by geology and/or climate, e.g. (Van Wyk, 1972, 1974): Acacia xanthophloea occurring only on basalt; Hyphaene natalensis being typical of streams in the arid basaltic region; Xanthocercis zambesiaca, Bridelia micrantha and Berchemia discolor associating with granite; and Acacia albida and Croton megalobotrys occurring only along streams of the arid region. The majority of typical riparian woody species in the Kruger National Park are widely distributed and include

(Van Wyk, 1972, 1974): _Phoenix reclinata, Ficus sycomorus, Acacia robusta, Schotia brachypetala, Ekebergia capensis, Trichilia emetica, Garcinia livingstonei, Syzygium cordatum, S. guineense, Mimusops zeyheri, Diospyros mespiliformis, Nuxia oppositifolia, Rauvolfia caffra, Breonadia microcephala_ and _Kigelia africana_.

Twenty major vegetation regions

The result of superimposing all the variation discussed in the previous section, is a pattern that closely corresponds with Van Wyk's (1972) vegetation map of the Kruger National Park. The various regions comprising this pattern are informally named with Van Wyk's (_op. cit._) synonyms quoted in parantheses. The vegetation type terminology used in discribing the regions is after Werger & Coetzee (1978). The regions, grouped according to rainfall, are the following:-

A. Azonal Region

Rainfall is of secondary importance only, along stream banks.

1. Riparian

Conspicuous riparian bush or elements thereof and various riparian forb communities, are common throughout the Kruger National Park. Numerous woody species contribute to a quite distinct vegetation. Riparian bush of the Arid Region differs in composition from that of the Semi-arid Region and the sections through the granitic plains differ from those on the basaltic plains. The riparian bush in the basaltic region is also characteristically sparse in cover.

B. Subhumid regions

Normal annual rainfall in these regions approaches or exceeds 700mm.

2. Subhumid Plains

("Terminalia/sicklebush veld")

These are the undulating granitic plains in the area around Pretoriuskop. The soils are sandy and highly leached and the vegetation is mainly Broad-orthophyll Plains Bushveld, dominated by Subtropical Subhumid *Terminalia sericea* Sandveld. The Region shares several species with nearby Subtropical Subhumid Mountain Bushveld of the Drakensberg Escarpment foothills, as well as a few species with Temperate Subhumid Mountain Bushveld of the interior plateau.

3. Southern Subhumid Hills and Mountains

("Mixed montane vegetation")

Included here are the hills and mountains around Malelane. The vegetation is mainly Subtropical Subhumid Mountain Bushveld characterized by several species with a particularly restricted far-southern African distribution. At high altitudes the vegetation grades into Moist Cool-temperate Grassland.

4. Northern Subhumid Hills and Mountains

("Punda Milia sandveld")

The Punda Milia hills are formed by sandstone of the Waterberg System. The vegetation is typically a mosaic of three communities (Coetzee, Gertenbach & Joubert, 1978; Van Rooyen, 1978):- (a) Rocky sandstone summits are dominated by *Kirkia accuminata*, *Afzelia quanzensis* and *Combretum apiculatum*, which are a rather typical Dry Mountain Bushveld combination. (b) Arid Mountain Bushveld with _Androstachys johnsonii_ is dominant on dry sheet outcrop. (c) Subtropical Subhumid Mountain Bushveld with _Burkea africana, Pteleopsis myrtifolia_ and _Pseudolachnostylis maprouneifolia_ as the most prominent woody plants, occurs on leached sandy soils. The latter community has distinct Subhumid, Tropical and Temperate, affinities.

C. Semi-arid Regions

These regions have a normal annual rainfall of 500-700mm.

5. Semi-arid Granitic Plains

("Red bush-willow veld")

The south-western quarter of the Kruger National Park, between the Crocodile and Timbavati Rivers, is largely undulating granitic country with 500-700mm rainfall. Broad-orthophyll Plains Bushveld predominates on sandy upland sites and Microphyllous Thorny Plains Bushveld predominates in clayey bottomlands. The most common dominent woody species in broadleaved communities are _Combretum apiculatum, C. zeyheri_ and _Terminalia sericea_. Bottomlands have _Acacia nigrescens_ Tropical Plains Thornveld, with _Acacia gerrardii, Combretum hereroense_ and _C. imberge_, as well as Brackish Thornveld communities, dominated by _Acacia grandicornuta, Acacia tortilis_ and others. Upland and bottomland communities are often separated by a zone of seasonally inundated grassland where drainage water from the sandy summits is forced to the surface by clayey bottomland soils.

6. <u>Semi-arid Amphibolitic and Andesitic Plains</u>

Gertenbach[3] (pers. comm.) pointed out a distinct vegetation region that is associated with amphibolite of the Swaziland System and andesite of the Waterberg System in the northern Semi-arid zone (cf. Schutte, 1974a). The amphibolitic area borders on the Northern Subhumid Hills and Mountains of Punda Milia. The nearby Semi-arid andesitic areas form enclaves in the Arid Granitic Plains Region near the northern boundary of the latter. The landscape on the Semi-arid Amphibolitic and Andesitic Plains is flat with deep red loamy soils. The vegetation is Broad-orthophyll Plains Bushveld dominated by <u>Combretum collinum</u> subsp. <u>suluense</u> and <u>Pterocarpus rotundifolius</u>.

7. <u>Semi-arid Doloritic Plains</u>

("Knobthorn/marula veld")

Enclaves of flat clayey plains, with <u>Acacia nigrescens</u> Tropical Thornveld occur within the Semi-arid Granitic Plains Region. Some are mesic with <u>Sclerocarya caffra</u> and others (cf. Gertenbach, 1978) are drier with stunted <u>Acacia nigrescens</u>.

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3. Mr W.P.D. Gertenbach, Research Institute, Private Bag X402, Skukuza, South Africa 1350.

8. Semi-arid Basaltic Plains

("Knobthorn/marula veld")

Most of the south-eastern quarter of the Kruger National Park, between the Crocodile and Olifants rivers, is Acacia nigrescens Tropical Plains Thornveld on flat clayey plains, underlain by basalt. Major physiognomic variations are respectively distinguished by Acacia gerrardii, Sclerocarya caffra and stunted Acacia nigrescens without emergent trees. The latter variation is the driest.

9. Semi-arid Karoo Sediment Plains

("Delagoa thorn thickets")

In the 500-700mm annual rainfall region, a typical catena on soils over Karoo Sediments includes: (a) Broad-orthophyll Terminalia sericea- and Combretum zeyheri - dominated Plains Bushveld in loose-sandy upland sites; (b) Dichrostachys cinerea Thornveld on relatively trophic sandy soils somewhat lower down the slopes; (c) Albizia petersiana - dominated Bushveld on massive, cemented sand; (d) Acacia welwitschii Brackish Thornveld of bottomlands; which border on (e) Riparian Bush, usually with Spirostachys africana.

10. Semi-arid Sand Plateau

("Pumbe sandveld")

A flat plateau covered by a deposit of loose sand, occurs at Pumbe on the Lebombo Range. Although the general character of the surrounding vegetation shows that the climate is Arid, the vegetation of the sand overburden belongs to a Semi-arid type because of the compensating effect of sand. The vegetation is Broad-orthophyll Plains Bushveld, dominated by Combretum zeyheri and Terminalia sericea.

11. Semi-arid Hills and Inselberge

("Mixed Red bush-willow veld")

The Lebombo Mountains south of Nwanedzi, as well as iselberge south of the Timbavati River, fall in the Semi-arid Region. Non-rocky slopes are quite similar to Broad-orthophyll and Thornveld plains communities, which identify this vegetation region as Dry Mountain Bushveld. It is nevertheless a relatively mesic variation of Dry Mountain Bushveld. A number of Arid-area indicators, including the most typical Dry Mountain Bushveld species, *Kirkia acuminata*, are absent. Otherwise, outcrops have the usual characteristic species complement for Dry Mountain Bushveld.

D. Arid regions

In the Arid regions the normal annual rainfall ranges from 400mm to 500mm.

12. Arid Granitic Plains

("Red bush-willow/mopani veld")

Most of the north-western quarter of the Park belongs to this region, which is undulating granitic country. The typical mosaic here is *Combretum apiculatum* - dominated sandy upland sites and *Colophospermum mopane* - dominated clayey, bottomland sites; i.e. Broad-orthophyll Plains Bushveld on uplands and Broad-sclerophyll Plains Bushveld in bottomlands. The pattern resembles that on the Semi-arid Granitic Plains but with broad-sclerophyll *Colophospermum mopane* largely replacing microphyllous thorny *Acacia nigrescens* and its associates.

13. <u>Arid Doloritic Plains</u>

("Shrub mopani veld")

The undulating Arid Granitic Plains are interrupted by flat clayey doloritic peneplains. Here Broad-sclerophyll Arid Bushveld, dominated by <u>Colophospermum mopane</u> shrubs, predominates.

14. <u>Arid Basaltic Plains</u>

("Shrub mopani veld")

Most of the north-eastern quarter of the Park is flat basaltic plains with clayey soil and an annual rainfall of between 400mm and 500mm. The vegetation here is Broad-sclerophyll Arid Bushveld dominated by <u>Colophospermum mopane</u> shrubs up to 2m tall; i.e. quite similar to the Arid Doloritic Plains.

15. <u>Arid Karoo Sediment Plains</u>

("Tree mopani veld")

<u>Colophospermum mopane</u> forms patches of Brackish Woodland on the sodic soils of the southern Madzaringwe Valley and its extension. The landscape is flat and occurs on coal bearing Ecca Shales of the Karoo System.

16. Southern Spiny Arid Bushveld

("Terminalia/Commiphora/Knobthorn veld")

Southern Spiny Arid Bushveld occurs most extensively on the hot and dry undulating slopes towards the Olifants River, the lower Nwanedzi Spruit[4] and the Makongolweni Spruit. These areas form the southern boundary of the Arid Region. The soils are skeletal or shallow and calcareous. *Acacia exuvialis, Combretum apiculatum, Grewia bicolor* and typical Spiny Arid Bushveld species predominate on the skeletal soils. On somewhat deeper soils all except *Grewia bicolor* are less common, while the latter species and *Acacia nigrescens* are dominant.

17. Northern Spiny Arid Bushveld

("Mixed mopani veld")

Northern Spiny Arid Bushveld occurs largely on the hot and arid undulating slopes towards the Levubu and Limpopo Rivers and on the slopes of the Shilahlandonga Valley. Soils are shallow with abundant lime concretions (Van Wyk, 1972). *Colophospermum mopane* is typically dominant, followed by an admixture of typical Spiny Arid Bushveld species, which become more common towards bottomland sites.

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4. Spruit is a southern African term for small perennial as well as seasonal streams, including also drainage lines that flow only for a short while after a storm.

18. Arid Sand Plateau

("Wambija sandveld")

The Nwambia Plateau is flat with Quaternary sand over Cretaceous sediments. The calcareous Shilahlandonga Valley divides the plateau into a northern and a southern section. *Baphia massaiensis* and *Guibourtia conjugata* shrubs of even height are dominant and the former uniquely characteristic, of the red-sand vegetation found on the upper part of the southern plateau (Van Rooyen, 1978). On the more yellowish and less arid sands of the gently sloping northern plateau and remainder of the southern plateau, the vegetation is quite different - the physiognomic structure is diverse and the most prominent woody species are *Sclerocarya caffra*, *Xeroderris stuhlmannii*, *Combretum apiculatum*, *C. collinum* and *Terminalia sericea* (Van Rooyen, 1978). These two sandveld communities have distinctive tropical species, as does the adjoining Arid Sandstone Hills Region along the Levubu River.

19. Arid Sandstone Hills

("Karoo Sandveld")

The rocky uplands between the Madzaringwe Valley and Pafuri, along the Levubu River, are formed by Cave Sandstone of the Karoo System. The vegetation is mostly the outcrop variation of Dry Mountain Bushveld. Other prominent communities in this region include Arid Mountain Bushveld, dominated by *Androstachys johnsonnii*; and Tropical *Terminalia sericea* Sandveld with *Adansonia digitata*, on Quaternary Sand patches (Coetzee, Gertenbach & Joubert, 1978; Van Rooyen, 1978). The occurrence of a distinct tropical flora differentiates these Arid Sandstone Hills from other Dry Mountain Bushveld areas in the Kruger National Park.

20. <u>Arid Inselberge, Ridges and Rhyolitic Range</u>

This Region includes: the Lebombo Mountain Range north of Nwanedzi; granitic inselberge; and syenitic, doloritic, quartzitic and rhyolitic hills and ridges north of the Timbavati and Olifants rivers. The vegetation is Dry Mountain Bushveld, with non-rocky slopes resembling Broad-orthophyll and Broad-sclerophyll Plains Bushveld. Rocky areas have the more exclusively Dry Mountain Bushveld variation, including general and arid, outcrop species.

The Central District

The Central District of the Kruger National Park measures 5 500km^2 and includes 60 per cent of the Semi-arid portion (annual rainfall 500-650mm, cf. Gertenbach, 1980) of the Park. The District stretches over 100-130km from the Olifants River in the north to the Sabie River in the south (Fig. 1). Its width is between 40km and 60km. The western boundary on granite is artificial and the Central District is adjoined here by privately owned nature reserves. The eastern boundary, which is also the political boundary of the Republic of South Africa with Mocambique, occurs on the Lebombo Mountain Range.

Much of the Arid portion of the Central District falls in the 1 700km^2 studied by Gertenbach (1978). The present study covers the remaining 3 800 km^2 of the Central District, which is largely semi-arid and excludes the area that is both north of the Satara-Orpen road and west of the main road from Satara to the north (Fig. 1). Major vegetation regions included in the present study are:

(a) Riparian (Region No. 1);
(b) Semi-arid Granitic Plains (5);
(c) Semi-arid Doloritic Plains (7);
(d) Semi-arid Basaltic Plains (8);
(e) Semi-arid Karoo Sediment Plains (9);
(f) Semi-arid Sand Plateau (10);
(g) Semi-arid Hills and Inselberge (11);
(h) Southern Spiny Arid Bushveld (16); and
(i) Arid Rhyolitic Hills (20).

III. PHYTOSOCIOLOGY AND VEGETATION STRUCTURE (1): METHODS

Vegetation sampling and synthesis was in the Braun-Blanquet Tradition, coupled with detailed, mainly physical, soil analysis and with classification of physiognomic structure. Special procedures were introduced to subsample different height classes of plants and to quantify physiognomic structure in a manner of consequence to large mammals and man.

Data gathering

Sampling units were distributed over the study area to represent the typical pattern of conspicuous vegetation and physiographic variation in each landscape. These patterns were identified on aerial photos, after a ground reconnaissance in conjunction with existing geological and vegetation maps.

The rationale followed is given by Coetzee & Nel (1978). It was held that differences within homogeneous physiographic and vegetation physiognomic units were "obviously small compared to differences between these units, duly considering the criteria on which the vegetation is to be classified" (Coetzee & Nel, 1978). To this may be added that the Braun-Blanquet classification approach emphasizes the joint response of species to the environment. Where striking physiographic and vegetation physiognomic variation is present, it is unlikely that many species would respond jointly to some quite unrelated environmental factor or complex; or that more important differences than those between stratification units, remain hidden from manifesting in vegetation physiognomy, or as conspicuous physiographic features associated with controlling habitat factors. It is most unlikely that major patterns were missed as a result of (Coetzee & Nel, 1978):

(a) subsampling stratification units along roads that served as representative traverses;

(b) avoiding narrow boundaries between units;

(c) saving sampling units in large homogeneous areas in order to capture the full pattern of variation in more diverse landscapes; and

(d) excluding decidedly heterogeneous sites and those that are not at all representative of statification units for which they were intended.

Stratification was done informally, without attempting to record the extent of deviation from complete randomness. A strong random element was nevertheless retained. Sampling sites were random points in homogeneous sections of stratification units, albeit random points along roads or in areas away from boundaries. Sampling sites were also placed at any distance from roads where the latter did not reach stratification units. Sites, predetermined on aerial photos, were accepted irrespective of species composition and preconceptions as to the typical species composition of supposed community types.

Releves were recorded during February to May, 1976. Sampling sights are shown in Fig. 1 (Folder).

Woody structure and composition

The technique used to sample woody structure and composition was introduced by Coetzee & Gertenbach (1977). The following brief description of the technique was abstracted, in places verbally, from Coetzee & Gertenbach (1977):-
The technique provides for calculating per species, stem growth form and height class: (a) canopy regime, expressed as percentage cover regime, at different height levels; (b) total projected canopy cover regime; and (c) density. Furthermore, quadrat size is determined independently at each site for each height class of plants to suit the density and distribution of those plants. Irregular distribution of individuals or low densities result in large quadrats including many individuals,

whereas regular distribution or high densities lead to smaller quadrats, including fewer individuals. A square quadrat is enlarged stepwise, retaining a fixed quadrat centre, until the height class to be recorded occurs in four equal sectors (quadrants) around the centre.

Cable or rope is used to construct a rectangular cross with four equal arms of 25m length each and calibrated at 5m intervals. For each height class four test squares are determined, one in each of the quadrants delimited by the cross. The test square is the smallest, from the following possibilities, that would include a rooted portion of a plant of the relevant height class: 5m x 5m; 10m x 10m; 15m x 15m; 20m x 20m and 25m x 25m. The largest of the four test squares determines the quadrat size for the height class of plant to be recorded. The quadrat is namely a square with centre at the centre of the cross and divided by the cross into four quarters, each the size of the test square. With the cross remaining in the same position, the procedure is repeated for each height class to determine the appropriate quadrat for that height class.

Thus quadrat sizes for sampling woody structure and composition in the present survey were $100m^2$, $400m^2$, $900m^2$, $1\ 600m^2$ and $2\ 500m^2$.

Species, stem growth form and canopy diameter at different levels were recorded for each individual of relevant height included in a quadrat. The three possible stem growth forms were:

(1) Tree Form (single stem);
(2) Light Shrub Form (2-4 stems); and
(3) Bushy Shrub Form (5+ stems).

For classifying plants by height and sectioning canopies, the following height levels were recognized: 0,5m (<0,75m); 1m (0,75-<1,5 m); 2m (1,5-<2,5 m); 3-5m (2,5m-<5,5m) and 6m+ (5,5m and higher). The reasons for choosing these boundaries are given elsewhere in this chapter (see "structural classification of vegetation").

Calculated percentages cover regime were converted to cover classes on the scale given in the following section on the field layer.

De Moor, Pooley, Neville & Barichievy (1977) also emphasized canopy regime at various height levels in describing woody sructure but used a "multi-stratal" point sampling technique instead of quadrats as in the present study.

It seems that in Europe, where the Braun-Blanquet Method was developed, there is little need to determine quadrat size independently for each stratum (cf. Westhoff & Van der Maarel, 1973; Mueller-Dombois & Ellenberg, 1974). A single quadrat size for all strata is also quite feasible in many southern African vegetation types (see Introduction for references) including Cool-temperate Subhumid Mountain Bushveld (Coetzee, 1974b, 1975; Bredenkamp, 1975).

However, Coetzee _et al_. (1976), working in warmer and drier Temperate Plains Bushveld, found it necessary to use larger quadrats for the woody vegetation than for the grass layer, particularly where physiognomic structure was to be properly recorded. The same experience in Tropical Plains Bushveld led to the development of the technique used here.

The field layer

Grasses and forbs were recorded in 10m x 20m quadrats. This size usually provides a useful picture of the species composition and dominants of the field layer in Temperate as well as Tropical Plains Bushveld (cf. Coetzee et al., 1976; Gertenbach, 1978; Van der Meulen, 1979). Species present were listed and assigned a projected canopy cover estimate in one of the following classes (cf. Mueller-Dombois & Ellenberg, 1974; Coetzee & Nel, 1978):

r	=	single individual, with negligible cover, that may prove to be an exception to the general distribution pattern of the species (an asterix denotes this "r" in Tables 2-9).
+	=	up to 1% cover.
1	=	>1-5% cover.
2a	=	>5-10% cover.
2b	=	>10-25% cover..
3	=	>25-50% cover.
4	=	>50-75% cover.
5	=	>75-100% cover.

Physiography

Physiographic features recorded include:

a) geology;
b) topographic position, i.e. crest, scarp, middleslope, footslope, valley bottom, levee and drainage line;
c) measured degree of slope and aspect (eight sections of the compass : N, NE, E, SE, S, SW, W, NW);
d) geomorphology, i.e. convex, concave, concavo-convex, flat, rocky and irregular;
e) height and percentage cover of outcrop;
f) surface stones - size, i.e. boulders, large, medium, small and gravel and amount, i.e. rare, frequent, abundant (Loxton, 1966); and

g) a soil profile description as used in the South African Soil Classification System (Mac Vicar, De Villiers, Loxton, Verster, Lambrechts, Merryweather, Le Roux, Van Rooyen & Harmse, 1977).

The soil profile descriptions included identification and classification of master horizons and the following data for each: depth; colour; distinctness and type of structure; percentages clay, silt, fine sand, medium sand, coarse sand; texture class; percentage gravel by visual comparison of gross volumes when separated from the rest of the soil; pH; presence of free carbonates; and conductivity.

Particle size, pH and conductivity per horizon were determined in the laboratory. Particle size analysis was by the Hydrometer Method as discussed by Black (1965, p. 562); pH (H_2O) was determined with a pH-Meter and pH-Combination Electrodes; and conductivity was measured for a water-saturated soil paste, using a Model MC 3 Portable Conductivity Measuring Bridge and Cell.

Finally, soil profiles were classified into forms and series according to the binomial system published by MacVicar *et al*., (1977).

Phytosociological table structuring

In the Braun-Blanquet School, the cover-abundance of plant species in stands of vegetation is presented in two-way tables. Each column represents a stand of vegetation, and each row a species. The cover of Species 3 in Stand 7 is entered in Row 3, Column 7. Thus entries down a column show cover values of all species occurring in that stand. The entries along a row are the cover values of one species in different stands. Several authors describe how rows and columns are re-arranged in order to group similar ones together (cf. Westhoff & Van der Maarel, 1973; Mueller-Dombois & Ellenberg, 1974; Werger, 1974). A group of similar rows represents species that usually occur together in the same stands. A group of similar columns represents stands belonging to one vegetation type.

Such classification renders the information more manageable (cf. Coetzee, 1979). Numerous species are reduced to a few species groups and numerous stands to a few vegetation types. Each vegetation type has a characteristic combination of species groups. Relationships between vegetation types are shown by the species groups they have in common and closely related vegetation types may be combined to form more general types.

After classification, species composition may be compared with related factors such as climate, physiography and animal impact, or with associated features such as species diversity or physiognomy. To facilitate such comparison, extra rows are added at the top of the table. The states of the non-species variables in the stands are then also entered in the appropriate columns. Thus differences in, e.g., soils, physiognomy and diversity, within and between vegetation types may be examined and related to species composition.

To date the classification of rows and columns in the phytosociological tables has remained partly intuitive. An International Working Group on Data Processing in Phytosociology has been rationalizing the traditional procedures, attempting to produce satisfactory tables by computer (cf. Van der Maarel, 1974; Holzner, Werger & Ellenbroek, 1978; Van der Maarel, Janssen & Louppen, 1978).

<u>The traditional approach</u>

Traditionally classification of rows and columns in the Tables is by visual inspection, simple calculations and somewhat complex and "unreconstructed logic-in-use" (Hull's, 1970, description of intuitive work). Computers may be used in a limited fashion to present tables quickly, accurately and ready for publishing according to specified sequences (cf. Van der Meulen, Morris & Westfall, 1978; Retief, unpublished). Hull (1970) pointed out that "Human beings can be trained to be quite efficient classifying machines. They can scan complex and subtle data and produce estimates of similarity with an accuracy which far exceeds the capacity of current techniques of multivariate analysis". Experienced phytosociologists, whatever their means of arriving at the result can generally agree on the finality of an ordered Table in all but the most trivial detail (cf. Mueller-Dombois & Ellenberg, 1974). Moreover their approach has been useful (Holzner *et al.*, 1978).

However, Hull (1970) adds that humans "as classifying machines ... have several undesirable qualities"; and that the purposes of scientific investigation are not merely to pursue usefulness but also to find "theoretical significance".

On theoretical significance

Holzner, Werger & Ellenbroek (1978) applied an automatic table structuring procedure based on a mathematical model discussed by Stockinger & Holzner (1973). According to Holzner *et al*. (1978) the model is based on small data subsets; and the major difficulty with large subsets arises when different species groups have overlapping distributions.

A primary aim in table structuring is to consolidate the patterns of entries in the table matrix (Coetzee, 1974a). This can be done when only two species groups have overlapping distributions. When more overlapping groups are added, difficult decisions may arise. Consolidating the matrix entries for Groups One and Two breaks up e.g., those for Group Three and *vice versa*.

Coetzee (1974a) and Coetzee & Werger (1975) refer to the same problem. Coetzee (*op. cit*.) emphasizes that overlapping groups show multidimensional relationships that indicate various alternative broader stand groups:- "Where vegetation-habitat relationships are multi-dimensional, only very homogeneous groups and vegetation types at the most detailed level of classification have no equally - or more plausible alternative classificatory possibilities. For some heterogeneous groups and vegetation types several classificatory possibilities may exist ... . A hierarchical arrangement merely draws attention to one such possibility, which has restricted value in interpreting vegetation-habitat relationships...".

A traditional phytosociological table shows the hierarchy as well as alternatives. The patterns that received priority in the consolidation process indicate the chosen hierarchy, but multi-dimensional relationships are not obscured (Coetzee, 1974; for further examples see Coetzee, 1975; Coetzee *et al*., 1976). In a strictly local survey it is not crucial which relationships are emphasized in the hierarchy as long as all are shown. However, when contributing to a regional syntaxonomy the choice of hierarchy is important. Coetzee (1974) opted for the choice that consolidates the distribution patterns in the Table as much as possible. The degree of consolidation obtained would then be greatest for: (a) species groups with many species that are strongly associated and have high constancies and high degrees of fidelity to the vegetation types in which they occur; and (b) stand groups with many species that belong to characteristic groups. Coetzee & Werger (1975) suggested that clusters be formed in such a manner that the number of ecological heterogeneities within a type is limited as far as possible. This approach entails having disjunct matrix patterns for the fewest possible number of species groups.

These are not the only criteria used by phytosociologists when they, in the words of Holzner et al. (1978) "subjectively overemphasize the importance of some species groups and present them in the table as coherent species releve clusters". However, it must be accepted that a standard structuring programme must base all decisions on the standard input data. Decisions based on other knowledge: (a) must remain the responsibility of the investigator; (b) is not the primary manner in which Tables are structured; and (c) would lead to untidy tables if the sample information is strongly overruled.

My own experience (in structuring tables semi-intuitively, informally reconstructing the logic involved and testing conclusions in subsequent applications) suggests the following major principles in dealing with small and large data sets - even though phytosociologists know and use various alternative routes, involving some manner of successively better approximations of the final results,the following are principles by which they may and probably do judge the finality of their tables:-

Species are classified agglomeratively on their correlated distributions, taking into account their distributions over the entire data set as may be shown in a Synoptic Table. From such a grouping of species the best possible agglomerative classification of releves into phytosociological units at one or more hierarchical levels, is made. Releves are classified on their similarities with respect to groups of correlated species. Such a classification, considering the distributions of species over the entire data set forms the basis for separating releves into various detailed Braun-Blanquet Tables. For each subset of releves represented by a separate table or part of a table, species may be reclassified agglomeratively, taking into account correlations within the new confines of distribution in the subset, to further endorse existing releve groupings and to expose new subdivisions of groups, hitherto obscured by the general grouping of species. The distribution and correlation of species within the confines of successively smaller groups of releves may be re-examined, species classified agglomeratively into new groups and releves classified agglomeratively in finer detail on the basis of new species groups until no determinable correlations between species within releve groups are formed. Throughout the procedure, groups of correlated species each form an axis on which similarities and dissimilarities are determined. New axes form new dissimilarities but species groups based on correlations over the entire sample take precedence over the grouping of species within the more restricted limits of a subset of releves. The latter does, however, serve to define releve groups within releve groups. Releves are, therefore, classified in steps, agglomeratively at each step but divisively from step to step as the smallest classes resulting from each step are re-examined.

Similarly when data from two or more _ad hoc_ classifications are combined and species distributions over wider areas are considered, species correlations, species groups, subsequent releve similarities and releve groups may require adjustment at a broad level of classification. Some species groups take precedence as others are obscured when releves are added and the options that take precedence at a broad level are those based on correlations over the fullest possible distribution ranges of species. For this reason a good projection based on reconnaissance data or experience, of the phytosociological behaviour of species over their entire distribution areas could be useful in choosing between multi-dimensional relationships when constructing a hierarchy. For the same reason also, fixing definitions and ranks of alliances, orders and classes should be postponed until Synoptic Tables, integrating local surveys, cover a sufficiently large area. The rank of association will be discussed in the next subsection.

The Stockinger & Holzner (1973) model seems quite appropriate for classifying releves and species, first for the entire data set and then again for each successively smaller subset, provided the problem of choosing between incompatible multi-dimensional relationships can be solved. For this choice species groups must be given priority objectively based on the normal input data, e.g. as suggested by Coetzee (1974) and discussed earlier in this subsection. Groups selected for disjunct matrix patterns are then not regarded as "essential species groups" (_sensu_ Stockinger & Holzner, 1973; Holzner, Werger & Ellenbroek, 1978) for that particular arrangement of releves.

The final arrangement of species groups takes into account syntaxonomic ranks of the syntaxa primarily characterized by these groups (cf. Werger, 1973b for examples). The uppermost block of matrix entries in any group of columns belong to differential species (including character species) of the association. These are immediately followed by blocks for subordinate units and then successively alliances orders and classes. Differential species for alliances follow immediately after those for the relevant associations and their subordinate units, before the table proceeds to differentials for the next group of associations. Ranks are not a mere function of the data set and therefore the final sequence of species groups should be specified after the syntaxonomic phase.

Separation of data subsets from synoptic onto detailed tables depends partly on the necessity to re-arrange species to show the finer subdivisions of subsets. This could be allowed for in an elegant programme. Because this decision is also to some extent a matter of convenience of presentation, the investigator requires an option to influence this step. For any table (synoptic- or subset-) the grouping of individual species into essential species groups should be according to their distribution over that entire table.

Syntaxonomic considerations

Several Braun-Blanquet Type surveys have been conducted in southern Africa (cf. Werger & Edwards, 1976; Van der Meulen, 1979), each contributing to- and directly compatible with an eventual classification system for the Sub-continent. Where sufficiently large areas were surveyed, the first steps towards fixing foundations for a syntaxonomic system have been taken by assigning ranks and names according to the Code of Phytosociological Nomenclature published by Barkman, Moravec & Rauschert (1976). In studies of small areas, belonging to phytosociologically poorly known vegetation, such binding steps have been wisely avoided.

In this study the decision to fix syntaxonomic ranks and names according to the Nomenclatural Code, was based on the following considerations:-

a) <u>Choosing a level for the rank of association</u>

According to Principle VI of the Code, the association is the basic rank in the hierarchy of syntaxa. This does not mean that the association is the smallest unit characterized by faithful species. The Principle has a practial meaning only. The level chosen is a matter of convenience and associations have been aptly described as "useful stepping stones across the swamp of variation" (Anonymous cf.[1] Westhoff, pers.comm.). To serve this purpose, associations should be a limited number of distinct, homogeneous (homotoneous) syntaxa that may be used by a variety of people for a variety of purposes over a major subdivision of a phytochorological Domain, e.g. in the present context, over the Bushveld. At successively more detailed levels of classification the number of syntaxa become prolific, their definitions become more complex, variation between syntaxa less discontinuous, syntaxa boundaries more arbitrary and more stands are transitional between syntaxa, particularly if data from a wide area are considered. Recognition of syntaxa and familiarisation therewith, over a large area, become prohibitive at too detailed classification levels. On the other hand, too broad a classification level results in undue heterogeneity in floristic composition, habitat, life processes and appearance. A compromise is therefore necessary: broad enough to be manageable but detailed enough to be usefully homogeneous.

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It seems that in Europe the association concept was originally similar to the aforegoing. However, the practice of accommodating numerous detailed vegetation units in the formal nomenclatural system has led to inflation of the rank of association (Pignatti, 1968; Mueller-Dombois & Ellenberg, 1974). In contemporary European phytosociology the original role of associations as practical "orientation points" in applied vegetation science is now fulfilled by the rank of alliance (Mueller-Dombois & Ellenberg,1974).

Detailed local classifications could lead to a prolific number of different community types. Mueller-Dombois & Ellenberg (1974) make the pertinent point that they "consider it useful to maintain an unsystematic status for abstract vegetation communities in all cases where the emphasis is on intensive local vegetation studies. However, a hierarchical scheme becomes very desirable where the emphasis lies on developing a vegetation synopsis at a more extensive geographical scale". This is a useful approach and could in southern Africa reserve the rank of association for its original practical purpose.

The Nomenclatural System provides for four major hierarchical levels, i.e. with the rank of association, alliance, order and class, respectively. These levels should be chosen to provide approximately equally useful degrees of successive abstraction.

The necessity to compromise between the manageability of few syntaxa and the homogeneity of many, and to space ranks conveniently, calls for a reconnaissance-type overview of the various major axes of floristic variation and their accompanying habitat factors, within a general vegetation type such as Bushveld. Such an overview exists (See Chapter II and Werger & Coetzee, 1978).

b) Naming syntaxa

Syntaxa names in this thesis are based mainly on grasses and woody species as these are the dominant growth forms in all communities studied. The general distribution of these species are well documented, which is useful in choosing diagnostic combinations.

c) On the need for ranks and names in preparing a classification system for general use

Appreciation for the benefits of the Braun-Blanquet System will grow as the System becomes established and is put to use. Such appreciation will in turn help expand and establish the System, making it more useful. Much of the merit of the System stems from its hierarchical nature and particularly from having the rank of association for the basic "stepping stones" in the classification system. Assigning this rank illuminates the stepping stones, encouraging people to use them to obtain an overview of the vegetation of an area. On the other hand, providing a classification system without the key to using it could lead to regrettable disillusionment.

d) Limited commitment

In the present study ranks are assigned only to associations and, where two or more closely related associations are discussed, to the alliance to which they belong.

Structural classification of vegetation

The classification system proposed here is based simply on canopy regime at three height levels. Although the system may have wider application, it is in the first instance a special purpose one and intended for the woody component of Bushveld (see Ch. I).

Canopy regime

Canopy regime at a specific height level is expressed as percentage horizontal area occupied by sections of canopies occurring within that height level. Canopy regime classes are based on the Braun-Blanquet cover-abundance scale, slightly modified to be a cover scale. The lower limit of the lowest cover class is 0,1 per cent (taken from Walker & Edwards, unpublished). These cover classes can be estimated. For the latter purpose Edwards[2] (pers. com., cf. Werger, 1974a) suggested relating cover to distance between plant canopies, expressed as number of canopy diameters. Individuals may be immagined to have circular canopies of the average cover and to be evenly spaced in triangular arrangement. The concomitant conversion from number of diameters apart to percentage cover is given in Table 1.

Height levels

Three height levels are recognised, i.e. the:

(1) Shrub Level, from 0,75m - <2,5m;
(2) Brush Level, from 2,5m - <5,5m; and
(3) Tree Level, from 5,5m upwards.

The boundaries between height levels were chosen:

(a) to coincide with human height and browse and eye level limits of major herbivores (impala browse up to 1,5m and kudu up to 2m, whereas giraffe and elphant reach up to 5m);

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(b) to coincide with height definitions generally set for major growth forms (i.e. for up to approximately 2m tall single- and multi- stemmed schrubs; 3-5m tall, low trees and multi-stemmed shrubs; and tall trees, i.e. trees sensu stricto, which exceed 5m (cf. Grunow, 1965; Fosberg, 1967); and

(c) to fall between heights expressed in round figures, so that approximations to the nearest meter are made away from class boundaries rather than toward them.

Although height levels are named with regard to growth forms of corresponding height, tall growth froms may contribute to canopy regime at lower levels. Thus tall trees may account for most of the canopy regime at the brush or shrub levels also.

There is considerable overlap between low trees and tall shrubs. Therefore, a special collective term to denote trees and/ or shrubs of 3-5m height is useful as such, as well as for naming the corresponding height level. The proposed usage of "brush" conforms loosely to one of the common English definitions, viz. "small trees and shrubs" (Coulson, Carr, Hutchinson & Eagle, 1962); and to ecological usage as in "brushland" defined as "an area characterized by shrubby vegetation" and "brush pasture", defined as "a pasture with a natural cover of trees and shrubs, where a large part of the forage secured by livestock comes from browsing woody plants" (Hanson, 1962). Sosebee & Wright (1979) and Wright (1979) use the term brush, as in the present context, for a mixture of low trees and shrubs (e.g. text on top of Page 10 in Wright, 1979). Related meanings ascribed to the term are in some respects decidedly narrower than that of "brush" in the present context, e.g. underwood, where a taller stratum is indicated and thicket, indicating dense growth.

Structure classes

Classification may be on the upper-, on a subordinate- or on all canopy levels and on major or detailed cover classes, according to emphasis and detail required. Class names indicate the nature of classification and level of detail:-

(a) Major regime class of the upper canopy level

The upper canopy level is identified as the highest of the three with canopy regime exceeding one percent, i.e. canopies separated by less than eight times their diameter. Taller canopies separated by eight to thirty times their diameter (cover class '+'), are regarded as scattered emergents. Six structural classes are recognised by assigning the upper canopy level to one of two major canopy regime classes (Table 1):

Table 1. Classification of Bushveld by cover regime of three canopy levels. Nouns identify the upper canopy level (cover exceeding 1%) and its major cover class (1 - 25% or 25% +). The adjectives "sparse moderate, and dense" identify detailed cover regime of upper canopy level. Elaboration by dependant clauses, using the adjectives and adverbs provided in parenthesis, describe canopy regime at the remaining height levels.

EXAMPLE: "moderately scrubby, moderate brushveld, with scattered trees" (upper canopy level at 3 - 5m covering 5 - 12%, canopy at 1 - 2m covering 50 - 75% and emergent canopies at 6m+ covering 0,1-1%).

COVER			CANOPY LEVEL					
Braun-Blanquet class symbol	% Cover	No. of canopy diameters separating canopies	Shrub (0,75m – <2,5m)		Brush (2,5m – <5,5m)		Tree (5,5m +)	
+	0,1-1	8-30	scattered shrub		scattered brush		scattered trees	
1	>1-5	3-8	sparse(ly)		sparse(ly)		sparse	
2a	>5-12	2-3	moderate(ly)	shrubveld (shrubby)	moderate(ly)	brushveld (brushy)	moderate	treeveld
2b	>12-25	1-2	dense(ly)		dense(ly)		dense	
3	>25-50	touching-1	sparse(ly)		sparse(ly)		sparse	
4	>50-75	touching-1	moderate(ly)	scrub(by)	moderate(ly)	thicket(ed)	moderate	bush
5	>75-100	overlapping	dense(ly)		dense(ly)		dense	

(A) 1-25% cover (canopies 1-8 diameters apart)

1. SHRUBVELD (upper canopy level at shrub height, i.e. 1-2m);
2. BRUSHVELD (upper canopy level at brush height, i.e. 3-5m);
3. TREEVELD (upper canopy level at tree height, i.e. 6m+);

(B) >25-100% cover (canopies separated by less than 1 diameter)

4. SCRUB (upper canopy level a shrub height, i.e. 1-2m);
5. THICKET (upper canopy level at brush height, i.e. 3-5m); and
6. BUSH (upper canopy level at tree height, i.e. 6m+).

Where a field layer dominated by grasses forms the highest canopy level, the relevant strucural type is GRASSVELD, which may have scattered shrub, brush or trees with less than 1 per cent canopy regime.

(b) Detailed regime class of the upper canopy level

The adjectives "sparse", "moderate" and "dense" denote detailed regime class of the upper canopy level as subdivided by the Braun-Blanquet scale (Table 1).

For the three major classes with relatively low cover of the upper canopy level, i.e. for shrubveld, brushveld and treeveld, the adjectives sparse, moderate and dense respectively designate Braun-Blanquet cover value 1 (1-5%), 2a (>5-12%) and 2b (>12-25%). For the classes with high cover, i.e. for scrub, thicket and bush, the adjectives sparse, moderate and dense indicate

Braun-Blanquet cover values of 3 (>25-50%), 4 (>50-75%) and 5 (>75-100%) respectively. Examples are "sparse scrub" (upper canopy level at 1-2m, covering 25-50 per cent), "moderate brushveld" (upper canopy level at 3-5m, covering 5-12 per cent), or "dense bush" (upper canopy level at 6m+, covering 75-100 per cent).

(c) Lower canopy levels and levels with scattered canopies

More elaborate classification is effected by:

i) adding dependent clauses at the beginning of class names to describe canopy regimes exceeding one per cent and occurring below the upper canopy level or to indicate the absence of such canopy; and

ii) indicating height levels with scattered canopies covering 0,1 - 1 per cent, at the end of class names.

Subordinate canopy levels are classified by height and cover in the same manner as upper canopy levels. To form the relevant dependent clauses, the nouns shrubveld, scrub and brushveld become the adjectives shrubby, scrubby and brushy; the noun thicket becomes the verb thicketed; and adjectives sparse, moderate and dense are replaced by the adverbs sparsely, moderately and densely (Table 1).

Examples are:

i) moderately shrubby, sparse brushveld (canopy at 1-2m covering 5-12 per cent and upper canopy level at 3-5m covering 1-5 per cent);

ii) sparsely scrubby, moderate brushveld (canopy at 1-2m covering 25-50 per cent and upper canopy level at 3-5m covering 5-12 per cent);

iii) moderately scrubby, sparsely thicketed, sparse treeveld (canopy at 1-2m covering 50-75 per cent, canopy at 3-5m covering 25-50 per cent and canopy level at 6m+ covering 1-5 per cent).

Height levels with scattered canopies covering 0,1 per cent are indicated by the clauses "with scattered shrub/brush/trees" for levels 1-2m, 3-5m and 6m+ respectively.

Examples in class names are:

i) sparse shrubveld, with scattered brush and trees (upper canopy level at 1-2m covering 1-5 per cent and emergent canopies covering 0,1-1 per cent at 3-5m and at 6m+);

ii) dense treeveld, with scattered shrub (upper canopy level at 6m+ covering 12-25 per cent, canopy at 3-5m, if present, covering less than 0,1 per cent and canopy at 1-2m covering 0,1-1 per cent); and

iii) densely shrubby, moderate brushveld, with scattered trees (canopy at 1-2m covering 12-25 per cent, upper canopy level at 3-5m covering 5-12 per cent and emergent canopies at 6m+ covering 0,1-1 per cent).

Some photographic examples are provided in Figs. 2-20 (Appendix 5).

(d) On application

Three symbols, each representing a Braun-Blanquet cover value of a different height level, are sufficient to classify a vegetation stand to any level of detail mentioned in the aforegoing description. As an example, "+ob" indicates Braun-Blanquet cover values of + (0,1-1%), absent and 2b (>12-25%) at height levels 1-2m, 3-5m and 6m+ respectively. Translated, this is "non-brushy dense treeveld, with scattered shrub" or "dense treeveld" or simply "treeveld".

An expanded coding system shows the height class and species of plants contributing most to the canopy at each height level. Appendix 1 is an example. Heights are represented by T for tree, B for brush and S for shrub heights. Thus 1B; aT; 1(T) means sparsely shrubby, moderately brushy, sparse treeveld, with 6m+ tall plants, i.e. trees (T), contributing most to canopy regime at the tree (6m+) and brush (3-5) levels; and 3-5m tall plants, i.e. brushes (B) contributing most of the canopy at the shrub (1-2m) level. Six-letter species codes (cf. Coetzee & Gertenbach, 1977) are used to show species contributing most at each level, e.g. 1B-ACANIG; aT-SCLCAF,ACANIG; 1T-SCLCAF and Figs. 2-20 (Appendix 5).

Classification in the present study is based on data collected by the technique described by Coetzee & Gertenbach (1977) and summarised earlier in this chapter under the sub-heading "Woody structure and composition", of the heading "Data gathering".

IV. PHYTOSOCIOLOGY AND VEGETATION STRUCTURE(2): RESULTS

The Synoptic Table (Table 2), which groups species on their overall distribution in the study area, shows major differential species groups and community types. These are then dealt with in more detail in Tables 3-9, where species are to some extent re-ordered in the more limited context of particular communities. The re-ordering amplifies some communities established in the Synoptic Table and also brings out additional detailed subdivisions.

A. Synoptic Species Classification

Species groups in the Synoptic Table are named according to their habitat preferences and numbered. In the detailed Tables (3-9) species appear under the same numbered headings, unless re-ordered to show their additional diagnostic value in the new context. Diagnostic species are all classified as "differential". Owing to the geographic limits and particular emphasis of the study, no attempt was made to assign the status of various types of "character" species.

Species Groups 1-16 in Table 2 distinguish between plant communities and have distinct ecological amplitudes for various habitat factors determining plant communities. Differential groups 1-15 each occur in two to several associations and therefore determine floristic-ecological relationships between associations, whereas Group 16 species essentially are exclusive to individual communities.

Species in Groups 17-18 occur either too generally or too sporadically to form differential groups in the Synoptic Table. Group 17 includes generally occurring species with over 30 per cent presence in the releves comprising Table 2. Group 18 contains sporadic species occurring in 10-30 per cent of all releves. Poor differential species that occur in fewer than 10 per cent of all releves are excluded from Table 2.

Groups 1-2 (Indicators of deflocculated soils)

Deflocculated soils are common in the sodic bottomlands of granitic and Karoo Sediment landscapes in the western Central District and occur also on clayey basaltic plains that have been puddled by heavy grazing and trampling for prolonged periods during wet seasons. Group 16 includes numerous species that are exclusive to specific kinds of deflocculated soils. Group 1, however, are indicators of such soils generally, including puddled soils, and Group 2 are characteristic for a variety of sodic soil types, excluding puddled soils. Extensive puddling of clayey basalt-derived soil occurred in parts of the Tshokwane, Metsi-Metsi and Nkhelenga areas (Fig. 1).

Groups 3-8 (Soil texture indicators)

Soil texture, various other soil factors, rainfall and temperature may interact and have amplifying or counter-balancing effects in determining the suitability of habitats for plant species. The habitat of Group 3-8 species in Table 2 may, nevertheless, be largely characterized in terms of soil texture, at least for some specific climatic region:-

(a) Group 3 occurs on soils with single grain structureless sandy loam or sandier texture throughout the profiles. Such soils are typical of granitic upland sites in the western Central District, some sandstone areas, e.g. near Merheya. Quaternary sand at Pumbe on the Lebombo Range and soils of the Mispah Form (shallow, lacking B horizon) of the Lebombo rhyolitic hills. Relatively sandy areas, but with less than 550mm normal annual rainfall, e.g. in parts of the Olifants River valley, are excluded.

(b) Group 4 species are like those in Group 3, but also tollerate massive structureless A horizons and/or deflocclated clayey B horizons, of sodic soils, provided that massive A horizons of solonetz soils are at least 250mm thick. Sodic soils suitable to Group 4 species are found in 1-3^{o} sloping bottomlands of granitic and Karoo Sediment areas in the western Central District. Lateral underground drainage in sandy A horizons on gentle slopes are conductive to leaching in the A horizon and probably also to erosion of the tops of deflocculated B horizons (cf. Thompson, 1965, quoted by Dye, 1977) and thus to loose and/or deep A horizons. Sodic soils with loose A horizons are of granitic origin, whereas those with massive A horizons are typical of Karoo Sediment bottomlands.

(c) Group 5 species require either sandy or gravelly or shallow soils. Deeper than 450mm soils with sandy clay loam, or more clayey texture, throughout the profile, i.e. the deeper soils of basaltic plains in the eastern Central District, are avoided. On similarly clayey soils with gravelly lithocutanic B horizons that merge gradually into weathering rock, somewhat greater soil depths may be recorded for these species.

(d) Group 6 species are common in areas where the annual rainfall exceeds 550mm, except on sodic soils, sand or loamy sand. Favourable conditions are met mainly on the rhyolitic hills away from the Olifants River gorge, the basaltic plains south of Tshokwane as well as the doloritic plains and non-sodic granitic bottomlands in the western Central District.

(e) Group 7 species avoid sand and loamy sand, i.e. granitic upland sites and aeolian deposits.

(f) Group 8 species avoid soils with sandy, loamy sand or sandy loam texture throughout the soil profile, i.e. granitic upland sites and shallow soils of the Mispah Form on rhyolitic hills.

Groups 9-15 (Moisture regime indicators)

The habitats of species in Groups 9 to 15 (Table 2) may be characterized by moisture regime as determined by climate and soils:-

(a) Group 9 species occur on soils with sand, loamy sand or sandy loam textures throughout their profiles, as well as in more clayey areas where the normal annual rainfall exceeds 550mm, but excluding sodic soils. Their distribution includes virtually the entire granitic area with sandy upland sites, non-sodic clayey bottomlands and clayey doloritic plains. Also included are Mispah soils on the rhyolitic hills south of Nwanedzi and the high rainfall basaltic plains south of Tshokwane.

(b) Group 10 species avoid only particularly arid parts of the study area, i.e. the undulating slopes down to the Olifants River, where the rainfall is below 500mm; the equally arid rhyolitic hills along the Olifants River; vertic soils, which occur mainly on the plains north of Mavumbye and Mbatsane; and solonetz soils with thin massive A horizons, found mainly in level bottomlands on Karoo Sediments.

(c) Group 11 species are partial to dry areas such as the sodic soils found in bottomlands on granite and Karoo Sediments; and the vertic and other clayey basaltic plains - including also trampled and puddled areas - with 500-550mm rainfall, between the Shitstalaleni firebreak in the north and Tshokwane in the south (Fig. 1). However, the arid rhyolitic hills north of Nwanedzi (Fig. 1) and the arid basaltic plains with less than 500mm normal annual rainfall, on the slopes of the Olifants River valley, are excluded.

(d) Group 12 species are typical of all dry to arid areas. They avoid sandy and loamy sand granitic uplands, the mesic rhyolitic hills south of Nwanedzi and the high (550mm+) rainfall basaltic plains south of Tshokwane (Fig. 1). Included are the entire clayey basaltic plains north of Tshokwane, with less than 550mm normal annual rainfall, and the rhyolitic hills north of Nwanedzi.

(e) Group 13 species are like those in Group 11 in their distribution, but avoid sodic soils.

(f) Group 14 occurs in decidedly arid habitats except on vertic soils. The most common habitats for this group include sodic soils of granitic and Karoo Sediment bottomlands; puddled basaltic soils such as the trampled soils at Tshokwane, Metsi-Metsi, Nkhelenga, Guweni Dam and along the Makongolweni Spruit; and the arid basaltic and rhyolitic region along the Olifants River, where the rainfall is less than 500mm per annum.

(g) Group 15 species have optima on shallow trampled basaltic soils and the arid basaltic and rhyolitic areas with less than 500mm rainfall along the Olifants River. Some members also occur on vertic soils, found commonly in Landscape 7 (Ch. VII).

Group 16 (Association specific)

Included here are several differential species groups with narrow ecological amplitudes. As these groups are largely exclusive to specific associations their indicator values are dealt with as the habitats of these associations.

TABLE 3. CHLORIDO VIRGATAE - JUSTICEION FLAVAE (ALLIANCE ON DEFLOCCULATED SOIL)

RELEVE NUMBERS		333222222311213333322111132222220212222222111112 11
		300212010049160000044694615224343954568998387387133
		395571690415161306765982594680917683787712703571013
ASSOCIATION NUMBER		1 2 3 4
LANDSCAPE NUMBER		1144444444444244444445944666666566323332232222 2
HABITAT GEOLOGY (B=BASALT, G=GRANITE, K=KAROO SEDIMENT, R=RHYOLITE)		GGKKKKKKKKKKKKKKKKKKKKRKKBBBBBBBBBGGGGGGGGGGGGG
RELIEF (C=CREST, M=MIDDLESLOPE, F=FOOTSLOPE, V=VALLEY BOTTOM)		FVMVVVMVMMVFVVFFFMMVMMFCMMMMFCMVMMFCMVVFFMVMFMMVFMM
SLOPE (DEGREES)		0000000000000000000000000000000000000000000000000
		00000000100101222220201001110200210202312203220423
SURFACE (F=FLAT, N=CONVEX)		FFFFFFFFFFFFFFFFFFNFFFFFFFFFFFFFFNFFFFFFFFFFFFF
A HORIZON-DEPTH (DM; +<1DM)		+123++3422236134325 4 333 34 +2 +4342+2+++1322233 22
-COLOUR (D=DARK, I=DUSKY RED, R=RED, Y=YELLOW)		DDDDDDDDIDYDIYDDDRDDYIDYDDID DDDIDDDRDDDDDDDIDDIDD
-STRUCTURE (A=APEDAL, C=MASSIVE M=MODERATE, W=WEAK)		CCCCCCCCCCAAAACACCCCAAACACCC WWWWWWWWMAAA AAAAAAAA
-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM(Y), Z=SAND(Y))		ZZZZZZZZZZLLZLLZZZZLZ LZZZLZ C ZZZZZZLLZSZLZZZLZZL
		LLLLLLLLL ZZ ZZLLLLZI ZLLLZL L IIILLIZZLLLZLL ZZ Z
-CLAY (%)		1111111111 1 1 111114 111111 3 2221121 111111 1
		12315393920931935470001153 13 2001358505011111199046
-PH (X 10)		565554555546564555455555635 6665565656565556454 35
		910735591481326425500447229 0 128450515251075039891
-CONDUCTIVITY (MICROMHOS X .1)		00000001 00000000000000000000 000000000 0000000000
		2121181213111101010138111 20 4924242321 21222121 34
		2900049650795070709578086 57 5014611003 08050846 10
B HORIZON-DEPTH (DM; *>9DM)		7 5 * * *7* * 6 3727**63 94 5
-STRUCTURE (A=APEDAL, C=MASSIVE M=MODERATE, S=STRONG, W=WEAK)		SSSSSSSSC SSASSS SCCCCSC CM WMWCMSMWSSSSSSSSSSSSS
-CLAY (%)		13343222 4222332 3331123 13 333333332333 323222 2
		7327096130028428 01243501081 718193019511959775709
-PH (X 10)		7555666 6675 65 6454554 56 666555567778866768 6
		7179509 3467048 5758089 82 1049798132952881011
-CARBONATES (P=PRESENT, O=ZERO)		OPOOOOOOO OOOOOO OOOOOOO OO OOOOOOOOPOPPOOOOOO O
-CONDUCTIVITY (MICROMHOS X .1)		000010000 000000 0000000 00 00000000211010110 20
		794322 52 660364 3021111 41 573938249376482173 6
		00610305 386684 6874012 21 912821640055110000 2
SOIL FORM (STD. ABBREVIATIONS, MACVICAR ET AL., 1977)		SSSSSSSSPMSSCSES MSCPHPSCMPSC MSGTBSSGEESESESEESSEE
		SSSSSSSSNSSSVSSSSSSVNUNSVSNSA YWSAOWWSSSSSSSSSSSSS
SOIL SERIES NUMBER (MACVICAR ET AL., 1977)		22222222312232 2112333323133 111 1311 2 2 2 22
		5549656560556 5006663646070 005 0006 5 6 5 45
NUMBER OF SPECIES		0000000000000000000000000000000000000000000000000
		3333434244253454464432443324354434433243244432221 34
		6644853452629169634225818826805745489731830139863 33
GROWTH FORM PREFIX: F=FORB, G=GRASS, W=WOODY SU=SUCCULENT		
DIFFERENTIAL SPECIES FOR- (SPP. NAMES, PRESENCE VALUES)		
EUCLEO DIVINORI- ACACIETUM WELWITSCHII (ASSOCIATION 1)		
F ACHYRANTHUS ASPERA	23	AA+1+ ++++++++ + + + + 1 + + ++ +
W ACACIA WELWITSCHII	13	AAAAA 1B3+AB 1
F SOLANUM COCCINEUM	14	+++++ + ++++ + + + +
F ACHYROPSIS LEPTOSTACHYA	17	+ ++++ ++++ 1 ++ + + ++ +
F BARLERIA ELEGANS	8	+ +++++++
F INDIGOFERA SCHIMPERI	11	+ +++ + + * + + ++
W DINOCANTHIUM HYSTRIX	7	*+ +*1 ++
F ASPARAGUS SETACEUS	6	+++ + + +
G ERAGROSTIS CYLINDRIFLORA	7	+++ ++ + +
-ASS. 1.1		
G SPOROBOLUS NITENS	16	3AA1B11++ + + ++ +1 +
W MAYTENUS TENUISPINA	9	+++ 1+BA 1 *
W PAPPEA CAPENSIS	9	*+ *11A + + *
W ACACIA GRANDICORNUTA	7	A5++ + 1 +
G ENTEROPOGON MACROSTACHYUS	6	A+++13
SU KALANCHOE LANCEOLATA	7	+ ++++ + +
F AMARANTHUS THUNBERGII	5	+ + +++
F BLEPHARIS TRANSVAALENSIS	7	++ ++ + ++
W CAPPARIS TOMENTOSA	4	++ + +
F RHINACANTHUS SP.	5	++ + + +
SU PORTULACA QUADRIFIDA	3	1 + +
-ASS. 1.1.1		
F CYATHULA CRISPA	4	111 +
-ASS. 1.1.2		
W SPIROSTACHYS AFRICANA	7	+ *AAA A +
W CARISSA BISPINOSA	6	++*+ + +
-ASS. 1.2		
W GREWIA FLAVESCENS	14	++++1+ + + 1 + + 1+ +
JUSTICEO FLAVAE - ALBIZIETUM PETERSIANAE (ASSOCIATION 2)		
W ALBIZIA PETERSIANA	18	* + 1+* +AA11AA41A AA +
F WALTHERIA INDICA	19	+ 1+++++ ++++ +++ + + +
G POGONARTHRIA SQUARROSA	18	+1 1+1+B++1++ + + + + ++
G SPOROBOLUS FIMBRIATUS	15	+ R + AB11++ 1 + + + + +
W PELTOPHORUM AFRICANUM	11	+ + *1 + + * * + + +
F MELHANIA FORBESII	9	+ + + +++ + + +
-ASS. 2.1		
G BRACHIARIA NIGROPEDATA	10	+11A+ +++ + +
COMBRETUM APICULATUM	9	+ +1++ + + + +
W LANNEA STUHLMANNII	11	+ ++* * + + * * +
W DALBERGIA MELANOXYLON	10	+ ++ ++ + + + + +
W COMBRETUM ZEYHERI	4	++ A *
F PHYLLANTHUS INCURVUS	8	+ + + ++ + + +
-ASS. 2.1.1		
F ASPARAGUS BUCHANANII	4	+ ++ +
F CYPERUS RUPESTRIS	4	++ + +
W ACACIA SENEGAL ROSTRATA	5	++ **+
G TRICHOLAENA MONACHNE	2	+ 3
-ASS. 2.1.2		
G SCHMIDTIA PAPPOPHOROIDES	10	+ +++ + + + ++ +
F THUNBERGIA DREGEANA	4	+++ +
F RHYNCHOSIA TOTTA	5	+ +++ +
F MELHANIA DIDYMA	3	+++
W TERMINALIA SERICEA	4	+ ++ +
F LEUCAS SEXDENTATA	2	++
PUPALEO LAPACEAE- ACACIETUM NIGRESCENTIS (ASSOCIATION 3)		
W ACACIA NIGRESCENS	18	+ +11* * 1++11+AA + + ++
F BOERHAVIA DIFFUSA	9	+ +++++ ++
G BOTHRIOCHLOA RADICANS	10	++++B+A + A +
F HELIOTROPIUM STEUDNERI	7	+ +++ +1 +
F IPOMOEA SINENSIS	9	+ + + ++ +++
G ERAGROSTIS CILIANENSIS	9	+ + + ++ ++ + +
-ASS. 3.1		
G ARISTIDA ADSCENSIONIS	6	++ 14++
G ENNEAPOGON CENCHROIDES	6	1 + ++ +1
G TRAGUS BERTERONIANUS	8	++ + + + +++
ALBIZIO HARVEYI- EUCLEETUM DIVINORI (ASSOCIATION 4)		
W ALBIZIA HARVEYI	18	+ ++ + 3+ +++++ +1++++ +
W ORMOCARPUM TRICHOCARPUM	15	++ +*+1*+ ++++ ++
F KOHAUTIA VIRGATA	16	+ + 1++ + + ++++ +++ ++
F CORCHORUS ASPLENIFOLIUS	14	+ + + + ++ +++ ++++ +
W COMBRETUM HEREROENSE	17	+1 1+*++ + 1*+ * * + ++1
F EPALTES GARIEPINA	9	+ ++ ++ + ++ +
F GEIGERIA ORNATIVA	8	+ + + ++ +++
-ASS. 4.1		
G DIGITARIA ARGYROGRAPTA	5	B+3+A
G ERAGROSTIS HETEROMERA	4	+1 + +
-ASS. 4.2		
F CASSIA MIMOSOIDES	13	+ + + ++ + ++ ++ ++
W COMBRETUM IMBERBE	10	+ + + + 1 * +++
F MONSONIA BIFLORA	6	+ + + ++
F TEPHROSIA PURPUREA	5	+ ++ + 1
F GOMPHRENA CELOSIOIDES	5	+ ++ + +
F KYLLINGA ALBA	7	+ ++ +++ +
F COMMELINA SUBULATA	4	++ + +
-ASS. 4.2.2		
F MARISCUS ARISTATUS	7	+ + ++ + B1
F CYPERUS AMABILIS	2	+A
G ERAGROSTIS GUMMIFLUA	5	+ + + ++
COMMON TO ASS. 1 - 3		
F PUPALIA LAPPACEA	23	++ ++++ ++++ ++ +++ +++++ ++ +
W ACACIA TORTILIS	22	+ + 1 + + ++ + +1+ 1++1B1+1++1
F COMMELINA BENGHALENSIS	19	+++++ ++++ ++++++++ ++
F BECIUM KNYANUM	19	+ + ++ + ++ + + + ++++ + 1+++
F HIBISCUS MICRANTHUS	17	++ + + ++ ++ +++++++ +
F HERMBSTAEDTIA ODORATA	12	+ + +++ +++++ + +
COMMON TO ASS. 1.2 - 4		
G DIGITARIA ERIANTHA	38	+ AB133333+31B3B+BBB+ + +AB+B3AAB1+4B+A 4B
G PANICUM COLORATUM	29	1 A 11++A+ A1 BB 1++ +3A3B1BA3++ 3 + +
G ERAGROSTIS RIGIDIOR	27	++ ++ ++ +++B+A1A+ +1 ++1 +1 1 ++ +
F EVOLVULUS ALSINOIDES	25	+ ++ +++ + ++++++ + + + +++++++ ++
G ERAGROSTIS SUPERBA	20	++ + ++ +++ +1 1+ ++1 + A1+ +
W SECURINEGA VIROSA	18	+ +* +++ ++11 + + + + 1 ++ +
TABLE 2 GROUP -		
1-SODIC AND PUDDLED SOILS		
F RUELLIA PATULA	30	+++1A+++++ + + + ++++++ ++++ + + +++ + +
F JUSTICIA FLAVA	29	++++++ A++1 + +++ ++ + + + ++ +++ + +++ +
F CYPHOCARPA ANGUSTIFOLIA	24	++1+++++ ++ + + + + + + + + +++ +
F TEPHROSIA SEMIGLABRA	17	++ + + + + + +1++B + + ++ +
2-SODIC SOILS		
W EUCLEA DIVINORUM	24	+++ABAA 1A+A + + 1* * + +++1 + + +
G DACTYLOCTENIUM AEGYPTEUM	23	+111 +A A A1 + ++ + BBBAA4B 4 1A
F IPOMOEA COPTICA	20	++++ ++ ++ ++ + ++++ ++ + ++
7-EXCLUDING NON-SODIC SOILS WITH SAND & LOAMY SAND PROFILES		
G THEMEDA TRIANDRA	14	R +1 + + + A1 ++ B B A +
10-EXCLUDING ARID AREAS, SUCH AS SODIC WITH THIN, MASSIVE A HORIZON OR VERTIC OR RAINFALL < 500MM		
F BLEPHARIS INTEGRIFOLIA	22	A+ + + ++ + ++ +++ ++ ++++1+ + +
F COMMELINA AFRICANA	18	+ + + +++ +++ ++ ++ ++ + ++
11-DRY AREAS SUCH AS SODIC, PUDDLED, VERTIC OR CLAYEY WITH 500-550MM RAINF.		
G CHLORIS VIRGATA	31	+ ++1+1 A A A ++ + + ++11++++++ +++A 1 +
12-EXCLUDING THE MOST MESIC SOILS AT > 550MM RAINFALL		
W GREWIA BICOLOR	29	++++ ++ + ++ + + A1+1+ + 1+++++++ + ++
W EHRETIA RIGIDA	23	++++++++ ++ + +++++ + + + ++
14-NON-VERTIC ARID AREAS: SODIC OR PUDDLED OR RAINFALL < 500MM		
F ABUTILON AUSTRO-AFRICANUM	29	++++++++++ + + ++ ++ +++++ ++ + ++ + +
F OCIMUM CANUM	19	+ +++ + + + + + + +++ ++ ++ + +
17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE > 30% PRESENCE IN THIS TABLE		
G PANICUM MAXIMUM	44	1+3+134AA51A3AB1BA3B43A3+33B++B 1A3A++11+* ++ A
W DICHROSTACHYS CINEREA	39	+++++ B1++ ++111+3+1BA3++A+++1++1A++ + + +++
G UROCHLOA MOSAMBICENSIS	38	+3+ ++3 3 A++ +1BA++++++B34BA+3B+B11 1+A++ 1
G ARISTIDA CONGESTA BARBIC...	37	+++ 1 +1 + +111++++ ++ B++ + 3++ ++A111A3111 +A
F CUCUMIS AFRICANUS	35	+++ ++++++++ ++++ ++++++++++++ +++++++ + +
F SOLANUM PANDURAEFORME	28	A ++ + A +++++ + ++ ++++1+11++ + + + + +
F LANTANA RUGOSA	20	+ + + +++ +++ + + +++++ + + +
F INDIGOFERA VICIOIDES	18	++ + + ++ + + +++ ++ + ++ + +
18-INFREQUENT, 10-30% OVERALL PRESENCE > 10% PRESENCE IN THIS TABLE		
F LEUCAS NEUFLIZEANA	16	+ + ++ +++ ++ ++ ++ + + +
W EHRETIA AMOENA	14	+ ++ + + + ++ + +++ ++
F LEUCAS GLABRATA	13	+ ++ + + + + + + + + + +
W GREWIA HEXAMITA	12	+ + ++ +++ *+ + +
W ZIZIPHUS MUCRONATA	10	+ + A + ++ + + +
F ACALYPHA INDICA	7	++ + + + + +
OTHER INFREQUENT SPECIES		
F TEPHROSIA BURCHELLII	13	+ ++ + + 1++ + + + + 1
F CROTALARIA SPHAEROCARPA	13	++ + + + + ++ + + + 1
W ACACIA GERRARDII	13	+ + + * + ** + + ++ + 1
W GREWIA MONTICOLA	12	+ + + + + ++ *+ + + +
F AGATHISANTHEMUM BOJERI	12	+++ + + + ++ + + + +
W RHUS GUEINZII	11	+ + + + + + + * + + +
F FIMBRISTYLIS HISPIDULA	11	A + + ++ ++ + + + +
F SIDA RHOMBIFOLIA	11	+ 1 ++++ ++ + + +
F PAVONIA BURCHELLII	11	+ + + +++ + 1++
F CUCUMIS METULIFERUS	10	+ +++ + ++ + + +
F PHYLLANTHUS ASPERULATUS	10	+ + +++ + ++ ++
F TRAGIA DIOICA	9	++ + ++++ + +
W ACACIA EXUVIALIS	9	+ * + + + + + ++
F OCIMUM URTICIFOLIUM	9	+++ + + +++ +
F DICOMA TOMENTOSA	9	+ + + + + + ++
F KOHAUTIA LASIOCARPA	8	+ + + + ++ + +
G HETEROPOGON CONTORTUS	8	+ + 1++ + + +
W SCLEROCARYA CAFFRA	8	+ + ++ A + + +
F IPOMOEA CRASSIPES	8	+++ + + ++ +
F SEDDERA SUFFRUTICOSA	8	+ + + + + +++
F PHYLLANTHUS PENTANDRUS	7	+ + ++ + + +
W LONCHOCARPUS CAPASSA	7	+ + + + +* +
F POLYGALA SPHENOPTERA	7	+++ + + + +
W CISSUS CORNIFOLIA	6	+ + + + + +
W SCHOTIA CAPITATA	6	*++ A + *
F SIDA OVATA	6	++ + + + +
G BRACHIARIA XANTHOLEUCA	6	++ + +++
G ARISTIDA CONGESTA CONGESTA	6	+ + + B + +
F GISEKIA AFRICANA	5	+ +++ +
W COMMIPHORA AFRICANA	5	+ + * + +
F ACANTHOSPERMUM HISPIDUM	5	3 + 1 + +
W MAYTENUS SENEGALENSIS	5	1 + + + *
F ALTERNANTHERA PUNGENS	5	++ + + +
W ACACIA NILOTICA	5	+ * + + +
F HIBISCUS PUSILLUS	5	+ + + + +
F MELHANIA REHMANNII	5	+ ++ + +
W MAERUA PARVIFOLIA	5	+ + + + +
F BULBOSTYLIS COLLINA	5	++ + + +
F SOLANUM INCANUM	5	1 + + + +
F CUCUMIS HIRSUTUS	5	+ + + + +
F HERMANNIA BORAGINIFLORA	5	+ + 1 ++
W CASSINE TRANSVAALENSIS	5	+ + + * +
W MANILKARA MOCHISIA	4	1 ++*
G SPOROBOLUS PECTINATUS	4	+ 1 + +
W CASSINE AETHIOPICA	3	*1 +
G ARISTIDA CURVATA	3	++ A
F CIENFUEGOSIA HILDEBRANDTII	3	++ 1
F DYSCHORISTE ROGERSII	3	1+ +
G CYMBOPOGON PLURINODIS	2	A +
G PEROTIS PATENS	2	+ B
F CYPERUS SPP.	2	A A
G SETARIA FLABELLATA	2	+ A
W ACACIA ERUBESCENS	1	1
W STRYCHNOS SPINOSA	1	1
W EUCLEA SCHIMPERI	1	1
F TULBAGHIA LEUCANTHA	1	1
F JUSTICIA MATAMMENSIS	1	A
F FUIRENA PUBESCENS	1	A
G ERAGROSTIS UNIGLUMIS	1	1
G ERAGROSTIS SP.	1	A
G DIHETEROPOGON AMPLECTENS	1	1

SEE APPENDIX 2 FOR RARE SPECIES WITH LOW COVER

B. Plant Communities

On the basis of various combinations of the differential species dealt within the previous section, twelve associations are recognized as shown in Table 2. Associations 1-4 of deflocculated soils are grouped into an alliance, which is analysed in Table 3. Another alliance, dealt with in Table 4, includes Associations 5 and 6 of mesic sandy soils. Association 7 of mesic clay and Association 8 of moderately dry clay have not been grouped into higher units and are dealt with separately on Tables 5 and 6 respectively. Table 7 shows an alliance of Association 9 and 10 of arid habitats. Association 11 of vertic soils (Table 8) and Association 12, an arid type (Table 9) are distinct and have not been grouped with any of the others.

CHLORIDO VIRGATAE - JUSTICEION FLAVAE all. nov.
(Alliance on deflocculated soil, Table 3)
Nomenclatural type: *Eucleo divinori-Acacietum welwitschii* ass. nov.

Habitat and location

Deflocculation, which drastically reduces pore space in the soil, may result from high sodium concentrations and from kneauing action such as tilling or trampling when the soil is wet (cf. Thompson, 1952; Hillel, 1971; Krynauw, 1977). Such conditions are highly characteristic of the *Chlorido virgatae - Justiceion flavae*.

Sodium occurs in granite as sodic plagioclase (albite) and Gertenbach (in prep, a) confirmed the consistent presence of high sodium concentrations in bottomland soils on Karoo sediments in the Central District. Sodium and clay released from weathering granite and Karoo sediments accumulate in bottomlands (cf. Dye, 1977; Webber, 1979). High concentrations of sodium deflocculate the clay, producing hard, impenetrable B horizons with columnar structure and/or massive cemented A horizons (Thompson, 1952). Such structure, typical of some associations in this alliance, is common in the granitic and Karoo Sediment regions of the western Central District. Sodic influence from adjoining rhyolitic and granophyric slopes are also evident in places on the basaltic plains. Sodium, which is the most soluble base, is kept dispersed through the soil profile by capillary water and raises the pH. At high pH, calcium and magnesium that may be present are precipitated as carbonates, thus relinquishing further sites on the clay colloids to sodium (Thompson, 1952; Dye, 1977).

Sodic soils of the _Chlorido virgatae - Justiceion flavae_ are typically solonetzic. Different solonetzic soil forms are of consequence to the vegetation. In gently sloping (1-3^{o}) bottomlands, conductive to lateral drainage, the solonetzic soils are of the Estcourt Form. This form has an orthic, usually single grain structureless A horizon, followed by a pale grey leached E horizon on an impenetrable solodized solonetz ("prismacutanic") B horizon. Estcourt soils are the typical solonetzic soils of the granitic region where they are also commonly calcareous. Karoo Sediment bottomlands, on the other hand, are usually almost entirely level, with poor internal drainage. The leached E horizon is absent and the A horizon is massive. Such soils belong to the Sterkspruit Form, defined as an orthic A horizon over a prismacutanic B horizon.

Traditional summer grazing areas of migratory blue wildebeest and zebra on the clayey basaltic plains have been particularly heavily grazed and trampled by these animals for several decades (Kloppers,[1] pers. comm.). Notable among these are the Tshokwane, Nkhelenga, Metsi-Metsi, Lindanda, Makongolweni, Guweni, Gudzane Dam and Bangu areas. The latter area belongs to an arid climate and topography but some of the others have evidently acquired floristic relationships with sodic and/or arid areas as a result of severe grazing.

Most releves classified in the deflocculated soil alliance come from the Tshokwane- and adjoining Nkhelenga area. According to Kloppers (pers. comm.) the Tshokwane area has undoubtedly been trampled more than any of the others, with e.g. the soil at one stage entirely bare. The rainfall, which is higher at Tshokwane than in the other trampled areas, further north, might have been an additional factor favouring puddling. Some sodic colluvium from adjoining granophyric aeas occurs in low areas on the Tshokwane and Nkhelenga basaltic plains and seems to contribute to deflocculation here.

The deflocculated condition may render tampled soils or the B horizons of solonetzic soils arid at times, owing mainly to poor infiltration and increased thermic conductivity (cf. Krynauw, 1977). In sodic B horizons aridity may be further enhanced by high solute suction. On the other hand, because sodic soils and their bottomland relief units are poorly drained, they may regularly become waterlogged in the rainy

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1. Mr J.J. Kloppers, Head, Conservation Management, Private Bag X402, Skukuza 1350, South Africa.

season; the sandy A horizons of solonetz soils more readily than their impenetrable B horizons. Perculation from sandy summits is forced to the A horizon and surface by the B horizon, thus readily causing waterlogging of the A horizon and sustaining seasonal seepages.

Other salient habitat conditions that may favour plants with special tolerances and requirements include poor aeration, which is also associated with deflocclation; and the contribution of sodium as such to the nutrient status as well as its effects on other cations in the soil solution and on their interaction with the vegetation (cf. Russel, 1961; Black, 1968).

Structure

Structural variation in the *Chlorido virgata - Justiceion flavae* is correlated with floristic composition and associated habitat characteristics.

Grassveld and shrubveld occur on duplex soils of the granitic region, which characteristically have single grain structureless sandy A horizons. Grassveld is associated with 200-300mm deep A horizons, whereas shrubveld occurs on shallower than 100mm A horizons (Table 3, Appendix 1). But for the waterlogging, such loose sandy A horizons might carry broadleaved brushveld and treeveld of mesic sandy habitats (Tables 2 & 4, Appendix 1).

It seems that waterlogging, like drought, can be tolerated by microphyllous treeveld, which occurs on duplex soils with massive (cemented) sandy A horizons. This treeveld is either shrubby or scrubby and brushy or thicketed. Brushveld and thicket occur on the non-duplex soils. With high clay content and high conductivity of the B horizon the shrub and brush regimes of treeveld, brushveld and thicket are sparse to moderate; otherwise they are usually densely shrubby and brushy to scrubby and thicketed (Table 3, Appendix 1).

Floristic composition

Species of Groups 1 and 2 in Table 2 are highly characteristic of the Aliance. Floristic relationships with other vegetations are varied. In keeping with the deflocculated arid nature and clay content of puddled soils and solodized solonetzic B horizons, general aridity and clay indicators are well represented. Conversely and concomitant with the sandy and often moist A horizons of the solonetz soils, the Alliance also has numerous general indicators of mesic and sandy conditions. Floristic relationships with shallow soils also exist, probably owing to the hard impenetrable B horizons of the solonetzic soils:-

Strong relationships with dry and arid areas such as trampled clayey soils, vertic soils, and clayey soils with rainfall below 550mm, are indicated by species of Groups 11, 12 and 14 in Table 2. Notable among these, because of their regular presence, are *Acacia tortilis*, *Chloris virgata*, *Grewia bicolor*, *Ehretia rigida*, *Hibiscus micranthus* and *Abutilon austro-africanum*. Other aridity indicator groups are absent except in the puddled soil association where aridity indicators such as *Heliotropium steudneri*, *Enneapogon cenchroides*, *Boerhavia diffusa*, *Tragus berteronianus* and *Pavonia patens* of Group 13 (Table 2) are distintively present.

Relationships with communities of fine-textured soils include the presence of Group 7 and 8 species, e.g. *Themeda triandra*, *Panicum coloratum*, *Acacia nigrescens* and *Securinega virosa*.

Species Groups 4 and 5 link the *Chlorido virgatae - Justiceion flavae* with associations on coarse-textured soils. Group 4 is largely absent, however, from the association of puddled basaltic soil.

1. *Eucleo divinori - Acacietum welwitschii* ass. nov.
(Table 3)
Nomenclatural type: Releve 217

Habitat

This association is typical of level Karoo Sediment and some granitic bottomlands with Sterkspruit grootfontein or closely related soils, characterized by an orthic A horizon with 6-15 per cent clay and coarse sand, and a non-red prismacutanic B horizon. Major subcommunities are associated with differences in colour, structure and texture of the A horizon, whereas minor variations are associated with clay content of the B horizon. These are differences that are accommodated within the Sterkspruit grootfontein Series.

Structure

Structural variation within this association is inventorized in Appendix 1. The structure is generally treeveld, which is sparsely to moderately shrubby and brushy where both clay content and conductivity of the B horizon are high, e.g. exceeding 30 per cent and 350 micro mhos respectively; and densely shrubby and brushy to scrubby and thicketed at lower clay percentage and conductivity.

Floristic composition

Highly characteristic woody species of this Association comprise two southern African Lowveld endemics (cf. Coates Palgrave, 1977). One of these, *Acacia welwitschii* subsp. *delagoensis* is the most common dominant or codominant woody species of the Association. It does not occur in the two releves on granite (Releves 333 and 309, Table 3). The other is *Dinocanthium hystrix*, which has the typical xeromorphic growth form of Spiny Arid Bushveld (see Ch. II and Association 10). The following are also virtually exclusive to the *Eucleo* divinorum - Acacietum welwitschii: the annual grass Eragrostis cylindrifolia and the forbs Achyranthes aspera, Achyropsis leptostachya, Indigofera schimperi, Barleria elegans and others (Tables 2 & 3). Subcommunities are, furthermore, well characterized by strongly exclusive species.

Species of Group 10, Table 2, which avoid only the arid-most areas, are distinctly absent from this Association. Notable woody examples are Sclerocarya caffra, Dalbergia melanoxylon, Lonchocarpus capassa and Lannea stuhlmannii.

Dominant species vary considerably between subcommunities and variations thereof.

1.1 Brushveld and treeveld with Sporobolus nitens, on duplex soils with dark, massive A horizons

The subcommunity on soils with dark massive structureless sandy loam A horizons is characterized by the presence of the woody species Maytenus tenuispina, Spirostachys africana, Acacia grandicornuta, Pappea capensis, Capparis tomentosa, Carissa bispinosa var. acuminata, Albizia anthelmintica, Lycium shawii, Boscia mossambicensis, B. foetida subsp. rehmanniana and Cassine aethiopica; the grasses Sporobolus nitens and Enteropogon macrostachyus; and several forbs (Tables 2 & 3). Two variations are apparent.

1.1.1 Sparsely shrubby, moderately brushy, brushveld and treeveld with Cyathula crispa

Variation 1.1.1 is typically sparsely shrubby, sparsely to moderately brushy, sparse to moderate treeveld. Trees contribute most to the shrub and brush. The variation is further differentiated by the forb Cyathula crispa, which is among the subdominants in the field layer. On Karoo Sediments the tree and brush levels as well as the upper shrub level (2m) are dominated by Acacia welwitschii subsp. delagoaensis. On granite these levels are dominated by Acacia grandicornuta (Table 3). Dominants and subdominants of the field layer usually include five or more of the following: the grasses *Sporobolus nitens*, *Enteropogon macrostachyus*, *Dactyloctaenium aegypteum*, *Urochloa mossambicense* and *Panicum maximum*; and the forbs *Achyranthus aspera*, *Portulaca quadrifida*, *Cyathula crispa*, *Ruellia patula*, *Cyphocarpa angustifolia*, *Blepharis integrifolia*, *Solanum panduraeforme* and *S. incanum*.

1.1.2 Densely shrubby to scrubby, densely brushy to thicketed treeveld with *Spirostachys africana*

Variation 1.1.2 is typically densely shrubby, densely brushy, moderate treeveld; with shrubs and brushes filling in the area between trees. This variation is floristically differentiated by the woody species *Spirostachys africana*, *Pappea capensis* and *Carissa bispinosa*. The former two are usually among the dominants or subdominants. A high cover for *Euclea divinorum* is also strongly characteristic. The tree level is dominated by either *Acacia welwitschii*, which in places also dominates the brush l'evel, or *Spirostachys africana*. The brush and shrub layers are usually dominated by *Euclea divinorum* or *Maytenus tennuispina* and in places by *Cassine aethiopica*. Other woody species that are occasionally subdominant include *Acacia grandicornuta*, *Dinocanthium hystrix*, *Grewia flavescens*, *Zizyphus mucronata*, *Maytenus senegalensis*, *Euclea schimperi* and *Strychnos spinosa*. Field layer dominants include the grass *Panicum maximum*, which generally associates with woody plants and is commonly the sole dominant in this densely woody vegetation and *Enteropogon macrostachyus*, which is known in some areas as a shade-tolerant unpalatable grass (McDonald,[2] pers. comm.). In such areas *E. macrostachyus* possibly gains

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2. Mr I. McDonald, Natal Parks, Game and Fish Preservation Board, P.O. Box 25, Mtubatuba 3935, South Africa

dominance over _P. maximum_ with heavy grazing pressure. Typical subdominants of the field layer include the grasses _Sporobolus nitens_, _Chloris virgata_, _Enneapogon cenchroides_, _Dactyloctaenium aegypteum_ and _Aristida congesta_ subsp. _barbicollis_; and the forb _Ruellia patula_.

1.2 Treeveld with _Grewia flavescens_ on red and yellow, loose, sand and loamy sand A horizons

Soils of this subcommunity differ from those of the former in respect of one or more striking features shown in Table 3. A horizons in the treeveld with _Grewia flavescens_ are redder or yellower or looser or sandier at least. Slopes are also commonly steeper.

Distinctive floristic features include _Grewia flavescens_ as well as relationships with the _Justiceo flavae - Albizietum petersianae_ through the presence of several species. These include the woody _Albizia petersiana_, the grasses _Digitaria eriantha_ and _Panicum coloratum_, the forb _Ipomoea coptica_ and members of species Groups 4 and 5 (Table 2) of relatively sandy and shallow soils, notably the grass _Eragrostis rigidior_ and the forbs _Waltheria indica_, _Evolvulus alsinoides_ var. _linifolius_ and _Tragia dioica_.

Structure is varied and related to conductivity and clay content of the B horizon in a manner similar to that in the _Sporobolus nitens_ Subcommunity. High clay, high conductivity B horizon soils carry vegetation with sparse to scattered shrub and brush (Releves 166 & 195), or if brush and shrub cover are high (Releve 141) these occur on trees with canopies extending down, and on stunted brushy forms of the dominant tree species, which is _Acacia welwitschii_. Conversely, soils with less clay and lower conductivity in the B horizon also have _Acacia welwitschii_ as the dominant but, as in the other Subcommunity, are moderately to densely brushy and shrubby with a different species dominating these lower levels. A horizon colour and texture as well as slope, indicate better aeration in the treeveld with *Grewia flavescens* than in the subcommunity with *Sporobolus nitens*. Concomitantly, *Dichrostachys cinera* subsp. *africana* var. *africana* is the dominant brush and/or shrub species in the denser phases of the treeveld with *Grewia flavescens* (cf. Werger & Coetzee, 1978, for support of this view of the habitat preference of the relevant species).

Panicum maximum is usually among the dominants and is sometimes overwhelmingly dominant as in Releve 141, which also has a distinctly high cover of *Acacia welwitschii* subsp. *delagoensis* (Table 3). Occasionaly dominant or codominant grasses include *Urochloa mossambicense*, *Chloris virgata*, *Dactyloctaenium aegypteum*, *Digitaria eriantha* and *Panicum coloratum*. The forbs *Justicia flava* and *Solanum panduraeforme* may reach five per cent cover or more.

2. *Justiceo flavae* - *Albizietum petersianae* ass. nov. (Table 3)
Nomenclatural type: Releve 246

Habitat

The *Justiceo flavae* - *Albizietum petersianae* occurs on Karoo Sediment soils with thick A horizons and sodic characters such as massive structureless A or B horizons, or duplex profiles, or both. Salient habitat characteristics are deep, moist, sodic sandy soils. A horizons are typically 300-400 mm thick with loamy sand or sandy loam texture and pH of 5,0-5,5. Soils typically belong to the Estcourt, Sterkspruit, Pinedene, Clovelly and Mispah forms. The Association occupies a catenal position above the *Eucleo divinorum* - *Acacietum welwitschii* of level bottomlands and the terrain is usually gently sloping (1-2^{o}). Lateral internal drainage down the gentle slopes may be responsible for erosion of deflocculated B horizons with resulting deep A horizons, as well as for the E horizons of the Estcourt soils.

Structure

Structure in this Association is strongly related to soil depth and drainage (Table 3, Appendix 1).

Open shrub and brush layers with relatively high cover in the tree layer occur on shallow soils, such as Mispah soils, which have orthic A horizons directly on rock; or on the equivalent of shallow soils, such as the Estcourt Form, which has an impermeable B horizon. The structure here is typically sparsesely shrubby, sparsely brushy or moderately shrubby, moderately brushy, sparse to moderate treeveld.

A similar structure but with high brush cover relative to shrub cover, is found on comparatively deeper soils. The vegetation here is typically sparsely shrubby, moderately brushy or moderately shrubby, densely brushy, treeveld. The soils commonly belong to the Pinedene Form, which has an orthic A horizon, followed by a yellow-brown apedal B horizon over a gleycutanic B horizon.

Densely shrubby to scrubby, densely brushy to thicketed vegetation, with trees absent to sparse, occurs on relatively deep and well-drained soils such as the Clovelly and Hutton forms, which have orthic A horizons on respectively yellow-brown and red B horizons.

Floristic composition

Albizia petersiana subsp. *evansii*, which is locally virtually exlusive to this Association, is also usually its dominant or subdominant woody plant (Tables 2 & 3). The species is a characteristically multi-stemmed tree or brush. The subspecies is a southern African Lowveld endemic, which within the Kruger National Park is largely confined to the Karoo Sediments (Coates Palgrave, 1977; Van Wyk, 1972). A few other species are diagnostic within Alliance context and three subcommunities are distinguished (Table 3).

The dominant woody species at brush and shrub levels are usually either Albizia petersiana subsp. evansii (e.g. Releves 142, 169, 245, 300, 303, 306 and partly 254) or Dichrostachys cinerea subsp. africana var. africana (Releves 165, 198, 226, 246). A. petersiana is dominant on Mispah soils and duplex or related soils, such as the Estcourt, Sterkspruit and Pinedene forms, whereas D. cinerea is typically dominant on the better drained Clovelly soils. The preference of D. cinerea for well-aerated soils is supported by Werger & Coetzee (1977) and is apparent also in the subcommunity with Grewia flavescens, of the Eucleo divinorum - Acacietum welwitschii. Where A. petersiana dominates the brush and shrub levels, the same species is also the dominant tree if trees are present. However, where D. cinerea dominates the lower levels, the tree level, if present may be dominated by A. petersiana, Acacia welwitschii or Lonhocarpus capassa.

Digitaria eriantha and Panicum maximum are consistently dominant or subdominant in the field layer. The former is the common dominant on Mispah, Estcourt, Sterkspruit and Pindene soils, where brush and shrub cover are relatively low. P. maximum is the common dominant in densely brushy to thicketed densely shrubby to scrubby stands, which typically occur on soils of the Clovelly and Hutton forms and where D. cinerea is usually dominant at the brush and shrub levels (Releves 165, 169, 198, 246, Table 3, Appendix 1). Occasional subdominants include Pogonarthria squarrosa, Urochloa mossambicense, Sporobolus fimbriatus, Eragrostis rigidior and Panicum coloratum.

Floristic variation based on the mere presence of groups of associated species, coincides loosely with the variation in habitat, vegetation structure and dominant species mentioned already (Table 3, Appendix 1). Two subcommunities may thus be distinguished.

2.1 Brushveld and treeveld with Combretum apiculatum on gentle slopes

Slopes in the first subcommunity are approximately two degrees, which is distinctly steeper than in its counterpart. Estcourt and Mispah soils predominate and the brush and shrub cover is sparse to moderate. The Subcommunity is differentiated by the woody species Combretum apiculatum subsp. apiculatum, Lannea stuhlmannii, Dalbergia melanoxylon, Combretum hereroense and Combretum zeyheri as well as the high constancy of the grass Brachiaria nigropedata. The dominant grass is nearly always Digitaria eriantha.

Two variations are apparent (Table 3):

(2.1.1) the first, with Acacia nigrescens, is typical of footslopes; whereas
(2.1.2) the second, typical of middleslopes, is differentiated by the woody species Terminalia sericea and Peltophorum africanum, the grasses Sporobolus fimbriatus and Schmidtia pappophoroiddes and several forbs.

2.2 Other brushveld, thicket and treeveld on level to extremely gentle slopes

The subcommunity on gentler 0-1° slopes and predominantly Clovelly, Pinedene and Hutton soils, is negatively differentiated. This subcommunity is typically densely shrubby to scrubby and/or densely brushy to thicketed, usually with Dichrostachys cinerea dominant at these levels and with Panicum maximum as the dominant grass. The Subcommunity occurs on middleslopes and shares differential species, e.g. the grass Sporobolus fimbriatus and the woody Peltophorum africanum, with the middleslope variation of the subcommunity with Combretum apiculatum (Table 3).

3. *Pupalio lapaceae - Acacietum nigrescentis* ass. nov. (Table 3) Nomenclatural type: Releve 257

Habitat

The *Pupalio lapaceae - Acacietum nigrescentis* occurs on those parts of the basaltic plains that have been most severely grazed and trampled particularly by blue wildebeest and zebra, for several decades. The most extensive example is the Tshokwane-Nkhelenga-Metsi-Metsi area (Fig. 1). Van der Schijff (1959) singled out the Tshokwane area as an example of veld that had been trampled owing to artificial water supplies. Braack (1964-1972) produced a map depicting the area immediately around Tshokwane as the most trampled in the present study area. According to Kloppers[3] (pers. comm.) the Tshokwane area has undoubtely been trampled more than any other part of the Central District basaltic plains.

The Association owes its distinct character to exclusive floristic affinities with both the moderately dry, clayey Association 8 of basaltic plains and the present Alliance of the deflocculated soils. Exclusive relationships with Association 8 include e.g., the combination of a poor presence of Group 4 species and distinct presence of Group 13 species; whereas unique affinities with the Alliance of deflocculated soils include e.g., the presence of Group 1 species (Table 2). The landscape (No. 6) and associated habitat characteristics - including climate, geology, topography, geomorphology and soil series - of the *Pupalio lapaceae - Acacietum nigrescentis*

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3. Mr J.J. Kloppers, Head, Conservation Management, Private Bag X402, Skukuza 1350, South Africa.

(Association 3), as well as geographic location, correspond to those of the _Acacio gerrardii_ - _Acacietum tortilis_ (Association 8), which accounts for their exclusive floristic relationships (Tables 3 & 6). However, the habitat of Association 3 has been considerably more heavily grazed and trampled than that of Association 8 and consequently, one may presume, soils are also more deflocculated and perhaps with altered mineral content. Deflocculation, if present, is shared only with sodic soils and offers a likely explanation for the exclusive floristic affinities between sodic soil and trampled basaltic soil vegetations.

Trampled areas belonging to the _Pupalio lapaceae_ - _Acacietum nigrescentis_ occur on the southern basaltic plains of the Central District where the mean annual rainfall is 500-650mm. The rainfall is lower on the northern basaltic plains where trampled areas belong to the more arid _Acacio nigrescentis_ - _Grewión bicoloris_ (Table 7). Examples of the latter Alliance may also be found on shallow soils of the Mispah Form in the southern, relatively high rainfall, area.

The basaltic plains are gently undulating and releves of Association 3 are from crests, middleslopes and footslopes. Soils typically belong to the Glenrosa (orthic A, lithocutanic B horizon), Mayo (melanic A, lithocutanic B horizon), Swartland (orthic A, pedocutanic B horizon) and Bonheim (melanic A, pedocutanic B horizon) forms. A horizons are commonly dark, weakly structured, with sandy loam, sandy clay loam and clay loam texture; their depths vary from 400mm to less than 100mm and pH from 5,4 to 6,8, depending on subcommunity. B horizons typically have 30-40 per cent clay and pH of 5,7 to 6,8. Profile depth, which varies with subcommunity, ranges from 200mm to 1000mm.

Structure

Structural variation in the *Pupalio lapaceae - Acacietum nigrescentis* sample is not correlated with observed soil characteristics. The structure is typically sparsely to moderately shrubby, sparse to moderate brushveld, occasionally with scattered to sparse tree cover (Appendix 1).

Floristic composition

The distincly mixed relationships of the *Pupalio lapaceae - Acacietum nigrescentis* with the Deflocculated Soil Alliance and Association 8 were treated in discussing the habitat. Within alliance context the *Pupalio lapaceae - Acacietum nigrescentis* is differentiated by clay-associated species, including the woody *Acacia nigrescens*, the grasses *Bothriochloa radicans* and *Eragrostis cilianensis* and the forb *Ipomoea sinensis* subsp. *blepharosepala*; as well as by the forbs *Boerhavia diffusa* var. *hirsuta* and *Heliotropium steudneri* var. *leiopodium*, which occur in dry and arid areas, except on sodic soils (Tables 2 & 3).

On the less than 700mm deep soils, belonging to the Mayo, Glenrosa, Swartland and Oakleaf forms, the shrub and brush layers are dominated by *Acacia nigrescens* and/or *A. tortilis* (Releves 96, 237, 239, 241 and 257). *Grewia bicolor* may be among the dominants on extremely shallow soils of the Mispah Form, where habitat tends towards arid (Releve 241). *Dischrostachys cinerea* subsp. *africana* var. *africana* is the sole dominant in the shrub and brush layers on deeper than 1 000mm soils, belonging to the Bonheim Form (Releves 143 and 258).

Dominants in the field layer vary with subcommunities, which coincide approximately with the abovementioned soil characteristics and associated dominant woody species.

3.1 Urochloa mossambicense - Aristida spp.- dominated brushveld

Differential species of this subcommunity include the grasses Aristida adscensionis, which may be dominant, Enneapogon cenchroides and Tragus berteronianus and the forbs Dicoma tomentosa and Seddera suffruticosa. The grasses Aristida congesta subsp. barbicollis may also be dominant, but the usual dominant and otherwise subdominant or codominant of the field layer is the grass Urochloa mossambicense. Occasionally the grasses Panicum maximum or Bothriochloa radicans may share (sub-) dominance with U. mossambicense (Table 3).

3.2 Panicum maximum - P. coloratum - Digitaria eriantha - Themeda triandra - Bothriochloa radicans - dominated brushveld and treeveld

Dominants in the field layer, here, are distinctively the grasses Panicum coloratum or P. maximum. Subdominants usually include either of these two species together with some combination of Urochloa mossambicense, Digitaria eriantha, Themeda triandra and Bothriochloa radicans.

4. Albizia harveyi - Eucleetum divinori ass. nov.
(Table 3)
Nomenclatural type: Releve 282

Habitat

Granitic duplex soils with dark A horizons and pH of the A and/or B horizons exceeding 6,0 and 7,0 respectively, are characteristic of this Association. pH of the A horizon is rarely below 5,5 and that of the B horizon seldom below 6,8 (Table 3). Included are all granitic soils of the Estcourt Form as well as relatively high pH Sterkspruit (Form) soils. The pH values of B horizons in these duplex soils are higher than those of granitic duplex soils with vegetation belonging to

Association 7 (P < 0,05 Two-tailed Mann-Whitney U Test using normal approximation with tie correction, N1 = 6, N2 = 11, Tables 3 & 5). The Esctourt soils typically occur on middleslopes of the undulating granitic terrain, where clay and sodium from the leached sandy summits begin to accumulate; whereas these relatively high pH Sterkspruit soils are usually on valley floors or footslopes with less than 3^{o} slope. Relatively low pH, granitic Sterkspruit soils, commonly found on 3-4^{o} middleslopes, carry stands of the Themedo triandrae - Acacietum gerrardii (Association 7, Table 5).

A horizon depth in the Albizio harveyi - Eucleetum divinori varies from less than 100mm to 300mm; structure is apedal, single grain; and texture is typically sand, loamy sand and sandy loam. The deflocculated B horizons usually have between 25 per cent and 35 per cent clay. Free carbonates are occasionally present.

Structure

Structure in this Association correlates with A horizon depth and both of these relate to floristic classification into subcommunities (Table 3, Appendix 1). The subcommunity that is predominantly sparse shrubveld with scattered brush occurs on soil with shallower than 200mm A horizons, whereas the subcommunity that is grassveld or sparse brushveld, with or without scattered shrub and brush, occurs on soils with 200-300mm thick A horizons (P < 0,01, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, N1 = 5, N2 = 8).

Floristic composition

Species that are largely confined to this Association, within the study area, include the grasses Digitaria argyropgrapta and Eragrostis heteromera, the sedges Mariscus aristatus, Kyllinga alba and Cyperus amabilis, the forbs Geigeria ornativa, Epaltes gariepina, Commelina subulata and

Gomphrena celocioides and other species, shown in Table 2. Most of these occur in particular subcommunities and variations. The woody plants Ormocarpum trichocarpum and Albizia harveyi are notable among those distinctive for the entire Association in Alliance context (Table 3). These two species have relatively clayey and mesic-clayey affinities respectively (Groups 8 & 10, Table 2).

Dominant woody species vary independantly of subcommunites and may include Albizia harveyi (most commonly), Combretum hereroense, Euclea divinorum, Albizia anthelmintica, A. petersiana subsp. evansii, Manilkara mochisia and Grewia monticola (Appendix 1).

Digitaria eriantha and Dactyloctaenium aegypteum are usually among the dominants and subdominants of the field layer. Others vary with subcommunity.

4.1 Shrubveld with Digitaria argyropgrapta on soils with shallow A horizons

This subcommunity typically occurs on the soils with shallow A horizons, where sparse shrubveld predominates. Differential features include the presence of Digitaria argyropgrapta, which is also commonly dominant or subdominant and the dominance or subdominance of Panicum coloratum (Table 3).

4.2 Grassveld and brushveld with Cassia mimosoides on soils with relatively deep A horizons

The subcommunity on soils with relatively deep A horizons is characteristically grassveld with occasional or scattered shrub and brush, and brushveld. Differential species include the woody Combretum imberbe and the forbs Cassia mimosoides and Monsonia biflora. Two variations are distinguished as shown in Table 3:-

TABLE 4. POGONARTHRIO SQUARROSAE - COMBRETION APICULATI (ALLIANCE ON MESIC SAND)

```
RELEVE NUMBERS                                   [illegible]
ASSOCIATION NUMBER                               5                         6
LANDSCAPE NUMBER                                 [illegible]
HABITAT
GEOGRAPHY & RAINFALL (S=SOUTH-
        N=NORTH, OF NWANEDZI)                    [illegible]
GEOLOGY (O=DOLORITE,G=GRANITE,
        Q=QUATERNARY, R=RHYOLITE,
        Z=SANDSTONE)                             [illegible]
RELIEF (C=CREST,F=FOOTSLOPE,
        M=MIDDLESLOPE)                           [illegible]
SLOPE                    (DEGREES)               [illegible]
SURFACE   (F=FLAT,C=CONCAVE,
          CONVEX, N=CONVEX,
          R=ROCKY, U=CONCAVE)                    [illegible]
ROCK (% X 10: <1,+=1-9)                          [illegible]
ROCK HGT (M) <0.5, +=0.5-0.9)                    [illegible]
BOULDERS  (A=ABUNDANT,                           [illegible]
STONES     F=FREQUENT, R=RARE)                   [illegible]
A HORIZON-DEPTH  (DM) <10M)                      [illegible]
-COLOUR (D=DARK, I=DUSKY RED,
         R=RED, Y=YELLOW)                        [illegible]
-TEXTURE (C=CLAY, T=CLAY LOAM,
  L=LOAM(Y), S=SILTY, Y=SAND(Y))                 [illegible]
-CLAY                          (%)               [illegible]
-PH                                              [illegible]
-CONDUCTIVITY (MICROMHOS X 10)                   [illegible]
B HORIZON - DEPTH  (DM) >90M)                    [illegible]
-TEXTURE       (L=CLAY LOAM,
   L=LOAM(Y), Z=SAND(Y))                         [illegible]
SOIL FORM (STD. ABBREVIATIONS,
        MACVICAR ET AL., 1977)                   [illegible]
SOIL SERIES NUMBER
        (MACVICAR ET AL., 1977)                  [illegible]
NUMBER OF SPECIES                                [illegible]

GROWTH FORM PREFIX:
  F=FORB, G=GRASS, W=WOODY
  SU=SUCCULENT

DIFFERENTIAL SPECIES FOR-
(SP. NAMES, PRESENCE VALUES)

  PEROTIDO PATENTIS -
  TERMINALIETUM SERICEAE
  (ASSOCIATION 5)
G  SPOROBOLUS FIMBRIATUS         34  [illegible]
G  PEROTIS PATENS                33  [illegible]
W  LANNEA STUHLMANNII            37  [illegible]
F  TEPHROSIA SERICEA             29  [illegible]
F  CASSIA ABSUS                  21  [illegible]
F  CLERODENDRUM TERNATUM         21  [illegible]
W  STRYCHNOS MADAGASCARIENSIS    19  [illegible]
F  COMMELINA ERECTA              19  [illegible]
F  INDIGOFERA FILIPES            18  [illegible]
F  HELIOTROPIUM STRIGOSUM        20  [illegible]
F  PHYLLANTHUS MADERASPATENSIS   19  [illegible]
F  ANGIOFERA SANGUINEA           16  [illegible]
F  APTOSIMUM LINEARE             17  [illegible]
F  LEUCAS GLABRATA               18  [illegible]

 -ASS. 5.1
W  COMBRETUM MOLLE               13  [illegible]
W  PSEUDOLACHNOSTYLIS MAPRO...    3  [illegible]

 -ASS. 5.2
G  ARISTIDA CONGESTA CONGESTA    15  [illegible]
F  HERMANNIA TRIDENTATA          15  [illegible]
G  SETARIA FLABELLATA            10  [illegible]

 -ASS. 5.2.1
F  TEPHROSIA FORBESII             5  [illegible]

 -ASS. 5.2.2
G  ELIONURUS MUTICUS              4  [illegible]

 -ASS. 5.3
F  HARPAGOPHYTUM PROCUMBENS       6  [illegible]

 -ASS. 5.4
F  HIBISCUS MICRANTHUS           25  [illegible]
G  OROPETIUM CAPENSE             16  [illegible]
F  HIBISCUS SIDIFORMIS           12  [illegible]

 -ASS. 5.4.1
F  ACALYPHA INDICA               21  [illegible]
F  ABUTILON AUSTRO-AFRICANUM     14  [illegible]
F  CYPHOCARPA ANGUSTIFOLIA       13  [illegible]
G  ARISTIDA ADSCENSIONIS         10  [illegible]
F  PUPALIA LAPPACEA               6  [illegible]
F  ACHYRANTHUS ASPERA            10  [illegible]
F  SOLANUM COCCINEUM              9  [illegible]

  DIHETEROPOGONO AMPLECTENTIS-
  OZOROETUM ENGLERI
  (ASSOCIATION 6)
G  THEMEDA TRIANDRA              34  [illegible]
F  BLEPHARIS INTEGRIFOLIA        31  [illegible]
G  DIHETEROPOGON AMPLECTENS      26  [illegible]
W  OZOROA ENGLERI                26  [illegible]
W  PELTOPHORUM AFRICANUM         18  [illegible]
F  PHYLLANTHUS PENTANDRUS        17  [illegible]
F  THESIUM GRACILARIOIDES        16  [illegible]
F  INDIGOFERA HETEROTRICHA       15  [illegible]
F  DALECHAMPIA GALPINII          12  [illegible]

 -ASS. 6.1
W  MUNDULEA SERICEA               7  [illegible]
F  LEUCAS SEXDENTATA              7  [illegible]
G  ARISTIDA SP.                   5  [illegible]

 -ASS. 6.2
G  PANICUM DEUSTUM                4  [illegible]
F  ASPARAGUS SP.                  6  [illegible]
W  GALPINIA TRANSVAALICA          6  [illegible]
F  PELLAEA VIRIDIS                5  [illegible]
W  PAPPEA CAPENSIS                4  [illegible]

 -ASS. 6.3 & 6.4
G  PANICUM COLORATUM             19  [illegible]
W  ACACIA GERRARDII              16  [illegible]

 -ASS. 6.4
G  ANDROPOGON GAYANUS            15  [illegible]
F  CRABBEA HIRSUTA               24  [illegible]
F  SECOERA SUFFRUTICOSA          17  [illegible]
G  BRACHIARIA SERRATA             8  [illegible]

 -ASS. 6.4.2
G  CYMBOPOGON PLURINODIS         12  [illegible]

 COMMON TO ASS. 5 & 6
F  EVOLVULUS ALSINOIDES          37  [illegible]
F  WALTHERIA INDICA              36  [illegible]
F  POLYGALA SPHENOPTERA          37  [illegible]
F  KOHAUTIA VIRGATA              31  [illegible]
F  TEPHROSIA BURCHELLII          33  [illegible]

 COMMON TO ASS. 5.4 & 6
F  EUPHORBIA NEOPOLYCNEMOIDES    28  [illegible]
F  IPOMOEA SINENSIS              25  [illegible]
F  HIBISCUS PUSILLUS             24  [illegible]
F  COMMELINA AFRICANA            24  [illegible]

 TABLE 2 GROUP -

  3-SAND, LOAMY SAND &
    SANDY LOAM SOIL PROFILES
    RAINFALL > 550MM
G  TRICHONEURA GRANDIGLUMIS      52  |+ |+++1++A |B 1+A++++++11++++ |+++++++ ++++ +++ +++ |++ +++ |+A + +
F  MELHANIA DIDYMA               39  + + |+ ++ | ++ |++ + |++++++ + + |+ ++++ ++ | + + + ++ |+ ++ + |+ + ++
G  RHYNCHELYTRUM VILLOSUM        28  + |+ + | + + + ++++ | +++ + +++1 +1 + + |+ + ++ +

  4-SAND TO SANDY CLAY LOAM
    TOPSOILS, RAINFALL > 550MM
G  POGONARTHRIA SQUARROSA        64  + +B |AABA1BB+3111A1++AA3B+A1A++1+ A1A++1ABA1B |++B+++ |+ A+++ |++ ++1 + |+1 ++
G  BRACHIARIA NIGROPEDATA        56  +++ B+ + A+A1 A ++B++++A+ |1+1+ + +A + 1 |AAAA+1 |B+1BBB1 +1B++AA+ |++ A+1+
W  COMBRETUM ZEYHERI             56  1BA 3B11AAAA1A11A1 |A+A1111+A1A 11+A |1A1+1A | + A11++ 111A1 11+ ABB1
F  AGATHISANTHEMUM BOJERI        51  ++ *+++++++1++++ |+++++1+ + ++++R+ |+++++++ ++ + + | ++ ++ + + ++
G  ERAGROSTIS RIGIDIOR           39  + A++1+ +++ 1+ |++ +++A+1 + +++ +1A++A+ ++ + | A ++ | +
F  THUNBERGIA DREGEANA           34  ++ + ++++ + + + |+ + +++ + ++++ +++++ + |++++ + + + +
F  FIMBRISTYLIS HISPIDULA        31  |A+ ++++++ + + + A | + ++ + + | + 11++A | + + |+ + + |+ ++
F  PHYLLANTHUS INCURVUS          28  |+ +++ +++++ |+++ ++ + | + + |+ +++ + |+ +

  5-AVOID MESIC TO MODERATELY
    DRY, DEEP, CLAYEY SOILS
W  COMBRETUM APICULATUM          76  1 +AA11+1 +1+1A 11 |AAA+1A11AABAA11AA111+BAA11+AA11 +AAAA11A+11+1 |A1A11+A113A+BBA33
W  CISSUS CORNIFOLIA             56  +1++1+ ++ ++ + +* |+ ++1++++1*+ 1++*++++++++ ++ +++ + ++ ++++ ++ |+ + +1
F  TRAGIA DIOICA                 41  ++ + + ++ |+ + + + +++ + + + ++++ ++ ++ B+ ++++ +++++++ +++
G  SCHMIDTIA PAPPOPHOROIDES      41  + +B + +11+++++A+A |+A 3+1 ++ |AA ++AB+ + A 1 + + 1 + + + ++
W  ACACIA EXUVIALIS              32  * + + + + ++++ +1 1+++ ++ |+ ++ ++ + *+ * + |* |+A + +

  9-MESIC AREAS-RELATIVELY SANDY
     &/OR > 550MM RAINFALL
     BUT EXCLUDING SODIC SOILS
F  RHYNCHOSIA TOTTA              51  + +++ A+++ ++ +++ + + + + + |+++++++ ++ |++++++ + + ++++++++++ |+++++ ++
W  MAYTENUS HETEROPHYLLA         41  ++ |+ * + +* * + +*+ + 1++ +* + + + |+++++++ ++ +* +1 1++++ +
W  PTEROCARPUS ROTUNDIFOLIUS     30  + A1 B1+11 B+ 1 B 1 B | A ++1A11A+A1 AAAA
F  IPOMOEA CRASSIPES             25  |+ ++ +++ ++ + + ++ + +++++ + ++ ++ ++

  10-EXCLUDING ARID AREAS, SUCH
     AS SODIC WITH THIN, MASSIVE
     A HORIZON OR VERTIC OR
     RAINFALL < 500MM
G  HETEROPOGON CONTORTUS         59  + B+ AA3 +++++B+++ 1A A1+ ++ 1++ + |++++1++ ++1+A+ + +A+1A +++ |A++ +1++++ ++ +A
W  SCLEROCARYA CAFFRA            56  1+++ ++1111 1A111 + +111 ++A1 1BAA |A+*1 1 A ++++ + +1+* +++++++ + ++1+1
F  CASSIA MIMOSOIDES             52  ++++++++++++++++++ ++ + +++ ++ + ++ + + ++ + ++++1+ + +++ ++ + + + + + ++
W  DALBERGIA MELANOXYLON         44  1* +++++++++ ++* ++*+++ + + + + +++ ++++ + **+* + * 1++ + +*
G  ERAGROSTIS SUPERBA            38  ++*+ + + 1++++ +++++1+ + ++ + 1 + + + + ++++1 +++ +A+
W  ALBIZIA HARVEYI               33  + + + + ++ ++ + ++ + +1 +1++1+ ++++1+1+ + A + +
W  LONCHOCARPUS CAPASSA          32  + +++ +* + +++ + ++ +++ ++ +*++ 1 + + + *+ 1 1 + +
W  GREWIA MONTICOLA              25  + +1 + ++ ++ + 1++ ++ + ++ 1+ + +* + + +
F  SIDA CHRYSANTHA               25  + ++ + + + + + + ++ +++ ++ + ++ + + + + +

  17-GENERAL DISTRIBUTION,
     > 30% OVERALL PRESENCE
     > 30% PRESENCE IN THIS TABLE
G  DIGITARIA ERIANTHA            83  B3BB+B33AAA++A+BABA33B1B+331A1ABBAB+BB3A3AB+A+3B+A4B+BB3BB+BBABBB+B33B331A+BBB1AA11
G  PANICUM MAXIMUM               79  A3A1BB+1333 +1+BBBB+113++++BA1+AAAAABA+41++ABBB+++++AA3A+3+A1BBB+ +A++A++A +++ B++
G  ARISTIDA CONGESTA BARBIC...   64  ++ ++ ++ + ++ + +++++A+A1A1A11+B1+A +++ ++++1B13+ +++++++++ ++++++ +++B1+11
W  DICHROSTACHYS CINEREA         62  + ++ +++++ ++ ++ +++ ++ +1+++1++1 +1++ * + +++++++ + ++++ +++++ +* +++++++ +++
F  INDIGOFERA VICIOIDES          40  + + + + + + ++ + + ++++ + + ++ ++++ +++++++ ++ ++ +1+++ + +
F  CUCUMIS AFRICANUS             32  + + + + +++ + ++ ++ +++++ + +++ ++ + + + + + + + +
F  PHYLLANTHUS ASPERULATUS       27  ++ ++ + + + + + +++ ++++ + + ++ + + ++ + + +
G  UROCHLOA MOSAMBICENSIS        26  + +1 + + + + + + + 3 ++ ++ 1 1+ + + + + ++ + +

  18-INFREQUENT,
     10-30% OVERALL PRESENCE
     > 10% PRESENCE IN THIS TABLE
F  HERMBSTAEDTIA ODORATA         37  ++ ++ +++ + +++ + +++ +++ ++ + ++ ++ + + + + ++ + +++ +++
F  SOLANUM INCANUM               24  + + + + + ++ + ++ + + + + ++ + +++++++
W  ZIZIPHUS MUCRONATA            24  + + + + + * * +A+ +1+ + + * + ++ *+ * + +
F  HERMANNIA BORAGINIFLORA       23  + ++ + + + + + + + + + ++++ + + ++ + +
F  CORCHORUS ASPLENIFOLIUS       15  + ++ + + + + ++ + + ++ + +
W  GREWIA HEXAMITA               14  + + ++ * 1 + * + * + +++
F  CUCUMIS HIRSUTUS              14  + ++ + + + + + + + + ++
W  EHRETIA AMOENA                12  + + + + + + ++ + * + +
F  LEUCAS NEUFLIZEANA            11  + ++ + + ++ + ++ +
F  LEDEBOURIA SPP.               10  + + + ++ + + + +

OTHER INFREQUENT SPECIES
W  ACACIA NIGRESCENS             24  + + 1 + 1 + AB A1A+ + +A + + * + 1 1+ 1+
G  TRICHOLAENA MONACHNE          23  + + + A + A+ ++11A ++ + ++ 1 + + + + +
W  GREWIA BICOLOR                22  + A + + ++ 1+ + ++ +* ++ * 1 +++1+
F  LANTANA RUGOSA                21  + ++ + + + +++ + + + +++++ + ++ +
G  EUSTACHYS MUTICA              20  + + + +++ + + + + + ++ + + + + + +
F  SOLANUM PANDURAEFORME         20  + ++ + + ++ ++++ + + +++ + + +
F  SPHEDAMNOCARPUS PRURIENS      17  + ++ + + + + ++++ ++ + ++
G  BRACHIARIA XANTHOLEUCA        17  1 + + +++ + + + + +++++ ++
F  STRIGA ASIATICA               17  ++ + + + + ++ + + + + + + +
F  ASPARAGUS BUCHANANII          16  + + + + + + + + + ++++ + + +
F  TALINUM CAFFRUM               15  + ++ + + + + + + + ++ ++ +
F  KOHAUTIA LASIOCARPA           15  + + ++ + ++ ++ + + + + + +
W  COMBRETUM HEREROENSE          14  * * 1 + + + + + +1 + + * 1
F  CERATOTHECA TRILOBA           14  ++ + + + + + + + + ++ +
F  CLEOME MONOPHYLLA             14  ++ ++ + + + + + + + + +
F  HELIOTROPIUM STEUDNERI        13  + ++ ++ + + + + + + + +
W  XIMENIA CAFFRA                13  + + + + * +1 1 * * * *
G  TRAGUS BERTERONIANUS          13  ++ ++ + + + + + + ++ +
F  VIGNA ANGUSTIFOLIA            13  ++ +++ + + ++ + + + + ++
F  RUELLIA PATULA                13  + + + + +++++ + + ++
F  CYPERUS OBTUSIFLORUS          12  + + + ++ + + ++ + + +
F  DYSCHORISTE ROGERSII          12  + +++ + + + + ++ ++
F  IPOMOEA OBSCURA               11  ++ ++ + + +++ + +
F  MACROTYLOMA MARANGUENSE       11  + + + + B + + + + + +
F  VIGNA UNGUICULATA             11  + + + + + + + ++ +
F  TRAGIA RUPESTRIS              10  + + + ++++ + + +
F  TRICLISERAS SCHINZII          10  + * + + ++ + + + +
F  COMMELINA AFRICANA            10  + + + + + ++ + + +
F  CROTALARIA SPHAEROCARPA       10  + + + ++ ++ + +
F  CRABBEA VELUTINA              10  + + + + + + + + +
W  COMMIPHORA AFRICANA           10  ++ * *+ ++ + * +
F  COMMELINA BENGHALENSIS        10  + ++ + + +++ + +
F  OCIMUM URTICIFOLIUM           10  ++ + + + + + + + +
F  LIMEUM VISCOSUM                9  ++ + + + + + + +
F  RUELLIA CORDATA                9  + + + + + ++ ++
W  ORMOCARPUM TRICHOCARPUM        9  + + * + + ++ + +
F  HERMANNIA QUARTINIANA          9  + + ++ + + + + +
F  CROTALARIA MONTEIROI           9  + + + + + ++ +
F  STYLOCHITON NATALENSE          9  + + ++ ++ + + +
F  ECBOLIUM REVOLUTUM             9  ++ + + + + + + +
G  ENNEAPOGON CENCHROIDES         9  A + + + + + + B +
W  CASSIA ABBREVIATA              9  A ** + + + + * +
F  TEPHROSIA PURPUREA             9  + + + + ++++ 1
F  JUSTICIA PROTRACTA             8  ++ + ++ + + +
F  TEPHROSIA ELONGATA             8  + + + + + + ++
W  ACACIA BURKEI                  8  +1+ * 1 + * +
F  CHASCANUM HEDERACEUM           8  + + + + + + + +
F  GISEKIA AFRICANA               8  + + + ++ + + +
F  KYLLINGA ALBA                  8  ++ + + + ++ +
F  MARISCUS REHMANNIANUS          8  + + + + + + ++
F  VERNONIA FASTIGIATA            8  + + + + + + ++
F  HEMIZYGIA BRACTEOSA            8  + +++ + + + A
F  SIDA RHOMBIFOLIA               8  ++ ++ + + ++
W  SECURINEGA VIROSA              8  + + +++ + + 1
F  COMMELINA ERECTA               8  + + + + + + + +
F  ORTHOSIPHON AUSTRALIS          8  + + ++ + + + +
F  PAVONIA BURCHELLII             8  + + + + + + +
F  JUSTICIA FLAVA                 8  + + ++ ++ + +
W  BALANITES MAUGHAMII            7  + 1+ + + + +
F  BIDENS BITERNATA               7  + + + + + + +
W  CASSIA PETERSIANA              7  + ++ + + ++
F  INDIGOFERA BAINESII            7  + + + + + + +
G  ENNEAPOGON SCOPARIUS           7  + + 1 + + B +
W  MAYTENUS SENEGALENSIS          7  + + + + + * +
SU KALANCHOE LANCEOLATA           7  ++ + + + + +
F  HELICHRYSUM NUDIFOLIUM         7  + + + +++ +
F  MONSONIA OVATA                 7  +++ + ++ +
F  VERNONIA POSKEANA              7  + + + ++ + +
F  VIGNA DECIPIENS                7  + + + + + + +
F  DICOMA TOMENTOSA               7  + + + + A + +
W  GREWIA FLAVESCENS              7  + + 1 * + + +
G  CHLORIS VIRGATA                7  + + + ++ ++
W  EHRETIA RIGIDA                 6  + + + 1+ +
G  ARISTIDA SP.                   6  1 + + + + +
W  GREWIA MONTICOLA               6  1 1 + ++ *
W  DOMBEYA ROTUNDIFOLIA           5  1 1 * 1 +
G  OROPETIUM CAPENSE              5  + B + + +
G  ANDROPOGON SCHIRENSIS          4  + A + +
G  BOTHRIOCHLOA RADICANS          3  B + 1
G  UROCHLOA BRACHYURA             3  +1 +
W  ACACIA ERUBESCENS              2  + 1
W  ACACIA TORTILIS                2  1 +
W  ALBIZIA PETERSIANA             2  1 +
G  CYMBOPOGON EXCAVATUS           2  A +
W  ACACIA WELWITSCHII             1  A
W  COMBRETUM COLLINUM             1  1
W  GREWIA VILLOSA                 1  1
G  LOUDETIA FLAVIDA               1  1
F  VERNONIA NATALENSIS            1  1

   SEE APPENDIX 2 FOR RARE
   SPECIES WITH LOW COVER
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4.2.1 Grassveld and brushveld with Dichrostachys cinerea, Urochloa mossambicense and Ocimum americanum

This variation seems to have relatively high A horizon clay content and relatively low A horizon conductivity P = 0,07, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, N1 = 2, N2 = 6).

4.2.2 Grassveld and brushveld with Mariscus aristatus, Cyperus amabilis and Eragrostis gummiflua

A second variation occurs on soils with seemingly distictively low clay percentage of the A horizon and relatively high A horizon conductivity.

POGONARTHRIO SQUARROSAE - COMBRETION APICULATI all. nov.
(Alliance on mesic sand, Table 4)
Nomenclatural type: Perotido patentis - Terminalietum sericeae ass. nov.

Habitat and location

This Alliance occupies soils with sandy, sandy loam and loamy sand texture throughout the profile, in the 500-650mm rainfall region. These conditions are met:

(a) on the fersiallitic sands and loams of upland sites in the Archaean Granite-Gneiss region of the study area;
(b) on similar soils of some upland sites in the Karoo Sandstone region;
(c) on Quaternary sand at Pumbe on the Lebombo Mountain Range, near the 500mm rainfall isohyet; and
(d) on rhyolite-derived lithosols of the relatively wet Lebombo Mountains south of Pumbe.

Soils of the Granite-Gneiss, Quaternary and Sandstone regions generally belong to the Glenrosa, Hutton and Clovelly Forms, whereas the Lebombo Mountain lithosols include talus slopes and soils of the Mispah Form. Communities within the Alliance are related to these differences.

Structure

The structure of vegetation types within this alliance is varied and partly related to Association and soils. In the _Perotido patentis_ - _Terminalietum sericeae_, where soils are relatively deep, shrub and brush regimes usually belong to similar cover classes and trees are present with scattered to moderate cover. Trees are also present on the (relatively deep) rhyolitic talus slope variations of the _Diheteropogono amplectentis_ - _Ozoroetum engleri_. On the shallow rhyolitic soils of the latter Association, however, trees are usually absent and brush and shrub regimes are mostly unequal, with either the one or the other dominant. In both Associations brushes are usually the chief contributors at the brush and shrub levels (Table 4, Appendix 1).

Floristic composition

Group 3 species in Table 2 are virtually exclusive to this Alliance. Included are the grasses _Trichoneura grandiglumis_ and _Rhynchelytrum villosum_, the forb _Melhania didyma_, and others.

Exclusive relationships are largely through Group 4 and 9 species with vegetation in high rainfall areas, on soils with relatively coarse-textured A horizons (Table 2); i.e. with much of the _Chlorido virgatae_ - _Justiceion flavae_ of deflocculated soils (Associations 1, 2 & 4) and with a subcommunity of the _Themedo triandrae_ - _Acacietum gerrardii_ (Association 7). The alliance on mesic sand is distinctly avoided by Group 8 species (Table 2) which prefer relatively fine-textured soil profiles.

5. Perotido patentis - Terminalietum sericeae ass. nov. (Table 4)
Nomenclatural type: Releve 176

Habitat

The Perotido patentis - Terminalietum sericeae occurs most extensively on residual soils in upland sites of the undulating Granite-Gneiss region in the western Central District. Local stands occur also in sandy upland sites on Karoo Sandstone and on a small Quaternary Sand plateau of the Lebombo Mountains near Pumbe (Fig. 1).

The soils have been classified and mapped by Harmse (1978) as fersiallitic sands and loams typical of the 500-800mm rainfall zone. The mean annual rainfall for this Association in the study area is 500-650mm.

Soil texture of the Quaternary deposits is loamy sand to sandy loam with approximately 10-15 per cent clay in the A horizons. The granitic upland sites are consistently less clayey than the Quarternary deposits ($P < 0,01$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N1 = 5$, $N2 = 32$, Table 4). A horizons of granitic upland sites are sandy to loamy sand containing less than 10 per cent clay. Soils of the Hutton and Mispah Forms are typical of three subcommunites, whereas the Glenrosa Form predominates in a fourth. Three major soil series are involved: the Hutton Form is represented mainly by the Hutton portsmouth Series, which has an orthic A horizon, over a red apedal non-calcareous B horizon containing 6-15 per cent clay and coarse sand; the Mispah Form is represented by the Mispah mispah Series, which is a non-calcareous orthic A horizon on hard rock; and the Glenrosa Form is usually represented by the Glerosa glenrosa Series, which has an orthic A horizon with 6-15 per cent clay and coarse sand, over a non—calcareous lithocutanic B horizon.

Structure

Structure in this Association is mostly shrubby brushveld and shrubby, brushy treeveld (Appendix 1). Trees are: (a) largely absent in the subcommunity on Quaternary Sand; (b) scattered to sparse in the predominantly granitic subcommunites that have soils belonging mostly to the Mispah, Hutton and Clovelly forms; and (c) scattered to sparse and commonly moderate to dense also, in the variation that has soils belonging mainly to the Glenrosa Form (Appendix 1).

Floristic composition

Differential species that are exclusive to this Association or one or more of its subcommunites, are shown in Table 2. The most constant among those occurring in two or more subcommunites are the woody plants *Terminalia sericea* and *Strychnos madagascariensis*, the grass *Perotis patens* and the forbs *Cassia absus*, *Clerodendrum ternatum*, *Commelina erecta*, *Indigofera filipes*, *Heliotropium strigosum* and *Indigofera sanguinea* (Tables 2 & 4).

Dominant and subdominant woody species regularly include *Combretum zeyheri*, *C. apiculatum* and *Sclerocarya caffra*. On deeper than 600mm soils of the Hutton and Clovelly forms *Terminalia sericea* and/or *Pterocarpus rotundifolius* are also among the dominants and subdominants that cover more than one per cent ($P < 0{,}02$, Two-tailed Chi-square Test, $N=7$; Table 4, Appendix 1). *Sclerocarya caffra* is by far the most commonly dominant tree. Occasionally dominant trees include *Combretum apiculatum*, *Acacia nigrescens*, *Lannea stuhlmannii* and *Lonchocarpus capassa*. Dominant brush and shrub species correlate significantly with soil characteristics. At these levels *Combretum apiculatum* and occasionally *Acacia nigrescens*, are dominant mostly on soils of the Glenrosa Form, where B horizons grade into rock and on shallower than 600mm soils of the Mispah, Hutton and Clovelly Forms. Although *Combretum* zeyheri, Terminalia sericea and Pterocarpus rotundifolius also occur on the aforementioned soils, either of these latter species are typically the dominant shrub and brush species on deeper than 600mm Hutton and Clovelly soils (P = 0,03 for brush, Two-tailed Chi-square Test, N = 41, i.e. excluding 6 releves with other dominants or soil forms than those mentioned; P = 0,07 for shrub, Two-tailed Fisher's Exact Test, N = 35, i.e. excluding 12 releves with other dominants or from other soils than those mentioned).

The grasses Digitaria eriantha, Panicum maximum and Pogonarthria sguarrosa are constantly dominant in all subcommunites. Additional dominants that vary with subcommunity include Sataria flabellata, Brachiaria nigropedata, Sporobolus fimbriatus, Aristida congesta subsp. barbicollis and Schmidtia pappophoroides.

5.1 Brushveld and thicket with Combretum molle and Pseudolachnostylis maprouneifolia on Quaternary Sand

A floristically distinct subcommunity occurs on a Quaternary Sand plateau at Pumbe. Floristically atypical Releve 170 is from a well-elevated level plateau of weathering Karoo Sandstone in Landscape 5 (Ch. VII). Included in the subcommunity are soils of the Hutton, Mispah and Glenrosa Forms. A horizons have loamy sand to sandy loam texture and the clay content of 11-16 per cent is consistently higher than in other subcommunities of this Association.

Releve 34 from a deep soil of the Hutton shorrocks Series represents sparsely shrubby, moderately brushy, sparse treeveld. Trees are absent from the moderately shrubby, moderate brushveld to scrubby thicket of the other, shallower, soils (Table 4, Appendix 1).

Presence of the woody plants Combretum molle and Pseudolachnostylis maprouneifolia is highly distinctive (Table 2). C. molle may be among the dominants (Appendix 1).

The exclusive presence of P. maprouneifolia in this subcommunity suggests that it avoids some mineral(s) in the granitic area:- P. maprouneifolia is typical of sandy areas including granitic sandy areas in warm-temperate to tropical Central Africa where the rainfall exceeds 700mm per annum (cf. Coates Palgrave, 1977; Gomes E. Sousa, 1967; Hall-Martin,[4] pers. com., Hursh, 1960; Van Wyk, unpubl).

According to Hall-Martin[4] (pers. comm.) this species, where it appears on granitic soils of Malawi is particularly common on relatively well-leached sand above and towards the edges of dambos. The Central District subcommunity does not occur on an exceptionally sandy soil and is on somewhat more clayey soil than the subcommunities of granitic upland sites. In the relatively dry southern part of its range, which includes tropical and warm-temperate regions, granitic sandy areas are avoided, probably because here, at less than 700mm rainfall, granitic soils are insufficiently leached.

Cassia abbreviata subsp. bearana is the dominant tree in the treeveld of Releve 34. Dominants at the shrub and brush levels vary and may include Combretum molle, C. apiculatum, Terminalia sericea, Cassia abbreviata subsp. bearana and Grewia bicolor (Appendix 1).

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4. Dr. A. Hall-Martin, Research Institute, Private Bag X402, Skukuza 1350, South Africa.

The grasses _Digitaria eriantha_ and _Panicum maximum_ are common dominants and subdominants in the field layer. Occasional additional dominants or subdominants include the grasses _Eragrostis rigidior_, _Enneapogon cenchroides_, _Heteropogon contortus_, _Schmidtia pappophoroides_ and _Pogonarthria squarrosa_ (Table 4).

5.2. Brushveld and treeveld with _Terminalia sericea_, _Pterocarpus rotundifolius_ and _Setaria flabellata_ on relatively deep granitic and sandstone-derived soils of the Hutton and Clovelly forms

Within the context of the _Perotido pententis Terminalietum sericea_ of the Central District, the present subcommunity is strongly associated with 700mm and deeper soils of the Hutton and Clovelly Forms ($P < 0,01$, Two-tailed Chi-square Test with Yates' correction, $N = 47$; Table 4.) The Subcommunity occurs on flat to convex summit areas of undulating granitic terrain (Table 4).

The structure is sparsely to densely shrubby, sparsely to densely brushy, sparse treeveld, or similar brushveld with or without scattered trees.

Overall exclusive differential features include the presence and occasional dominance of the grasses _Setaria flabellata_ and _Aristida congesta_ subsp. _congesta_, the presence of _Merremia tridentata_ subsp. _angustifolia_ and the regular dominance of the woody _Terminalia sericea_. The regular presence and dominance of the woody _Pterocarpus rotundifolius_ (Species Group 9) is diagnostic within Association context (Tables 2 & 4).

Scelerocarya caffra is most commonly the dominant tree. In this subcommunity of deep soils, _Combretum zeyheri_ is dominant at the brush and shrub levels on the relatively dry soils of the Mispah Form, or of convex terrain excluding soils of the Clovelly Form; whereas on wetter soils, i.e. those of the Clovelly Form, or in flat to concave terrain excluding soils of the Mispah Form, Pterocarpus rotundifolius and Terminalia sericea dominate the shrub level (P = 0,02, Two-tailed Fisher's Exact Test, N =14, Table 4, Appendix 1).

Common field layer dominants and subdominants with cover exceeding one per cent include the grasses Digitaria eriantha, Panicum maximum, Pogonathria squarrosa, Brachiaria nigropedata and Setaria flabellata; particularly the first three mentioned.

Three variations of the Subcommunity are shown in Table 4:-

5.2.1 Brushveld and treeveld with Tephrosia forbesii

The first variation occurs mainly in convex and otherwise dry terrain; is brushveld with scattered trees or sparse treeveld; is differentiated by the forb Tephrosia forbesii subsp. interior; typically has Combretum zeyheri as the dominant shrub and brush; and consistently has cover values of 25-50 per cent for either Panicum maximum or Digitaria eriantha (Table 4, Appendix 1).

5.2.2 and 5.2.3 Other brushveld and treeveld

The second and third variations include relatively dry soils and/or terrain with Combretum zeyheri as the dominant brush and shrub, as well as relatively moist situations where Pterocarpus rotundifolius and Terminalia sericea are dominant at the brush and shrub levels. The terrain is characteristically flat to concave. The second variation (5.2.2) is represented by three releves where the grass Elionurus muticus is characteristically present as well as dominant or subdominant. Both exceptional releves where trees are absent are included in this group of three (Table 4, Appendix 1). The third variation (5.2.3) is floristically negatively defined.

5.3 Brushveld and treeveld with Harpagophytum procumbens on relatively shallow granitic and sandstone-derived soils of the Hutton Form

The habitat is typically relatively shallow soils of the Hutton and Mispah forms on flat to convex upland sites in the undulating granitic landscape. The structure is typically sparsely to densely shrubby, moderate to dense brushveld with scattered trees or similarly shrubby and brushy sparse to moderate treeveld. The occurrence of the forb Harpagophytum procumbens is characteristic (Table 4.) Combretum apicalutum is commonly dominant at one or more woody height levels. Dominant and subdominant grasses covering more than one per cent usually include Digitaria eriantha and Heteropogon contortus plus a selection from Panicum maximum, Pogonarthria squarrosa, Brachiaria nigropedata, Trichoneura grandiglumis, Schmidtia pappophoroides, Sporobolus fimbriatus and Perotis patens.

This Subcommunity is linked to the next by: the shallowness of the non-stoney, non-rocky part of the substrate; the consistency of high cover values for the woody Combretum apiculatum and the high constancies of the grass Sporobolus fimbriatus and the woody Acacia exuvialis.

5.4 Brushveld and treeveld with Acacia nigrescens, Oropetium capense, Eragrostis superba, Hibiscus micranthus and Euphorbia neopolycnemoides on granitic and sandstone-derived soils of the Glenrosa and Mispah forms

Soils of the Glenrosa Form are characterized by orthic A horizons over lithocutanic B horizons. "The concept (of the latter) is one of minimal development of an illuvial B horizon in weathered rock" (MacVicar et al., 1977). In granitic and doloritic areas of the Central District, these immature gravelly B horizons occur near major drainage lines such as the Sabie, Sand, Nwaswitsontso and Ripape rivers. The present subcommunity typically occurs on Glenrosa soils with sandy and loamy sand A horizons. Included are upland sites on undulating granitic terrain, which are characteristically sandy, but also some doloritic sites with a sandy texture, presumably owing to granitic influence.

The Subcommunity structure varies mainly from shrubby brushveld with scattered trees to shrubby brushy, sparse to dense treeveld. Shrub and brush cover may be sparse to dense.

Distinctive floristic features indicate the periodic relative dryness of the habitat of this subcommunity, as compared with that of other subcommunities of the Perotido patentis - Terminalietum sericeae. Within the study area the desiccation-tolerant grass Oropetium capense (Gaff & Ellis, 1974), is uniquely characteristic of the Subcommunity (Table 4). Within Alliance context the presence of the forb Hibiscus micranthus of dry habitats (Group 12, Table 2) is also highly characteristic and one variation includes additional diagnostic species linking this vegetation to that of relatively arid habitats (cf. Table 4). The presence of the other species mentioned in the heading is also differential and the grass Sporobolus fimbriatus characteristically covers more than one per cent in this Subcommunity. Woody species with cover values most commonly exceeding one per cent include Combretum apiculatum and C. zeyheri, which almost invariably dominate the brush and shrub layers (Appendix 1). Sclerocarya caffra commonly dominates the tree layer where, however, the following may also have this status: Lannea stuhlmannii, Acacia nigrescens and Combretum apiculatum (Appendix 1). Regular dominants and subdominants of the field layer include the grasses Digitaria eriantha, Panicum maximum, Pogonarthria squarrosa and Sporobolus fimbriatus (Table 4). Other dominant grasses vary with soil depth.

5.4.1 Brushveld and treeveld with Aristida congesta subsp. barbicollis among the dominants, on dark topsoils

This variation typically has dark topsoils (P = 0,03, Two-tailed Fisher's Excact Test, N = 20, Table 4). The presence of Acalypha indica and other species as shown in Table 4, as well as the consistent and high cover of the grass Aristida congesta subsp. barbicollis in the field layer, are characteristic.

5.4.2 Brushveld and treeveld with high cover of Schmidtia pappophoroides and/or Eragrostis rigidior, on dusky red to red topsoils

The second variation typically has dusky red or red A horizons (see Ass. 5.4.1).

6. Diheteropogono amplectentis - Ozoroetum engleri ass. nov (Table 4)
Nomenclatural type: Releve 261

Habitat

This Association covers most of the rhyolitic hills of the Lembombo Mountains south of Pumbe, away from the dry Olifants River valley and with rainfall exceeding 500mm. Soils are stoney and less than 0,5m high outcrop is common. Most of these soils belong to the Mispah mispah Series, i.e. a non-calcareous A horizon on hard rock. The Milkwood dansland Series, which is a melanic A horizon with 15-35 per cent clay on hard rock or hard pan, is also occasionally encountered. Another typical soil type is mixed stoney colluvium. Soil textures for all three types are sandy loam with 10-20 per cent clay.

Subcommunities differ in respect of geomorphology, rainfall and associated soil colour, slope and soil type.

Structure

Tree cover is typically absent or scattered but sparse treeveld may also occur. The usual structure is shrubby brushveld, with shrub and brush cover varying from sparse to dense. Dense shrub and/or brush cover is strongly associated with the relatively dry Lebombo Mountains between Nwanedzi and Pumbe, where the average annual rainfall is 500-550mm ($P < 0{,}001$, Two-tailed Fisher's Excact Test, $N = 36$, Table 4, Appendix 1; Rainfall isohyets from Webber, 1979 and Gertenbach, 1980). South of Nwanedzi, where the rainfall exceeds 550mm, shrub as well as brush cover are almost exclusively less than ten per cent, usually sparse or moderate. Brush cover may be scattered to absent on hard panlike surfaces.

Floristic composition

The most distinctive species for the entire Association include the woody Ozoroa engleri, the grass Dipeteropogon amplectens and the forbs Euphorbia neopolycnemoides and Indigofera heterotricha (Table 2). The sandy loam soil texture and 500mm+ rainfall places this Association in an intermediate position between comparatively sandy communities of equally high rainfall, on the one hand, and comparatively clayey and/or drier communities, on the other hand. Species of relatively sandy habitats, e.g. the woody Combretum zeyheri, the grasses Trichoneura grandiglumis, Rhynchelytrum villosum, Pogonarthria squarrosa and Brachiaria nigropedata and the forbs Melhania didyma and Agathisanthemum bojeri, of Groups 3 and 4 (Table 2), are shared with its alliance companion, the Perotido patentis - Terminalietum sericeae. Relatively clay-loving species, however, which are absent or infrequent in the Perotido patentis - Terminalietum sericeae, are common in the Diheteropogono amplectentis - Ozoroetum engleri. Notable examples are the woody Peltophorum africanum, the grass Themeda triandra, which is also among the most common dominants in the field layer, and the forbs Thesium gracilarioides and Ipomoea sinensis, of Groups 6-7 (Table 2).

Combretum apiculatum is the woody species that is most constantly among the dominants or subdominants exceeding one per cent cover and does so regularly in all subcommunities (Table 4). The species furthermore attains total projected canopy cover in excess of ten per cent most regularly in the relatively dry region north of Nwanedzi (P < 0,01, Two-tailed Fisher's Exact Test, N = 36, Table 4). In Subcommunity 6.2, where trees are most commonly found, the dominant tree is usually _C. apiculatum_ and the latter species is also the most commonly dominant brush species in all subcommunities (Appendix 1).

C. appiculatum is characteristically commonly the dominant at the shrub level in the relatively dry summit variation north of Nwanedzi, i.e. in Association 6.4.2 (P < 0,01, Two-tailed Fisher's Exact Test, N = 36, Table 4, Appendix 1). The dominance of _P. rotundifolius_ at the shrub level correlates with dusky red soil colours of hue 2.5 YR and values and chromas below 4 (P = 0,05, Two-tailed Fisher's Exact Test, N = 35 - Releve 229 with unknown soil colour excluded). These dusky red soils in turn are clearly associated with the high rainfall region south of Nwanedzi (P = 0,04, Two-tailed Fisher's Exact Test, N = 35; Table 4). _Combretum zeyheri_ typically seems to be the dominant shrub contributor on the moderate to steep non-rocky slopes (P = 0,01, Two-tailed Fisher's Exact Test, N = 36, Table 4, Appendix 1).

Digitaria eriantha is most commonly among the dominants of the field layer. Others that vary with subcommunity, include: _Themeda triandra_, which has low cover and/or constancy in the subcommunities of hard panlike surfaces and steep rocky slopes; _Aristida_ spp. on the hard panlike surfaces of Association 6.1; _Panicum deustum_, which is exclusive to Association 6.2 of steep rocky slopes; _Brachiaria nigropedata_, particularly on summits south of Nwanedzi; _Panicum maximum_, also south of Nwanedzi, but excluding hard panlike surfaces and including steep, rocky slopes; and _Andropogon gayanus_, particularly north of Nwanedzi (Table 4).

6.1 Grassveld, sparse shrubveld and sparse brushveld with *Mundulea sericea* and a field layer dominated by *Aristida* spp., *Digitaria eriantha* and *Brachiaria nigropedata*, on hard panlike surfaces

Habitat

The hard panlike surfaces that are characteristic of this subcommunity occur commonly on level to gently sloping flat plateaux or indistinct gentle middleslope terraces. The soils belong to the Mispah and Milkwood forms and are extremely shallow on unbroken rock or hardpan. Low outcrop may be present and stones are frequent.

Structure

The Subcommunity has a characteristically stunted, sparse woody cover, often contrasting sharply with adjoining or interrupting broken rocky areas, or deeper looser soils, with denser woody vegetation. Trees are absent, brush absent to sparse and shrub usually sparse (Appendix 1).

Floristic composition

The woody *Mundulea sericea*, and *Aristidia* sp. and the forb *Leucas sexdentata* are virtually or entirely exclusive to this subcommunity. The Subcommunity is further differentiated by species shared with the relatively sandy Association 5, e.g. *Evolvulus alsinoides*, *Polygala sphenoptera* and *Kohautia virgata*. *Combretum apiculatum* is usually the dominant brush and shrub (Table 4; Appendix 1). The grasses *Aristida* sp. and/or *A. congesta* subsp. *barbicollis* dominate the field layer. *Digitaria eriantha* may be codominant and *Brachiaria nigropedata* is commonly subdominant (Table 4).

6.2 Brushveld and treeveld with a field layer dominated by a combination of *Digitaria eriantha*, *Panicum maximum* and *P. deustum*, on steep, mesic slopes with uneven rocky surfaces

Habitat

This relatively mesic subcommunity was sampled mostly on slopes that are steeper than 10° and up to 29° with uneven surfaces of low broken outcrop. Boulders and stones are frequent to abundant. Soils typically consist of mixed talus of varying texture.

Structure

Trees are scattered or form a sparse canopy layer. Brush cover is moderate to dense and shrub cover sparse to moderate (Appendix 1).

Florisitic composition

Species that are exclusive to this subcommunity, within the study area, include the woody *Galpinia transvaalica*, the grass *Panicum deustum* and the forb *Pellaea viridis*. The woody *Pappea capensis* and the straggler *Asparagus buchananii* are also differential within the Association. *Combretum apiculatum* is consistently among the dominants or subdominants. *Pterocarpus rotundifolius* and *Combretum zeyheri* may be dominant at the shrub level and *Combretum molle* may contribute most at the tree and brush levels. *Combretum apiculatum*, however, seems to be the most common dominant at all levels (Table 4, Appendix 1). *Digitaria eriantha* is usually the dominant grass, with *Panicum maximum* and *P. deustum* subdominant. *Themeda triandra* and *Diheteropogon amplectens* occasionally cover more than one per cent of the surface.

6.3 Brushveld with Pterocarpus rotundifolius and a field layer dominated by a combination of Themeda triandra, Digitaria eriantha, Brachiaria nigropedata and Panicum maximum, on level to gently sloping non-panlike summits south of Nwanedzi

Habitat

This Subcommunity occurs on 0-3° crests with loose, moderately stony, sandy loam and loam soils of the Mispah and Milkwood forms, in the relatively high rainfall Lebombo Mountain region south of Nwanedzi. The soils are shallow and a moderate cover of less than 0,5m tall outcrop is typical (Table 4).

Structure

The usual structure of this subcommunity is sparsely to moderately shrubby, sparse or moderate brushveld. Trees are absent to scattered.

Florisitic composition

The characteristic species combination is shown in Table 4. The presence of Pterocarpus rotundifolius, with field layer dominants listed in the heading and absence of Andropogon gayanus, are diagnostic. The woody P. rotundifolius, Combretum apiculatum and C. zeyheri are usually present, with at least one of these but usually two or all three species each covering 1-10 per cent (Table 4). Trees are uncommon. Combretum apiculatum is the usual dominant at the brush level but C. zeyheri occasionally also has this status. Pterocarpus rotundifolius is a common dominant at the shrub level. Occasional other dominants at this level include Ozoroa engleri, Combretum apiculatum and C. zeheri (Appendix 1). The field layer is typically dominated by the grasses Themeda triandra, Digitaria eriantha, Brachiaria nigropedata and Panicum maximum (Table 4).

6.4 Brushveld and thicket with *Andropogon gayanus* in the relatively dry region and occasionally on summits that usually have little or no outcrop

Habitat

The present subcommunity occurs in the relatively dry region north of Nwanedzi and occasionally on summits with little or no outcrop, in the south. One variation occurs on summits in the south and on moderately steep slopes, whereas another occurs on gentle summits in the north.

Structure

The woody component of the dry *Andropogon gayanus* Subcommunity is commonly denser than in the other three subcommunities of the higher rainfall region, possibly owing to generally deeper soils suggested by the usually low outcrop cover (Appendix 1). Trees may be absent or scattered or form a sparse canopy layer.

Floristic composition

The grass *Andropogon gayanus*, which is usually prominent, is the most diagnostic feature. Other differential species are shown in Tables 2 and 4. The Subcommunity has two variations:-

6.4.1 Brushveld, thicket and treeveld with *Combretum zeyheri* and/or *Pterocarpus rotundifolius* present and mostly dominant at the shrub level

The variation with *C. zeyheri* and/or *P.rotundifolius* occurs on moderately steep slopes of 8-15^{o} with non-rocky but abundantly stoney mixed colluvial soil, as well as on Mispah soils of some of the gentle summits in the relatively high rainfall region south of Nwanedzi. Occasional trees include *Combretum apiculatum*, *Diospyros mespiliformis*, *Acacia nigrescens* and *Lonchocarpus capassa*. The brush level, which has scattered to thicketed cover, is dominated by *Combretum apiculatum* and *C. zeyheri*. The shrub level is usually dominated by *C. zeyheri* and/or *P. rotundifolius* (Appendix 1).

The field layer is typically dominated by the grasses *Themeda triandra*, *Andropogon gayanus* and *Digitaria eriantha*.

6.4.2 Brushveld, thicket and treeveld with *Cymbopogon plurinodis* and *Brachiaria xantholeuca*, on gently sloping, non-panlike summits north of Nwanedzi

The second variation occurs on shallow stoney soils of the Mispah Form on relatively gentle 1-4^{o} slopes with regular low outcrops, in the relatively dry region north of Nwanedzi. The presence, albeit with low cover, of the grasses *Cymbopogon plurinodis* and *Brachiaria xantholeuca* is characteristic (Table 4). *Combretum apiculatum* is typically overwhelmingly dominant at all woody height levels. The grasses *Themeda triandra*, *Andropogon gayanus* and *Digitaria eriantha* regularly cover more than five per cent of the surface and are the usual field layer dominants (Table 4). Other grasses with occasionally high cover include *Diheteropogon amplectens*, *Panicum maximum* and *Aristida congesta* subsp. *barbicollis*.

TABLE 5. THEMEDO TRIANDRAE - ACACIETUM GERRARDII (ASSOCIATION ON MESIC CLAY)

	RELEVE NUMBERS		221212 2121112212221 2111111212211 222222222222222222 32222222 / 132402 671380081119 0988793038933 8876557768594565 56567649 / 850884 193938752468 2198664283843 2936463529434905 16201779
	ASSOCIATION NUMBER		7
	LANDSCAPE NUMBER		339693 323222333332 4332223323333 633666666636 2566 6666663
	HABITAT GEOLOGY (B=BASALT, D=DOLORITE, G=GRANITE, K=KAROO SEDIMENT, R=RHYOLITE, Z=SANDSTONE)		DDRBRD GDGGGDDDDDG GGDGDGGDDGDDDD DDRBBBBBGRGBBBZ BBBBBBBG
	RELIEF (C=CREST, F=FOOTSLOPE, M=MIDDLESLOPE, V=BOTTOMLAND)		CMFMMM FMFMMMFMCFF CCHMMMMMFMFVF MMMCCMCCCVCFMCMF VCFCMFF
	SLOPE (DEGREES)		000010 000000 0000 00 000000000 0000000000000000 00000000 / 134100 413342 3112132 25323412220 10110100101022020 21010222
	SURFACE (F=FLAT, I=CONCAVO-CONVEX, N=CONVEX, U=CONCAVE)		NFUFIF FFNUFNNFFNUF NFUFFFUNUFFFUF FFFFUFFFFFFFNFFF FFFUFFFF
	ROCK (% X 10; <1, *=1-9) / ROCK HEIGHT (M; <.5, *=.5-9)		**000 0+00000000000 0+00000+0300 0000+000000000000000000000
	A HORIZON-DEPTH (DM; <10M)		+233 524342322 3133232242112322 122122321 2233222 332 2223+
	-STRUCTURE (A=APEDAL, C=MASSIVE, M=MODERATE, S=STRONG, W=WEAK)		WW W WAACWAWWSWWC AWWWWWWWWWWWW WAMMWWWWWWWSW WWWSWWWWWW
	-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM(Y), Z=SAND(Y))		ZCZZSZ LZZZZ ZZZZL LZZZZZZZZLZCZZ LZCZCCCZCZZCZC ZCCZCCZL / LLLILT ZZLIL LLIIZ LLILIIIL ILLII ILILLLLICILLIL ILLIL IZ
	-CLAY (%)		121213 121 11121 1121242111212 212222332321222 2332342 / 436141 896340759111 6203503269134 2975765048692 6429215125
	-PH (X 10)		665545 5555455555445 45545554545 6545565656655555 6656555 / 345471 404388178554 848197048777 16699372713089 994096085
	-CONDUCTIVITY (MICROMHOS X .1)		001030 000000000000 000 000100001 0100000 000000 00000000 / 470111 321344616328161 615237169 3122222 421211 133243340 / 315601 212604193024665 0840986509 3305642 456259 056391110
	B HORIZON - DEPTH (DM; <90M)		44 6 7 7 64 6 54544 82 ** 86 3772457420 7565425 *487
	-COLOUR (D=DARK, G=GREY, I=DUSKY RED, R=RED, Y=YELLOW)		RI D DYYYDGIIDIRDDDID R II YRRRRDRRIRDDDDI IIRRRIDRDDDRRD
	-TEXTURE (SEE A-HORIZON)		ZZ Z ZZZCZZZZZZZZZ ZZZ ZZ ZZZZ CZCZCCZZCCCZCZCZ CCCCCCZ / LI I IC CICIIICLIL CI CICC I I LI C CLL CC
	-CLAY (%)		12 3 4224432332231331 32 3233 424155135434443 345555543 / 75010 376835741579 9004000500 4052 5818331045343079 7531004
	-PH (X 10)		66 5 566567755656 555544 5 564 5665566556755556 95656666 / 56 9 06780472867 987369 4 495 71046308912797574 83822119
	-CONDUCTIVITY (MICROMHOS X .1)		0 0 006010000000 000 3 0 010 000000000000000000 00000000 / 3 1 489370322548 121 5 2 242 22335232225322224 54331610 / 1 1 704020030150 830 0 9 001 9008963596303750 15110037
	SOIL FORM (STD. ABBREVIATIONS, MACVICAR ET AL., 1977)		SMAG SSSSSSVGWBVSMGMGGMVVMVSVS MVVGGBBMMSASWSGGG MSMBMSBS / WYRS SSSSSSASOOASYYSYSSYAAYADADY YAASSDOYYWRWEWSSS YWYOYWOS
	SOIL SERIES NUMBER (MACVICAR ET AL., 1977)		1131 322223113123 11111331 21 1111331133 1111 11131112 / 0006 055665080005 050580100 01 0 1088001020031880 02000105
	NUMBER OF SPECIES		000000000000000000000000000000000000000000000000000000000 / 433333444333443444 5444444334323 333333333323223 4222222 / 013302564269562205 122046261586 86711631988967513 99737867
	GROWTH FORM PREFIX: F=FORB, G=GRASS, W=WOODY		
	DIFFERENTIAL SPECIES FOR- (SPP. NAMES, PRESENCE VALUES)		
	THEMEDO TRIANDRAE-ACACIETUM GERRARDII (ASSOCIATION 7)		
F	DAHLERIA OXYPHYLLA	19	+ + + + + + + + + + + + + + + + + +
	-ASS. 7.1		
W	COMBRETUM HERERDENSE	29	+111 +++1 111++1 ++A+B 11++A+ + + * *
W	ACACIA NIGRESCENS	27	11 A 1 A11A11A 1A++ 111 + ** 1 + 1
W	CISSUS CORNIFOLIA	27	+ + +*+++ ++ ++ ++++ + + + + + +
W	COMBRETUM APICULATUM	19	1 + 1++A +1111 ++1 +++ * +
W	COMBRETUM ZEYHERI	13	+ 1 1 * + +++ + 1+
F	TEPHROSIA BURCHELLII	14	+++ +++ ++ ++ + + + + +
F	TRAGIA DIOICA	14	++ ++++ ++ ++ + ++ +
W	GREWIA BICOLOR	11	+ ++ + 1 1 ++ + +
W	BOLUSANTHUS SPECIOSUS	11	+ 1 + * +++ 11+ *
	-ASS. 7.1.2		
F	IPOMOEA COPTICA	11	+ ++ ++ ++ + + +
W	EUCLEA DIVINORUM	10	1 +* **+* 1+ +
F	EVOLVULUS ALSINOIDES	9	+++ + + + +
F	ABUTILON AUSTRO-AFRICANUM	9	+ + +++ + +
F	RUELLIA PATULA	7	+ + + ++
F	HERMBSTAEDTIA ODORATA	5	+ + + + +
	-ASS. 7.1.2 & 7.1.3		
G	ERAGROSTIS RIGIDIOR	23	+ +1++A++ + +++++ + + + R R
F	GNATHISANTHEMUM ADJERI	13	+++ + ++ +++ + + +
W	ACACIA EXUVIALIS	13	+ ++ +1 + + ++ +*+ + +
G	POGONARTHRIA SQUARROSA	12	1 ++ ++++++ +
F	CORCHORUS ASPLENIFOLIUS	13	+++ + ++ + +++ ++ +
F	PHYLLANTHUS INCURVUS	9	+ + +++ +
	-ASS. 7.1.3		
G	UROCHLOA BRACHYURA	13	+ + + +++ ++++ + +
	-ASS. 7.1.3 & 7.2		
W	PTEROCARPUS ROTUNDIFOLIUS	22	+ + A11++A1* 3111 1+ 1A + AAA
F	RHYNCHOSIA MINIMA	21	++ +++ 1++ ++++ ++ ++A1+ + +
F	CHASCANUM HEDERACEUM	18	+ ++ ++ ++ ++++++ + ++ ++
F	THESIUM GRACILARIOIDES	15	+ + ++ ++ +++ ++++ + +
	-ASS. 7.1.3 - 7.3		
F	VERNONIA OLIGOCEPHALA	23	+ + + +++ +++ +++++++ + ++++ ++
W	LONCHOCARPUS CAPASSA	23	+ + +++ * ++ + ** 1+ + ++ + + *+++ +
	-ASS. 7.2 & 7.3		
F	HELIOTROPIUM STEUDNERI	12	+ + ++ ++ + + ++++
F	VIGNA UNGUICULATA	9	+ + + + + + + ++
	TABLE 2 GROUP -		
	6-RAINFALL > 550MM BUT EXCLUDING SAND & LOAMY SAND A HORIZONS & SODIC SOILS		
W	PELTOPHORUM AFRICANUM	22	B*1+1 + +** + 11 A1 + * ++++ + *
F	CRABBEA HIRSUTA	21	+ + ++ ++ + ++ +++ +++ + ++ + + +
G	CYMBOPOGON PLURINODIS	18	A1 A+ 1+ + + A 1+ + 1 AA+ + +
	7-EXCLUDING NON-SODIC SOILS WITH SAND & LOAMY SAND PROFILES		
G	THEMEDA TRIANDRA	57	33+ABB133+B43+B3B+34B33444A3344B343BB3A343BB4444A54B343A4
F	IPOMOEA SINENSIS	38	+ + + + +++ ++ ++ ++++++++ ++++ ++ ++ +++++++ + +
G	PANICUM COLORATUM	31	+ B BA A + ++ +B + B+ +A++ BABB+ A + +AA31 B+
F	PHYLLANTHUS PENTANDRUS	20	+ ++ ++ + +++ + + ++ ++ + ++ ++
	8-EXCLUDING NON-SODIC SOILS WITH SAND, LOAMY SAND & SANDY LOAM PROFILES		
G	BOTHRIOCHLOA RADICANS	33	+AAA++ A+ +*B+++ + + 3+ A++ +++3A + ++1 AA1
W	COMBRETUM IMBERBE	26	1 ++ ++ ++ + + ++++ ++ ++* + ++++ ++ +
W	ORMOCARPUM TRICHOCARPUM	19	+ + + + + + +++++++ + + + + * +
	9-MESIC AREAS-RELATIVELY SANDY &/OR > 550MM RAINFALL BUT EXCLUDING SODIC SOILS		
F	IPOMOEA CRASSIPES	42	++ + ++ + ++ +++ ++++11++++++++++++++++++++++A++
W	MAYTENUS HETEROPHYLLA	34	+ ++1 + *+++++ +1 111++1+1 + +*+ * *+ *+ +*++
W	XIMENIA CAFFRA	20	+ + + + + + + * * + ** + 1 +++* ++
	10-EXCLUDING ARID AREAS, SUCH AS SODIC WITH THIN, MASSIVE A HORIZON OR VERTIC OR RAINFALL < 500MM		
G	HETEROPOGON CONTORTUS	45	+1+ ++ A +1+ +++ AAA++A++ ++11B+AA++3+++ +1A+A++A + +
W	SCLEROCARYA CAFFRA	42	11 A 1 +1 * + 11 11+1+*+1111 *++11+1* 1++ ++111+ + **+
W	ACACIA GERRARDII	42	4+A+1 A+A1+1 ++ 1+1 ++++ ++ +1++ + +1*+++** +++++A +
W	ALBIZIA HARVEYI	39	++ +11+ + + + 1+++ +++++++*+++ +1 +* +A++1++++1
G	ERAGROSTIS SUPERBA	36	+ +++ ++ ++++++++ + ++ + + ++++ +++++++ + + + +++
F	CASSIA MIMOSOIDES	35	+ ++ +++ + ++ +++ ++++ ++ +++++ ++++ + ++ + ++++
W	DALBERGIA MELANOXYLON	32	++ + ** + 1++++++ +* * +++*+ +++++ +++ + + +
W	LANNEA STUHLMANNII	27	+1+1 + *1+ 1 + + *1 1+ +++++ +**1** +
F	HIBISCUS PUSILLUS	23	+ + +++++ + +++++ ++ +++ + ++ + +
F	COMMELINA AFRICANA	23	+ ++++ ++ + ++ + ++ + + ++++++ ++
F	BLEPHARIS INTEGRIFOLIA	18	+ + ++ ++ + + + + + + +++ ++ +
	17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE > 30% PRESENCE IN THIS TABLE		
G	PANICUM MAXIMUM	55	B14+4A+1+B++1+A1+3++4A+1A+BAA1A1++1++++111 +++A+A +++++A+
G	DIGITARIA ERIANTHA	54	BB 3+34BB3 +AA13BBAA+B3A1A3BBAAA+BAB3BBA1BA4B+A 4++31ABB1
G	UROCHLOA MOSAMBICENSIS	48	+1++ +1+1+ABB34+A+ 1+++ +1+A1 1 A+A+ +1+1+++A++R++ ++AA
W	DICHROSTACHYS CINEREA	48	1+1*++1++1 ++++ B+A +1+1+++11+++1++1+1 1 A+++11+* ++11
F	LANTANA RUGOSA	41	++ +++ ++++++++ +++++++++ ++++++ ++++ +++ +++ ++ ++
F	SOLANUM PANDURAEFORME	31	+++ ++ ++B+ + + + ++ + ++ +++ ++ + +++ + ++++
G	ARISTIDA CONGESTA BARBIC...	25	++++B+A ++A++A++ + + + + + + ++ + +
F	INDIGOFERA VICIOIDES	25	+ + 1 +++++ + ++++ + ++ ++ ++ + + + + +
F	CUCUMIS AFRICANUS	20	+++++ ++++ ++ ++ + + + +++ +
	18-INFREQUENT, 10-30% OVERALL PRESENCE > 10% PRESENCE IN THIS TABLE		
F	SOLANUM INCANUM	17	+ + ++ + ++++++ + + ++ ++
F	RHYNCHOSIA TOTTA	15	+ + + + ++ + + + + ++++ +
F	VERNONIA FASTIGIATA	14	+++ ++ + + + + + + ++ +
W	ZIZIPHUS MUCRONATA	13	1 + +++ + 1 + * * + + +
W	EHRETIA AMOENA	9	* + + + + + + + *
W	CASSIA ABBREVIATA	8	+ ** + * + + +
	OTHER INFREQUENT SPECIES		
G	EUSTACHYS MUTICA	17	+ + + + ++ ++ ++ ++ ++++ 1
W	SECURINEGA VIROSA	16	*+ + * + + ++ * + +*++ + 1
F	CUCUMIS HIRSUTUS	15	++ + ++ + +++ + ++ + + +
W	EHRETIA RIGIDA	15	+ +++ ++ + + + +++ + + +
F	SIDA CHRYSANTHA	12	+ + + + + ++ + ++ + +
W	GREWIA MONTICOLA	11	+ + 1 +++ + + + + +
F	MERREMIA PALMATA	10	+ + + + + + + + + +
F	THUNBERGIA DREGEANA	10	+ ++ + + +++ + +
F	OCIMUM URTICIFOLIUM	10	+ + ++ ++ ++ + +
F	SIDA RHOMBIFOLIA	10	++ + + + + + + + +
F	HERMANNIA BORAGINIFLORA	10	+ + +++++ + + +
W	MAYTENUS SENEGALENSIS	9	* + 1 1+ + + + +
F	CYPHOSTEMMA HUMILE	9	+ + +++ + + + +
F	TEPHROSIA RETUSA	9	+ + + + + ++ + +
G	BRACHIARIA NIGROPEDATA	8	+++ A+ + + +
F	CLERODENDRUM TERNATUM	8	+ + + + + ++ +
F	KOHAUTIA VIRGATA	8	+++ + + ++ +
W	DIOSPYROS MESPILIFORMIS	8	+ + ++ + * ++
F	POLYGALA SPHENOPTERA	8	+ + + + + + + +
F	TEPHROSIA ELONGATA	8	+ + + + + + + +
F	PHYLLANTHUS ASPERULATUS	8	+ + + + + ++ +
F	DECORSEA GALPINII	7	+ + + 1+ + +
F	HIBISCUS MICRANTHUS	7	+ + + + + + +
F	PAVONIA BURCHELLII	7	+ + + ++ + +
F	CHLOROPHYTUM SPP.	6	+ +++ + +
F	STRIGA ASIATICA	6	+ + + + + +
F	DOLICHOS TRILOBUS	6	+ +++ + +
W	GREWIA HEXAMITA	6	++ + + + +
F	SIDA DREGEI	6	+ ++ ++ +
W	OZOROA ENGLERI	5	+ + + + *
G	SETARIA WOODII	5	+ + R + R
F	EUPHORBIA CHAMAESYCE	5	+ + + + +
F	VIGNA ANGUSTIFOLIA	5	+ + + + +
F	ASPARAGUS SP.	5	+1 + + +
G	SPOROBOLUS FIMBRIATUS	5	+ + + + 1
F	TERAMNUS LABIALIS	5	+ + + + +
G	SCHMIDTIA PAPPOPHOROIDES	5	+ ++ + +
F	ASPARAGUS BUCHANANII	5	+ + + + +
F	CHAETACHME BURCHELLII	5	+++ + +
G	CHLORIS VIRGATA	5	+ + + + +
F	HELIOTROPIUM STRIGOSUM	5	+ + ++ +
F	OXALIS SPP.	5	+ + + + +
F	WALTHERIA INDICA	5	++ + + +
G	CYMBOPOGON EXCAVATUS	4	+ B 1 +
W	ALBIZIA PETERSIANA	4	+ + 1 +
F	MACROTYLOMA MARANGUENSE	4	+ A + +
G	DIHETEROPOGON AMPLECTENS	4	+ 1 A +
F	RHYNCHOSIA DENSIFLORA	3	+ + A
G	SETARIA FLABELLATA	3	+ + 1
F	STYLOSANTHUS FRUTICOSA	3	+A +
W	COMBRETUM COLLINUM	2	1 +
W	ACACIA WELWITSCHII	1	1
G	DIGITARIA ERIANTHA	1	4
W	GREWIA FLAVESCENS	1	1
G	SORGHUM VERSICOLOR	1	1

SEE APPENDIX 2 FOR RARE SPECIES WITH LOW COVER

ALLIANCE UNSPECIFIED:-

7. *Themedo triandrae - Acacietum gerrardii* ass. nov. (Association on mesic clay, Table 5).
Nomenclatural type: Releve 192

Habitat and location

The Association on mesic clay is restricted to and predominant in the bottom parts of the undulating granitic country in the western Central District; on the doloritic plains interrupting this granitic region; on the relatively moist basaltic plains south of Tshokwane, where the rainfall is 550-600mm, and on some rhyolitic footslopes. Mean annual rainfall in these areas is 550-600mm and the soils are more clayey than sandy loam in at least one horizon, particularly the B horizon.

The subcommunity (Ass. 7.1) that is mainly from granitic doloritic and rhyolitic regions, has less clay in the A and B horizons than the two subcommunities (Ass. 7.2 & 7.3) associated mainly with basalt ($P < 0.01$, $N_1 = 23$, $N_2 = 31$. i.r.o. A horizons; $P < 0,01$, $N_1 = 24$, $N_2 = 25$, i.r.o. B horizons, Mann-Whitney U tests using normal approximation with tie correction, Table 5). Therefore Asociation 7.1 soils are relatively moist, with low water runoff and good internal drainage through A horizons. Moreover, the granitic and doloritic examples of Association 7.1 occur in mosaic pattern with the particularly sandy upland sites of Association 5 (Table 4). Accordingly Association 7.1, of granitic bottomlands, doloritic plains and rhyolitic footslopes has distinctive floristic links with the alliance on mesic sand (Table 4) and other communities with coarse-textured soils (Table 2); while such relationships are lacking in the drier, predominantly basaltic subcommunities (Ass. 7.2 and 7.3; Table 2; cf. floristic subsection). The latter two subcommunities, particularly Association 7.3, which occurs on soils with extremely clayey B horizons, share the highly distinctive Heliotropium steudneri with dry and arid areas (Table 2). Floristic variations within the predominantly granitic, doloritic and rhyolitic subcommunity are associated with B horizon clay and pH and with differences in soil form.

Several soil forms are common in the Themedo triandrae - Acacietum gerrardii. The seasonally waterlogged Sterkspruit Form (orthic A on prismacutanic B horizon) is highly characteristic of granitic bottomland examples of Association 7.1. In contrast with the level to gently sloping high pH Sterkspruit soils of the Chlorido virgatae - Justiceion flavae (Table 3), the Sterkspruit soils of the variation of the Themedo triandrae - Acacietum gerrardii discussed here, are on moderately sloping (3-4°) middleslopes and seem to have lower pH values ($P \approx 0{,}05$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N_1 = 6$, $N_2 = 6$, Tables 3 & 5).

Subcommunities of the Themedo triandrae - Acacietum gerrardii, seem to be related to moisture regimes of the soils.

Mesic soils may include the following:-

(a) The Glenrosa Form (orthic A horizon on lithocutanic B horizon), because of its particularly gravelly and broken rocky B horizon, is in this respect relatively moist compared to soils with pedocutanic B horizons. An orthic A horizon also indicates relatively moist conditions as compared with melanic A horizons.

(b) Dark cutans are compounds of decomposed organic matter with calcium and magnesium and are formed under moderately dry conditions where the latter two elements are insufficiently leached. Red structured B horizons such as in the Shortlands Form, therefore suggest wetter conditions than pedocutanic B horizons.

(c) The Valsrivier Form (orthic A horizon and pedocutanic B horizon on unconsolidated material) could conceivably be moister than a similar soil (Swartland) where the pedocutanic B horizon rests on saprolite rather than unconsolidated material in sofar as the unconsolidated gravel acts as the more effective reservoir of available water. Such a moisture source is buried relatively deep. The Valsrivier Form is here strongly associated with dolorite ($P < 0{,}01$, Two-tailed Chi-square Test, $N = 57$, Table 5).

(d) Soils of the Sterkspruit Form (orthic A horizon and prismacutanic B horizon) are sodic and deflocculated, with associated arid properties. They are, however also seasonally waterlogged and therefore have decidedly moist characteristics.

(e) The Willowbrook, Pinedene and Westleigh forms have subsoil horizons with respectively grey matrix colours, colour variegation and mottles and concretions, owing to periodic saturation with water.

Comparatively dry soils may include the Bonheim Form (melanic A horizon on pedocutanic B horizon), the Swartland Form (orthic A horizon with pedocutanic B horizon on saprolite and the Mayo Form (melanic A horizon on lithocutanic B horizon).

Such indications offer explanations for the soil preference of the subcommunities of the _Themedo triandrae - Acacietum gerrardii_. The supposedly mesic Glenrosa, Shortlands, Valsrivier, Sterkspruit, Willowbrook, Pinedene and Westleigh forms on the one hand, are preferred by the mainly granitic, doloritic and rhyolitic Association 7.1 releves, whereas the mainly basaltic Association 7.2 plus 7.3 releves, which have distinct arid floristic affinities, is typical of the supposedly drier Bonheim, Swartland and Mayo Forms ($P = 0{,}03$, Two-tailed Chi-square Test, $N = 54$, Table 5).

Structure

Structure in the _Themedo triandrae - Acacietum gerrardii_ is predictable from habitat features such as geology, soil form, depth to lithocutanic B horizons or to saprolite underlying A horizons, percentage clay, and soil textural classes. Moisture regime relates in a consistent manner to the effect of these various factors on structure.

Trees are commonly absent, or scattered or present as a sparse layer, but occasionally also form moderate to dense layers (Appendix 1). Sparse to dense treeveld is here typical of the doloritic region and common also on granitic soils of the Sterkspruit Form ($P < 0,01$, Two-tailed Chi-square Test, $N = 57$, for association of tree cover in excess of one per cent with releves belonging either to granitic Sterkspruit soils or to doloritic areas; Table 5, Appendix 1).

Brush cover usually varies from scattered to moderately brushy. Thicketed stands are exceptional (Appendix 1). Brush cover of more than five per cent is characteristically common in the relatively mesic Association 7.1 ($P = 0,01$, Two-tailed Chi-square Test, $N = 57$, Table 5, Appendix 1), and within Association 7.1, on the granitic, rhyolitic and Karoo sediment soils rather than on doloritic soils ($P = 0,04$, Two-tailed Chi-square Test, $N = 32$, Table 5, Ch. IV). These soils where the brush cover is high are of the relatively mesic forms mentioned in the paragraph on habitat, but excluding those with pedocutanic or red structured B horizons. The soils with low brush cover are therefore, either relatively dry, or else wet but relatively deep and without impeded drainage ($P < 0,01$, Two-tailed Chi-square Test, $N = 31$, Table 5, Appendix 1 - for soils that are litholitic or of the Glenrosa, Sterkspruit, Willowbrook and Pinedene forms with high brush cover, versus Bonheim, Mayo Swartland, Valsrivier and Shortlands forms with low brush cover, in Association 7.1).

In Association 7.1 shrub cover of over five per cent is also associated with granitic, rhyolitic and Karoo Sediment soils rather than with doloritic soils ($P = 0,02$, Two-tailed Chi-square Test, $N = 31$, Table 5, Appendix 1). Shrub cover in the other two subcommunities is usually scattered to sparse Appendix 1.).

Floristic composition

The Association on mesic clay has few exclusive species and these have low constancies. Notable examples are the forbs *Vernonia oligocephala*, *Barleria oxyphylla* and *Rhynchosia minima* (Table 2). More useful diagnostic features include a combination of mesic species of sandy and/or high rainfall areas (Groups 6 and 9, Table 2) and species that avoid non-sodic soils with sand, loamy sand or sandy loam throughout their profiles (Group 8, Table 2). Noteworthy examples of these mesic differentials are the woody *Maytenus heterophylla*, *Pterocarpus rotundifolius* and *Ximenia caffra*, the grasses *Cymbopogon plurinodis* and *Eustachys mutica*, and the forbs *Ipomoea crassipes*, *Crabbea hirsuta* and others (Groups 6 & 9, Table 2). The relevant species of clayey habitats include the woody *Acacia nigrescens*, *Securinega virosa*, *Combretum imberbe* and *Ormocarpum trichocarpum*, and the grass *Bothriochloa radicans* (Group 8, Table 2). These differentials are of varying presence and constancy. The brushy *Acacia gerrardii* (Group 10, Table 2) has its clear optimum and diagnostic constancy in this Association. Woody dominants vary with subcommunities and their variations. The outstandingly commonly dominant grasses of the Association on mesic clay are *Digitaria eriantha* and *Themeda triandra*. The latter has its distinct optimum here, where its cover values exceed 25 per cent more regularly than in the association of moderately dry clay (Ass. 8), which ranks next in this respect ($P < 0,01$, Two-tailed Chi-square Test, $N = 103$). Other commonly dominant grasses have optimum cover values in different subcommunities and variations and include *Panicum maximum*, *Urochloa mossambicense*, *Heteropogon contortus*, *Bothriochloa radicans* and *Panicum coloratum*.

7.1 Brushveld, thicket and treeveld with *Combretum hereroense*, *Acacia nigrescens* and *Cissus cornifolia*, typical of rhyolitic, granitic and doloritic examples of this Association

This is the most mesic of the three subcommunities, occurring mainly on middle to lower rhyolitic slopes, in 1-5^{o} sloping granitic and doloritic bottomlands and on doloritic plains. The clay content of the A horizons, which are lower than in the other two subcommunities, is typically less than 25 per cent. B horizons also usually have relatively low clay contents of less than 35 per cent.

Trees may be absent or form a sparse to moderate treeveld canopy. The treeveld is typical of doloritic areas and some granitic soils of the Sterkspruit Form. Brush cover varies from sparse to thicketed with the denser brush occurring on relatively wet soils with lithocutanic B horizons or impeded drainage (cf. general discussion of Association structure).

The Subcommunity is well-differentiated particularly by woody species of Group 5 (Table 2) which avoid moderately dry to arid deep clayey soils. These Group 5 differentials are *Combretum hereroense*, *Cissus cornifolia* and *Combretum apiculatum*. Another differential with high presence and relatively high cover, is *Acacia nigrescens* (Table 5).

Three variations of this subcommunity are shown in Table 5. The first two, have relatively high B horizon pH values in comparison with the third ($P < 0,05$, Two-tailed Mann-Whitney U Test, using normal approximation with tie correction, $N_1 = 9$, $N_2 = 16$). The first variation, on various geological formations, has relatively well-drained soils whereas the second variation typically occurs on soils that are regularly saturated with water, i.e. the Sterkspruit, Willowbrook and Pinedene forms ($P = 0,02$, Fisher's Exact Test, $N = 18$, Table 5).

7.1.1 Brushveld, thicket and treeveld of well-drained high pH soils

(a) The Acacia gerrardii - dominated rhyolitic phase occurs on non-stoney moderate to moderately steep, 4-10°, lower middleslopes and footslopes. The topsoil conductivities in the two representative Releves, 108 and 120, are characteristically high, i.e. 3 100 and 1 050 micro mhos respectively.

The structure of the rhyolitic phase is densely shrubby to scrubby, dense brushveld and thicket. Acacia gerrardii brushes dominate the shrub and brush levels (Appendix 1). The field layer is overwhelmingly dominated by a tall dense stand of Panicum maximum (Table 5).

(b) The Acacia nigrescens - dominated doloritic phase is represented by three releves of which two had 1-9 per cent low doloritic outcrop. These were the only two doloritic releves of the Association that had this much outcrop.

Structure in the doloritic phase was sparsely shrubby, sparse to dense treeveld, with scattered to moderate brush cover. Acacia nigrescens is the dominant tree, with shrub and brush dominants as shown in Appendix 1. The field layers were dominated by the grasses Themeda triandra and Digitaria eriantha.

7.1.2 Brushveld and treeveld with Euclea divinorum, Ipomoea coptica, Abutilon austro-africanum and Ruellia patula, mainly of soils that are regularly saturated with water

The most typical soils of this variation belong to the Sterkspruit Form, Grootfontein Series, i.e. an orthic A horizon with 6-15 per cent clay and coarse sand, over a predominantly non-red prismacutanic B horizon (MacVicar et al., 1977). A horizon structure may be single grain or massive. The sodic soils of this vegetation variation are on bottomland slopes towards young spruits in relatively profusely dissected granitic terrain. Examples are common between the Nwaswitsontso River and the upper reaches of the Ripape Spruit. Included are the Ripape Spruit upper reaches, its tributary Vutome drainage system and young granitic tributaries of the Nwaswitsontso, such as the Tswayini, Misane and Hlulavambe (Fig. 1). The pH of B horizons in these Sterkspruit soils, although high in subcommunity context, seems generally lower than in Sterkspruit soils of the often more level bottomlands of the Chlorido virgatae - Justiceion flavae (Alliance on deflocculated soil), along older drainage courses such as the Sabie, Sand and Nwaswitsontso rivers ($P \approx 0.05$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N_1 = 6$, $N_2 = 6$, Tables 3 and 5). Other typical soils of the present variation belong to the Willowbrook and Pinedene forms, which, like the Sterkspruit Form, are regularly saturated with water.

The structure here is sparsely shrubby to scrubby, sparse to dense brushveld, or more commonly sparsely shrubby to moderately shrubby, sparsely to moderately brushy, sparse to moderate treeveld. Acacia nigrescens most commonly dominates the tree level. Occasionally dominant trees include Sclerocarya caffra and Acacia welwitschii (Appendix 1). Other woody species with occasionally prominent cover include Combretum hereroense, C. apiculatum, Acacia gerrardii, Dichrostachys cinerea and Albizia harveyi (Table 5, Appendix 1). Themeda triandra and Digitaria eriantha are typically the dominant grasses, with Urochloa mossambicense subdominant. Occasional subdominants include Eragrostis rigidior, Panicum coloratum, Bothriochloa radicans and Aristida congesta subsp. barbicollis (Table 5).

Differentiating species include the presence of deflocculated soil indicators such as Euclea divinorum, Ipomoea coptica, Ruellia patula and Abutilon austro-africanum (Groups 1, 2 & 14, Table 2) and the scarcity of Dalbergia melanoxylon (Table 5).

7.1.3 Brushveld and treeveld with *Urochloa bracyura* (as well as species such as *Combretum hereroense, Acacia nigrescens* and *Cissus cornifolia* in combination with species such as *Pterocarpus rotundifolius, Lonchocarpus capassa, Rhynchosia minima* and *Vernonia oligocephala*), on well-drained, low pH soils

The low pH variation is common on doloritic soils but may also occur on granitic slopes. The latter slopes may well have doloritic influence, because dolorite is commonly found in the lower parts of granitic terrain where the presence of dolorite might have been responsible for bottomland formation.

The structure here is sparsely shrubby to scrubby, sparse to dense brushveld and sparsely to densely shrubby, sparsely to densely brushy, sparse to moderate treeveld. *Acacia nigrescens* and *Sclerocarya caffra* are the commonly dominant trees of the treeveld.

As shown in Table 5, the woody *Maytenus heterophylla* characteristically has relatively high cover in this variation. The presence of the grass *Urochloa brachyura* and the usual absence of the grases *Panicum coloratum* and *Bothriochloa radicans*, are also highly characteristic (Table 5). Another conspicuous differential feature includes the combined presence of, on the one hand, members of a group of species with *Combretum hereroense, Acacia nigrescens* and *Cissus cornifolia,* and on the other hand, members of two groups containing, e.g. *Pterocarpus rotundifolius, Rhynchosia minima, Vernonia oligocephala* and *Lonchocarpus capassa* (Table 5).

Common dominants of the shrub and brush levels include *Pterocarpus rotundifolius, Combretum hereroense, Dichrostachys cinerea, Peltophorum africanum* and *Bolusanthus speciosus* (Appendix 1).

The grass *Themeda triandra* is usually overwhelmingly dominant in the field layer but may exceptionally be subdominant to *Panicum maximum*. The grasses *Digitaria eriantha* and *Heteropogon contortus* are typical subdominants, covering 5-25 per cent each (Table 5).

7.2 Shrubveld, brushveld and treeveld with *Pterocarpus rotundifolius, Rhyncosia minima* and *Chascanum hederaceum, (plus Maytenus heterophylla* and *Lannea stuhlmannia*), on the one hand, in combination with *Panicum coloratum* and *Bothriochloa radicans* on the other hand, mainly on moderately clayey basaltic soils

The subcommunity occurs from watersheds to valleys on level to two degrees sloping basaltic plains. The typical basaltic soils of the subcommunity are of the Glenrosa, Mayo, Swartland and Bonheim forms. The releves are from south of Tshokwane where the rainfall is 550-600mm and, therefore, relatively high. B horizon clay content is not as high as in the next, drier, subcommunity ($P < 0,05$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N_1 = 8$, $N_2 = 16$, Table 5), but higher than in the previous subcommunity (see general discussion of Association 7 habitat).

Tree cover is absent to sparse, brush cover varies from scattered to sparse and shrub cover from scattered to moderate (Appendix 1).

The subcommunity shares a number of differential species with the variation on well-drained, low pH soils, of the previous subcommunity, eg. the woody *Pterocarpus rotundifolius* and the forbs *Rhynchosia minima, Chascanum hederaceum* and *Thesium gracilarioides*. However, the present subcommunity is differentiated from the aforementioned variation by the grasses *Panicum coloratum* and *Bothriochloa radicans* and by lack of differential species of the former subcommunity, such as *Combretum hereroense, Acacia nigrescens* and *Cissus cornifolia* (Table 5).

Common woody dominants are Sclerocarya caffra in the tree layer and Dichrostachys cinerea and Pterocarpus rotundifolius in the brush and shrub layers (Table 5, Appendix 1). Themeda triandra is usually the dominant grass, with Digitaria eriantha a subdominant. Occasional subdominant grasses include Panicum coloratum, P. maximum, Heteropogon contortus and Urochloa mossambicense.

7.3 Grassveld, shrubveld and brushveld on extremely clayey basaltic soils

This least mesic subcommunity, like the former subcommunity, occurs on level terrain to two degrees slopes, on basaltic plains in the 550-600mm rainfall region south of Tshokwane, but on drier soils with distinctly more clay in their B horizons (see Ass. 7.2). Soils usually belong to the relatively dry Swartland, Mayo and Bonheim Forms (Table 5).

Trees are typically absent in this subcommunity and brush is commonly absent to scattered. The structure may be grassveld with or without scattered shrub, sparse shrubveld with scattered brush, or sparse to moderate brushveld with scattered to sparse shrub (Appendix 1).

Differential features include the presence of Vernonia oligocephala and Lonchocarpus capassa as in Association 7.1.3 and 7.2, the presence of Heliotropium steudneri, which is shared with Association 7.2, and the lack of differential species of Association 7.1 and 7.2 (Table 5). Dominant species in sparse and moderate shrub and brush layers include Dichrostachys cinerea, Albizia harveyi and Acacia gerrardii (Appendix 1). Themeda triandra is the usual dominant and Digitaria eriantha, Panicum coloratum and Bothriochloa radicans occasionally have cover values of over five per cent.

TABLE 6. ACACIETUM GERRARDIO-TORTILIS (ASSOCIATION ON MODERATELY DRY CLAY)

		Presence	Relevé data
	RELEVE NUMBERS		21111122100100000101100220101210201100103100 0
			35656633467179967917668843848551636165455414 56
			56031243823443255451484546253453129234556094 93
	ASSOCIATION NUMBER		8
	LANDSCAPE NUMBER		66666666676666766666666666666676666 7767 9777
	HABITAT GEOLOGY (B=BASALT, R=RHYOLITE, Z=SANDSTONE)		BBBBBBBBBBBBBBBBBBBBBBZBBBBBBBBBBZBBBBBRBBB
	RELIEF (C=CREST, F=FOOTSLOPE, M=MIDDLESLOPE, V=BOTTOMLAND)		CMMMCMCMMCMVMMMCMMVCMMMCMMMCMMMCCCMCFCFMMVVMCM
	SLOPE (DEGREES)		000000000000000000000000000000000000000000000
			002010000011111011200001001000100040201004100
	SURFACE (F=FLAT, I=CONCAVO-CONVEX, N=CONVEX, U=CONCAVE)		FFFFFFFFFFFFFFFNFFNFFFFFFFFFFFFINFFNFNUFFFNFFF
	A HORIZON-DEPTH (DM; +<1DM)		221212222+2+211+2 +122122112221+2+ 412222 312
	-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM, Z=SANDY)		CCCZCZCZCCZCLC CZCCCZZZZZZZZCLZZCZZZZLC CZZCCC
			LLLI ILILLIL L LLLLLLIIIILIIL IILILII LIL L
	-CLAY (%)		32324232222323 2133211222122221232121 23 312343
			27157706698503 75028592219436487155495809 57440
	-PH (X 10)		656555556666655656667656555655555655665555
			0508899222411065131001031291747886168972 65689
	-CONDUCTIVITY (MICROMHOS X ,1)		0000000000000010000000000 000100000000000000
			5684753348462422825545432 27 932063291572986578
			5636251616188966785005405 18 424292805511687785
	B HORIZON - DEPTH (DM; *>9DM)		646 4434 6774 65 7 5555453*44 32 966 4 6
	-COLOUR (D=DARK, G=GREY, I=DUSKY RED, R=RED, Y=YELLOW)		DRDDIDRDRDIRDD DIRRD RIRRRRIRRR RI YDDRDR RGD
	-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM, Z=SANDY)		CCCCCCCCCCCCC CCCCC ZCZZZCZ ZZ CC ZZCZCZ CCC
			L L I CCI I CI IC I C
	-CLAY (%)		4454445364444 64344 2333242 32 34 345253 465
			4345474653 2957 53665087671280900062022111 40937
	-PH (X 10)		57566558 66565 75557 6666666 65 46 676665 666
			72345370 17178 79854 3354501 28 53 173289 476
	-CONDUCTIVITY (MICROMHOS X ,1)		000000000000 10000 0000000 00 00 000000 000
			565682346664 07428 5232442 22 34 158383 776
			052976550004 68 01471 2899019 55 00 260490 145
	SOIL FORM (STD. ABBREVIATIONS, MACVICAR ET AL., 1977)		MGMBBMGGGBBGBM BBGHBMGMGGGGMSGGMMGM AMMSBO MWS
			YSYODYSSSOGSOY OOSUDWSYSSSSYWSSWWSY DYYWOA YOW
	SOIL SERIES NUMBER (MACVICAR ET AL., 1977)		11133111133131 331331111111 111111 311131 1 3
			08001088700900 006700 6086680 860060 001017 0 2
	NUMBER OF SPECIES		000000000000000000000000000000000000000000000
			332232233233333332233333333233232222223221312
			126919805746828068672453916560321794529155927 6
	GROWTH FORM PREFIX: F=FORB, G=GRASS, W=WOODY		
	DIFFERENTIAL SPECIES FOR- (SPP. NAMES, PRESENCE VALUES)		
	-ASS. 8.1		
F	BARLERIA PRIONITIS	7	+++1+ + +
G	ERAGROSTIS CILIANENSIS	13	+++++ + + * + + + + +
G	CHLORIS ROXBURGHIANA	3	++ +
F	ACALYPHA INDICA	5	+++ + +
F	CUCUMIS METULIFERUS	2	++
	-ASS. 8.2		
W	SCLEROCARYA CAFFRA	26	+ ++*1++1+A * 11111+11 111 A + +
W	LONCHOCARPUS CAPASSA	21	+ +++ ++ +*++ ++* +++ + + 1 *
F	VERNONIA FASTIGIATA	18	++ +++++ + + +++++ ++ + +
F	INDIGOFERA VICIOIDES	18	+ + ++++ * +++ + ++ + + + + +
W	DALBERGIA MELANOXYLON	17	+ + +++* +1 ++ ++ +++ 1 +
F	CORCHORUS ASPLENIFOLIUS	16	++ ++ + + ++ ++ + ++++ +
	-ASS. 8.1 & 8.2.1		
G	CHLORIS VIRGATA	20	1+++++11+ +*++ + ++ R + + +
W	ORMOCARPUM TRICHOCARPUM	17	1 *++ +++ + +++ ++ +1 + +
F	DYSCHORISTE ROGERSII	13	B+++ + + +++++ + +
	-ASS. 8.1 & 8.2.1.1		
W	MAYTENUS SENEGALENSIS	10	+ + + 1+*+ ** +
	-ASS. 8.2.1.2		
F	JATROPHA SP.	14	+ +++++++++ + + + +
F	SERICOREMA SERICEA	12	++ *+++ + + + + + +
F	INDIGOFERA RHYTIDOCARPA	9	+ + + + ++ + + +
	-ASS. 8.2.2		
F	CUCUMIS HIRSUTUS	10	+ + ++** +++ +
F	IPOMOEA CRASSIPES	8	+ + *+++ + +
W	COMBRETUM HEREROENSE	8	++ ++ 1 1 + +
F	CROTOLARIA MONTEIROI	6	+ + ++++
	-ASS. 8.3		
G	CENCHRUS CILIARIS	14	+ + B + A A ++311++B
G	SCHMIDTIA PAPPOPHOROIDES	8	1 1 + + ++3 +
W	CORDIA SINENSIS	5	+ ++ ++
	TABLE 2 GROUP -		
	7-EXCLUDING NON-SODIC SOILS WITH SAND & LOAMY SAND PROFILES		
G	THEMEDA TRIANDRA	44	++1+33+A11333511BA+33B3B3B1141BB+3ABB13B4 BAA
G	PANICUM COLORATUM	41	B1BBAA3BB++ 1+13B+3B1B+++B+1 +B+3B +A1+B+ A++
F	IPOMOEA SINENSIS	29	++++++++ + + *++++ ++++ ++* ++ + + + + + +
F	PHYLLANTHUS PENTANDRUS	21	+ + ++++++++ + ++ + ++++ + + +
	8-EXCLUDING NON-SODIC SOILS WITH SAND, LOAMY SAND & SANDY LOAM PROFILES		
G	BOTHRIOCHLOA RADICANS	39	14BB ++44BBB+3 4++ABB4+ 44A43 +134AB1B ++13+
W	ACACIA NIGRESCENS	36	111++ A ++1+11+ 1+ 1++AA+1*11+1 B1A 11++ A+
W	SECURINEGA VIROSA	31	1+++1+* + + ++1 ++1+++++ + + ++ + +*++ ++
W	COMBRETUM IMBERBE	24	+ * ++++ ++ ++ + * ++*+ + ++1 ++ ++
	10-EXCLUDING ARID AREAS, SUCH AS SODIC WITH THIN, MASSIVE A HORIZON OR VERTIC OR RAINFALL < 500MM		
F	CASSIA MIMOSOIDES	34	+++1 +++++++ +++ +++4++ ++++ + ++++ +++ + +
G	ERAGROSTIS SUPERBA	20	+ + + + + + ++ ++ + + ++++++ + +
W	LANNEA STUHLMANNII	15	+++ ++ +111 + 11 1 * +
G	HETEROPOGON CONTORTUS	15	+ ++++ + ++ + ++ 1+ 1 +
W	ACACIA GERRARDII	15	+11+ + + ++ + 1 1 ++ + +
	11-DRY AREAS SUCH AS SODIC, PUDDLED, VERTIC OR CLAYEY WITH 500-550MM RAINF.		
W	ACACIA TORTILIS	24	1+++++ + * + 1++++++ + + +*+1 ++
	12-EXCLUDING THE MOST MESIC SOILS AT > 550MM RAINFALL		
W	EHRETIA RIGIDA	32	+++++++ ++1 + +++ ++1+++*++++ ++ ++ +++
	13-NON-SODIC DRY TO ARID AREAS: PUDDLED SOILS OR RAINFALL < 550MM		
F	HELIOTROPIUM STEUDNERI	40	+++++++++ + + ++++ ++++ +++++++++++++++++++
F	BOERHAVIA DIFFUSA	27	++ + ++++ + +++++++ *+ + + + + + + + ++ +
F	EUPHORBIA CHAMAESYCE	21	+++++ + + +++++ + ++ + + + +++
G	BRACHIARIA XANTHOLEUCA	17	+ ++* + +++ ++ + + + + +++
	17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE > 30% PRESENCE IN THIS TABLE		
G	DIGITARIA ERIANTHA	41	1 AAB3B11 +11+13+114BB1 3+1A1+1BAA +3+AA++ A13
W	DICHROSTACHYS CINEREA	35	11*1++ + ++ + + ++1++A +11++1+1 +++++ +1++ +
G	ARISTIDA CONGESTA BARBIC...	35	B+BB1 1+A ++++A A++ +++++++ + ++ +++ A+ + +1+
G	UROCHLOA MOSAMBICENSIS	32	A1++ B3 1 + +++++A+++++A+ +B1 ++ + +A+1+
G	PANICUM MAXIMUM	31	AA+1 +++ +++ + + ++A1+11B*1++1 1A 1 1 3A
F	SOLANUM PANDURAEFORME	28	+ + + A++ ++++*+ + ++ +++++++ + + ++ ++ +
F	CUCUMIS AFRICANUS	17	++++ + + ++ ++ ++ ++ + + +
F	TEPHROSIA BURCHELLII	16	++ ++ +++ + ++ + + ++ + +
F	PHYLLANTHUS ASPERULATUS	14	+ + ++ + +* + + + +++ +
	18-INFREQUENT, 10-30% OVERALL PRESENCE > 10% PRESENCE IN THIS TABLE		
F	TALINUM CAFFRUM	16	+ ++ + + + + + + ++ ++ +++
F	LEDEBOURIA SPP.	9	+ + ++ + + + ++
W	ZIZIPHUS MUCRONATA	7	+ + + + * * +
F	HERMANNIA BORAGINIFLORA	6	+ ++ + + +
F	RHYNCHOSIA TOTTA	5	++ + + +
	OTHER INFREQUENT SPECIES		
W	COMMIPHORA AFRICANA	13	+ + ++ * + * * * + + ++
W	GREWIA BICOLOR	13	+ 1 + 1+ +1 + ++ +++
W	ALBIZIA HARVEYI	12	+ ++ 1 1 1 + ++ +1 +
F	LANTANA RUGOSA	11	++ + + + ++++ + +
F	CROTALARIA SPHAEROCARPA	11	+ A +++ + + + + + +
F	HIBISCUS PUSILLUS	10	+ + + + + ++ + + +
F	PAVONIA BURCHELLII	10	++ + + + ++ + + +
F	SIDA CHRYSANTHA	10	+ + + + *+ ++ + +
F	SEDDERA SUFFRUTICOSA	9	+ + ++++ + + +
G	TRAGUS BERTERONIANUS	9	+ + + + + + + + +
F	COMMELINA ERECTA	9	+ + + ++ + + + +
G	ENNEAPOGON CENCHROIDES	8	R + + + + + + +
F	HIBISCUS MICRANTHUS	8	+ + + + + + + +
W	GREWIA MONTICOLA	8	+ + + + + + + +
F	COMMELINA AFRICANA	8	+ +++ + + + +
F	SIDA RHOMBIFOLIA	8	+ ++ + ++ + +
W	XIMENIA CAFFRA	8	+ + + ++ + + +
F	HYBANTHUS ENNEASPERMUS	8	+ + + + + + ++
F	MERREMIA PALMATA	8	+ + + + + + + +
F	COCCINIA REHMANNII	8	* + +* + + + +
F	CYPHOSTEMMA SUBCILIATUM	6	+ + ++ + +
F	HELIOTROPIUM STRIGOSUM	6	+ + + + + +
W	CISSUS CORNIFOLIA	6	+ + ** * +
F	RHYNCHOSIA MINIMA	6	+ + + + + +
F	BLEPHARIS INTEGRIFOLIA	6	+ ++++ +
F	CYPERUS OBTUSIFLORUS	5	+ + + + +
F	RHYNCHOSIA DENSIFLORA	5	+ * ++ +
F	POLYGALA ERIOPTERA	5	++ +* +
W	ACACIA EXUVIALIS	5	+ + + + +
W	MAERUA CAFRA	5	+ + + + +
W	OZOROA ENGLERI	5	++ + + +
F	IPOMOEA COSCINOSPERMA	4	1+ + +
W	SESBANIA SESBAN	3	A + +
G	SETARIA WOODII	3	1 + *
F	CLERODENDRUM TERNATUM	2	+ 1
W	COMBRETUM APICULATUM	2	1 +
F	EPALTES GARIEPINA	1	A

SEE APPENDIX 2 FOR RARE SPECIES WITH LOW COVER

ALLIANCE UNSPECIFIED:-

8. Acacietum gerrardio-tortilis ass. nov.
(Association on moderately dry clay, Table 6).
Nomenclatural type: Releve 255

Habitat and location

The Acacietum gerrardio-tortilis is largely restricted to the 500-550mm rainfall basaltic plains between Tshokwane and Shitstalaleni (Fig. 1). Enclaves of vegetation belonging to comparatively arid types occur within the general distribution area of the moderately dry Acaciatum gerrario-tortilis. These arid enclaves occur in strongly undulating terrain and heavily grazed bottomlands, found near the major drainage courses of the Nwanedzi, Sweni, Makongolweni, lower Guweni and the Mrunzuluku. The vegetation of these arid enclaves belongs to the Themedo triandrae - Grewietum bicoloris (Association 9; see Landscape 6, Ch. VII).

Three subcommunities and variations thereof, within the Acacietum gerrardio-tortilis are associated with differences in A and B horizon conductivity and clay content, grazing pressure and soil colour. Association 8.1, which has been subject to heavy grazing, and Association 8.3, which occurs in mosaic-type association with the Setarietum woodii (Association 11, of vertic soils, have higher A horizon and B horizon conductivities than Association 8.2 ($P < 0{,}05$ for A horizon conductivity, $N_1 = 14$, $N_2 = 31$; and $P < 0{,}01$ for B horizon conductivity, $N_1 = 13$, $N_2 = 26$, - Two-tailed Mann-Whitney U tests using normal approximation with tie correction, Table 6).

The most typical soil forms of the Acacietum gerrardio-tortilis are, Bonheim (melanic A horizon over a pedocutanic B horizon), Mayo (melanic A horizon over a lithocutanic B horizon) and Glenrosa (orthic A horizon over a lithocutanic B horizon). A horizons have 15-35 per cent clay and B horizons are non-calcareous. The Bonheim soils are of the

Bonheim dumasi Series, defined as having 15-35 per cent clay in the A horizons, with non-red, non-calcareous B horizons. The Mayo soils are of the Mayo mayo Series, which is also typified by 15-35 per cent clay in the A horizon and non-calcareous B horizon. The Glenrosa soils are likewise, because of 15-35 per cent clay in the A horizons and non-calcareous B horizons, classified into the Glenrosa williamson, Glenrosa trevanian and Glenrosa robmore series, which differ in respect of the grade of sand in their A horizons.

Structure

Woody structure in this community varies with subcommunity and associated habitat characteristics. Treeveld occurs on soils with relatively low A horizon and B horizon clay content ($P < 0{,}01$, $N_1 = 16$, $N_2 = 25$, i.r.o. A horizon; $P < 0{,}05$, $N_1 = 13$, $N_2 = 23$. i.r.o. B horizon, Two-tailed Mann-Whitney U tests, using normal approximation with tie correction; three non-basaltic releves excluded) and is associated with Association 8.2 ($P < 0{,}01$, Two-tailed Chi-square test, $N = 43$). Grassveld, on the other hand, occurs on soils with high A horizon clay content ($P < 0{,}05$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N_1 = 7$, $N_2 = 34$; three non-basaltic releves excluded) and is associated with Association 8.3 ($P < 0{,}01$, Two-tailed Chi-square Test, $N = 43$). Brushveld and shrubveld occurs in all subcommunities but is associated mainly with Association 8.1 ($P = 0{,}02$, Two-tailed Chi-square Test, $N = 43$), which has been subject to heavy grazing.

Floristic composition

The Acacietum gerrardio - tortilis does not have uniquely characteristic differential species. The following combination of species groups is, however, quite distinctive:- Included are clay-associated species of Groups 7 and 8 (Table 2), notably the woody Acacia nigrescens, Securinega virosa, Combretum imberbe and Ormocarpum trichocarpum, the grasses Themeda triandra, Panicum coloratum and Bothriochloa radicans and the forb Ipomoea sinensis; and Groups 11 to 13 species of dry and arid areas, notably the woody Acacia tortilis and Ehretia rigida, the grasses Chloris virgata and Brachiaria xantholeuca and the forbs Heliotropium steudneri, Boerhavia diffusa, and Euphorbia chamaesyce; but excluding Groups 14 and 15 species of extremely arid areas, e.g. Combretum mossambicense and Ceratotheca triloba. The absence of Combretum apiculatum and other Group 5 species (Table 2) also distinguishes the present Association from several others, including the Acacio nigrescentis - Grewion bicoloris of arid habitats.

Acacia nigrescens is the most regularly dominant or subdominant woody species (Table 7). Sclerocarya caffra is commonly and typically a dominant or subdominant woody species on the relatively mesic, low clay content soils of Association 8.2.2 (Table 6). The latter species is nearly always the dominant tree where trees are present, i.e. in Association 8.2 (Appendix 1). Dichrostachys cinerea and Acacia nigrescens are the most commonly dominant shrub forming species and A. tortilis and A. nigrescens the dominant brush forming species in the shrubveld and shrubby brushveld of the heavily grazed Association 8.1. A. nigrescens is also the most commonly dominant shrub and brush contributor in Association 8.2 (Appendix 1). Other dominants of the shrub and brush layers of Association 8.2 include a variety of species, notably Dichrostachys cinerea, Acacia gerrardii and Albizia harveyi (Appendix 1). Scattered shrubs in the grassveld Association 8.3 may include Acacia nigrescens, Cordia ovalis and others.

The grasses _Digitaria eriantha, Themeda triandra, Panicum coloratum_ and _Bothriochloa radicans_ are regular dominants and subdominants of the field layer. _Aristida congesta_ subsp. _barbicollis_ an indicator of severe grazing impact or other forms of disturbance (cf. Chippendall, 1955), is a regular dominant/subdominant grass of the trampled Association 8.1 (Table 6). _Panicum maximum_ is typically among the dominant and subdominant grasses of the trampled Association 8.3 and the relatively mesic Association 8.2.2, probably owing to the relatively high tree, brush and shrub cover in these vegetation types.

P. maximum typically seems to concentrate under tree, brush and shrub canopies. Other common grasses, covering less than one percent in quadrats but with constancies in 10m x 20m quadrats exceeding 40 per cent, are _Urochloa mossambicense, Chloris virgata_ and _Eragrostis superba_ (Table 6). Equally common forbs are _Heliotropium steudneri, Cassia mimosoides, Ipomoea sinensis, Boerhavia diffusa, Solanum panduraeforme, Euphorbia chamaesyce_ and _Phyllanthus pentandrus_ (Table 6).

8.1 Shrubveld and brushveld with _Barleria prionitis_ and _Eragrostis cilianensis_ (and with _Aristida congesta_ subsp. _barbicollis_ among the dominant grasses) of the severely grazed Lindanda Plains

The Lindanda Plains are dominated by this subcommunity and form part of a larger complex, which comprises the traditional summer grazing area of large numbers of migratory blue wildebeest and zebra. This complex extends from the Lindanda Plains towards the Sweni-Makongolweni-Guweni-Nungweni drainage lines (Braack, 1973; Smuts, 1972).

The Lindanda Plains are in gently undulating terrain and are flat and level to gently sloping (2^{o}). The surface is non-rocky and non-stoney and soils belong to the Bonheim dumasi, Bonheim glengazi, Mayo mayo and Glenrosa robmore series, i.e. with more than 15 per cent clay, mostly 15-35 per cent clay, in the A horizon and non-calcareous B horizons. A horizon pH is between 5,5 and 6,0 and recorded conductivity of the A horizons varies from 460 micro mhos to 830 micro mhos (Table 6). B horizon clay content is typically between 40 and 45 per cent.

The vegetation structure here is mainly sparse shrubveld with scattered brush and sparsely to moderately shrubby, sparse brushveld.

According to informal observations by various people, including local rangers, the shrub cover on the Lindanda Plains has increased substantially over the past decade. Such change has however not been measured. It is, nevertheless, noteworthy that notorious "bush encroachment" species contribute distinctively to shrub and brush cover in this subcommunity.

The distinctive species composition is strongly related to animal impact. Severe grazing and concomitant trampling may favour woody species such as *Acacia tortilis* subsp. *heteracantha* and *Dichrostachys cinerea* subsp. *africana*, which are generally regarded as invaders of overgrazed and otherwise disturbed veld (Van der Schijff, 1957) and are listed among the trees and shrubs involved in bush encroachment in the Kruger National Park (Van der Schijff, 1959). *A. tortilis* subsp. *heteracantha* is characteristically a dominant brush species of this subcommunity and *D. cinerea* subsp. *africana* is distinctively commonly the dominant contributor to the shrub layer (Appendix 1). The subcommunity is, furthermore, strongly characterized by the presence of the field layer pioneer plants *Eragrostis cilianensis* (cf. Henderson & Anderson, 1966) and *Barleria prionitis*. The grass *Bothriochloa radicans*, which seems to be favoured by a harsh burning regime, deep clayey soils, a dry climate and heavy grazing (Table 2; pers. obs.) and *Aristida congesta* subsp. *barbicollis*, which increases in disturbed areas, including overgrazed and trampled areas (Henderson, & Anderson, 1966), are distinctively common dominants (Table 6).

8.2 Shrubveld, brushveld and treeveld with Sclerocarya caffra and Lonchocarpus capassa, on relatively low conductivity soils (Mesic subcommunity)

The mesic subcommunity is associated with soils where A and B horizon conductivities are usually less than 600 micro mhos.

As shown in Table 6, this subcommunity is differentiated from the other two by the presence of species that avoid arid habitats. These are the Group 10 (Table 2) woody species, Sclerocarya caffra, Lonchocarpus capassa and Dalbergia melanoxylon.

Two variations of this subcommunity differ in respect of both A and B horizon clay content of the soil ($P < 0,01$; $N_1 = 14$, $N_2 = 17$, for A horizon clay; $N_1 = 12$, $N_2 = 14$, for B horizon clay, Two-tailed Mann-Whitney U tests, using normal approximation with tie correction, Table 6) and in respect of the occurrence of dark B horizons ($P = 0,01$, Fisher's Exact Test, $N = 27$, Table 6).

8.2.1 Shrubveld, brushveld and treeveld with Ormocarpum trichocarpum and Chloris virgata on relatively clayey soils that commonly have dark B horizons

This variation occurs extensively on the basaltic plains north of the Nwanedzi River in the vicinities of Mananga and Mbatsane (Fig. 1). Soil A horizons typically have a sandy clay loam to clay loam texture with 25-35 per cent clay, and B horizon texture is clay, usually with 42-65 per cent clay (Table 6). The B horizons are commonly dark. Two further subdivisions are associated with differences in slope angle ($P = 0,05$, Mann-Whitney U test, using normal approximation with tie correction, $N_1 = 6$, $N_2 = 9$).

The structure is commonly sparse shrubveld, with or without scattered brush and trees, but may also be grassveld, brushveld or treeveld (Appendix 1).

As shown in Table 6, Choris virgata, Ormocarpum trichocarpum and Dyschoriste rogersii are distinctive and Acacia tortilis is characteristically rare or absent. The several woody species that may be dominant at various levels are shown in Appendix 1 and include Sclerocarya caffra, Lannea stuhlmannii, Acacia nigrescens, Dalbergia melanoxylon and others. Field layers are commonly dominated by a combination of the grasses Themeda triandra, Panicum coloratum, Digitaria eriantha, Bothriochloa radicans, Urochloa mossambicense and Aristida congesta subsp. barbicollis (Table 6).

Several species in various species groups of Table 6 differentiate between:

(8.2.1.1) a subdivision on virtually level terrain; and

(8.2.1.2) a subdivision of gently sloping terrain.

8.2. Brushveld and treeveld with Sclerocarya caffra and Panicum maximum cover commonly exceeding one per cent, on soils with relatively low clay content and red to dusky red B horizons

This variation is common on the basaltic plains north of Tshokwane (Fig. 1). A horizons are sandy loam to sandy clay loam with typically 15-25 per cent clay. B horizon textures include clay, sandy clay and sandy clay loam, with 20-45 per cent clay (Table 6). B horizons are usually red and dusky red.

The woody structure is typically sparsely to moderately shrubby, sparsely to moderately brushy, sparse to moderate treeveld and sparsely to moderately shrubby, sparse to moderate treeveld with scattered brush (Appendix 1). Sclerocarya caffra and Panicum maximum are characteristically among the dominant species and the presence of, e.g., Combretum hereroense, Cucumis hirsutus and Ipomoea crassipes is differential (Table 6).

8.3 Grassveld, usually with _Cenchrus ciliaris_ and/or _Schmidtia pappophoroides_ and/or _Cordia sinenses_ , on high conductivity, particularly clayey, soils

The grassveld subcommunity was recorded on non-vertic soils, occuring in mosaic-type association with the _Acacio nigrescentis_ - _Setarietum woodii_ of predominantly vertic soils in the Ntomeni-Gudzani-Mapetane-Shitsalaleni area; and on some low plains elsewhere in the general distrubution area of the _Acacietum gerrardio-tortilis_.

A and B horizon conductivities are usually higher than 550 micro mhos; and B horizon clay content is well over 40 per cent except in soils of floodplain examples where it may be considerably lower (e.g. Table 6, Releves 155 & 340). Included are Mayo mayo and Mayo msinsini soils (melanic A horizon over a non-calcareous lithocutanic B horizon), the Bonheim glengazi series (over 35 per cent clay in a melanic A horizon over a non-red, non-calcareous pedocutanic B horizon), the Swartland reveillie Series and Swartland hogsback Series (i.e. respectively with red B horizon with 15-35 per cent clay and non-red B horizon with over 55 per cent clay; in both instances an orthic A horizon over a pedocutanic B horizon underlain by saprolite), the Oakleaf highflats Series (orthic A horizon over a red, non-calcareous neocutanic B horizon with over 35 per per cent and the Willowbrook Form, which is a melanic A horizon over a G horizon.

Differential species, within Association context, include the shrub _Cordia sinensis_ and the grasses _Cenchrus ciliaris_ and _Schmidtia pappophoroides_ (Table 6).

TABLE 7. ACACIO NIGRESCENTIS - GREWION BICOLORIS (ALLIANCE OF ARID HABITATS)

	Relevé data
RELEVE NUMBERS	[illegible]
ASSOCIATION NUMBER	9 … 10
LANDSCAPE NUMBER	[illegible]
HABITAT	
GEOLOGY (B=BASALT, R=RHYOLITE, Z=SANDSTONE)	[illegible]
SLOPE (DEGREES)	[illegible]
RELIEF (C=CREST, F=FOOTSLOPE, M=MIDDLESLOPE, V=BOTTOMLAND)	[illegible]
ROCK (% X 10; +<1, *=1-9)	[illegible]
ROCK HEIGHT (+<,5, *=,5-,9)	[illegible]
BOULDERS (A=ABUNDANT,	[illegible]
STONES F=FREQUENT, R=RARE)	[illegible]
A HORIZON-DEPTH (DM; +<1DM)	[illegible]
-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM(Y), Z=SAND(Y))	[illegible]
-CLAY (%)	[illegible]
-PH (X 10)	[illegible]
-CONDUCTIVITY (MICROMHOS X ,1)	[illegible]
B HORIZON -DEPTH (DM; *>9DM)	[illegible]
-COLOUR (D=DARK, I=DUSKY RED, R=RED, Y=YELLOW)	[illegible]
-TEXTURE (C=CLAY, I=CLAY LOAM, L=LOAM, Z=SANDY)	[illegible]
CLAY (%)	[illegible]
-PH (X 10)	[illegible]
-CONDUCTIVITY (MICROMHOS X ,1)	[illegible]
SOIL FORM (STD. ABBREVIATIONS, MACVICAR ET AL., 1977)	[illegible]
SOIL SERIES NUMBER (MACVICAR ET AL., 1977)	[illegible]
NUMBER OF SPECIES	[illegible]

GROWTH FORM PREFIX:
F=FORB, G=GRASS, W=WOODY

DIFFERENTIAL SPECIES FOR-
(SPP. NAMES, PRESENCE VALUES)

	Species	Presence	Relevé data
	THEMEDO TRIANDRAE-GREWIETUM BICOLORIS (ASSOCIATION 9)		
G	DIGITARIA ERIANTHA	45	[illegible]
G	THEMEDA TRIANDRA	37	[illegible]
W	EHRETIA RIGIDA	31	[illegible]
F	IPOMOEA SINENSIS	30	[illegible]
G	HETEROPOGON CONTORTUS	26	[illegible]
F	CROTALARIA SPHAEROCARPA	21	[illegible]
G	ERAGROSTIS SUPERBA	21	[illegible]
W	COMBRETUM IMBERBE	21	[illegible]
G	ARISTIDA ADSCENSIONIS	20	[illegible]
W	COMBRETUM HEREROENSE	20	[illegible]
F	CASSIA MIMOSOIDES	18	[illegible]
W	ORMOCARPUM TRICHOCARPUM	17	[illegible]
	-ASS. 9.1		
W	GREWIA MONTICOLA	15	[illegible]
F	ACHYRANTHUS ASPERA	12	[illegible]
W	MAYTENUS HETEROPHYLLA	7	[illegible]
F	JUSTICIA FLAVA	9	[illegible]
F	SOLANUM COCCINEUM	7	[illegible]
F	DALECHAMPIA GALPINII	6	[illegible]
W	ALBIZIA HARVEYI	5	[illegible]
F	ASPARAGUS SP.	3	[illegible]
F	BARLERIA LANCIFOLIA	2	[illegible]
F	CUCUMIS METULIFERUS	2	[illegible]
F	PHYLLANTHUS INCURVUS	6	[illegible]
F	PUPALIA LAPPACEA	6	[illegible]
F	CYPHOSTEMMA CONGESTUM	3	[illegible]
F	OCIMUM URTICIFOLIUM	4	[illegible]
G	ENNEAPOGON SCOPARIUS	2	[illegible]
F	MELHANIA DIDYMA	9	[illegible]
W	EUCLEA DIVINORUM	3	[illegible]
	-ASS. 9.2		
W	SCLEROCARYA CAFFRA	19	[illegible]
F	HELIOTROPIUM STRIGOSUM	10	[illegible]
W	DALBERGIA MELANOXYLON	8	[illegible]
F	JATROPHA SP.	8	[illegible]
	-ASS. 9.3 & 9.4		
W	ACACIA TORTILIS	30	[illegible]
G	ERAGROSTIS CILIANENSIS	27	[illegible]
G	CHLORIS VIRGATA	21	[illegible]
W	GREWIA FLAVESCENS	16	[illegible]
	-ASS. 9.4 & 10		
W	TERMINALIA PRUNIOIDES	33	[illegible]
F	MELHANIA REHMANNII	27	[illegible]
W	COMMIPHORA GLANDULOSA	25	[illegible]
	BOSCIO ALBITRUNCAE-TERMINALIETUM PRUNIOIDIS (ASSOCIATION 10)		
F	TRIBULUS TERRESTRIS	21	[illegible]
F	APTOSIMUM LINEARE	14	[illegible]
W	BOSCIA ALBITRUNCA	14	[illegible]
F	GISEKIA AFRICANA	15	[illegible]
F	ABUTILON AUSTRO-AFRICANUM	16	[illegible]
G	ARISTIDA CURVATA	11	[illegible]
F	SANSEVIERIA HYACINTHOIDES	11	[illegible]
F	MARISCUS REHMANNIANUS	11	[illegible]
F	COMMICARPUS AFRICANUS	9	[illegible]
F	LIMEUM VISCOSUM	8	[illegible]
	-ASS. 10.1		
F	HERMANNIA GLANDULIGERA	12	[illegible]
F	JUSTICIA PROTRACTA	11	[illegible]
	-ASS. 10.1.1		
G	SPOROBOLUS NITENS	8	[illegible]
F	CYPHOCARPA ANGUSTIFOLIA	5	[illegible]
F	AMARANTHUS THUNBERGII	5	[illegible]
F	RHINACANTHUS SP.	5	[illegible]
	-ASS. 10.1.2		
F	WALTHERIA INDICA	11	[illegible]
F	TRICLISERAS GLANDULIFERA	10	[illegible]
F	CARDIOSPERMUM CORINDUM	8	[illegible]
W	RHIGOZUM ZAMBESIACUM	6	[illegible]
F	ELYTRARIA ACAULIS	7	[illegible]
	-ASS. 10.2		
F	PRIVA AFRICANA	10	[illegible]
F	DICOMA TOMENTOSA	16	[illegible]
F	KOHAUTIA OMAHEKENSIS	5	[illegible]
F	ACALYPHA SEGETALIS	4	[illegible]
	TABLE 2 GROUP -		
	5-AVOID MESIC TO MODERATELY DRY, DEEP, CLAYEY SOILS		
W	COMBRETUM APICULATUM	40	[illegible]
G	SCHMIDTIA PAPPOPHOROIDES	37	[illegible]
W	ACACIA EXUVIALIS	25	[illegible]
	7-EXCLUDING NON-SODIC SOILS WITH SAND & LOAMY SAND PROFILES		
F	SEDDERA SUFFRUTICOSA	41	[illegible]
G	PANICUM COLORATUM	40	[illegible]
F	PHYLLANTHUS PENTANDRUS	39	[illegible]
	8-EXCLUDING NON-SODIC SOILS WITH SAND, LOAMY SAND & SANDY LOAM PROFILES		
W	ACACIA NIGRESCENS	66	[illegible]
G	BOTHRIOCHLOA RADICANS	61	[illegible]
W	SECURINEGA VIROSA	28	[illegible]
	12-EXCLUDING THE MOST MESIC SOILS AT > 550MM RAINFALL		
W	GREWIA BICOLOR	66	[illegible]
F	HIBISCUS MICRANTHUS	43	[illegible]
	13-NON-SODIC DRY TO ARID AREAS: PUDDLED SOILS OR RAINFALL < 550MM		
F	HELIOTROPIUM STEUDNERI	55	[illegible]
G	BRACHIARIA XANTHOLEUCA	53	[illegible]
G	ENNEAPOGON CENCHROIDES	50	[illegible]
G	TRAGUS BERTERONIANUS	40	[illegible]
W	COMMIPHORA AFRICANA	39	[illegible]
F	PAVONIA BURCHELLII	37	[illegible]
F	BOERHAVIA DIFFUSA	34	[illegible]
F	EUPHORBIA CHAMAESYCE	29	[illegible]
	15-ARID AREAS WITH RAINFALL < 500MM		
F	CERATOTHECA TRILOBA	34	[illegible]
W	COMBRETUM MOSSAMBICENSE	27	[illegible]
F	HYBANTHUS ENNEASPERMUS	23	[illegible]
	17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE > 30% PRESENCE IN THIS TABLE		
W	DICHROSTACHYS CINEREA	54	[illegible]
F	PHYLLANTHUS ASPERULATUS	53	[illegible]
G	ARISTIDA CONGESTA BARBIC...	52	[illegible]
G	PANICUM MAXIMUM	52	[illegible]
G	UROCHLOA MOSAMBICENSIS	41	[illegible]
F	CUCUMIS AFRICANUS	40	[illegible]
F	TEPHROSIA BURCHELLII	38	[illegible]
F	SOLANUM PANDURAEFORME	37	[illegible]
F	LANTANA RUGOSA	30	[illegible]
F	INDIGOFERA VICIOIDES	27	[illegible]
	18-INFREQUENT, 10-30% OVERALL PRESENCE > 10% PRESENCE IN THIS TABLE		
F	CORCHORUS ASPLENIFOLIUS	37	[illegible]
F	ACALYPHA INDICA	28	[illegible]
F	HERMANNIA BORAGINIFLORA	24	[illegible]
F	RHYNCHOSIA TOTTA	24	[illegible]
W	GREWIA HEXAMITA	20	[illegible]
F	VERNONIA FASTIGIATA	20	[illegible]
F	TALINUM CAFFRUM	14	[illegible]
W	CASSIA ABBREVIATA	12	[illegible]
W	ZIZIPHUS MUCRONATA	11	[illegible]
F	SOLANUM INCANUM	11	[illegible]
	OTHER INFREQUENT SPECIES		
W	CISSUS CORNIFOLIA	21	[illegible]
W	MAERUA PARVIFOLIA	21	[illegible]
F	TRAGIA DIOICA	19	[illegible]
W	GREWIA VILLOSA	19	[illegible]
F	EVOLVULUS ALSINOIDES	18	[illegible]
F	LIMEUM FENESTRATUM	17	[illegible]
F	HERMBSTAEDTIA ODORATA	14	[illegible]
F	OCIMUM CANUM	13	[illegible]
F	SIDA CHRYSANTHA	13	[illegible]
F	COMMELINA ERECTA	12	[illegible]
F	TRAGIA RUPESTRIS	12	[illegible]
F	BECIUM KNYANUM	12	[illegible]
F	CORBICHONIA DECUMBENS	12	[illegible]
F	CLEOME ANGUSTIFOLIA	11	[illegible]
F	COMMELINA BENGHALENSIS	11	[illegible]
F	HIBISCUS SIDIFORMIS	11	[illegible]
F	SIDA RHOMBIFOLIA	11	[illegible]
F	COCCINIA REHMANNII	11	[illegible]
F	DYSCHORISTE ROGERSII	11	[illegible]
F	INDIGOFERA RHYTIDOCARPA	10	[illegible]
G	CENCHRUS CILIARIS	10	[illegible]
F	CLERODENDRUM TERNATUM	10	[illegible]
F	CHASCANUM PINNATIFIDUM	10	[illegible]
F	SERICOREMA SERICEA	10	[illegible]
F	POLYGALA ERIOPTERA	9	[illegible]
F	CRABBEA VELUTINA	9	[illegible]
F	ASYSTASIA SUBBIFLORA	9	[illegible]
W	LANNEA STUHLMANNII	9	[illegible]
W	LONCHOCARPUS CAPASSA	8	[illegible]
F	BLEPHARIS INTEGRIFOLIA	8	[illegible]
F	KYLLINGA ALBA	8	[illegible]
F	INDIGOFERA HETEROTRICHA	8	[illegible]
F	SIDA DREGEI	8	[illegible]
W	XIMENIA CAFFRA	8	[illegible]
F	COMMELINA ERECTA	8	[illegible]
F	LEUCAS NEUFLIZEANA	7	[illegible]
G	ARISTIDA BIPARTITA	7	[illegible]
G	TRICHOLAENA MONACHNE	7	[illegible]
F	MERREMIA PALMATA	7	[illegible]
G	POGONARTHRIA SQUARROSA	7	[illegible]
F	LEUCAS GLABRATA	7	[illegible]
F	LEDEBOURIA SPP.	7	[illegible]
F	CYPERUS OBTUSIFLORUS	7	[illegible]
F	EUPHORBIA NEOPOLYCNEMOIDES	7	[illegible]
G	FINGERHUTHIA AFRICANA	7	[illegible]
F	IPOMOEA MAGNUSIANA	7	[illegible]
F	MERREMIA KENTROCAULOS	7	[illegible]
G	SETARIA WOODII	7	[illegible]
F	ASPARAGUS BUCHANANII	7	[illegible]
F	ASPARAGUS SETACEUS	7	[illegible]
F	CROTOLARIA MONTEIROI	7	[illegible]
W	ACACIA SENEGAL ROSTRATA	6	[illegible]
G	SORGHUM VERSICOLOR	5	[illegible]
F	MELHANIA FORBESII	4	[illegible]
W	PELTOPHORUM AFRICANUM	4	[illegible]
G	ARISTIDA CONGESTA CONGESTA	3	[illegible]
G	CHLORIS ROXBURGHIANA	3	[illegible]
W	CORDIA SINENSIS	3	[illegible]
G	ERAGROSTIS RIGIDIOR	3	[illegible]
G	SPOROBOLUS PECTINATUS	3	[illegible]
F	RHYNCHOSIA MINIMA	3	[illegible]
F	ENDOSTEMON TERETICAULIS	2	[illegible]
W	PTAEROXYLON OBLIQUUM	2	[illegible]
W	TRICALYSIA ALLENII	2	[illegible]
W	ACACIA ERUBESCENS	2	[illegible]
W	CAPPARIS SEPIARIA	1	[illegible]
W	COMBRETUM ZEYHERI	1	[illegible]
F	CROTALARIA DAMARENSIS	1	[illegible]

SEE APPENDIX 2 FOR RARE SPECIES WITH LOW COVER

ACACIO NIGRESCENTIS - GREWION BICOLORIS all. nov.
(Alliance of arid habitats, Table 7)
Nomenclatural type: Boscio albitruncae- Terminalietum prunioidis ass. nov.

Habitat and location

This Alliance includes two associations from the most arid parts of the Central District basaltic plains.

Association 9 occurs in the 500-550mm rainfall zone as arid enclaves surrounded by the Acacietum gerrardio-tortilis (Association 8, Table 6). These arid enclaves are associated with: (a) heavily grazed and trampled areas near major drainage lines such as along the Makongolweni, Sweni, Mrunzuluku, lower Guweni, lower Nungwini and parts of the Metsi-Metsi Spruits; and (b) shallow, dry soils of stronly drained, well-dissected terrain, such as towards Nwanedzi where several spruits converge and higher up, along the Nwandezi and its upper reaches at Satara, in the vicinities of sheet outcrop. Association 9 also includes a subcommunity on deep talus soils of rhyolitic pediment slopes.

Association 10 occupies the arid basaltic and rhyolitic plains region adjoining the Olifants River. The rainfall here is less than 500mm (Webber, 1979; Gertenbach, 1980) and the terrain, which slopes down to the Olifants River from the Shitsalaleni Firebreak, is strongly dissected and has shallow soils. Aridity-enhancing grazing impact is also distinctively high in this area (Van Wyk, 1972).

Structural and floristic differences between and within the two associations relate to combinations of climate, soil texture, soil colour, soil depth and grazing impact, in a manner indicating that moisture regime, and perhaps directly associated factors, are the major determinants of the vegetation variation.

Structure

Vegetation structure in the Acacio nigrescentis - Grewion bicoloris varies with floristic composition and habitat.

The woody vegetation becomes stunted with increasing aridity such as at low rainfall, towards heavily grazed bottomlands and on deep non-litholitic, margalitic soils with high clay content. Thus the litholitic talus slopes of Association 9.1 have high tree cover (Table 7, Appendix 1). In the arid enclaves of the 500-550mm rainfall region, trees are common on watersheds that are not heavily grazed (Association 9.2) avoiding only deep, clay loam, non-litholitic, margalitic soils of the Bonheim Form (Releves 86 & 87); less common in heavily grazed bottomland areas (Ass. 9.3); and largely absent on the extremely shallow-, the shallow margalitic- and the shallow non-margalitic but relatively clayey soils of well-dissected areas (Ass. 9.4) that are floristically transitional to Association 10. Trees are also exceptional in Association 10 of the strongly dissected arid region along the Olifants River, where the rainfall is less than 500mm (Table 7, Appendix 1).

Shrub and brush cover, on the other hand appear to increase with aridity in this Alliance (cf. Appendix 1). The explanation seems to be that the Alliance spans a change-over from relatively mesic to relatively xeric dominant shrub and brush species. Shrub and brush cover are highest in the proportion of the Alliance dominated by species that are adapted to arid conditions. The major shrub- and brush-forming species of the most arid portions of the Alliance (Ass. 9.4 and Ass. 10), i.e. Grewia bicolor, Terminalia prunioides and Combretum apiculatum, are probably adapted to tolerate long periods of desiccated substrate, which typically support this Alliance; and able to exploit small quantities of rain that wet only the uppermost soil. Hence on the shallowest soils, where such small amounts of rain are more readily available to plants owing to the litholitic character of the uppermost substrate, shrub and brush cover are particularly high (Ass. 10.1). In more mesic vegetation, e.g. the Themedo triandrae - Acacietum gerrardii (Ass. 7 of the Alliance on mesic clay), prolonged desiccation of such shallow soils are limiting to the dominant shrub and brush species.

Floristic composition

The Acacio nigrescentis - Grewion bicoloris (Aridity Alliance) has the following diagnostic combination of species groups (Tables 2 & 7):

(a) Group 7 and 8 clay-associated species, particularly the woody Acacia nigrescens, the grasses Bothriochloa radicans and Panicum coloratum and the forb Phyllanthus pentandrus;
(b) Group 12 and 13 species of dry and arid areas, particularly the woody Grewia bicolor, which has its distinct optimum constancy of high cover values in this Alliance, the grasses Brachiaria xantholeuca, Enneapogon canchroides (which is characteristically common: (a) in the present Alliance; (b) on compacted soils with shallow A horizon of Ass. 4.1; and (c) on vertic soils of Ass. 11; and distinguishes the Alliance of arid habitats from Ass.8) and Tragus berteronianus and the forbs Hibiscus micranthus, Heliotropium steudneri, Boerhavia diffusa and Pavonia burchellii;
(c) Group 5 species, which further distinguish this arid Alliance from the Acacietum gerrardio-tortilis (Ass. 8, on moderately dry clay), and which avoid mesic to moderately dry deep clayey soils - notably the woody Combretum apiculatum and Acacia exuvialis and the grass Schmidtia pappophoroides (which, however, also occurs in the driest subcommunity of Ass. 8); and
(d) also differentiating this arid Alliance from the moderately dry Association 8, are Group 15 species of arid regions, notably the woody Combretum mossambicense, Commiphora glandulosa and Terminalia pruniodes and the forbs Ceratotheca triloba and Melhania rehmannii.

One of the two Associations of this Alliance (Ass. 10) is also uniquely characterized by association-specific species from Group 16.

Floristic affinities of this Alliance are through clay-associated species and through species of other dry and arid vegetation types (Groups 7, 8, 12, 13 and 15, Table 2), as well as through Groups 5 species with a variety of communities.

As indicated by species of Group 10 (Table 2), which avoid the most arid areas, the Themedo triandrae - Grewietum bicoloris (Ass. 9 of arid enclaves in the 500-550mm rainfall area) has a less markedly arid habitat than the Boscio albitruncae - Terminalietum prunioides (Ass. 10, adjoining the Olifants River in the less than 500mm rainfall region).

9. Themedo triandrae - Grewietum bicoloris ass. nov.
(Table 7)
Nomenclatural type: Releve 152

Habitat and location

One subcommunity on relatively deep litholitic soils of steep (12-30^{o}) pediment slopes occurs commonly on the west-facing slopes of the rhyolitic Lebombo Mountains north of the Shitsalaleni Firebreak, and on the west-facing slopes of the granophyric Nwamuriwa and Nkumbe Hills (Fig. 1). These slopes are stoney and the soils contain 10-26 per cent clay. Percentage clay varies with geology and correlates with vegetation differences.

The arid enclaves that form the major part of this Association are largely restricted to dissected terrain and/or heavily grazed areas associated with drainage systems of the basaltic terrain between the Nwanedzi River and the Lindanda Plains watershed (Fig. 1). The average rainfall here is

500-550mm. The terrain is gently undulating with slopes rarely exceeding two degrees. The surface is non-stoney with occasional low outcrop associated with the shallower soils (Table 7). Soils vary from shallow and non-calcareous to deeper and calcareous and have mainly 15-35 percent clay in their A horizons. Included are margalitic as well as non-margalitic and extremely shallow to moderately deep (400-600mm) soils. The relatively shallow soils belong to: The Mayo mayo Series (i.e. melanic A horizons with 15-35 per cent clay, on non-calcareous lithocutanic B horizons); the Williamson, Trevanian and Robmore Series of the Glenrosa Form (i.e. orthic A horizons with 15-35 per cent clay, on non-calcareous lithocutanic B horizons); the Milkwood dansland Series (i.e. non-calcareous melanic A horizons with 15-35 per cent clay, on hard rock); and the Mispah mispah Series (i.e. non-calcareous orthic A horizons on hard rock). The deeper soils belong to: the Dumasi and Weenen Series of the Bonheim Form i.e. melanic A horizons with 15-35 per cent clay, on non-calcareous as well as calcareous, non-red pedocutanic B horizons); and the Broekspruit and Swartland Series of the Swartland Form (i.e. orthic A horizons, on red calcareous or non-red non-calcareous pedocutanic B horizons with 35-55 per cent clay, over saprolite); pH of the A horizons ranges mainly from 5,7 to 6,3 (Table 7).

The basaltic subcommunities are largely related to topographic position, grazing impact and soil depth.

Structure

Woody, vegetation structure varies considerably in accordance with subcommunity and associated floristic composition and habitat.

Subcommunity 9.1 on deep litholitic soils of rhyolitic and granophyric pediment slopes has a relatively dense, tall woody growth including sparsely to densely shrubby, usually densely brushy, sparse to dense treeveld (Appendix I).

The three basaltic subcommunities form a sequence of decreasing tree cover and increasing shrub cover, corresponding to a gradient from moderately arid to more arid. Association 9.2, which has not been subject to severe grazing and occurs on level to one degree sloping sites in gently dissected terrain is the less arid of the three subcommunities. The structure in this subcommunity is sparse to moderate treeveld with scattered to sparse shrub and brush cover, except on deep soils of the Bonheim Form, where trees are absent.

Trees are commonly scattered or absent and only occasionally form a sparse layer in Association 9.3, which has been heavily grazed and trampled and has a somewhat more xerophytic species composition than Association 9.2. Brush is usually scattered to sparse; and shrub cover sparse to moderate, i.e. often higher than in Association 9.2 (Appendix 1).

Trees are virtually absent and shrub cover is high in Association 9.4, which has the most xerophytic species composition and occurs on shallow soils in dry, strongly dissected areas. The structure here is typically moderately shrubby brushveld (Appendix 1).

The scarcity of trees in the drier subcommunities is in accordance with the general trend on the basaltic plains; and the relatively high shrub cover in the most arid subcommunity is probably owing to the distinct presence of shrub-forming species that are adapted to efficiently utilize occasional light showers, as suggested in discussing the structure of the present Alliance.

Floristic composition

The presence of the following species in the Themedo triandrae - Grewietum bicoloris, differentiate this association from the more arid Boscio albitruncae - Terminalietum prunioides, which belongs to the same alliance (Tables 2 & 7):

(a) Group 10 species, which avoid extremely arid areas, notably the grasses Heteropogon contortus and Eragrostis superba and the forbs Cassia mimosoides and Sida chrysantha;

(b) some of the Group 7 and 8 clay-associated species that are rare in- or avoid, the most arid clayey areas, notably the woody Combretum imberbe and Ormocarpum trichocarpum, the grass Themeda triandra, which is highly constant in Association 9, and conspicuously absent from Association 10, and the forb Ipomoea sinensis;

(c) the general grass Digitaria eriantha (Group 17), which avoids only the three most extremely arid associations of the Central District; and

(d) the woody Ehretia rigida (Group 12) and Combretum hereroense (Group 5).

Constant differential species that are exclusive to the Themedo triandrae - Grewietum bicoloris are lacking.

Rhyolitic Association 9.1 is exceptional within this Association and the three basaltic subcommunities (Ass. 9.2, 9.3 & 9.4) share numerous distinctive floristic features, e.g. the presence and commonly high values for the grasses Bothriochloa radicans and Panicum coloratum and the presence of the woody Combretum imberbe and Ormocarpum trichocarpum, the grasses Heteropogon contortus, Eragrostis superba and Urochloa mossambicense as well as various forbs (Table 7).

In the Central District, the grass Bothriochloa radicans has its optimum cover and constancy in the three basaltic subcommunities of the Themedo triandrae - Grewietum bicoloris and is generally less prominent in more mesic and in extremely arid associations (cf. Tables 3-9).

Association 9.3 of heavily grazed bottomlands and Association 9.4 of dry, shallow soils in dissected terrain, are closely related and share a number of aridity and disturbance indicating floristic features that distinguish them from the less xeric Association 9.2. These features include (Table 7):

(a) the presence of Group 11 (Table 2) species, i.e. the woody Acacia tortilis and Grewia flavescens and the grasses Eragrostis cilianensis and Chloris virgata; and

(b) the common dominance of the woody Grewia bicolor.

9.1 Acacia nigrescens - Combretum apiculatum - Panicum maximum - dominated treeveld of deep litholitic soils on granophyric and rhyolitic pediment slopes

This subcommunity occurs on deep litholitic soils of west-facing slopes of the Nkumbe and Nwamuriwa Hills and of the Lebombo Mountains north of the Shitsalaleni Firebreak. The slopes are 12-30°, stoney, and bouldery. Soils on the slopes of the granophyric Nkumbe and Nwamuriwa Hills have sandier texture and higher pH than those of the relevant slopes of the rhyolitic Lebombo Mountains (P = 0,05, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, N1 = 3, N2 = 3, for percentage clay as well as pH). Floristic composition varies accordingly and two variations of the subcommunity are distinguished (Table 7).

Typical structure of both variations is a shrubby, moderately to densely brushy sparse to dense treeveld. The grass _Panicum maximum_ is overwhelmingly dominant in the field layer (Table 7). The woody _Combretum apiculatum_ is usually among the dominant shrub or brush species and _Acacia nigrescens_ is typically the dominant tree (Appendix 1).

9.1.1 Nkumbe-Nwamuriwa treeveld (Granophyric Variation)

Texture in the litholitic soils of this variation is sandy loam, with 10-17 per cent clay. On the basis of total cover, irrespective of height, _Combretum apiculatum_ and _Acacia nigrescens_ are approximately codominant. The presence of the woody _Sclerocarya caffra_ and _Albizia harveyi_ further distinguish this variation from the next (Table 7).

9.1.2 Northern Lebombo treeveld (Rhyolitic Variation)

This more clayey variation has litholitic soils with sandy clay loam texture. These soils contain 22-26 per cent clay, and the pH of 5,7-5,9 is lower than in the previous variation. The common predominance of _Acacia nigrescens_ on the basis of total woody vegetation cover, i.e. irrespective of height, and the presence of the woody _Euclea divinorum_ and the forb _Melhania didyma_, are distinctive (Tables 2 & 7).

9.2 Sclerocarya caffra - Acacia nigrescens - Bothriochloa radicans - Themeda triandra - Digitaria eriantha - dominated treeveld, brushveld and shrubveld of moderately dissected basaltic terrain without sheet outcrop

The major distribution area and habitat of this subcommunity are in the terrain which is moderately dissected by the tributaries of the upper Nwanedzi River i.e. in the Satara region and between the Nwanedzi River and the western Ngetemane Spruit; but excluding some shallow soil patches with occasional sheet outcrop in this region, because these have vegetation belonging to the more arid Association 9.4.

The structure on shallow soils is sparsely shrubby, sparse to moderate treeveld with brush being either sparse or thinly scattered. On deeper soils of the Bonheim Form, the structure is sparse shrubveld with scattered brush or sparsely shrubby brushveld (Appendix 1).

Aridity indicator Hybanthus enneaspermus (Group 15, Table 2) has its optimum constancy in this subcommunity. Its presence, together with the presence, often as the dominant tree, of Sclerocarya caffra from the more mesic Group 10 (Table 2), are highly distinctive of this subcommunity in Central District context. As discussed earlier, at Association level, the subcommunity also lacks a number of species and other features shared by the two drier subcommunities (Table 7).

The dominant tree species is typically Sclerocarya caffra, whereas the shrub and brush levels are dominated by Acacia nigrescens (Appendix 1). The grass Bothriochloa radicans is typically dominant in the field layer, with cover between 25 and 75 percent. The usual subdominants are the grasses Digitaria eriantha, Themeda triandra and Panicum coloratum.

9.3 *Acacia nigrescens* - *A. tortilis* - *Grewia bicolor* - dominated shrubveld brushveld and treeveld of heavily grazed basaltic areas near major drainage lines

This subcommunity occurs extensively on heavily grazed and trampled basaltic soils along the Makongolweni, Sweni, Mrunzuluku, Guweni, Nungweni and Metsi-Metsi spruits (Fig. 1). These low areas together with the associated higher Lindanda Plains form a complex traditionally providing summer grazing for large herds of zebra and blue wildebeest (see Association 8.1 and Braack, 1973; Smuts, 1972). Association 9.3 is strongly related, physiognomically, floristically and habitat wise, to the *Pupalio lapaceae* - *Acacietum nigrescentis* (Ass. 3), which also occurs on severely grazed and trampled basaltic soils but has distinct affinities with sodic soils, probably owing to a higher degree of soil compaction.

Association 9.3 includes 500-800mm deep soils with pedocutanic B horizons of the Swartland and Bonheim forms, and shallower soils with lithocutanic B horizons, belonging to the Glenrosa and Mayo forms (Table 7).

The structure may be sparse treeveld, sparse brushveld with or without scattered trees, or sparse to moderate shrubveld (Appendix 1).

The absence of the woody *Terminalia prunioides* and *Commiphora glandulosa* and of the forb *Melhania rehmannii*, serve to differentiate this Subcommunity from closely related Subcommunity 9.4.

Acacia nigrescens is usually the dominant tree. *A. tortilis* and *A. nigrescens* are the most common dominants of the brush level and *Grewia bicolor* and *A. nigrescens* the most common dominants of the shrub level. Occasional dominants at the shrub and brush levels include *Dichrostachys cinerea* subsp. *africana* and *Combretum imberbe* (Appendix 1). The grass *Bothriochloa radicans* is usually among the field layer dominants. Common codominants include the grasses Panicum coloratum and Aristida congesta subsp. barbicollis. Grasses with occasionally prominent cover include Digitaria eriantha, Themeda triandra, Schmidtia pappophoriodes, Panicum maximum and Urochloa mossambicense (Table 7).

9.4 Acacia nigrescens - Grewia bicolor - Combretum apiculatum - dominated brushveld with Digitaria eriantha and Terminalia prunioides and with arid usually basaltic physiography

Two releves of this most arid subcommunity occur on sandstone, on soils of the Mispah Form. The typical, basaltic phase occurs on other shallow, dry soils of the 500-550mm rainfall region, i.e:

(a) associated with low sheet outcrop;

(b) in the arid, dissected terrain at Nwanedzi; and

(c) towards similar dissected terrain along the Olifants River bordering on Association 10. These typical soils are usually of the Mayo, Glenrosa and Milkwood Forms (Table 7).

The usual woody structure is moderately shrubby, sparse brushveld, i.e. more shrubby that the other subcommunities, probably owing to its aridity-adapted dominant shrub species (see discussions of Alliance structure).

Association 9.4 is floristically distinguished by the presence of Group 15 (Table 2) species shared with Association 10. These are the woody Terminalia prunioides and Commiphora glandulosa and the forb Melhania rehmannii (Table 7). Common dominants at the brush level include Acacia nigrescens, Grewia bicolor and Combretum apiculatum; and G. bicolor is the most usual dominant at the shrub level (Appendix 1). Schmidtia pappophoroides and Pogonarthria squarrosa are the dominant grasses in the two releves from sandstone areas, where the A horizon clay content was 12 and 13 percent and the soils of the Mispah Form (Table 7). The field layer dominant of the more typical, basaltic, variation is the grass Bothriochloa radicans or occasionally Panicum coloratum (Table 7). Other occasionally prominent grasses are Digitaria eriantha, Themeda triandra, Enneapogon cenchroides and Panicum maximum (Table 7).

10. Boscio albitruncae - Terminalietum prunioidis ass. nov. (Table 7)
Nomenclatural type: Releve 14

Habitat and location

This association together with the transitional Association 9.4 comprise the Southern Spiny Arid Bushveld, which is one of twenty distinct vegetation delineated regions of the Kruger National Park (Ch. II). Van Wyk (1972) described this region as Terminalia/Commiphora/Knobthorn Veld, of which he writes: "....It is an undulating region in which the topsoil has been washed away and the mother rock is therefore visible everywhere. Low rainfall, extremely poor grass cover and severe grazing, all contribute to make it one of the driest areas in the Kruger Park.....". The rainfall is less than 500mm and the undulating terrain slopes down the Olifants River.

One subcommunity, the closest to the Olifants River and well-drained, occurs on 1-6^{o} stoney slopes with low outcrop and litholitic soils or soils of the Mispah Form (orthic A horizon on hard rock). Two unexplained variations of this subcommunity are apparent (Table 7).

Another subcommunity, further away from the Olifants River and with a somewhat lower density of drainage lines, occurs on 0-2^{o} non-stoney slopes without outcrop and with soils of the Glenrosa and Mayo forms, i.e. with lithocutanic B

TABLE 8. ACACIO NIGRESCENTIS - SETARIETUM WOODII (VERTISOLS)

```
-----------------------------------------------------------------------------
                                          |000|000000000000|**************
RELEVE NUMBERS                            |544|946794966 61|**************
                                          |397|053467617866|**************
-----------------------------------------------------------------------------
ASSOCIATION NUMBER                        |         11     |

LANDSCAPE NUMBER
                                          |7777|777667777 78|
HABITAT
GEOLOGY              (B=BASALT)           |BBBB|BBBBBBBBBBBB|

RELIEF     (C=CREST, D=SPRUIT,            |CDMV|FMMFMMMMVMD|
   F=FOOTSLOPE, M=MIDDLESLOPE,
              V=BOTTOMLAND)

SLOPE                (DEGREES)            |0000|000000000000|
                                          |1000|010110200 11|

SURFACE    (F=FLAT, U=CONCAVE)            |FFFF|UFFFFFFFFFFU|

A11/A HORIZON
-TEXTURE (C=CLAY, I=CLAY LOAM,            |CCCC|CCCZCCCZCCC|
           L=LOAM, Z=SANDY)               |    |    I LLI   L|

-CLAY                     (%)
                                          |4554|533131225 33|
                                          |1625|179091075 71|

-PH                       (X 10)          |7777|666667766 56|
                                          |6751|374150147 92|

CARBONATES(P=PRESENT,O=ABSENT)            |PPPP|OOOPOOOOPOO|

-CONDUCTIVITY (MICROMHOS X .1)            |1 11|1 101100111|
                                          |9 51|3 190398420|
                                          |5 19|0 261945200|

A12/B HORIZON
-CLAY                     (%)
                                          |7 44| 565 3 365 |
                                          |3023|05180304250|

-PH                       (X 10)          |7  8| 67 67 656 |
                                          |3  0| 52 77 348 |

CARBONATES(P=PRESENT.O=ABSENT)            |  P | P   P O O |

-CONDUCTIVITY (MICROMHOS X .1)            |11 1| 10000 010 |
                                          |67 2| 38778 518 |
                                          |60 3| 00621 107 |
SOIL FORM (STD. ABBREVIATIONS,
       MACVICAR ET AL., 1977)             |AAAA|AMAAAAABAAA|
                                          |RRRR|RYRRRRRORRR|
SOIL SERIES NUMBER
       (MACVICAR ET AL., 1977)            |4444|32343433433|
                                          |0200|01011020000|
-----------------------------------------------------------------------------
                                          |0000|000000000000|**************
NUMBER OF SPECIES                         |2322|222323221 21|**************
                                          |4335|457264239 36|**************
-----------------------------------------------------------------------------
 GROWTH FORM PREFIX:
   F=FORB, G=GRASS, W=WOODY
   SU=SUCCULENT

DIFFERENTIAL SPECIES FOR-
 (SPP. NAMES, PRESENCE VALUES)

 ACACIO NIGRESCENTIS-
 SETARIETUM WOODII
 (ASSOCIATION 11)
G  SETARIA WOODII                     14  |A+A1|AA3 +B5+3A3|
F  IPOMOEA COSCINOSPERMA              12  |++ +|+ ++++++++|
G  BRACHIARIA ERUCIFORMIS             10  |A+++| 1 ++++ 1  |
F  COCCINIA REHMANNII                  9  |++++|+++     ++ |
F  PHYLLANTHUS SP.                     9  |+ ++|++++++     |
F  TRAGIA INCISIFOLIA                  7  | ++ |+ +  ++  + |

  -ASS. 11.1
F  LEDEBOURIA SPP.                     4  |++++|           |
F  ANEILEMA DREGEANUM                  6  |++++| +  +      |
W  CORDIA SINENSIS                     7  |+1++| + +    +  |
F  COMMELINA FORSKAOLAEI               4  |+++ |  +        |
F  ASPARAGUS SETACEUS                  2  |+  +|           |
F  RHYNCHOSIA MINIMA                   3  |+ + |        +  |
W  MAYTENUS HETEROPHYLLA               3  |++  |         + |
F  CLEOME HIRTA                        2  | 1A |           |
F  ASPARAGUS SETACEUS                  2  | 1+ |           |

  -ASS. 11.2
F  HELIOTROPIUM STEUDNERI             12  |   +|+++++R+++++|
G  THEMEDA TRIANDRA                    9  |    |+++++ +1 1A|
W  COMBRETUM IMBERBE                   5  |    |+  ++ ++ + |
F  INDIGOFERA VICIOIDES                6  |    |++++++     |
W  DICHROSTACHYS CINEREA               6  |    |++ +   ++ +|


TABLE 2 GROUP -

  7-EXCLUDING NON-SODIC SOILS
    WITH SAND & LOAMY SAND
    PROFILES
G  PANICUM COLORATUM                  12  | ++1|++1  ++3+A+|

  8-EXCLUDING NON-SODIC SOILS
    WITH SAND, LOAMY SAND &
    SANDY LOAM PROFILES
W  ACACIA NIGRESCENS                  15  |+B+1|111A1+11+++|
G  BOTHRIOCHLOA RADICANS               6  | +  | 1 3    + ++|
W  SECURINEGA VIROSA                   5  |++ +|  +  +     |

 11-DRY AREAS SUCH AS
    SODIC, PUDDLED, VERTIC OR
    CLAYEY WITH 500-550MM RAINF.
W  ACACIA TORTILIS                     6  | +++|  +  +   1 |

 12-EXCLUDING THE MOST MESIC
    SOILS AT > 550MM RAINFALL
W  EHRETIA RIGIDA                      6  | + +|+ ++    +  |

 13-NON-SODIC DRY TO ARID AREAS:
    PUDDLED SOILS OR RAINFALL
    < 550MM
F  JATROPHA SP.                       10  |++++|+ ++  + ++ |
G  ENNEAPOGON CENCHROIDES              7  |++ +| + +++     |
G  BRACHIARIA XANTHOLEUCA              5  | +  | ++++      |

 15-ARID AREAS WITH RAINFALL
    < 500MM
F  CERATOTHECA TRILOBA                 9  |++++| +  +++ +  |
W  COMBRETUM MOSSAMBICENSE             8  |++  |+   ++   +++|

 17-GENERAL DISTRIBUTION.
    > 30% OVERALL PRESENCE
    > 30% PRESENCE IN THIS TABLE
G  PANICUM MAXIMUM                    15  |4B34|+3114A+131+|
G  DIGITARIA ERIANTHA                 14  |++AA|+AA+B3+B+3 |
F  PHYLLANTHUS ASPERULATUS            10  |+++ |+ ++ +++ + |
G  UROCHLOA MOSAMBICENSIS              6  | +  | +++ +    +|
F  TEPHROSIA BURCHELLII                6  |+   | + ++1+    |

 18-INFREQUENT.
    10-30% OVERALL PRESENCE
    > 10% PRESENCE IN THIS TABLE
F  VERNONIA FASTIGIATA                 8  |   +|  ++ ++ +++|
F  ACALYPHA INDICA                     6  |  + |++ +++     |
F  TALINUM CAFFRUM                     6  |  ++|  + +    ++|
F  CORCHORUS ASPLENIFOLIUS             2  |    |   ++      |

OTHER INFREQUENT SPECIES
G  ISCHAEMUM AFRUM                     4  | A  |5     +  +  |
F  CONVOLVULUS FARINOSUS               4  |    |+    *  ++  |
G  HETEROPOGON CONTORTUS               4  |    | +  +  +  +|
F  INDIGOFERA SCHIMPERI                4  |+   |  +     ++  |
W  LONCHOCARPUS CAPASSA                4  |    |*  +  +   +|
F  NEURACANTHUS AFRICANUS              4  |   +|  +    + + |
F  CUCUMIS AFRICANUS                   4  |   +|  + ++     |
F  BOERHAVIA DIFFUSA                   4  |    |  ++ *+     |
G  TRAGUS BERTERONIANUS                4  |    | + + R +    |
G  CENCHRUS CILIARIS                   4  |    |   ++ +   1 |
W  ACACIA NILOTICA                     3  |    |   ++ +     |
F  CLEOME ANGUSTIFOLIA                 3  | +  |     R +    |
W  COMBRETUM HEREROENSE                3  |    |    + +   +|
G  FINGERHUTHIA AFRICANA               3  |   +|   ++      |
F  GISEKIA AFRICANA                    3  | +  |     * +    |
W  GREWIA BICOLOR                      3  |    | +   ++    |
F  RUELLIA PATULA                      3  | +  |    ++     |
F  TEPHROSIA PURPUREA                  3  |    |       +++ |
G  ARISTIDA CONGESTA BARBIC...         3  |    | 1 +     + |
F  COMMELINA ERECTA                    3  |    |+ +  +     |
F  PHYLLANTHUS PENTANDRUS              3  |    |  ++   +   |
W  COMMIPHORA GLANDULOSA               3  |+ * |     +     |
F  JUSTICIA PROTRACTA                  3  | +  |    ++     |
W  BALANITES MAUGHAMII                 1  | 1  |           |
G  SETARIA FLABELLATA                  1  |    |   A       |
F  TEPHROSIA RETUSA                    1  |    |1          |

  SEE APPENDIX 2 FOR RARE
  SPECIES WITH LOW COVER
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horizons (Table 7). The differences in soil types between the two subcommunities are significant ($P < 0,01$, Two-tailed Fisher's Exact Test, $N = 21$, Table 7). Association 10.2 also has soils with higher pH than the soils of the more strongly drained Association 10.1 closer to the Olifants River ($P < 0,01$, Two-tailed Mann-Whitney U-test using normal approximation with tie correction, $N_1 = 9$, $N_2 = 16$, Table 7).

Structure

Both subcommunities are shrubby brushveld but the brush and shrub cover are higher in Association 10.1, with shallow soils of the Mispah Form, than in Association 10.2, with deeper soils of the Glenrosa and Mayo forms (Appendix 1).

High shrub and brush cover in this association is through species that seem to be specially adapted to low infrequent rainfall and/or shallow soils that dry out quickly. These species are Grewia bicolor, Combretum apiculatum, Acacia exuvialis and Terminalia prunioides. They seem to be adapted to exploit temporary wetting of the uppermost soil and such water is most readily relinquished to plants by shallow, stoney and gravelly soils. Such shallow, stoney and gravelly soils are relatively dry soils in relatively high rainfall areas. The soils dry quickly and species in relatively high rainfall areas would be less tolerant of long periods of desiccation (cf. Ass. 7). However, in arid areas where species can tolerate arid spells, the advantages of the water relinquishing properties of such soils after showers may be more important than their quick-drying properties and they may thus become the relatively moist soils in relation to brush and shrub cover (see discussion at Alliance level and in Section 9).

Brush and shrub species in the subcommunity of shallow, stoney Mispah mispah soils are aridity adapted species and brush and shrub cover is therefore relatively high. Shrub cover in the subcommunity on deeper Glenrosa and Mayo soils is also by these species and therefore relatively low. Brush cover in the deeper soil subcommunity is by Acacia nigrescens, which does not belong to the aforementioned specially adapted group and produces comparatively low cover in this arid region (Appendix 1).

Floristic composition

Differential features of this association include:

(a) the characteristic species combination of the Alliance;

(b) the unique relationship with Subcommunity 9.4 through the presence of the woody Terminalia prunioides and Commiphora glandulosa and the forb Melhania rehmannii; and

(c) the presence of several Association-specific species of Group 16, such as tne woody Boscia albitrunca, the forbs Tribulus terrestris, Aptossimum lineare and others, including species that differentiate subcommunities, e.g. the woody Rhigozum zambesiacum and the forbs Hermannia glanduligera, Justicea protracta, Tricliceras glandulifera, Priva africana, as well as less constant species (Tables 2 & 7).

Several species of the typical Spiny Arid Bushveld xeromorphic growth form, i.e. ".... a shrubby plant with small leaves and stubby or short spiny branchlets on long branches that are conspicuous owing to the small leaves, giving the plants a tangled spiny appearance" (Werger & Coetzee, 1978) occur in this association. Examples are Terminalia prunioides, Commiphora glandulosa, Boscia albitrunca, Rhigozum zambesiacum, Maerua parvifolia, Combretum mossambicense and Sesamothamnus lugardii.

Dominants vary with subcommunity.

10.1 Moderately to densely shrubby, sparse to dense brushveld and thicket, with *Combretum apiculatum* (and dominated by *C. apiculatim*, *Terminalia prunioides*, *Acacia nigrescens* and *Grewia bicolor*), on shallow stoney soils with outcrop.

This subcommunity occurs on shallow, stoney, soils that are litholitic or of the Mispah mispah Series.

The woody *Combretum apiculatum* is a constant and conspicuous differential species and also commonly dominates the entire shrub to brush level. Alternatively *Terminalia prunioides* or *Acacia nigrescens* may be the dominant brush species; and either of the latter two species or *Grewia bicolor* is the dominant shrub. Less commonly dominant shrub and brush species include *Acacia exuvialis*, *Combretum imberbe* and *Acacia tortilis* (Appendix 1). The grasses *Aristida congesta* subsp. *barbicollis* and *Bothriochloa radicans* are the most common field layer dominants and the grass *Brachiaria xantholeuca* also commonly has high cover values. *Enneapogon cenchroides* and *Schmidtia pappophoroides* are occasionally abundant (Table 7).

A number of species differentiate between Phases 10.1.1 and 10.1.2 (Table 7) but the habitat differences between these two subdivisions have not been identified.

10.2 Sparse shrubveld and sparsely to moderately shrubby, sparse brushveld with *Panicum coloratum*, and *Euphorbia chamaesyce* and abundant *Urochloa mossambicense* and dominated by *Acacia nigrescens* and *Grewia bicolor*, on non-stoney soils without outcrop

Soils of the Mayo Form in this subcommunity are typically calcareous and of the Mayo tshipise Series (15-35 percent clay in a melanic A horizon, and a calcareous B horizon). Soils of the Glenrosa Form may be calcareous and of the Glenrosa lekfontein Series (15-35 percent clay in an orthic A horizon, and a calcareous B horizon) or non-calcareous and of the Glenrosa williamson or Glenrosa robmore Series (15-35 percent clay in an orthic A horizon, and a non-calcareous B horizon).

Acacia nigrescens is typically the dominant brush and *Grewia bicolor* the dominant shrub species (Appendix 1). The grass *Urochloa mossambicense* is the field layer dominant where A horizon conductivity exceeds 600 micro mhos, whereas the grass *Aristida congesta* subsp. *barbicollis* is dominant at lower conductivities (P = 0,03, Two-tailed Mann-Whitney U Test, using normal approximation with tie correction, $N_1 = 3$, $N_2 = 4$). Releves 57 and 36, where *Bothriochloa radicans* is dominant, are atypical of this association. The grass *Enneapogon cenchroides* is occasionally codominant or subdominant (Table 7).

ALLIANCE UNSPECIFIED:-

11. *Acacio nigrescentis* - *Setarietum woodii* ass. nov. -
(Association on vertic soils, Table 8)
Nomenclatural type: Releve 95

Habitat and location

Vertic soils, which in the Central District carry this Association, occur extensively on middle slopes, on footslopes and in bottomlands of the gently undulating basaltic plains that form the watershed between the Olifants and Nwanedzi rivers (Fig. 1). The slopes are $0-2^{o}$. The vertic soils and attendant *Acacio nigrescentis* - *Setarietum woodii* occur here in mosaic-type association with soils of the Mayo, Swartland and Bonheim Forms that occur mainly as enclaves on upper middleslopes and plateaux. These enclaves carry the grassveld subcommunity (Ass. 8.3) of the *Acacio gerrardii* - *Acacietum tortilis*.

Local patches of vertic soils with vegetation belonging to the *Acacio nigrescentis* - *Setarietum woodii*, occur elsewhere on the Central District basaltic plains close to the Lebombo Mountains. The zone occupied by the main body of vertic soils and the outliers are associated with the presence of amygdal or olivine basalt that is conductive to the forming of montmorillonite (Venter,[6] pers. comm.).

The vertic soils of the *Acacio nigrescentis* - *Setarietum woodii* are of the Arcadia Form. Soil series are related to subcommunities, which differ in respect of A11 horizon clay content and pH ($P < 0,05$, Two-tailed Mann-Whitney U tests using normal approximation with tie correction, $N_1 = 4$, $N_2 = 11$); and A12 or B horizon conductivity ($P = 0,01$, Two-tailed Mann-Whitney U Test using normal approximation with tie correction, $N_1 = 3$, $N_2 = 8$; Table 8). Free carbonates are significantly common in A11 horizons of the subcommunity with relatively clayey, high pH, high conductivity soils and uncommon in A11 horizons of the other subcommunity ($P = 0,03$, Two-tailed Fisher's Exact Test, $N = 15$, Table 8).

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6. Mr. F. Venter, Research Institute, Private Bag X402, Skukuza 1350, South Africa.

Structure

The common structural types of this Association are:

(a) grassveld with scattered shrub and brush; and

(b) sparsely shrubby, sparse brushveld. Grassveld as well as brushveld are not uncommon on middleslopes, footslopes and bottomlands including drainage lines. Moreover, both subcommunities include grassveld and brushveld. Grassveld is associated with the highest conductivity A11 horizons, i.e. where this soil conductivity exceeds 1300 micro mhos ($P < 0,05$, Two-tailed Mann-Whitney U Test, using normal approximation with tie correction, $N_1 = 5$, $N_2 = 8$; Table 7; Appendix 1).

Floristic composition

The *Acacio nigrescentis - Setarietum woodii* has several highly exclusive species (Table 2, Group 16). These are the grasses *Setaria woodii*, *Brachiaria eruciformis* and *Ischaemum afrum* and the forbs *Ipomoea coscinosperma*, *Coccinia rehmannii*, *Phyllanthus* sp. and *Tragia incisifolia*, as well as the Association 11.1 forbs *Aneilema dregeanum* and *Commelina forskaolaei* (Tables 2 & 8).

In addition, the Association shares with other clayey areas, Groups 7 and 8 differential species, of which the woody *Acacia nigrescens* and the grass *Panicum coloratum* are the most constant; and several Groups 12, 13 and 15 differential species with other arid areas (Tables 2 & 8).

Acacia nigrescens is typically the dominant brush and shrub species in the brushveld phase and occurs also among the scattered shrub and brush in the grassveld phase (Appendix 1). *P. maximum* seems to consistently dominate the field layer in Association 11.1 (Table 8). The field layer in Association 11.2

may be dominated by one or more of the grasses Panicum maximum, Setaria woodii and Digitaria eriantha; and less commonly by the grasses Ischaemum brachyaterum or Bothriochloa radicans (Table 8).

11.1 Grassveld and brushveld with Aneilema dregeanum and Cordia sinensis, on calcareous vertic soils

Soils in this subcommunity are of the vertic Arcadia wanstead Series, i.e. calcareous and with self-mulching surface. A11 horizons have more than 40 percent clay, pH exceeding 7,0 and contain free carbonates (Table 8). Conductivities of A11 and A12 horizons are relatively high and exceed 1100 micro mhos. The grassveld phase occurs on the highest conductivity soils.

Differential species are shown in Table 8 and include the woody Cordia sinenses, the forbs Aneilema dregei, Commelina forskaolaei and others. Acacia nigrescens is the dominant woody plant in the brusnveld phase and the grass Panicum maximum dominates the field layers of both phases (Appendix 1 & Table 8).

11.2 Grassveld, brushveld and treeveld with Heliotropium steudneri and Themeda triandra, on non-calcareous vertisols

The soils of this subcommunity are also of the vertic Arcadia Form or less commonly near-vertic and of the Mayo or Bonheim Forms. Those of the Arcadia Form are typically non-calcareous, with self-mulching surface and accordingly belong to the Arcadia rydalvale, Arcadia rooidraai and Arcadia nagana Series. A11 horizons typically have less than 40 percent clay, pH of 7,0 or less and lack free carbonates (Table 8). Soil conductivities are generally lower than in Association 11.1. Releve 68 is strongly transitional to Subcommunity 11.1 in respect of habitat and species composition (Table 8).

TABLE 9. ANDROSTACHYETUM (ARID WITH FOG)

RELEVE NUMBERS		002	007	001	003	006	008	004
ASSOCIATION NUMBER				12				
LANDSCAPE NUMBER		11	11	11	11	11	11	11
HABITAT								
GEOLOGY (R=RHYOLITE)		R	R	R	R	R	R	R
RELIEF (C=CREST, M=MIDDLESLOPE)		M	M	M	C	C	C	C
SLOPE (DEGREES)		26	35	30	02	02	03	07
SURFACE (F=FLAT, N=CONVEX, R=ROCKY, U=CONCAVE)		F	R	U	N	N	N	N
ROCK (% X 10; +<1, *=1-9)		0	6	+	2	*	+	0
ROCK HEIGHT (M; +<.5, *=.5-.9)			2	1	+	+	+	
BOULDERS (A=ABUNDANT,		F		A	F	F		R
STONES F=FREQUENT,		F		F	A	F		F
GRAVEL R=RARE)		F		R	A	F		A
A HORIZON								
-COLOUR (D=DARK, R=RED, Y=YELLOW)		R		D	Y	R		D
-TEXTURE (L=LOAM, Z=SANDY)		L		ZL	ZL	ZL		ZL
-CLAY (%)		18		16	17	12		15
-PH (X 10)		60		52	51	56		52
-CONDUCTIVITY (MICROMHOS X .1)		131		190	009	011		084
SOIL FORM (STD. ABBREVIATIONS, MACVICAR ET AL., 1977)					MS	MS	MS	MS
SOIL SERIES NUMBER (MACVICAR ET AL., 1977)					10	10		10
NUMBER OF SPECIES		037	028	045	017	028	028	024

GROWTH FORM PREFIX:
F=FORB, G=GRASS, W=WOODY
SU=SUCCULENT

DIFFERENTIAL SPECIES FOR-
(SPP. NAMES, PRESENCE VALUES)

	ANDROSTACHYETUM (ASSOCIATION 12)								
W	ANDROSTACHYS JOHNSONII	7	5	4	5	3	3	4	4
F	COMMELINA BENGHALENSIS	6	+	+	+		+	+	+
F	CRABBEA VELUTINA	5	+	+	+		+	+	
F	PELLAEA VIRIDIS	6	+	+	+	+	+	+	
F	SOLANUM INCANUM	4	+				+	*	+
F	BIDENS PILOSA	4	+		+		+		+
F	ACHYRANTHUS ASPERA	4	+	+				+	+
F	KYLLINGA ALBA	4			+	+	+	+	
F	ADENIA DIGITATA	3	+		+	+			
	-ASS. 12.1								
W	BOSCIA ALBITRUNCA	4	+	+	A			*	
W	HYMENOCARDIA PARVIFOLIUM	3	A	+	A				
F	UNKNOWN SP.	3	1	+	+				
SU	CISSUS ROTUNDIFOLIA	3	+	+	+				
SU	MONADENIUM LUGARDAE	4	+	+	+		+		
F	SANSEVIERIA SP.	3	*	+	+				
F	STYLOCHITON NATALENSE	3	+	+	+				
F	ASPARAGUS SETACEUS	4	+	+	+	+			
F	KEDROSTIS SP.	2	+		+				
F	JATROPHA VARIIFOLIA	2	+		+				
F	ASPARAGUS FALCATUS	2		+	+				
F	RHYNCHOSIA TOTTA	2	+		+				
W	CASSIA ABBREVIATA	2	+		1				
W	STRYCHNOS DECUSSATA	2	+		1				
W	EUPHORBIA CONFINALIS	3	B	A	*				
G	PANICUM MAXIMUM	3	3	A					1
W	ACALYPHA GLABRATA	3	+	+				*	
F	LANTANA RUGOSA	2	+	+					
F	STRIGA GESNERIOIDES	2	+	+					
F	LEDEBOURIA SP.	2	+	+					
F	PAEDERIA FOETENS	2	+	+					
W	RHOICISSUS REVOILII	2	+	+					
W	CAPPARIS SEPIARIA	2	+	+					
W	HOLMSKIOLDIA TETTENSIS	2	1	+					
G	PANICUM DEUSTUM	1			3				
	-ASS. 12.2								
G	BRACHIARIA XANTHOLEUCA	5	+			+	1	B	4
F	VIGNA UNGUICULATA	4				+	+	+	+
G	TRAGUS BERTERONIANUS	4				+	+	+	+
F	TEPHROSIA BURCHELLII	3				+		+	+
G	SETARIA PALLIDE-FUSCA	3				+	+	+	
F	CLEOME MACULATA	3				+	+	+	
W	COMMIPHORA AFRICANA	3				+	+		+
F	SELAGINELLA DREGEI	1				3			
G	ARISTIDA TRANSVAALENSIS	2				A	+		
F	ENDOSTEMON TERETICAULIS	3					+	1	+
F	INDIGOFERA VICIOIDES	3					+	+	+
F	HIBISCUS MICRANTHUS	3					+	+	+
F	EUPHORBIA NEOPULYCNEMOIDES	3					+	+	+
	TABLE 2 GROUP -								
	12-EXCLUDING THE MOST MESIC SOILS AT > 550MM RAINFALL								
W	GREWIA BICOLOR	3		+	A			+	
	17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE > 30% PRESENCE IN THIS TABLE								
F	PHYLLANTHUS ASPERULATUS	5	+	+			+	+	+
F	CUCUMIS AFRICANUS	3	+				+		+
	OTHER INFREQUENT SPECIES								
W	DICHROSTACHYS CINEREA	2	+					+	
F	BULBOSTYLIS COLLINA	2				+		+	
F	CASSIA MIMOSOIDES	2				+			+
F	BECIUM KNYANUM	2					+		+
W	CRYPTOLEPIS OBTUSA	2					+		+
F	OXYGONUM SINUATUM	2						+	+
F	CORCHORUS ASPLENIFOLIUS	2						+	+
G	CYMBOSETARIA SAGITTIFOLIA	2					3	*	
W	COMBRETUM APICULATUM	2					+	+	
W	OZOROA ENGLERI	2					+	+	
W	PAVETTA CATOPHYLLA	2		+			*		
G	DIGITARIA ERIANTHA	2		+			+		
W	LANNEA STUHLMANNII	1	3						
W	CROTON GRATISSIMUS	1	1						
W	CROTON SYLVATICUS	1			1				
F	CYPERUS RUPESTRIS	1				1			

SEE APPENDIX 2 FOR RARE
SPECIES WITH LOW COVER

Species that differentiate this variation from the former include the woody Combretum imberbe and Dichrostachys cinerea subsp. africana, the grass Themeda triandra and the forbs Heliotropium steudneri and Indigofera vicioides (Table 8). Acacia nigrescens is the dominant woody species in the brushveld phase. The grasses Setaria woodii, Panicum maximum and Digitaria eriantha are the most common field layer dominants.

ALLIANCE UNSPECIFIED:-

12. Androstachyetum ass. nov.
(Association of arid substrates, with heavy winter fog, Table 9)
Nomenclatural type: Releve 8

Habitat and location

The Androstachyetum is typically dense evergreen woody stands of Androstahys johnsonii. These stands seem to select arid habitats with frequent heavy winter fog. Such are the salient synecological characteristics in terms of a hypothesis presented here in an attempt to relate the peculiar vegetation composition and structure, as well as species morphologie, phenology and distribution, to the habitat and location of this association. The central idea is that perhaps A. johnsonii has the ability to obtain an essential water supply by absorbing moisture from fog through its leaves, hence the unique features of this species and of the Androstachyetum.

The hypothesis includes the following suggestions:-

(a) A. johnsonii, owing to its evergreen character and ability to absorb fog directly through its leaves, has access to air moisture that is unavailable to other plants, and thus becomes strongly competitive in foggy habitats with arid soils. The soils may be arid either owing to low rainfall, or to arid physiography such as shallow soil on unbroken rock, or to rainfall and physiography.

(b) Its evergreen character enables A. johnsonii to take up and utilize the typical early morning fog associated with coastal areas and river valleys in winter.

(c) A. johnsonii stands are typically outstandingly dense, with canopies touching or interlocking, even where these stands select the most arid soils in a region. This is ascribed to the peculiar major source of moisture, which whenever present is available in excess to as much canopy as can be accommodated by space and sunshine; i.e. spacing of individuals is not primarily determined by root competition for water.

(d) The ability to form such dense stands once established must contribute to strong competitive exclusion of other vegetation types from otherwise potentially suitable habitats; A. johnsonii stands are typically separated from surrounding vegetation types by boundaries that are particularly abrupt and not associated with physiographic boundaries (Werger & Coetzee, 1978).

(e) Although arid substrates are tolerated and contribute to establishing A. johnsonii stands, the species, once established, may also expand onto more favourable adjoining soils from which it may benefit through its roots. The species grows taller and denser on deep litholitic soils or broken rocky areas than on shallow soils with sheet outcrop as discussed in the next subsection.

(f) The slow-growing nature and extremely hard, durable wood; the thick, white, villose covering of young twigs and under-surfaces of leaves; and the habit of leaves curling over and under in times of drought (Van Wyk, 1972) are presumably xeromorphic features (cf. Van Vuuren, 1961) that corroborate with arid conditions that are only occasionally alleviated on quick-drying soils, either by fog, or by rain or by both.

(g) The following points regarding the distribution of A. johnsonii may be added in support of the aforementioned suggestions:-

A. johnsonii is a tropical southern African species where it is restricted to arid habitats such as arid climates (cf. Schulze & McGee, 1978) and rocky areas with sheet outcrop and shallow soils (cf. Coates Palgrave, 1977; Compton, 1966; Van Rooyen, 1978; Van Wyk, 1974); and more specifically those arid habitats where the chances are greatest for coastal fog, or the fog associated with river valleys owing to temperature inversion and cold air drainage during winter nights, or low stratus cloud on mountains. In major river valleys such fog may extend over adjoining arid slopes. The distribution of A. johnsonii is as follows (cf. Coates Palgrave, 1977; Compton, 1966; Van Wyk, 1972; Werger & Coetzee, 1978; and various other references cited by the latter)-

(i) The species occurs on arid valley slopes where major rivers cut through the Lebombo Mountain range of low hills in the eastern Lowveld, i.e. from south to north: the Mbuluzi Poort in Swaziland; the Nwanedzi Poort and its tributary Msimbitsane Valley on the South Africa-Mocambique border; the Olifants River Poort on the same border; and the Limpopo River Poort and its tributary Shilahlandonga and Malonga Valleys, where Mocambique, Zimbabwe and South Africa meet.

(ii) The distribution extends westwards through the rocky sandstone country along the Luvuvhu River tributary of the Olifants River. Here its habitats are either conceivably or obviously arid. The species also extends northwards up the Arid Bushveld of the Save River basin in Zimbabwe.

(iii) *Androstachys johnsonii* stands are extensive in southeastern Mocambique alternating with *Julbernardia* sp. savanna on the semi-arid to arid plains bordering on the coastal zone.

(iv) A north-eastern outlier occurs in a narrow coastal zone of Dry Deciduous Thicket (*Guibourtia* sp., *Pseudoprosopis* sp.) in Mosambique.

Much of the Lebombo Mountains north of the Nwanedzi and Olifants River poorts have essentially equally low and erratic rainfall and no physiographic features other than proximity to major river valleys distinguish the terrain of *Androstachys johnsonii* stands from that of much of the surrounding Dry Mountain Bushveld. Moreover *A. johnsonii* is not restricted to typically valley relief units but occurs also on adjoining summits where it breaks off abruptly in the absence of any obvious physiographic boundaries such as slope or relief units, or soil differences. Relatively high soil conductivities are common in the present *Androstachyetum* sample from the Olifants River Poort. However, such high conductivities are seemingly not correlated with other physiographic features and may well be secondary, owing to the influence of the dense stands of *A. johnsonii*.

(h) Further support for the contention that *A. johnsonii* stands are associated with fog comes, e.g. from the preference of lichens for these communities. The beardlike lichens of *Usnea* sp. are strongly associated with *A. johnsonii* stands, occurring e.g. commonly in such stands in the Punda Milia area (Van Rooyen[7] pers. comm.) and the Olifants River Poort. Other lichens are also characteristically abundant in these stands and in the Olifants River Poort largely cover most stones as well as the occasional smooth-barked tree trunks such as *Strychnos decussata* and *Cordia parvifolium*. Fog, associated with the Olifants-Letaba River System near the Poort through the Lebombo Range has been a common winter early morning hinderance to aerial census teams. P. Wolff[7](pers. comm.) reports that night and early morning fog commonly occurs in and along drainage lines of the Central District in winter and inverted winter temperature gradiants have been measured in the Central District by Gertenbach[7] (pers. comm.).

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7. Messrs. L.E. Van Rooyen, P.J. Wolff, and W.P.D. Gertenbach, Kruger National Park, Private Bag X402, Skukuza 1350, South Africa.

The present small Central District sample of seven *Androstachyetum* releves is from rhyolitic Lebombo Mountain hills adjoining the Olifants River. The sample includes relatively deep rhyolitic soils and broken outcrop from steep slopes, which form one subcommunity; and less steep summit stands on shallow soils of the Mispah mispah Series (i.e. a non-calcareous orthic A horizon on hard rock), which represent another subcommunity. Percentage clay is between 10 and 20 and pH values range from 5,1 to 6,0. Conductivities vary enormously and may be as low as 90 or 110 micro mhos or up to 1900 micro mhos (Table 9). Soil colour is also variable and the sample shows no indications of a relationship between colour, pH and conductivity.

Structure

Total woody vegetation cover is over 50 percent to over 75 percent in the subcommunity of steep slopes with relatively deep litholitic soils, and between 25 per cent and 75 percent in the subcommunity on shallow Mispah soils of summits. The woody vegetation in the latter subcommunity is also more stunted (Appendix 1).

Floristic composition

The *Androstachyetum* is the most unique Association of the Central District. Relatively few species are shared with other communities described here. A large number of species, on the other hand, are largely specific to the *Androstachyetum* in the context of the present survey. These belong to Group 16 (Table 2) and include:

(a) the upper stratum woody species, *Androstachys johnsonii* (dominant), *Euphorbia confinalis* (succulent and occasionally high cover but subdominant) and *Strychnos decussata*;

(b) the shrubby to brushy Cordia parvifolium, Holmskioldia tettensis and Capparis sepiaria (also a climber and occurs in bush elsewhere);

(c) the woody climbers, Crytolepis obtusa and Rhoicissus revoilii, which occur elsewhere in riparian and other bush;

(d) the herbaceous climbers, Adenia digitata (with tuber), Cissus rotundifolia (succulent) and Paederia foetens;

(e) the annual grasses Setaria palide-fusca and Cymbosetaria sagittifolia;

(f) the forbs Actinopteris radiata (not in Table 9), Crabbea velutina, Acalypha glabrata, Bidens pilosa, Cleome maculata, Endostemon tereticaulis, Monadenium lugardae (succulent), Sansevieria dessertii (leathery, drought tolerant perennial with rootstock water storage); and others.

The few constant differential species shared with other vegetation types belong largely to Groups 12-14 (Table 2) of dry and arid areas and include: the shrubby Grewia bicolor and Commiphora africana; the annual grasses Brachiaria xantholeuca and Tragus berteronianus; and the forbs Hibiscus micranthus and Commelina benghalensis. The woody Boscia albitrunca is also shared with the arid Boscio albitruncae - Terminalietum prunioidis (Spiny Arid Bushveld, Ass. 10).

General, Group 17, species are well represented in the Androstachyetum (Table 2).

As shown in Appendix 1, all woody height levels are entirely dominated by Androstrachys johnsonii. Field layer dominants vary with subcommunity and subordinate habitat differences.

12.1 Euphorbia confinalis - Androstachys johnsonii Bush, of broken bouldery outcrop and steep slopes

This subcommunity occupies steep middleslopes of 25-35° with relatively deep litholitic soils or broken bouldery outcrop with relatively moist cracks and crevices.

The structure is typically scrubby, thicketed dense bush contrasting sharply with surrounding vegetation, also on aerial photographs (Appendix 1). The scrub is concentrated just below the brush level and the understorey is quite open below 2m - strongly shaded by the dense canopy.

Differential species are shown in Table 9. Androstachys johnsonii is dominant at all woody levels. Subdominant woody plants include Euphorbia confinalis, Cordia parvifolium and Boscia albitrunca (Table 9). The grass Panicum maximum, which is also differential for this subcommunity and P. deustum are the field layer dominants.

12.2 Androstachys johnsonii Shrubveld and Thicket, with Brachiaria xantholeuca, of summit Mispah mispah soils

The more arid subcommunity occupies shallow Misph mispah soils of the convex summits, which may slope up to seven degrees before breaking into the steep middleslopes occupied by the former subcommunity. Sheet outcrop is typical of the proper summits which slope up to three degrees.

Woody structure varies from densely shrubby sparse brushveld on particularly shallow soils with abundant sheet outcrop of gentle summit slopes, e.g. Releve 3, to scrubby thicket on steeper slopes with less outcrop occurring towards the summit edges where there is some accumulation of soil, e.g. Releves 4 and 8 (Appendix 1, Table 9). The brushes and shrubs are multi-stemmed. Brushes usually also dominate the shrub level except on the shallowest soils where the vegetation is stunted and shrubs dominate the shrub level (Appendix 1, Table 9).

Differential species for this subcommunity are shown in Table 9. Androstachys johnsonii is entirely dominant at all woody levels. The desiccation-tolerant fern Selaginella dregei, the grass Aristida sp., cf. A. transvaalensis, are dominant and the sedge Cyperus rupestris subdominant in the field layer of the phase with abundant sheet outcrop. In the less rocky variation Brachiaria xantholeuca is dominant, or subdominant to Cymbosetaria sagittifolia.

V. LANDSCAPES (1): CONCEPTS AND METHODS

Introduction

The previous chapter classifies and characterises vegetation stands according to species composition and structure. Ecological discussion of the resulting vegetation types centres around the nature of their abiotic habitats and how abiotic features relate to their floristic and structural characteristics, similarities and differences. The present- and following chapters identify examples of a particular category of ecosystem to which the vegetation types and their habitats contribute. These vegetation types and their habitats are discussed in such ecosystem context.

A stand of vegetation contains numerous small ecosystems, concerning. e.g., a decaying log; or a living plant in a local example of its species' niche. A stand of vegetation may, also, demarcate a single ecosystem, to which it contributes as an assemblage of plants, living in a habitat that comprises various niches. Moreover, stands of vegetation belonging to different vegetation types may contribute to one ecosystem with one medium- to large- herbivore community. One therefore finds ecosystems within ecosystems as well as corresponding hierachies of abiotic and biotic ecosystem components. Table 10 proposes and analyses three hierarchial categories of ecosystems that are delineated by vegetation, i.e. by assemblages of plant individuals. Each successive category is structurally more complex than the former. The table shows the corresponding categories for the entire vegetation component and entire abiotic component at each hierarchical level. Table 10 also serves to integrate the classification of Land by MacVicar _et al._ (1974), the Braun-Blanquet phytosociological system and Acocks' (1975) system of Veld Types, into a single scheme for

TABLE 10. THREE PROPOSED HIERARCHICAL CATEGORIES FOR VEGETATION-DELINEATED ECOSYSTEMS AND THEIR MAJOR VEGETATION AND ABIOTIC COMPONENTS. THE CATEGORIES OF FAUNAL AND MICROBIOLOGICAL COMPONENTS WOULD VARY ACCORDING TO THE TAXONOMIC GROUP.

HIER-ARCHICAL LEVEL	ABIOTIC COMPONENT (MACVICAR ET AL., 1974)	VEGETATION COMPONENT	VEGETATION-DELINEATED ECOSYSTEM
1	Ecotope	Association (sensu Barkman et al., 1976)	LANDSCAPE UNIT (Association and other biota in Ecotope)
2	Land Type	Association Complex (cf. Westhoff & V.d.Maarel, 1973)	LANDSCAPE (Association Complex and other biota in Land Type)
3	Land System	Veld Type (sensu Acocks, 1975)	ECOLOGICAL PROVINCE (Veld Type and other biota in Land System)

categorizing natural ecosystem types. Also integrated into this scheme, as is explained in the following section, are:

(a) Thornthwaite's climatic classification system (Schulze & McGee, 1978), which seems most appropriate to explain major southern African vegetation types (Werger & Coetzee, 1978); and

(b) King's (1963) classification system for major geomorphological regions. The name "Landscape" (Table 10) is suggested for the category of ecosystem that is to be further dealt with in this and the following chapter.

Landscapes as ecosystems

A "landscape" in this context comprises a recurrent pattern of plant associations with its associated fauna and abiotic habitat. The habitat component of such a landscape is a "land type", which has a distinct macro-climate, terrain form and soil pattern; may be suitably mapped at 1:250 000 scale; and comprises several "ecotopes" (MacVicar *et al*., 1974). Each ecotope, i.e. "a particular habitat within a region", has its own distinct vegetation type and the same ecotope with its associated vegetation type may be found in several types of landscape (cf. MacVicar *et al*., 1974).

The various Central District landscapes mapped in Fig. are useful as conservation management units in the Kruger National Park bacause, within each landscape, the component habitats of plant communities are strongly interdependent and the area occupied by an animal community may include several plant communities. Moreover, in the Kruger National Park, natural biological organization at the landscape level in itself forms part of the conservation heritage, to be managed as such. Artificial construction and associated bush clearing, e.g., not only destroys the individual organisms directly involved but disturbs the community to which they belong and, in the same way, the landscape.

Within one biogeographic region, the major determinants of land type and landscape are macro-climate, terrain form and soil pattern (cf. MacVivar *et al*., 1974; Ch II). Terrain form depends largely on macro-climate, geology and geomorphological province (King, 1963); and soil pattern depends on all these. Landscapes of a biogeographic region may, therefore, conveniently be characterised by, and named after, macro-climate, geology and geomorphologic provinces. Macro-climate regions thus employed are after Thornthwaite as mapped by Schulze & McGee (1978) and geomorphologic provinces are after King (1963). Where justified by different patterns of plant associations, different landscapes within one climatically, geologically and geomorphologically defined region are distinguished, and named after salient ecological features.

Landscape data

The data and results discussed in Chapter IV provided the material for describing the ecotopes and plant associations of the various landscapes. The faunal descriptions are concerned almost entirely with medium to large herbivores and are based largely on data from the 1979 aerial ecological monitoring surveys by Joubert (unpubl.).

Joubert (unpubl.), following and elaborating upon De Vos (unpubl.), divided the Kruger National Park into geographic grid squares, which are approximately 2,1km x 2,3km (i.e. 4,9km^2) each. Various types of ecological data may be inventorised per grid square. At present such data include, e.g., the presence of the various landscapes mapped and described here (Fig. 1, Chapter VI). Also inventorised are the annual aerial ecological monitoring data provided by Joubert (unpubl.), including animal sensus data, vegetation structure and phenology and surface water. All these data are routinely entered into a computerised data bank and processing system developed by Retief (unpubl.).

Data processing

The landscapes mapped in Fig. 1 were delineated on the basis of community complexes that are recurrent patterns of the plant associations described in Chapter IV. Boundaries were drawn during aerial surveys and on aerial photos (Trigonometrical Survey Office, 1974). The relationships between component communities and abiotic habitat were determined as described in Chapters III & IV.

The computerised grid-square data on landscapes and animal densities and the attendant processing system (see "Landscape data", previous heading) was used to:

(a) print grid distribution maps of landscapes and animal density classes, at the same scale; and

(b) ordinate landscapes and medium to large herbivore species on the basis of their interrelationships, using the Correspondence Analysis Technique (Hill, 1973 & 1974).

Correspondence Analysis

Correspondence Analysis (also known as Reciprocal Averaging) (Benzecri *et al*., 1973, according to Hill, 1973 & 1974; Greenacre, 1978) has, in recent years, been applied to many problems requiring ordination of species and sampling units in phytosociological studies. Correspondence Analysis may be explained as follows:-

Given a two-way table showing the occurrence of attributes (e.g. animal species) in a set of sampling units (e.g. landscapes), the algorithm begins by assigning a set of arbitrary scores to the animal species, ranging say, from 0-100. Scores can then be computed for each landscape, based on a weighted average of the animal species occurring in them. The result of this iteration is a set of landscape scores. These scores may then be standardised to range from 0-100, and the algorithm then calculates a new set of animal species scores based on the landscape scores. If this procedure is repeated, the scores eventually converge to a unique ordination of species and landscapes, independent of the starting scores. This algorithm gave rise to the term "reciprocal averaging" (Hill 1973).

A mathematically equivalent algorithm, based on an eigenvector analysis of the two-way table after certain standardisation of the data, will result in the same final ordinations (Benzecri et al., 1973 according to Hill 1974; Greenacre, 1978). The latter technique is especially suitable if multiple axes of ordination are extracted.

Correspondence analysis is similar in principle to Weighted Averaging (Ellenberg, 1948; Whittaker, 1948; Curtis & McIntosh, 1951, according to Gauch, 1977) except that the algorithm will produce an objective representation based solely on the data and not dependent on any initial subjective choice of weights.

Gauch, Whittaker & Wentworth (1977), have compared the performance of Correspondence Analysis favourably with other ordination techniques. Greenacre (1978) has described the choice of data suitable for Correspondence Analysis, as well as the limitations that may be placed on the interpretation of the results.

An improved algorithm for Correspondence Analysis, called Detrended Correspondence Analysis, was developed by Hill (1979). This version "....avoids the 'arch' or 'horseshoe' problem of [Correspondence Analysis] (the second axis is frequently a quadratic distortion of the first axis), and also it scales ordination axes to avoid the contraction of axis ends in [Correspondence Analysis]".

In the present study a two-way table of landscapes and animal species (Table 11) and subsets of this table matrix were used as input for a number of conventional and detrended Correspondence Analyses. The matrix of this two-way table shows the number of individuals of each species in each landscape. Species' abundances and concomitant landscape types were available for 4,9km^2 grid blocks as discussed in the aforegoing section ("Landscape data"). The 4,9km^2 grid blocks were grouped according to dominant landscape. Total number of individuals of each animal species were then calculated for each group of grid squares belonging to the same landscape.

Table data was retrieved and the table constructed by computer programme from the ecological data bank at Skukuza (Retief, unpubl.). The conventional Correspondence Analyses were carried out through a computer programme developed by Retief (unpubl.) and based on a similar programme developed by Tabet[1] (unpubl.) and described by Greenacre[2] (unpubl.).

Detrended Correspondence Analysis was effected through a programme called Decorana (Hill, 1979).

Detrended Correspondence Analysis was used merely to confirm the results of conventional Correspondence Analysis. Discussion are based on the results of conventional Correspondence Analysis for two reasons:

(a) available programmes for the conventional version provide more information, thus allowing better interpretation, than available programmes for the detrended version; and

(b) the mathematical background to the detrended algorithm has not been fully published, which renders interpretation of the results unreliable.

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VI LANDSCAPES (2): RESULTS OF ORDINATION OF HERBIVORES AND LANDSCAPES

Introduction

Densities of medium to large herbivore species in geographic grid blocks of the various landscapes studied, are shown in Table 11. The results of two Correspondence Analyses with this data are contained in Tables 13 and 16. One Detrended Correspondence Analysis was carried out with the same data.

Tables 13 and 16 provide a useful indication of landscape preferences and contribute to an understanding of more detailed habitat preferences of the herbivore species. However, landscapes change with season as well as with burning and medium term rainfall cycles. Animal preferences for landscapes and the emphasis placed on different habitat factors, may therefore vary with season and from one year to the next. Ecological tolerances are also not equally narrow for all species and the occurrence of species in a particular landscape at the time of survey may be more or less incidental. As this was not primarily a study of herbivore ecology, these various factors could not be taken into account. Neither was the literature on the ecology of the animals concerned, studied. These limitations should be borne in mind when examinging the results presented in the present chapter.

The first Correspondence Analysis (Tables 12 & 13) included all species and landscapes. In this analysis buffalo (breeding herds) and elephant (breeding herds) each essentially required an ordination axis to themselves. The first analysis was therefore used to identify the preferred landscapes of buffalo and elephant breeding herds. The remaining species, except roan, which are not accounted for in these first five axes, were dealt with in a second analysis (Tables 14 & 16).

TABLE 11. NUMBER OF GRID BLOCKS AND AVERAGE NUMBER OF EACH SPECIES PER GRID BLOCK AND PER KM^2 FOR THE VARIOUS LANDSCAPES STUDIED. (LANDSCAPE AND SPECIES SEQUENCES AS IN TABLES 13 AND 16; T = TOTAL COUNT IN ALL GRID BLOCKS; K = AVERAGE DENSITY PER KM^2)

Landscape (Chapter VII reference)		8.3/4/6	4	3	6.7-14	1	5	9b	6.2-6	6.1/13/14	7	9a	2	10	8.1/5/6	11
Number of Grid Blocks		30	56	89	72	5	18	19	157	22	88	106	207	9	30	5
Buffalo Breeding Herds	T	0	150	318	500	0	0	0	1850	0	150	480	1540	0	350	0
	K	0	0,5	0,7	1,4	0	0	0	2,4	0	0,3	0,9	1,5	0	2,4	0
Elephant Breeding Herds	T	0	105	90	66	0	95	0	15	0	16	224	77	6	42	0
	K	0	0,4	0,2	0,2	0	1,1	0	0,0	0	0,0	0,4	0,1	0,1	0,3	0
Impala	T	3354	3129	2786	3382	301	847	774	2048	54	729	4685	5000	476	994	49
	K	22,8	11,4	6,4	9,6	12,3	9,6	8,3	2,7	0,5	1,7	9,0	4,9	10,8	6,8	2,0
Zebra	T	282	141	438	325	2	60	132	1590	746	1221	1252	868	154	269	3
	K	1,9	0,5	1,0	0,9	0,1	0,7	1,4	2,1	6,9	2,8	2,4	0,9	3,5	1,8	0,1
Blue Wildebeest	T	121	221	111	345	3	71	13	1188	871	573	287	515	24	74	0
	K	0,8	0,8	0,3	1,0	0,1	0,8	0,1	1,5	8,1	1,3	0,6	0,5	0,5	0,5	0
Ostrich	T	0	5	10	11	0	1	1	66	13	21	8	15	0	0	0
	K	0	0,0	0,0	0,0	0	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0	0	0
Tsessebe	T	0	0	8	0	0	0	0	0	18	0	4	8	0	0	0
	K	0	0	0,0	0	0	0	0	0	0,2	0	0,0	0,0	0	0	0
Kudu Breeding Herds	T	72	98	135	185	10	16	91	466	74	424	539	465	21	70	15
	K	0,5	0,4	0,3	0,5	0,4	0,2	1,0	0,6	0,7	1,0	1,0	0,5	0,5	0,5	0,6
Kudu Bulls	T	12	11	32	21	0	5	1	40	3	48	68	49	4	1	0
	K	0,1	0,0	0,1	0,1	0	0,1	0,0	0,1	0,0	0,1	0,1	0,0	0,1	0,0	0
Ground Hornbill	T	9	5	8	4	4	3	0	14	0	10	24	16	0	0	0
	K	0,1	0,0	0,0	0,0	0,2	0,0	0	0,0	0	0,0	0,0	0,0	0	0	0
Sable Breeding Herds	T	0	5	51	18	0	0	4	4	6	45	0	107	0	0	0
	K	0	0,0	0,1	0,1	0	0	0,0	0,0	0,1	0,1	0	0,1	0	0	0
Sable Bulls	T	0	0	0	0	0	0	0	3	0	4	0	13	0	0	0
	K	0	0	0	0	0	0	0	0,0	0	0,0	0	0,0	0	0	0
Warthog	T	10	68	78	75	28	29	2	145	66	55	54	240	0	24	2
	K	0,1	0,2	0,2	0,2	1,1	0,3	0,0	0,2	0,6	0,1	0,1	0,2	0	0,2	0,1
Reedbuck	T	0	1	0	4	0	0	0	6	1	1	10	2	0	0	0
	K	0	0,0	0	0,0	0	0	0	0,0	0,0	0,0	0,0	0,0	0	0	0
Waterbuck	T	64	4	90	159	0	0	25	225	0	70	180	47	4	3	3
	K	0,4	0,0	0,2	0,5	0	0	0,3	0,3	0	0,2	0,3	0,0	0,1	0,0	0,1
Elephant Bulls	T	20	18	20	39	0	1	6	55	6	17	46	56	1	10	0
	K	0,1	0,1	0,0	0,1	0	0,0	0,1	0,1	0,1	0,0	0,1	0,1	0,0	0,1	0
Giraffe	T	210	183	229	235	23	20	96	390	74	155	220	376	20	82	1
	K	1,4	0,7	0,5	0,7	0,9	0,2	1,0	0,5	0,7	0,4	0,4	0,4	0,5	0,6	0,0
Buffalo Bulls	T	22	47	19	50	5	3	29	66	0	17	51	106	0	9	5
	K	0,1	0,2	0,0	0,1	0,2	0,1	0,3	0,1	0	0,0	0,1	0,1	0	0,1	0,2
White Rhino	T	0	18	0	1	0	9	0	5	0	7	2	6	0	0	0
	K	0	0,1	0	0,0	0	0,1	0	0,0	0	0,0	0,0	0,0	0	0	0

Detrended Correspondence Analysis of the submatrix that excluded buffalo, elephant and roan, established that "horseshoe" type distortion (cf. Ch. V) or lack of down-weighting of rare species did not invalidate the conclusions arrived at by standard Correspondence Analyses.

Presentation of results

Tables 13 and 16, of the first two correspondence analyses, provide data on each species and each landscape under the following headings (desciptions are adapted from a programme description by Greenacre, 1978).

A. In respect of the total ordination

Total Representation

This is the "quality" of the representation of species and Landscapes in the subspace of five ordination axes. This quantity can be considered either as the squared correlation of this element with the subspace or as the squared cosine of the angle that it makes with the subspace. It is calculated by summing the squared correlations for all the ordination axes.

Relative Number in sample

Numbers of animals of each species as well as numbers of grid squares of each landscape, are scaled to sum to 1 000 animals and 1 000 grid squares for the total sample.

Relative inertia

Inertia of each animal species or landscape is defined as its relative abundance in the sample, multiplied by its squared chi-square distance from the centre of gravity in the species or landscape space. Inertias are scaled to sum to 1 000 for all species and 1 000 for all landscapes.

B. In respect of each of the five ordination axes

Coordinate

Coordinates of landscapes and of species on each ordination axis are multiplied by 1 000 and expressed as an integer.

Representation

Representation of an element (species or landscape) on an ordination axis is expressed as the squared correlation of the element with that axis, i.e. the squared cosine of the angle that it makes with this axis, multiplied by 1 000 and listed as an integer.

Contribution

Contribution of a species or a landscape to the n-th axis is its inertia accounted for by this axis (the n-th non-trivial eigenvalue), rescaled so that all such inertias associated with the n-th axis, sum to 1 000.

First Correspondence Analysis

Table 12 lists the twelve principal ordination axes required to represent the total inertia. Percentage of total species inertia (= percentage of total landscape inertia) accounted for by each axis as well as cumulative percentage inertia accounted for with each additional axis, are shown.

TABLE 12. INERTIA ACCOUNTED FOR BY SUCCESSIVE AXES IN THE FIRST CORREPONDENCE ANALYSIS.

AXES OF INERTIA	PERCENTAGE OF TOTAL INERTIA	CUMULATIVE PERCENTAGE INERTIA
1	60,6	60,6
2	19,5	80,1
3	8,3	88,4
4	4,2	92,6
5	3,0	95,7
6	1,4	97,1
7	1,1	98,2
8	0,7	98,9
9	0,5	99,4
10	0,4	99,8
11	0,1	99,9
12	0,1	100,0

Table 13 shows the results of the first analysis, which included all species and landscapes. These elements were ordinated in a five-axes subspace, which accounted for 95,7 per cent of the total inertia. The first two species in the table, i.e. buffalo- and elephant breeding herds, are the ones left out of the subsequent analyses. The rest of the species and landscapes' sequences are as in Table 16, which gives the results of the second analysis.

TABLE 13. RESULTS OF FIRST CORRESPONDENCE ANALYSIS : COORDINATES, REPRESENTATION AND CONTRIBUTION OF EACH ANIMAL SPECIES AND EACH LANDSCAPE, OR GROUP OF LANDSCAPE UNITS, ON EACH ORDINATION AXIS.

	ELEMENTS	Total Representation	Relative no. in sample	Relative Inertia	Axis 1			Axis 2			Axis 3			Axis 4			Axis 5		
					Coordinate	Representation	Contribution	Coordinate	Representation	Contribution	Coordinate	Representation	Contribution	Coordinate	Representation	Contribution	Coordinate	Representation	Contribution
Animal Species	Buffalo Breeding Herds	996	97	172	-245	97	28	742	885	781	77	9	20	52	4	18	-21	1	4
	Elephant Breeding Herds	979	13	42	454	184	13	-241	52	11	-45	2	1	906	733	745	-94	8	11
	Impala	998	520	221	378	957	350	-68	32	36	32	7	18	-18	2	12	-5	0	2
	Zebra	981	136	169	-597	821	229	-154	55	48	-213	105	213	13	0	2	-7	0	1
	Blue Wildebeest	996	80	250	-591	827	343	-267	66	85	334	102	307	-6	0	0	- 37	1	11
	Ostrich	829	3	7	-841	712	9	280	78	3	22	1	0	-39	2	0	-189	36	9
	Tsessebe	732	1	12	-1335	285	6	-1149	211	13	1136	206	31	7	0	0	435	30	12
	Kudu Breeding Herds	899	49	37	-268	269	17	28	3	1	-397	591	265	4	0	0	98	36	44
	Kudu Bulls	771	5	4	-136	59	0	-39	5	0	-447	630	37	117	43	5	104	34	5
	Ground Hornbill	217	2	2	83	17	0	-40	4	0	-252	156	4	96	22	1	86	18	1
	Sable Breeding Herds	782	4	16	-124	12	0	151	17	1	-173	23	5	-112	10	4	986	720	400
	Sable Bulls	859	0	2	-378	69	0	624	186	2	-180	16	0	-54	1	0	1110	587	42
	Warthog	786	16	15	-200	117	3	95	26	2	300	260	49	108	34	13	347	349	181
	Reedbuck	549	0	1	-206	54	0	97	12	0	-258	84	1	216	59	1	-520	340	12
	Waterbuck	709	16	19	-83	16	1	161	60	6	-292	198	47	-169	67	31	-399	368	240
	Elephant Bulls	671	5	0	-25	10	0	177	481	2	-31	15	0	-70	78	2	-74	87	3
	Giraffe	542	42	7	0	0	0	34	19	1	29	14	1	-172	504	86	18	5	1
	Buffalo Bulls	350	8	7	168	86	1	198	119	4	-4	0	0	-166	85	15	140	60	14
	White Rhino	491	1	7	249	21	0	-392	51	2	298	29	3	1051	368	65	259	22	6
Landscapes (Ch.VII reference)	8.3/4/6	980	76	81	498	659		-255	174		55	8		-214	122		-79	17	
	4	946	77	61	445	709		-169	103		183	120		60	13		19	1	
	3	734	80	25	275	693		-29	8		-19	4		-2	0		56	29	
	6.7-14	847	99	24	231	611		33	13		88	88		-66	51		-84	84	
	1	679	7	15	591	454		-174	40		219	63		-152	31		264	91	
	5	978	21	43	469	307		-357	178		180	45		567	448		-16	0	
	9(b)	803	21	19	328	329		-193	115		-204	129		-271	228		22	2	
	6.2-6	994	149	180	-525	650		364	312		31	2		-10	0		-111	30	
	6.1/13/14	997	35	291	-1487	760		-706	172		435	65		-16	0		16	0	
	7	990	65	140	-722	687		-252	84		-385	196		-15	0		132	23	
	9(a)	945	148	39	146	228		-103	117		-199	428		97	101		-81	71	
	2	980	173	48	75	58		245	614		64	42		-2	0		161	266	
	10	679	13	10	186	127		-336	416		-172	109		-61	14		-58	13	
	8.1/5/6	632	35	13	61	28		259	500		11	1		113	95		-31	8	
	11	317	1	4	358	108		-83	6		-400	136		-223	42		170	25	

Axis 2 (Buffalo breedings herds)

Axis 2 represents 88,5 percent of all buffalo breeding herd inertia and is 78,1 percent determined by these animals (inertias, Table 13, sum to 1000; therefore: percentage inertia = inertia/10). Landscapes 2, 8.1/5/6 and 6.2-6 are also well represented by Axis 2 and, like buffalo breeding herds, have strongly positive coordinates on this axis, suggesting that buffalo breeding herds prefer these landscapes best. Landscape 10 is also well represented, but with a strongly negative coordinate, and seems to be avoided by buffalo. Buffalo breeding herds are large and should a herd's home range include more than one landscape, the analysis could be strongly biased by the position (presence or absence) of a single herd at the time of survey. However, the ecological picture that does emerge is based on substantial representation by several landscapes with appreciably strong positive and negative coordinates.

Buffalo seems to be partial to plains landscapes, with relatively large proportions of mesic types of rank field layers, such as the landscape unit with tropical Semi-arid Granitic Lowveld (Landscape 2) and the landscape unit with *Sclerocarya caffra* - dominated treeveld, of Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.2-6), the landscape unit with *Acacie gerrardii* - dominated brushveld (Landscape 6.1), and Vertic Tropical Semi-arid Basaltic Lowveld (Landscape 7) have similar types of field layers but seem to be avoided.

This avoidance may be apparent, owing to the small relative number of grid squares of these areas in the sample (2,4 per cent and 9,6 percent respectively) and the strong chance that a breeding herd could be absent from such a small part of its home range during the survey. Such temporary absence is particularly likely in these two instances because of the scarcity of surface water in these two landscapes. The seemingly preferred *Acacia nigrescens* - *Grewia bicolor* - dominated brushveld in the Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8.1) has an arid type of field layer that is nevertheless rank owing to the contribution of the grass *Urochloa mossambicense* (Ch. VII).

Landscapes and landscape units in which buffalo breeding herds were largely absent during the time of survey are generally either hilly or arid. Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9) is a hilly example. Arid examples include: (a) Tropical Semi-arid Lowveld on Karoo Sediment anticline with dolorite (Landscape 5); (b) the landscape unit with *Terminalia prunioides* - *Combretum apiculatum* - *Acacia nigrescens* - *A. exuvialis* - dominated brushveld, in the Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8.3); and (c) Tropical Semi-arid Karoo Sediment Lowveld (Landscape 4, with abundant sodic soils). Zonal Tropical Arid Rhyolitic Lowveld (Landscape 10), which is also avoided, is both hilly and arid.

<u>Axis 4 (Elephant breeding herds)</u>

Axis 4 represents 73,3 percent of all elephant breeding herd inertia and is 74,5 percent determinated by these animals. Tropical Semi-arid lowveld on Karoo Sediment anticline with dolorite (Landscape 5) is also particularly well represented on Axis 4, where it has a strongly positive coordinate, like elephant breeding herds. The latter animals seem to have had a special preference for this landscape at the time of survey. They were recorded mostly on the Kumana Plateau, which is typically moderately to densely shrubby, sparsely to moderately brushy, treeveld or with scattered trees. <u>Acacia nigrescens</u> is the dominant tree and <u>Dichrostachys cinerea</u> subsp. <u>africana</u> the dominant brush and shrub. Owing to the sandstone influence <u>D. cinerea</u> subsp. <u>africana</u> has a higher cover here than elsewhere on the basaltic plains (Ch. VII). Surface water was available at the time of survey (Joubert, unpubl.)

The dry section of the Lebombo Mountains that forms the dry part of Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9b), is well represented on Axis 4, with a strongly negative coordinate, and seems to be avoided by elephant breeding herds. The vegetation here is commonly moderately to densely shrubby, moderate to dense brushveld or thicket (Ch. VII), which does not appear to deter such breeding herds elsewhere. Unless the overwhelmingly dominant <u>Combretum apiculatum</u> is not acceptable, their absence seems to be owing to lack of surface water. Much of the terrain is level to gently sloping summit region, which is also not avoided elsewhere.

Second Correspondence Analysis

As shown in Table 14 the second analysis, which excludes buffalo and elephant breeding herds, also requires twelve axes to represent all the inertia of species and landscapes.

TABLE 14. INERTIA ACCOUNTED FOR BY SUCCESSIVE AXES IN THE SECOND CORRESPONDENCE ANALYSIS.

AXES OF INERTIA	PERCENTAGE OF TOTAL INERTIA	CUMULATIVE PERCENTAGE INTERTIA
1	76,2	76,2
2	11,0	87,2
3	4,4	91,6
4	3,4	95,0
5	1,7	96,7
6	1,1	97,8
7	0,9	98,7
8	0,7	99,4
9	0,3	99,7
10	0,1	99,8
11	0,1	99,9
12	0,1	100,0

Table 16 shows more results of the second analysis. The ordination is in five-axes subspace, which accounted for 96,7 percent of the total inertia.

The difference between the first and second analysis, in the percentage animal inertia accounted for in the five-dimensional ordination subspace, for species other than those omitted in the second analysis, are shown in Table 15.

TABLE 15. PERCENTAGE OF ANIMAL INERTIAS ACCOUNTED FOR IN THE TWO CORRESPONDENCE ANALYSES (BUFFALO- AND ELEPHANT BREEDING HERDS EXCLUDED).

SPECIES	% PER-SPECIES INERTIA ACCOMMODATED		
	FIRST ANALYSIS	SECOND ANALYSIS	DIFFERENCE
Impala	99,8	100	+ 0,2
Zebra	98,1	99,5	+ 1,4
Blue Wildebeest	99,6	99,9	+ 0,3
Ostrich	82,9	88,1	+ 5,2
Tsessebe	73,2	82,7	+ 9,5
Kudu breeding herd	89,9	97,0	+ 7,1
Kudu bulls	77,1	71,8	- 5,3
Ground Hornhill	21,7	21,6	- 0,1
Sable breeding herd	78,2	92,5	+ 14,3
Sable bulls	85,9	76,7	- 9,2
Warthog	78,6	81,0	+ 2,4
Reedbuck	54,9	47,3	- 7,6
Waterbuck	70,9	93,2	+ 22,3
Elephant bulls	67,1	59,1	- 8,0
Giraffe	54,2	53,6	- 0,6
Buffalo bulls	35,0	70,3	+ 35,3
White Rhino	49,1	65,4	+ 16,3
AVERAGE	71,5	76,5	+ 4,9

The most substantial changes were increases in representation for buffalo bulls, waterbuck, white rhino and sable breeding herds. All species except ground hornhill, reedbuck, giraffe and elephant bulls are well represented in the five-dimensional subspace of the second analysis. Ground hornbill and giraffe were equally poorly represented in the first analysis, whereas reedbuck and elephant bulls were somewhat better- but still poorly represented.

Animal species and landscapes are represented on the five ordination axes of the second Correspondence Analysis as follows (Table 16):-

TABLE 16. RESULTS OF SECOND CORRESPONDENCE ANALYSIS : COORDINATES, REPRESENTATION AND CONTRIBUTION OF EACH ANIMAL SPECIES AND EACH LANDSCAPE OR GROUP OF LANDSCAPE UNITS, ON EACH ORDINATION AXIS.

	ELEMENTS	Total Repre-sentation	Relative no. in sample	Relative Inertia	Axis 1			Axis 2			Axis 3			Axis 4			Axis 5		
					Coordinate	Represen-tation	Contribu-tion	Coordinate	Represen-tation	Contribu-tion	Coordinate	Represen-tation	Contribu-tion	Coordinate	Represen-tation	Contribu-tion	Coordinate	Represen-tation	Contribu-tion
Animal Species	Impala	1000	585	253	350	982	326	39	12	29	-13	2	9	-20	4	27	0	0	0
	Zebra	995	153	223	-610	887	260	-178	76	156	-27	2	9	-109	29	188	22	1	15
	Blue Wildebeest	999	90	323	-948	875	371	352	120	354	-32	1	8	40	2	14	-22	1	10
	Ostrich	881	3	12	-851	633	10	-76	5	1	-94	8	2	516	232	83	-62	3	2
	Tsessebe	827	1	15	-1279	295	6	1305	306	42	312	17	6	-677	83	36	838	126	112
	Kudu Breeding Herds	970	55	50	-281	298	20	-391	578	267	105	42	49	45	8	11	-107	44	131
	Kudu Bulls	718	6	6	-157	82	1	-417	577	33	103	35	5	-78	21	4	32	3	1
	Ground Hornbill	216	2	2	45	5	0	-242	154	4	81	17	1	-17	1	0	-122	39	6
	Sable Breeding Herds	925	5	23	-77	4	0	-202	30	6	1009	738	397	51	2	1	456	151	210
	Sable Bulls	767	0	3	-304	40	0	-324	45	1	1243	662	50	207	18	2	-65	2	0
	Warthog	810	18	22	-188	99	3	241	162	33	408	462	237	169	79	52	-51	8	10
	Reedbuck	473	1	1	-231	62	0	-287	96	1	-445	231	8	182	38	2	-198	46	4
	Waterbuck	932	18	29	-116	29	1	-335	240	64	-359	275	184	406	350	299	134	38	66
	Elephant Bulls	591	6	2	-31	10	0	-87	80	1	-23	6	0	217	483	29	34	12	1
	Giraffe	536	47	10	-16	4	0	3	0	0	22	8	2	166	431	132	77	93	57
	Buffalo Bulls	703	9	9	159	78	1	-66	14	1	186	107	24	356	388	113	-193	116	68
	White Rhino	654	1	9	175	11	0	402	57	5	301	32	7	-256	23	7	-1230	531	305
Landscapes (Ch.VII reference)	8.3/4/6	981	85	66	437	850		90	36		-127	73		-50	12		48	10	
	4	984	81	64	409	730		210	192		11	1		-19	2		-115	59	
	3	939	82	30	271	688		-17	3		53	26		3	0		154	222	
	6.7-14	940	99	33	246	631		77	62		-79	66		128	171		31	10	
	1	702	8	15	532	493		211	78		234	95		112	22		-90	14	
	5	893	22	21	366	469		257	232		17	1		-130	61		-191	130	
	9(b)	644	24	14	273	417		-171	165		-15	1		105	61		-6	0	
	6.2-6	990	129	152	-550	892		-39	5		-84	21		154	70		-27	2	
	6.1/13/14	996	40	340	-1473	876		527	112		-18	0		-134	7		57	1	
	7	991	69	170	-754	810		-330	155		107	16		-78	9		-26	1	
	9(a)	907	152	35	114	125		-179	482		-91	128		-78	94		-22	8	
	2	975	161	35	139	311		22	8		201	648		20	7		8	1	
	10	880	14	7	128	112		-93	60		-127	112		-291	578		52	18	
	8.1/5/6	536	31	7	123	232		-27	12		-25	10		-134	282		2	0	
	11	593	2	5	305	98		-386	158		172	31		361	138		-397	168	

Axis 1 (Impala and densely woody landscapes with arid type field layers, versus ostrich, tsessebe, kudu breedings herds and landscapes with open woody cover and mesic type field layers; zebra and blue wildebeest concentrated on a minor unmapped landscape unit)

Six species and ten landscapes are well represented by Axis 1. Of these, impala and seven landscapes have strongly positive coordinates and are therefore contrasted with the remaining five species and three landscapes, which have strongly negative coordinates. This juxtapositioning of species and landscapes is also largely one of: (a) arid types of climate and/or soils, with relatively densely shrubby or -brushy vegetation and short, sparse arid types of field layers, favoured by impala, versus (b) comparatively mesic types of climate and/or soils and comparatively more open woody layers; zebra and blue wildebeest concentrate on a minor, shortgrass unit of the latter group of landscapes, whereas ostrich, tsessebe and kudu breeding herds are associated with the predominant type of field layers, which have relatively long dense grass cover.

The minor unit was not mapped separately so that the latter distinction is not apparent in Table 16.

IMPALA

Axis 1 represents 98,2 percent of all impala inertia and impala is the only well represented species on this axis that has a positive coordinate (Table 16). Seven of these landscapes and landscape unit groups that are well represented on this axis have the same coordinate sign as impala and seem to be preferred by impala. Of these landscapes and landscape unit groups the following five are similarly arid, with dense woody cover and sparse, arid types of field layers, suggesting that these are among the salient features of impala habitat (Ch. VII):-

(1) Landscape units with _Terminalia prunioides_ - _Combretum apiculatum_ - _Acacia nigrescens_ - _A. exuvialis_ - dominated brushveld, _Terminalia prunioides_ - _Schmidtia pappophoroides_ - dominated brushveld and river complex in Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8.3/4/6);

(2) Tropical Arid Granitic Lowveld of the Sabie River Valley (Landscape 1);

(3) Tropical Semi-arid Karoo Sediment Lowveld (Landscape 4), which has predominantly dry, brackish soils;

(4) Tropical Semi-arid Lowveld on Karoo Sediment anticline with dolorite (Landscape 5), which has a dry type of substrate; and

(5) various types of distinctively dry landscape units in Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6), particularly those with: _Acacia nigrescens_ - _Grewia bicolor_ - _Terminalia prunioides_ - _Combretum apiculatum_ - dominated brushveld (Landscape 6.7) associated with extremely shallow soils where sheet outcrop is common and with strongly undulating terrain; and _Grewia bicolor_ - _Acacia tortillis_ - _A. nigrescens_ - dominated brushveld (Landscape 6.9) of heavily grazed bottomlands (Ch. VII and distribution maps by Joubert, unpubl.).

A preference of impala for the mesic section of Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9a) is also suggested by Table 16. The relatively high presence of impala here (Table 11) is due to concentrations of impala on the strongly rolling portions of the Lebombo Mountains where the major valleys of the Nwanedzi, Nwaswitsontso and Sabie rivers cut through this range (Joubert, unpubl.). The perennial water supply, largely lacking from other parts of the range, and possibly also the relatively high water runoff and hence arid substrate and vegetation associated with the strongly rolling topography, seem to be the key factors determining the presence of impala here.

The strong association of impala with Tropical Semi-arid Doloritic Lowveld (Landscape 3, Table 16) is shown by species distribution maps (Joubert, unpubl.) to be entirely due to high concentrations of impala in the relatively arid part with granitic influence, which occurs near the Sabie and Ripape rivers. The structure here is shrubby, brushy treeveld with at least one of these layers having moderate to dense canopy cover and the proportion of sparsely tufted grasses such as Aristida spp. is relatively high. The other major unit is largely avoided (Joubert, unpubl.; Ch. VII). This latter unit has a considerably lower woody vegetation cover together with Themeda triandra - dominated field layers that are among the tallest and densest in the study area.

ZEBRA AND BLUE WILDEBEEST

Zebra and blue wildebeest, together with ostrich, tsessebe and kudu breeding herds, are partial to Landscapes 6 and 7. These species and landscapes are strongly represented by Axis 1 and have strongly negative coordinates. The inclusion of zebra and wildebeest in the group is due to a concentration of these two species on the narrow brackish short grass, open woody, flood plains of the upper Mlondozi streams (Landscape 6.13, Ch. VII). The area had, moreover, shortly before been burned to ensure an adequate area of short grass grazing for a diminishing blue wildebeest population (pers. obs.; Joubert, unpubl.). The sparse woody cover and short grass are the conditions that through numerous informal observations have become axiomatic as major requirements of preferred zebra and particularly blue wildebeest habitat.

In high rainfall cycles, when grass growth is rank and not readilly checked, even by gregarious animals such as blue wildebeest, the latter species is forced to find the required short grass in special local habitats such as on sodic soils, or on recently burned areas, where grass is short despite the wet climate (cf. Ch. IV).

OSTRICH, TSESSEBE AND KUDU BREEDING HERDS

Ostrich, tsessebe, and kudu breedings herds form the remainder of the group that is ordinated with Landscapes 6 and 7 on the negative part of the first axis. These animals are well distributed in the extensive Landscape 6.1-6 and Landscape 5 (Joubert, unpubl.) and, therefore, seem to be associated with the typical tall dense grass layers.

Ostriches also attain their highest relative density in Landscape 6.1 but have substantially high relative densities in other areas that are well represented on the first Axis, with negative coordinates. These are Landscape 6.2-6, which is _Sclerocarya caffra_ - dominated treeveld of Non-vertic Tropical Semi-arid Basaltic Lowveld, and Landscape 7, which is Vertic Tropical Semi-arid Basaltic Lowveld. The species is further represented on Axis 4.

The relative number of tsessebe in the sample is extremely low (cf. Table 11). Only 38 animals were counted in the entire study area. The presence of a group of 18 animals in Landscape 6.1, 6.13 and 6.14 (Axis 1), two occurrences involving a total of four animals in Landscape 9a (Axis 2) and a group of eight animals in Landscape 3 (Axis 5), largely determine its ordination (Joubert, unpubl.; cf. Table 13). As shown in Table 11, tsessebe belong to the presently discussed Axis 1 group because of their relatively high density in _Acacia gerrardii_ - dominated brushveld of Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.1). The structure here is sparse to moderate brushveld with scattered to sparse shrub cover and the tall dense grass layer comprises species such as _Themeda triandra_, _Digitaria eriantha_ and _Panicum coloratum_ (Ch. VII).

Kudu breeding herds owe their position on the first axis to high relative densities in Landscapes 6.1-6, 5 and 7 as shown in Table 11. They have a particularly high relative density in the Vertic Tropical Semi-arid Basaltic Lowveld (Landscape 7, Ch. VII). The most prominent characteristic of this latter landscape is that it has a mosaic of tall dense grassveld alternating with sparsely to moderately shrubby, sparse to moderate brushveld that is entirely dominated by *Acacia nigrescens*. The latter is probably a preferred kudu browse species on such relatively open, clayey plains. Kudu breeding herds are further strongly represented on Axis 2.

Axis 2 (Kudu breeding herds, kudu bulls and landscapes with relatively dense woody layers, versus tsessebe, warthog, blue wildebeest and sparsely wooded plains; waterbuck and water; ground hornbill)

Axis 2 is determined largely by blue wildebeest of Landscapes 4 and 6.13 and by kudu breeding herds of Landscapes 9(a), 9(b), 11 and 7, and juxtaposes these two species and sets of landscapes (Table 16). Kudu breeding herds and kudu bulls are by far the best represented. Tsessebe are well represented because of their association with Landscape 6.1. Waterbuck, on the other hand, are well represented largely because of their association with the same landscape as the highly determinant kudu, but because of the abundance of water.

Although ground hornbill are represented better by Axis 2 than any of the other four axes, this is of little consequence because of their low total representation on the five axes.

KUDU BREEDING HERDS, KUDU BULLS AND WATERBUCK

Kudu breeding herds, kudu bulls and waterbuck are well represented on Axis 2, with strong negative coordinates (Table 16). As shown in Tables 11 and 16, kudu breeding herds and waterbuck have high relative densities in all landscapes that have strongly negative coordinates and good representation on Axis 2. Their good representation on this axis therefore seems to be owing to their association with these landscapes, i.e.:

(1) the mesic section of the Tropical Semi-arid Rhyolitic and Granophyric Lowveld, which is hilly terrain with mostly Combretum apiculatum - dominated and C. apiculatum - A. nigrescens - dominated, shrubveld, brushveld and treeveld (Landscape 9a, Ch. VII);

(2) the drier section of the Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9b, Ch. VII), which is similar in terrain and vegetation composition but with somewhat denser stands of C. apiculatum shrub and brush, than the mesic section;

(3) Tropical Arid Rhyolitic Lowveld of the Olifants River Valley, which is hilly terrain with predominantly brushveld, thicket and bush (Landscape 11, Ch. IV); and

(4) Vertic Tropical Semi-arid Basaltic Lowveld, which is a mosaic of grassveld and Acacia nigrescens - dominated shrubby brushveld (Landscape 7, Ch. VII).

Kudu bulls are well represented on Axis 2 because of their high relative densities in the first and last of the abovementioned areas (Tables 11 & 16).

The association of kudu with Landscape 7 is also discussed in Axis 1 context, with the suggestion that this association may be owing to A. nigrescens serving as a preferred browse species. Comretum apiculatum is probably also a major preferred kudu browse species (cf. Dayton, 1978). Kudu therefore seem to prefer shrubby, brushy areas dominated by A. nigrescens and/or C. apiculatum, and with the comparatively rank grass composition and structure, characterized by *Themeda triandra*. Such field layers are typical of the relatively clayey, semi-arid, basaltic and rhyolitic region.

Data from Joubert (unpubl.) show that waterbuck are almost absolutely associated with flowing streams and large dams. Water courses are mostly dry in the granitic region, even in summer, owing to the sandy well-drained nature of this region. The basaltic region, however, is clayey and poorly drained and many streams are semi-permanent here during wet rainfall cycles. The difference in internal drainage is probably also the reason why most large dams are in the basaltic region. This accounts for the good representation of both Vertic Tropical Semi-arid Basaltic Lowveld (landscape 7) and waterbuck on the same side of Axis 2. The high relative density of waterbuck in Tropical Semi-arid Rhyolitic and Granophyric Lowveld (landscape 9; cf. Table 11) and its association with this landscape on Axis 2 is owing to three major rivers traversing the rhyolitic and granophyric areas. Waterbuck concentrate along the Nwanedzi, Nwaswitsontso and Sabie rivers where they cut through these hills (Joubert, unpubl).

TSESSEBE, WARTHOG AND BLUE WILDEBEEST

Tsessebe, warthog and blue wildebeest, in that order, are the best represented species on the positive side of Axis 2. Well represented landscapes on this part of the axis include Nos. 4, 5 and 6.1/13/14. As shown in Table 11, tsessebe occur in Landscape 6.1/13/14, whereas warthog and blue wildebeest are well represented in all three Landscapes. The landscapes involved either generally have relatively sparse shrub and brush cover or the animals were concentrated in such parts of the landscape.

The association of a big herd of tsessebe with *Acacia gerrardii* - dominated brushveld of Nonvertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.1) is dealt with under Axis 1. The shrub cover here is sparse to thinly scattered and the sparse brushveld is dominated by *Acacia gerrardii*, which typically has a particularly thin, sparse canopy.

The association of blue wildebeest with a sparsely woody brackish unit along drainage lines (Landscape 6.13) is also discussed with the first axis. The same situation exists in Tropical Semi-arid Lowveld on Karoo Sediment Anticline with Dolorite, (Landscape 5) where the relatively high blue wildebeest density is due to small concentrations on the narrow brackish grassveld zones along the Sweni River and Mrunzuluku Spruit (cf. Joubert, unpubl.; pers. obs.). The dependence of blue wildebeest on such special habitats during wet cycles was mentioned in discussing the first axis. Warthog also occur in relatively high densities in both these landscapes (Table 11) owing to their preference for such special brackish habitats with short grass and open woody structure. They also occurred on sodic patches along the upper Mlondozi streams (Landscape 6.13). Substantial numbers of warthog occurred in such habitats at several small *Acacia welwitschii* - dominated sodic areas with pans that are scattered on the Kumana Plateau, Landscape 5 (Joubert, unpubl.; Ch. VII).

Blue wildebeest and warthog both occurred in relatively high densities in tropial Semi-arid Karoo Sediment Lowveld (Landscape 4), which is best represented on the positive side of Axis 2. Structure in this landscape is variable. Both species were recorded in an *Acacia welwitschii* - dominated treeveld variation with a distinctly open woody understorey and short field layers (Cf. Ch. VII & Joubert, unpubl.)

GROUND HORNBILL

Ground hornbills are poorly represented in this five-dimensional ordination. Although Axis 2 represents the species best within this subspace, the axis accounts for only 15,4 percent of ground hornbill inertia (Table 16). Nothing is therefore concluded about them.

Axis 3 (Sable breeding herds, sable bulls, warthog and granitic landscapes, versus waterbuck, reedbuck and rhyolitic and basaltic landscapes)

Axis 3 is largely determined by sable and warthog. Both species are particularly well represented on this axis and have strongly positive coordinates. They are associated with the two granitic landscapes (Landscapes 1 & 2), which are also distinctly well represented, with positive axis coordinates. The positive granitic side of the axis is contrasted with non-granitic areas of which the salient unifying factor is free surface water in streams and dams. Waterbuck are most strongly associated with such streams and dams. Therefore waterbuck as well as the basaltic and rhyolitic landscape where flowing streams and dams are common, are best represented on the negative side of this axis (Landscapes 9a, 10 and 8.3/4/6). Reedbuck have extremely low relative inertia in the sample (Table 16). A little group in the reasonably well represented Landscape 9a (Joubert, unpubl.) is therefore responsible for their relatively high density in this landscape (Table 11) and their good representation on Axis 3.

SABLE

The association of sable with the granitic landscapes on Axis 3 is due to their relatively high density in Tropical Semi-arid Granitic Lowveld (Landscape 2). Their overall distribution in the Kruger National Park suggests that they prefer flat to undulating plains or gently rolling terrain with a moderate to high cover of broad-leaved brush and trees in combination with tall grass (Joubert, 1976; Joubert, unpubl.). They are tall-grass grazers (Joubert, 1976; Joubert, unpubl.) but their affinity for broad-leaved brush and trees is not readily explained. The broad-leaved brush and trees may be either *Combretum* spp. - dominated as in relatively mesic habitats, or *Colophospermum mopane* - dominated as in drier habitats (Ch. II; Joubert, 1976). These requirements are met by

Combretum spp. in Landscape 2 with which sable is associated on Axis 3 (cf. Ch. VII).

In the semi-arid to subhumid granitic regions south of the Timbavati River, the broad-leaved woody component is mesophyllous, dominated by *Combretum* spp. Sable are common in such granitic regions towards Pretoriuskop and in the present study area between the Manzimhlope and Muthlumuvi spruits. In semi-arid granitic areas with a high proportion of relatively clayey bottomlands with microphyllous thornveld, sable are less abundant, e.g. in the catchments of the Kolwana and Pokolweni spruits (cf. Joubert, unpubl.). Sable may also occur in semi-arid doloritic landscapes with a strong granitic influence and a high proportion of broad-leaved, *Combretum apiculatum* trees, hence their occurrence in parts of the Tropical Semi-arid Doloritic Lowveld (Landscape 3) in the study area (Ch. VII; Table 11; Joubert, unpubl.).

These animals are largely absent in the relatively clayey parts of the semi-arid region south of the Olifants River, where the vegetation is typically microphyllous thornveld, including purely doloritic areas, the Karoo Sediment plains, and the basaltic plains. The long zone of semi-arid rhyolitic hills has apparently suitable broad-leaved vegetation but has only one herd of sable, presumably because the range is narrow and isolated by the eastern fence on one side and by the microphyllous semi-arid basaltic plains on the other side.

North of the Timbavati and Olifants rivers the climate is arid and broad-leaved, sclerophyllous *Colophospermum mopane* to a large extent replaces microphyllous thornveld on the various relatively clayey soils (Ch. II) of the granitic bottomlands, doloritic intrusions, Karoo Sediments and basaltic areas. Broad-leaved woody vegetation therefore occurs throughout the breadth of the Kruger National Park in the northern region and sable have an almost equally wide distribution here. Wherever *C. mopane* reaches brush or tree height in considerable densities, sable occur (cf. Joubert, 1976). Only *C. mopane* shrubveld, which occurs on particularly clayey soils with high montmorillonite content, is largely avoided.

WARTHOG

The association of warthog with granitic landscapes on Axis 3 is owing to high relative densities in both these Landscapes 1 and 2, but particularly in Landscape 1 (Table 11). They seem to concentrate (pers. obs.) on the sodic soils with short grass that are distinctly abundant in granitic areas. They occur in particularly high densities on the broad floodplains of Tropical Arid Granitic Lowveld of the Sabie River Valley (Landscape 1; cf. Table 11). Their preference for short grass, and their abundance in the Sabie River Valley is a well-known nuisance to members of the Skukuza golf club, striving to maintain their greens, as well as to airport personnel who maintain short grass next to a runway. Warthog preference is also discussed with Axis 2.

WATERBUCK

Waterbuck are on the non-granitic side of Axis 3 because of their association with dams and flowing streams. Such water sources are rare in the granitic region but abundant in various basaltic and rhyolitic and granophyric landscapes, as discussed earlier in the introduction to Axis 3 as well as with Axis 2.

REEDBUCK

Reedbuck are better represented here than on the other axes of the five-dimensional subspace. However, because of their extremely low relative inertia and poor total representation in this subspace, the species will not receive further attention here.

Axes 4 & 5

Axes 4 and 5 poorly represent the total inertia of species, and total representation in the five-axes subspace, of some of the species involved, is low. Little is therefore to be learned of the landscape preferences of species by extending the subspace from three to five-axes.

Detrended Correspondence Analysis

Arrangement of species and landscapes by Detrended Correspondence Analysis with down-weighting of rare species is only partly similar to that of the second Correspondence Analysis, using the same data. The results nevertheless seem quite amenable to interpretation that does not contradict the interpretation of the second Correspondence Analysis. The second axis of Detrended Correspondence Analysis is discussed to illustrate this point. The first axis is identical to that obtained from correspondence analysis.

Lack of sufficient output data from the Detrended Correspondence Analysis programme, however, precludes satisfactory interpretation.

The output essentially consists of coordinates of species and landscapes on the various axes. Lack of data on the degree of representation of species on an axis is particularly limiting. A species may conceivably have a moderately strongly positive or negative coordinate, yet be poorly represented on an axis and contributes virtually nothing to this axis, e.g. white rhino on Axis 1 of the second Correspondence Analysis (Table 16). Interpretation is further confounded because landscape coordinates are all positive while the species coordinates on the corresponding axis range from negative to positive extremes. Only broad trends are, therefore, briefly mentioned here:

Axis 1

The ranking of species and landscapes, by coordinates on the first axis, is exactly the same in the second Correspondence Analysis and Detrended Correspondence Analysis.

Axis 2 (Sable, white rhino, warthog and granitic and Karoo Sediment landscapes, versus waterbuck, kudu, zebra, reedbuck, basaltic and rhyolitic landscapes)

Landscapes on Axis 2 are ranked from granitic and Karoo Sediment via arid basaltic and rhyolitic types to mesic basaltic and rhyolitic types as follows (cf. Ch. VII):

(a) Tropical Arid Granitic Lowveld of the Sabie River Valley (Landscape 1);
(b) Tropical Semi-arid Lowveld on Karoo Sediment anticline with dolorite (Landscape 5);
(c) Tropical Semi-arid Karoo Sediment Lowveld Landscape 4);
(d) Tropical Semi-arid Granitic Lowveld (Landscape 2);
(e) various relatively dry landscape units of Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.7-14);
(f) the arid-most variation of Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8.3/4/6);
(g) Tropical Semi-arid Doloritic Lowveld (Landscape 3);
(h) the remaining unit of Tropical Arid Basaltic Lowveld (Landscape 8.1/5/6);
(i) Tropical Arid Rhyolitic Lowveld of the Olifants River Valley (Landscape 11);
(j) the northern, relatively dry, part of Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9b);
(k) *Acacia gerrardii* - dominated brushveld of Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.1/13/14);
(l) *Sclerocaraya caffra* - dominated treeveld of Non-vertic Tropical Semi-arid Basaltic Lowveld (Landscape 6.2-6);
(m) the southern, relatively mesic, part of Tropical Semi-arid Rhyolitic and Granophyric Lowveld (Landscape 9a);

(n) Zonal Tropical Arid Rhyolitic Lowveld (Landscape 10); and

(o) Vertic Tropical Semi-arid Basaltic Lowveld (Landscape 7).

The corresponding arrangement of species on Axis 2, is as follows: sable bulls, white rhino, sable breeding herds, wathog, buffalo bulls, ostrich, tsessebe, blue wildebeest, giraffe, elephant bulls, impala, ground hornhill, kudu breeding herds, kudu bulls, zebra, waterbuck and reedbuck. The species at the two ends of this gradient have particularly distinct optimum relative densities in various landscapes, whereas those in the middle, with the exception of blue wildebeest, do not have such marked optima (cf. Table 11).

SABLE BULLS, WHITE RHINO, SABLE BREEDING HERDS AND WARTHOG

At the one extreme, coinciding with the granitic and Karoo Sediment end of the landscape gradient, sable, white rhino and warthog are species with such clear optima. As shown in discussing Axis 3 of the previous analysis, sable have a high preference for the granitic part of the study area (see Table 16) presumably because of their wide association with broad-leaved bushveld. The affinity of warthog for granitic areas because of the abundant short grass habitats on sodic soils, is also discussed in the Axis 3 context of the previous analysis. White rhino attain optimum densities in landscapes of Karoo Sediments or landscapes with Karoo Sediment influence, also because of a preference for short grass on sodic soils and the abundance of such habitats in these landscapes (Table 11; & Joubert, unpubl.). In the second Corresondence Anaysis white rhino are represented mainly on Axis 5, which is not discussed because of the low amount of inertia involved and the poor representation in the total subspace of the species involved.

KUDU BREEDING HERDS, KUDU BULLS, ZEBRA, WATERBUCK AND REEDBUCK

The opposite extreme of Axis 2 of the Detrended Correspondence Analysis, is occupied by the following species, which have distinct optimum densities in the landscapes mentioned:

(a) kudu, which, as discussed under Axes 1 and 2 of the second Correspondence Anaysis, prefer rankgrass landscapes with abundant browse found mainly in mesic non-granitic landscapes;

(b) zebra, which have their optimum on sodic, shortgrass areas of the non-vertic basaltic plains (Landscape 6.13 Table 11); and

(c) waterbuck, which, as discussed in Axis 3 - context of the second Corresondence Anaysis, associate with streams and dams - the latter are a common factor shared by non-granitic semi-arid landscapes in the study area; and

(d) reedbuck, which are scarce, occurring in the mesic basaltic and rhyolitic areas.

COMPARISON OF AXIS 2 WITH SECOND CORRESPONDENCE ANAYSIS

Axis 2 is, therefore, essentially one of granitic and Karoo Sediment versus basaltic and rhyolitic areas, with various factors differently governing the preference of the species for either of the two groups of landscapes. A highly similar distinction, also juxtaposing sable and warthog on the one hand, with waterbuck on the other hand, is the essence of Axis 3 in the Second Correspondence Analysis.

VII. LANDSCAPES (3): DESCRIPTION OF CLIMATE, PHYSIOGRAPHIC AND VEGETATION PATTERNS, AND MEDIUM TO LARGE HERBIVORE FAUNA

Each landscape is described under four subheadings:- (a) An "Introduction" provides a brief description of the salient features of the ecosystem. Description of its climatic component is limited to a brief classification provided in the title and "Introduction", (b) "Physiographic pattern" deals more fully with physiograhic aspects of each ecotope of the land type, (c) "Vegetation pattern" elaborates on the association complex and (d) "Fauna" provides some detail on the medium and large herbivores of the landscape. However, these latter three sections also only deal with major physiographic features, the gross appearance of the vegetation in terms of structure and dominant species, and little more than a list of animal species that prefer the relevant landscape, or contribute significantly to its medium and large herbivore community. Access to supporting data and greater detail on physiography and vegetation is facilitated through cross references to associations and releves dealt with in Chapter IV and Appendix 1. Chapter VI similarly provides more detailed information on the fauna. Subsectioning under "Physiographic pattern" and "Vegetation pattern" are in accordance with landscape units. The number of a subsection is also the number of its landscape unit. Thus corresponding numbering and headings serve to link ecotopes and associations of the same landscape units.

Various landscapes and landscape units had not been well delineated at the time of sampling. Sampling stratification is therefore crude in comparison with the final classification system and some landscape units have been poorly sampled. This is apparent from the number of illustrative releves cited for each landscape unit. In some instances the same plant association contributes to more than one landscape but was properly sampled in one landscape only. The corresponding landscape unit for the other landscape is then poorly represented in the sample and may have remained undetected if scarce. Moreover, many drainage line associated landscape units have purposely not been sampled, pending a special drainage line survey. Such bottomland sites are, therefore, only quite superficially described. Bearing in mind these limitations, this Chapter has two other major uses:-

Landscapes are easier to identify than plant communities. Furthermore, component plant communities are here described only in terms of gross appearance in that particular landscape. Users wishing to identify a stand of vegetation phytosociologically may, therefore, find it easiest to first identify the landscape, using Fig. 1 (Map in folder), together with the vegetation pattern and physiographic pattern as summarised in the Table of Contents. They may thereafter identify the particular stand of vegetation in the section on "Vegetation pattern". Chapter IV will then provide more phytosociological information on the identified vegetation type. This was intensively tested for the entire 40km of roadside vegetation between Skukuza and Tshokwane and found to be successful. The test transect traversed Landscapes 1-4 and 6.

Similarly, identification of landscape and landscape unit and cross reference to Chapter IV will yield a quick indication of soil and other abiotic site characteristics.

1. Tropical Arid Granitic Lowveld of the Sabie River Valley

Introduction

A distinct landscape occurs in the granitic sections of the valleys of the perennial Sabie and Sand rivers. The landscape comprises only approximately 25 km^2 of the study area. Although the climate is semi-arid, the overall character of this ecosystem is more arid owing to the valley-associated physiography and biotic influence.

The average annual rainfall is 550-600mm (Gertenbach, 1980) and the granite, typically, is undulating. Soils on the crests are shallow, with high water runoff and are therefore dry. Clay and sodium released from weathering granite accumulate in bottomlands where they produce arid clayey, commonly sodic, soils (see Chlorido virgatae - Justiceion flavae, Ch. IV).

These arid soils support an arid type of vegetation, which, together with the perennial drinking water, encourage a high density of impala (Ch. VI). The impala in turn trample, browse, graze and manure this landscape. Superficial inspection of sandy crests reveals marked compaction of the soil crust, which must result in increased runoff and aridity. The summit field layers, which are sparse, forbaceous and favourable to impala, are structurally and floristically strongly related to arid vegetation types, particularly those of sodic and puddled soils. Woody structure is also altered by impala in the process. Through browsing they produce an open understorey, with a browse line at 1,5m, in most landscape units. However, on upland sites with shallow gravelly soils, retrogression of the field layer towards more arid types, is associated with increased shrub and brush cover.

The medium to large herbivore community consists largely of forb, shrub and brush browsers, shortgrass grazers and river and bushloving species, i.e. impala, giraffe, kudu, warthog, buffalo bulls and bushbuck.

Physiographic pattern

1.1 Crests and middleslopes with poorly developed soils

On the narrow watershed between the Sabie and Sand rivers, and on similar crests on the opposite sides, close to the rivers, the soils are usually less than 500mm deep and commonly litholitic. These soils are of the Mispah mispah Series (e.g. Releve 332, Ass. 5.4, Table 4 Ch. IV) or the

Glenrosa glenrosa Series (e.g. Releves 278 & 308, Ass. 5.4, Table 4, Ch. IV). A horizons are non-calcareous with coarse sand or coarse loamy sand texture, 6-15 per cent clay, conductivity of 200-1500 micro mhos and varying pH (4,6 - 6,7 in the examples cited). Trampling near the river is severe and profiles may have a weak tendency towards grain cohesion (i.e. massiveness, e.g. Releve 332).

1.2 Crests and middleslopes with moderately well-developed soils

Another crest ecotope of these river valleys has somewhat better developed soils, usually less than 500mm deep and of the Glenrosa glenrosa Series (e.g. Releves 140, 279 & 286, Ass. 5.4, Table 4, Ch. IV), but occasionally deeper and of the Hutton portsmouth Series (i.e. eutrophic, e.g. Releve 128, Ass. 5.4, Table 4, Ch. IV). A horizons are non-calcareous with coarse loamy sand texture, 6-15 per cent clay, conductivity of 160-250 micro mhos and a pH of 5,2-6,4 in the cited examples.

1.3 Well-drained, sandy, lower slopes

Some lower slopes have non-calcareous sand to sandy loam soils of the Glenrosa Form, similar to those of the previous ecotope but with a dissimilar vegetation structure and presumably higher conductivity. Releves 129 and 280 (Ass. 5.4, Table 4, Ch. IV) are examples. A horizon clay content here is 5-18 per cent, pH 5,0-6,3 and A horizon conductivities are 600 micro mhos in both examples.

1.4 Bottomlands with sodic duplex soils

The terrain is well-dissected by numerous young drainage lines where transition from the aforementioned crests and middleslopes to drainage lines is rapid. However, along the banks of the much older Sabie and Sand rivers, broad, flat, level to gently sloping bottomlands with sodic duplex soils occur extensively. The soils are of the Sterkspruit grootfontein Series, i.e. A horizons are orthic, with 6-15 per cent clay and coarse sand, and B horizons are prismacutanic and predominantly non-red. Releves 309 and 333 (Ass. 1.1, Table 3, Ch. IV) are examples. In these two examples, B horizon pH is 6,7-7,7 and conductivity of B horizons 540-700 micro mhos.

1.5 River banks and seasonal river beds

These habitats have not been sampled but carry a distinct vegetation that is briefly described in the following section.

Vegetation pattern

1.1 *Acacia exuvialis - A. tortilis - Grewia* spp. - *Dichrostachys cinerea - Ziziphus mucronata* - dominated brushveld and treeveld of crests and middleslopes with poorly developed soils

The vegetation of crests and summits near the rivers is classified as Association 5.4 (Table 4, Ch. IV).

As shown in Appendix 1, the structure of the sampled examples (Releves 278, 308 and 332, Ass. 5.4, Table 4, Ch IV) is moderately shrubby, moderately brushy treeveld or moderately shrubby brushveld, with *Sclerocarya caffra* as the most abundant tree and *Combretum apiculatum* as the most abundant brush species (Fig 2, Appendix 5). Representative releves are few, however, and casual inspection suggests that the brush and shrub cover comprises mainly *Acacia exuvialis, A. tortilis, Grewia bicolor, G. hexamita, G. flavescens, Dichrostachys cinerea* subsp. *africana* and *Ziziphus mucronata*.

The grass cover is sparse. Commonly abundant grasses include *Digitaria eriantha, Panicum maximum, Aristida congesta* subsp. *barbicollis* and *Pogonarthria squarrosa* (Ass. 5.4, Table 4, Ch. IV).

1.2 *Sclerocarya caffra* - *Combretum apiculatum* - dominated brushveld and treeveld of crests and middleslopes with moderately well-developed soils

The vegetation here also belongs to Association 5.4, which is inventorised in Table 4, Ch. IV. Releves 128, 140, 279 and 286 are representative.

Structure in this landscape unit is sparsely to densely shrubby, moderately brushy to thicketed, with trees scattered to dense. *Sclerocarya caffra* is the usual dominant tree and *Combretum apiculatum* is characteristically the dominant brush species. Shrub dominants vary and may include *Combretum zeyheri*, *Pterocarpus rotundifolius* and *Dichrostachys cinerea* subsp. *africana*. Dayton (1978), whose findings apply to this particular landscape unit, described a lack of *C. apiculatum* browse below 2,5m, owing to impala impact below 1,5m and to a lesser extent to kudu impact up to 2,5m.

Common grass dominants include *Sporobolus fimbriatus*, *Aristida congesta* subsp. *barbicollis*, *Pogonarthria squarrosa*, *Panicum maximum* and *Digitaria eriantha*.

1.3 *Acacia nigrescens* - *Combretum zeyheri* - *C. apiculatum* - dominated treeveld of well-drained, sandy lower slopes

Yet another phase of Association 5.4 (Table 4, Ch. IV) is found in this landscape, on lower slopes that are sandy but with presumably relatively high conductivity. This phase is unique in that its tree component resembles that of some clayey, non-sodic, granitic bottomlands, found in Landscape 2, but its field layer, as well as elements in its shrub and brush layers, resemble those of sandy granitic crests.

Releves 129 and 280 (Ass. 5.4, Table 4, Ch. IV), which are the only formal examples, are typical and are sparsely to moderately shrubby, moderately to densely brushy, moderate to dense treeveld (Appendix 1). The tree layer is dominated by

Acacia nigrescens but Sclerocarya caffra is usually also prominent. Prominent brushes and shrubs usually include A. nigrescens, Combretum zeyheri, C. apiculatum, Grewia monticola and Ziziphus mucronata.

Field layer dominants indicate sandy, well-utilized habitats and may include Sporobolus fimbriatus, Digitaria eriantha, Panicum maximum and Aristida spp.

1.4 Acacia grandicornuta - dominated brushveld and treeveld of bottomlands with sodic duplex soils

Sodic bottomland vegetation in this landscape typically belongs to Association 1.1.1 (Table 3, Ch. IV).

Acacia grandicornuta dominates all three woody levels in the typical sparsely shrubby, moderate brushveld, with scattered trees (e.g. Releve 333, Fig. 3, Appendix 5, Ass. 1.1, Table 3, Ch. IV); or sparsely shrubby, moderately brushy, sparse treeveld (e.g. Releve 309, Ass. 1.1, Table 3, Ch. IV; Appendix 1). This shrub layer is usually sparse up to the impala browse line at 1,5m.

Sporobolus nitens is usually the dominant grass in a short sparse field layer. The shade tolerant unpalatable (McDonald,[1] pers. comm.) Enteropogon macrostachyus or more palatable (Engelbrecht, unpubl.) Panicum maximum are subdominant and grow under woody canopies. A rich variety of forbs contribute considerably to the field layer. Forbs with commonly high cover include Achyranthes aspera, Cyathula crispa, Solanum panduraeforme and S. incanum (Table 3, Ch. IV).

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1. Mr I. McDonald, Natal Parks, Game and Fish Preservation Board, P.O. Box 25, Mtubutuba 3935, South Africa)

1.5 Riparian bush and thicket, and reed stands of seasonal river beds

Dense bush typically occurs on the banks of perennial watercourses in the major rivers of the granitic region. Thicket of similar species composition occurs on small elevated islands of the seasonal floodbeds. The floodbeds have dense 2-5m tall stands of the reed *Phragmitis australis*.

The following typical species list is a sample from the Sabie River bush and thicket near Skukuza:-

Woody *Salix woodii, Trema orientalis, Ficus capreifolia, F. sycomorus, Rubus rigidus, Acacia ataxacantha, A. burkei, A. nilotica, A. robusta, Schotia brachypetala, Cassia didymobotrya, Abrus precatorius, Zanthoxylum humile, Ekebergia capensis, Trichilia emetica, Securinega virosa, Phyllanthus reticulatus, Bridelia micrantha, Spirostachys africana, Maytenus senegalensis, Grewia flavescens, Ochna natalitia, Combretum erythrophyllum, Syzygium cordatum, S. guineense, Euclea natalensis, Diospyros mespiliformis, Nuxia oppositifolia, Cordia ovalis, Lantana camara, Lippia javanica, Breonadia microcephala*, *Kraussia floribunda*.

Grasses *Oplismenus hirtellus, Panicum deustum, Cymbosetaria sagittifolia* and *Sporobolus africanus*.

Forbs *Smilax kraussiana, Pupalia lappacea, Achyranthus aspera, Abutilon guineense, A. ramosum, Sida cordifolia, Melhania forbesii, Acanthospermum hispidum*.

Fauna

Impala have a strong preference for this and six other landscapes (Axis 1, 2nd Correspondence Analysis, Ch. VI). Average density in the present landscape was approximately 12,3 impala per km^2 (Table 11, Ch. VI). Warthog have a particular preference for this landscape (Axis 3, 2nd Correspondence Analysis; Axis 2, Detrended Correspondence Analysis: Ch. VI). Their density here was approximately 1,1 warthog per km^2 (Table 11, Ch. IV). Ground hornbill, with an average density of 0,2 per km^2, also had a distinct optimum in Landscape 1.

Other medium to large herbivores with a considerable presence in this landscape include giraffe ($\pm$0,9 individuals per km^2), kudu ($\pm$0,4 per km^2) and buffalo bulls ($\pm$0,2 per km^2). The dense riparian bush along the granitic section of the perennial Sabie River, is the most favoured bushbuck habitat in the Central District and among the most favoured in the entire Park.

The strongest determinants of the medium- to large-herbivore community in this landscape seem to be abundant browse (favouring impala, giraffe and kudu), aridity-associated short, sparse grass cover with abundant forbs (warthog, impala and kudu), abundant perennial water (impala and buffalo bulls) and riparian bush (bushbuck).

2. Tropical Semi-arid Granitic Lowveld

Introduction

Approximately 1 000km^2 of the study area belong to this landscape, which covers most of the western part of the Central District. The landscape is interrupted by large blocks of Tropical Semi-arid Doloritic Lowveld (Landscape 3). The mean annual rainfall is 550-600mm (Gertenbach, 1980).

As in the former landscape, the granite forms undulating terrain. Clay and sodium released from weathering granite accumulate in bottomlands, leaving leached sandy soils in upland sites and producing clayey, sometimes sodic duplex, soils in bottomlands (See Chlorido virgatae - Justiceion flavae, Ch. IV). The landscape, as a result, typically has a pattern of deep sandy summits, with broad-leaved deciduous Bushveld, each surrounded by a fringe of winter-dry grassveld on sloping duplex soils (Fig. 3). The grassveld merges into deciduous thornveld of lower slopes with various forms of clayey soils. Grassveld and sparse shrubveld also occur on duplex soils of valley bottoms along older spruits. Small, bouldery granitic hills, which are resistant erosional remnants of the pediplanation process, interrupt the undulating granitic peneplain. The hills have a distinct vegetation.

Field layers of the broad-leaved bushveld on sandy crests are relatively sparse, dominated by a mixture of short grasses and tall, but sparsely tufted, grasses. On the duplex soils the grassveld and Bushveld field layers consist of short grasses. Grasses in thornveld of weak to moderate structure clay are lush, relatively dense and tall.

The proportions of these components vary. Where drainage systems are young the proportion of broad-leaved summit Bushveld is high. Catchments with older spruits have larger proportions of grassveld and thornveld. The spruits are sandy and well-drained internally. Consequently, natural surface water is scarce except for short periods after rainstorms.

The major determinants of the medium- to large-herbivore community seem to be the abundance of trees and brushes, combined with relatively tall grass layers and the scarcity of water. The area is particularly favourable to sable antelope but the other animal species occur here in low densities as compared with their densities elsewhere in the study area. These latter species include, in order of abundance, impala, zebra, blue wildebeest, kudu breeding herds, giraffe, warthog, buffalo bulls, elephant bulls and kudu bulls.

Physiographic pattern

2.1 Bouldery inselberge

Inselberge with broken bouldery outcrop are rare in the study area but become more frequent towards the retreating escarpment. These inselberge of the granitic peneplain are erosional remnants of the pediplanation process. Unclassified Releve 194 is an example.

2.2 Crests with deep sandy soils

Crests in moderately weathered undulating terrain with low drainage line density commonly have deep sand and loamy sand soils with depth exceeding 700mm and 6-15 per cent clay in A and B horizons. These soils are predominantly of the Hutton portsmouth Series, i.e. an orthic A horizon, over a red apedal non-calcareous B horizon with coarse sand and 6-15 per cent clay (e.g. Releves 174, 176, 188, 190 & 295, Ass. 5.2, Table 4, Ch. IV). Quadrats 182 and 290 are less clayey and of the Longlands tayside and Hutton moriah Series respectively. The soil in Quadrat 182 has a thick E horizon and is, therefore, relatively wet. These deep sandy soils are also commonly of the Clovelly Form, which is similar to the aforementioned Hutton Form soils but the B horizon is wetter and yellow-brown, apedal. The Clovelly Form soils are of the Clovelly paleisheuwel Series, with less than six per cent clay (e.g. Releve 298, Ass. 5.2, Table 4, Ch. IV) and Clovelly denhere Series, with 6-15 per cent clay (e.g. Releve 130 & 223, Ass. 5.2, Table 4, Ch. IV). Occasionally the relatively deep sandy soils are of the Glenrosa glenrosa Series, i.e. with lithocutanic B horizons, and with coarse sand and 6-15 per cent clay in A horizons (e.g. Releves 177 & 203, Ass. 5.2, Table 4, Ch. IV).

2.3 Crests with relatively shallow sandy soils

Crests in strongly weathered terrain with high drainage line density have relatively shallow sandy and loamy sand soils, usually less than 700 mm deep and with 6-15 per cent clay in A and B horizons. Like the crests with deeper soils, the soils are mostly of the Hutton portsmouth Series, (e.g. Releves 197, 199, 205 & 296, Ass. 5.3 & Releves 191 & 302, Ass. 5.4.2; Table 4, Ch. IV), or occasionally of the similarly sandy Clovelly denhere Series (e.g. Releve 215, Ass. 5.3, Table 4, Ch. IV) and Glenrosa glenrosa Series (e.g. Releve 172, Ass. 5.3 & Releve 175, Ass. 5.4.2; Table 4, Ch. IV).

2.4 - 2.6 Duplex soils

Duplex soils are common on middleslopes and in bottomlands, and typically adjoin the sandy crests along a narrow boundary. The duplex soils may have loose granular, or cemented massive sandy A horizons; and strongly structured prismacutanic B horizons of deflocculated clay (cf. Ch. IV). The sandy A horizons are relatively thick in the zones bordering on the summit regions. Loose granular A horizons may occur from high slopes to bottomlands, whereas massive granular A horizons are more restricted to the lower slopes. B horizons have very hard consistencies.

Where an extremely leached E horizon is present, owing to lateral drainage over the top of the B horizon, the duplex soils are of the Estcourt Form. Towards the lower slopes and bottomlands, the E horizon is usually absent and the duplex soils of the Sterkspruit Form.

The hard impenetrable B horizons of the sodic soils force internal drainage water to the surface, causing seasonal seepages. These may result in small seasonal pans owing to utilization and associated trampling by herbivores. The deflocculated state renders these sodic soils highly susceptible to erosion where the vegetation cover is unduly disturbed.

Three major ecotopes with duplex soils occur in this landscape:-

(2.4) On level to gentle, usually 0-2^{o}, slopes with loose granular topsoils, the pH of A and B horizons usually exceed 5,5 and 6,8 respectively (e.g. Releves 131, 133, 171, 173, 180, 187 & 297, Ass. 4, Table 3, Ch. IV).

(2.5) Similar duplex soils with masive cemented A horizons occasionally occur in level to gently sloping bottomlands (e.g. Releve 210, Ass. 4.2, Table 3, Ch. IV).

(2.6) On steeper, 3-4^{o} slopes, pH values are comparatively lower (e.g. Releves 179, 183, 201, 213 & 216, Ass. 7.1.2, Table 5, Ch. IV)

2.7 Non-duplex bottomland soils

Non-duplex soils with loam to sandy clay loam A horizons and lithocutanic B horizons also commonly occur in well-drained, usually 3-5^{o} sloping, bottomlands. A horizons here typically have 15-35 per cent clay and coarse sand. The A horizons are commonly melanic, probably owing to doloritic influence in these granitic bottomlands (Venter,[2] pers. comm.). Where A horizons are melanic, the soils are of the Mayo mayo Series (e.g. Releves 132, 181, 186 & 202, Ass. 7.1.3, Table 5, Ch. IV). The soils with orthic A horizons are of the Glenrosa robmore Series (e.g. Releve 178, Ass. 7.1.3, Table 5, Ch. IV). Releve 189 (Ass. 7.1.3, Table 5, Ch. IV), is from a Glenrosa glenrosa soil with slightly less clay, i.e. 13 per cent, in the A horizon. Releves 139, 216 & 294 (Ass. 7, Table 5, Ch. IV), from relatively gentle, 2-3^{o}, slopes are

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2. Mr F. Venter, Research Institute, Private Bag X402, Skukuza 1350, South Africa.

respectively from duplex Sterkspruit sterkspruit and Sterkspruit grootfontein soils, which have prismacutanic B horizons with poor internal drainage, and from the Westleigh sibasa Series with a soft plinthic B horizon, which is also poorly drained internally. The latter three relatively poorly drained examples, are transitional to the duplex soil ecotopes. Releve 301, also from a duplex soil (Estcourt Form, Ass. 2.1.1, Table 3, Ch. IV), is from a boundary with the adjoining Karoo Sediment Landscape 4.

2.8 Drainage lines

These have not been sampled but are distinct ectotopes with sandy seasonal spruit beds and levees.

Vegetation pattern

2.1 Vegetation of bouldery inselerge

The following species list is from Mfenene and other granitic inselberge near the Nwatindlophu Spruit including Releve 194, and from another cluster of low hillocks, named Flagkoppie:-

Woody Aloe marlothii, Ficus ingens, F. soldanella, Ximenia caffra, Boscia albitrunca, Maerua parvifolia, Albizia forbesii, Acacia nigrescens, Dichrostachys cinerea subsp. africana var. africana, D. cinerea subsp. africana var. setulosa, Schotia brachypetala, Afzelia quanzensis, Cassia abbreviata, C. petersiana, Peltophorum africanum, Dalbergia melanoxylon, Lonchocarpus capassa, Erythrina lysistemon, Balanites maughamii, Commiphora mollis, C. neglecta, Ptaeroxylon obliquum, Securinega virosa, Phyllanthus reticulatus, Suregada africana, Spirostachys africana, Euphorbia cooperi, Sclerocarya caffra, Lannea stuhlmannii, Maytenus heterophylla, M. tenuispina, Cassine aethiopica, C. transvaalensis, Hippocratea *longipetiolata*, *Ziziphus mucronata*, *Berchemia discolor*, *Rhoicissus tridentata*, *Grewia bicolor*, *G. flavescens*, *G. hexamita*, *G. monticola*, *G. subspathulata*, *Dombeya rotundifolia*, *Sterculia rogersii*, *Ochna natalitia*, *O. pretoriensis*, *Combretum apiculatum*, *C. mossambicense*, *C. zeyheri*, *Cussonia natalensis*, *Pappea capensis*, *Manilkara mochisia*, *Euclea natalensis*, *Diospyros mespiliformis*, *Jasminum fluminense*, *Strychnos madagascariensis*, *S. spinosa*, *Ehretia amoena*, *E. rigida*, *Iboza riparia*, *Tricalysia allenii*, *Kraussia floribunda*, *Vangueria infausta*, *Pavetta catophylla*.

Grasses and forbs (list incomplete for areas sampled)

Panicum maximum, *Sansevieria hyacinthoides*, *Asparagus falcatus*, *A. minutiflorus*, *Pupalia lapacea*, *Achyranthes aspera*, *Abrus sp.*, *Dolichos linearis*, *Cissus quadrangularis*, *C. rotundifolia*, *Sarcostemma viminale*, *Dregea macrantha*, *Barleria affinis*.

2.2 *Combretum zeyheri* - *Pterocarpus rotundifolius* - *Terminalia sericea* - dominated treeveld and brushveld of crests with deep sandy soils

Crests with deep sand and loamy sand soils have vegetation belonging to Association 5.2 (Table 4, Ch. IV), e.g. Releves 130, 174, 176, 177, 182, 188, 190, 203, 223, 290, 295 & 298 (Fig. 4, Appendix 5).

The structure is mostly moderately to densely shrubby, moderate to dense brushveld or similarly shrubbby and brushy, sparse treeveld. *Sclerocarya caffra* is the dominant tree (Appendix 1). As discussed in Chapter IV (Ass. 5.2), *Combretum zeyheri* is dominant at the shrub and brush levels in relatively dry sites such as on convex terrain with Hutton soils. *Pterocarpus rotundifolius* and *Terminalia sericea* dominate the shrub and brush levels in wetter sites such as on soils of the Clovelly Form or in flat to concave terrain with soils of the Hutton Form. A narrow zone at the edge of the sandy summits, bordering on the impenetrable duplex soils, is particularly wet and leached owing to water forced to the surface. A pure stand of *T. sericea* in this zone, characteristically fringes summit areas. The dominant grasses of this landscape unit are *Digitaria eriantha*, *Panicum maximum* and *Pogonathria squarrosa* and, occasionally, *Brachiaria nigropedata* and *Setaria flabellata*.

2.3 *Combretum apiculatum* - dominated treeveld and brushveld of crests with relatively shallow sandy soils

Shallow sandy soils of crests in strongly weathered terrain have vegetation belonging to Associations 5.3 and 5.4 (Table 4, Ch. IV, e.g. Releves 175, 191, 197, 199, 205, 296 & 302).

The structure is typically moderately to densely shrubby, moderate to dense brushveld, or equally shrubby and brushy sparse to moderate treeveld. Tree layers are typically dominated by *Sclerocarya caffra*. Occasionally prominent trees include *Lannea stuhlmannii*, *Lonchocarpus capassa* and *Combretum apiculatum*. Brush and shrub layers are characteristically dominated by *Combretum apiculatum*. The variety of dominant grasses (Ch. IV) mostly include *Digitaria eriantha* and *Heteropogon contortus*.

2.4 Grassveld on high pH duplex soils with loose, granular A horizons

A grassveld fringe, which belongs to Association 4 (Table 3, Ch. IV), typically occurs immediately below the broad-leaved bushveld of crests (e.g. Releves 131 & 297, Ass. 4, Table 3, Ch. IV). On gentle slopes this grassveld zone may be wide (e.g. Releves 173 & 180, Ass. 4.2, Table 3, Ch. IV) and extend down to bottomlands (e.g. Releve 171, Fig. 5, Appendix 5, Ass. 4.2, Table 3, Ch. IV). Scattered shrubs of *Albizia harveyi* and *Ormocarpum trichocarpum* may occur. *Dactyloctaenium aegypteum* and *Digitaria eriantha* are typically the dominant grasses.

Where this landscape unit is narrow, shrubs and brushes from adjoining crest and bottomland units may occur and the structure is sparsely shrubby, sparse brushveld (e.g. Releve 133, Ass. 4.2, Table 3, Ch. IV).

In particularly wet sites, such as Releve 187 (Ass. 4.2, Table 3, Ch. IV), the field layer is dominated by mesophyllous grasses and sedges, e.g. Eragrostis atrovirens, Sporobolus smutsii, Cyperus amabilis and Mariscus aristatus.

2.5 Euclea divinorum - dominated sparse brushveld on bottomland duplex soils with massive A horizons

Releve 210 is representative of this vegetation, which belongs to Association 4.2 (Table 3, Ch. IV). This unit is therefore closely related to the previous grassveld unit and the one may grade into the other.

The typical Releve 210 (Ass. 4.2, Table 3, Ch. IV) is sparsely shrubby, sparse brushveld with Euclea divinorum brushes dominating both levels (Appendix 1). The dominant grasses here are Eragrostis superba and the usual (cf. former landscape unit) Dactyloctaenium aegypteum and Digitaria eriantha.

2.6 Acacia gerrardii - dominated brushveld and treeveld on well-drained, relatively low pH duplex soils

Relatively low pH duplex soils of moderate 2-3^{o} slopes typically occur as a zone immediately below the grassveld fringe (Landscape Unit 2.4). The vegetation belongs to Association 7.1.2 (Table 5, Ch. IV). Releves 183, 201 & 213 (Ass. 7.1.2, Table 5, Ch. IV), which have loose, granular A horizons, are the most representative of this landscape unit.

As shown in Appendix 1, the structure may be moderately shrubby moderately brushy, sparse treeveld or sparsely shrubby, sparse brushveld. Acacia nigrescens or Sclerocarya caffra are the dominant trees. Acacia gerrardii is typically dominant (e.g. Releves 183 & 213) or codominant (e.g. Releve 201) at the brush and shrub levels. Common field layer dominants include Digitaria eriantha, Themeda triandra and Panicum coloratum.

2.7 Pterocarpus rotundifolius - Combretum hereroense - Peltophorum africanum - Bolusanthus speciosus - Maytenus heterophylla - Acacia nigrescens - A. gerrardii - Sclerocarye caffra - dominated brushveld and treeveld of non-duplex bottomland soils

The vegetation of non-duplex bottomland soils, excluding drainage lines and their banks, belongs to Association 7.1 (e.g. Releves 132, 139, 178, 181, 186, 189, 216 & 294, Table 5, Ch. IV). Releve 301 (Ass. 2.1.1, Table 3, Ch. IV), is from the boundary with the adjoining, Karoo Sediment, Landscape 4, and is transitional.

Structure in this landscape unit is variable and may be sparsely to densely shrubby, sparsely to densely brushy, with trees absent, scattered or forming a sparse to moderate layer (Appendix 1). Sclerocarya caffra and Acacia nigrescens are usually the dominant trees where trees are present. Major contributors to total woody cover usually include three to five of the species mentioned in the heading of this landscape unit. Field data sheets show that in Releve 216 (Ass. 7.1, Table 5, Ch. IV), which is physiographically like Landscape Unit 2.6 and therefore transitional, Acacia gerrardii is accordingly among the first three woody dominants. The grasses Themeda triandra and Digitaria eriantha are usually the field layer dominants and Heteropogon contortus and Panicum maximum are commonly codominant or subdominant.

2.8 Drainage line vegetation

The youngest drainage lines have a vegetation that is barely distinctive from the surrounding bottomlands. Older drainage lines have sandy channels and levees and a vegetation that is fragments of riparian bush and thicket, and reed stands, of major rivers. (e.g. Landscape 1.5).

The palm *Phoenix reclinata* and the reed *Phragmites australis* are common in sandy seasonal streambeds.

Among the earliest prominant riparian trees commonly found on relatively young spruitbanks are *Acacia robusta, Schotia brachypetala, Trichilia emetica* and *Diospyros mespiliformis.* The shrub *Maytenus senegalensis* is similarly prominent and common.

Fauna

Only sable antelope have a distinct preference for this landscape. They have an affinity for a combination of broad-leaved brushveld and long grass and can tollerate travelling long distances to water (Axis 3, 2nd Correspondence Analysis & Axis 2, Detrended Correspondence Analysis, Ch. VI). Average sable density in this landscape is nevertheless only approximately 0,1 animals per km^2 (including breeding herds and bulls; Table 11, Ch. VI). The following scattered medium and large herbivores of this landscape have stronger preferences for other landscapes (Table 11, Ch. VI): impala, with average density of 4,9 per km^2 in the present landscape; zebra (0,9 per km^2); blue wildebeest (0,5 per km^2); kudu breeding herds plus bulls (0,5 per km^2); giraffe (0,4 per km^2); warthog (0,2 per km^2); buffalo bulls (0,1 per km^2); and elephant bulls (0,1 per km^2).

Densities of medium to large herbivores in this landscape are, therefore, low. The scarcity of natural surface water, particularly in dry cycles and in winter, is a major limiting factor. Woody vegetation, particularly on sandy summits, is dense in comparison with the nearby doloritic and basaltic plains. This is also limiting to some species.

This landscape is not optimal habitat for species such as impala, zebra, blue wildebeest and warthog, which seem to prefer short, arid types of field layers and nearby surface water. However, Landscape Units 6.4/5 of this landscape do provide refuge to small groups of these animals during wet cycles. Artificial water supplies also seem to render the landscape more favourale to these species.

3. Tropical Semi-arid Doloritic Lowveld

Introduction

The northernmost Central District example of this landscape falls outside the study area. This example covers approximately 80km^2. Its vegetation is mapped and described by Gertenbach (1978), who named it *Sclerocarya caffra/Acacia nigrescens* Savannah. The remaining Central District examples amount to 350km^2 of the present study area and occur as four major blocks (Fig. 1):-

a) A northern block occurs across the near-upper Nwaswitsontso River and includes the tributary catchments of the Mluwati, Tswayini, Malawu and Misane spruit systems.
b) Further south, almost adjoining the former, another block includes the middle Vutome and middle Shiweni catchments and the unnamed catchment inbetween. These catchments belong to the Ripape Drainage System and the block ends at the Ripape River in the south.
c) The Rooigrasvlakte plateau, between the middle Nwatindlophu, the Manzimahle and middle Mutlumuvi spruits, belongs to this landscape type.

d) The southernmost block includes much of the watershed region between the Mahungwana and Shibandlukeni spruits in the west and the Saliji Spruit in the east.

These doloritic blocks interrupt the Tropical Semi-arid Granitic Lowveld (Landscape 1) and adjoin the Tropical Semi-arid Karoo Sediment Lowveld (Landscape 4) in the east. The mean annual rainfall according to Gertenbach (1980) is between 550mm and 600mm.

The doloritic landscape is flat to gently undulating and slopes seldom exceed 3^{o}. Some landscape units are almost purely doloritic. However, where doloritic landscape blocks are small or narrow and towards the edges of large blocks, the granitic influence becomes strong. Occasionally granitic enclaves within predominantly doloritic landscapes are too small to represent a granitic landscape from watershed to watershed. Such enclaves occur as isolated granitic crests surrounded by doloritic slopes and are treated as a distinct unit of Tropical Semi-arid Doloritic Lowveld.

Crests and middleslopes usually have shrubby, brushy treeveld. Comparatively purely doloritic crests and middleslopes have sparse brush and shrub layers and a rank grass layer. Moderately dense shrub and brush layers together with sparser grass cover, on crests and middleslopes, are characteristic of granitic influence. Broadleaved <u>Combretum</u> spp., i.e. <u>C. apiculatum</u> and <u>C. zeyheri</u>, also become prominent with increasing granitic influence. The most purely doloritic crests and middleslopes are further characterized by the presence and dominance of the grass <u>Themeda triandra.</u> Absence of this grass and presence and abundance of the grasses <u>Sporobolus frimbriatus</u> and <u>Aristida</u> spp., are characteristic of strong granitic influence.

In bottomlands the predominantly doloritic sites are moderately shrubby to scrubby, whereas all woody cover is typically sparse to scattered on the sodic bottomlands associated with granitic influence.

Kudu bulls, sable breeding herds and ostriches have some preference for this landscape but nevertheless do not occur here in large numbers. Other species show no preference for this landscape and occur here in low densities.

Physiographic pattern

3.1 Outcrop

Doloritic outcrop is rare and occurs as low dome-shaped crests or hills. On these, the outcrop occurs as low rounded boulders without the abundant cracks, fissures and soil pockets associated with, e.g., granitic and rhyolitic outcrop.

3.2 Level doloritic plateau with relatively clayey A and deep clay B horizon

Soils on these plateaux are deep examples of the Mayo Form with relatively clayey A horizons (e.g. 600mm deep with 23 per cent clay, Releve 193, Ass. 7.1, Table 5, Ch. IV), and deep soils of the Valsrivier Form, with sandy clay and clay B horizons (e.g. Releves 288 & 289, Ass. 7, Table 5, Ch. IV). The Mayo Form is a melanic A horizon over a lithocutanic B horizon. The Valsrivier Form is an orthic A horizon over a pedocutanic B horizon, followed by unconsolidated material, which, in this instance, comprises a mixture of manganese concretions and granite-derived quartz.

3.3 Doloritic crests and middlleslopes with sandy clay loam and sandy clay B horizons

Soils on the relatively well-drained doloritic crests and middleslopes belong to: the Mayo mayo series, i.e. melanic non-calcareous A horizon with 15-35 per cent clay and lithocutanic B horizon, e.g. Releves 202 & 285 (Ass. 7.1, Table 5, Ch. IV); the Swartland Reveillie Series, i.e. an orthic A horizon and a red, non-calcareous pedocutanic B horizon with

15-35 per cent clay, e.g. Releve 218 (Ass. 7.1, Table 5, Ch. IV); the Bonheim dumasi Series, i.e. a melanic A horizon with 15-35 per cent clay and a non-red, non-calcareous, pedocutanic B horizon, e.g. Releves 212 & 224 (Ass. 7.1, Table 5, Ch. IV); and the Valsrivier sunnyside, Valsrivier herschel and Valsrivier arniston Series, i.e. an orthic A horizon and a non-calcareous red or non-red, pedocutanic B horizon with 15-55 per cent clay, over unconsolidated quartz and manganese concretions, e.g. Releves 136, 204, 208, 214 (Ass. 7.1, Table 5, Ch. IV) and 283 (Ass. 7.2, Table 5, Ch. IV). Slope angles vary from less than one degree to three degrees.

3.4 Enclaves of granitic crests on predominantly doloritic plains

Isolated granitic crests that are surrounded by strongly doloritic slopes form a distinct unit of Tropical Semi-arid Doloritic Lowveld. The soil sample here, included the Glenrosa glenrosa Series, i.e. an orthic A horizon with 6-15 per cent clay and coarse sand, over a non-calcareous, lithocutanic B horizon, e.g. Releves 184 and 209 (Ass. 5.4, Table 4, Ch. IV); the Hutton moriah Series, i.e. an orthic A horizon over a non-calcareous eutrophic, red apedal B horizon with 0-6 per cent clay and coarse sand, e.g. Releve 290 (Ass. 5.2.3, Table 4, Ch. IV); and the Clovely denhere Series i.e. an orthic A horizon over a non-calcareous, eutrophic, yellow-brown apedal B horizon with 6-15 per cent clay and coarse sand, e.g. Releve 222 (Ass. 5.4, Table 4, Ch. IV). The soil depth is variable and determines the vegetation physiognomy.

3.5 Doloritic crests and middleslopes with strong granitic influence

Granitic influence here is conductive to orthic A horizons and relatively low clay content, whereas doloritic influence promotes relatively high clay content and melanic A horizons. Thus the soils are of: (a) the Mispah mispah Series, i.e. an orthic A horizon on hard rock e.g. Releves 270 &

292 (Ass. 5, Table 4, Ch. IV); (b) the relatively sandy Glenrosa paardeberg and Glenrosa glenrosa Series, i.e. a non-calcareous orthic A horizon with less than 15 per cent clay and coarse sand, over a lithocutanic B horizon, e.g. Releves 220 & 281 (Ass. 5.4, Table 4, Ch. IV); (c) the relatively clayey Glenrosa robmore Series, which is a non-calcareous orthic A horizon with 15-35 per cent clay (17 per cent in this instance) and coarse sand, over a lithocutanic B horizon, e.g. Releve 207 (Ass. 7.1.2, Table 5, Ch. IV); and (d) another relatively clayey example, Releve 185 (Ass. 7.1.1, Table 5, Ch. IV) of the Willowbrook emfuleni Series, which is a melanic A horizon with 15-35 per cent clay (15,3 per cent in this example), over a G horizon (strong glay).

3.6 Doloritic footslopes

Soils recorded on doloritic footslopes that are non-sodic and therefore without strong granitic influence, include: the Glenrosa glenrosa Series, i.e. an orthic A horizon with 6-15 per cent clay and coarse sand, over a non-calcareous, lithocutanic B horizon, e.g. Releve 192 (Ass. 7.1, Table 5, Ch. IV); the Shortlands kinross Series, i.e. an orthic A horizon over a non-calcareous, eutrophic, red structured B horizon with 15-35 per cent clay, e.g. Releves 134 & 293 (Ass. 7.1, Table 5, Ch. IV); and the Valsrivier waterval Series, i.e. an orthic A horizon, over a non-calcareous, red, pedocutanic B horizon (with 35-55 per cent clay, followed by unconsolidated quartz stones and manganese concretions, e.g. Releve 138 (Ass. 7.1, Table 5, Ch. IV), Releves 179 & 229 (Ass. 7, Table 5, Ch. IV), which also belong here, are from sodic duplex soils of the Sterkspruit grootfontein Series. Releve 179 is, however, from a soil with a considerably thicker A horizon than other Releves from the same soil type and phytosociological unit (Ass. 7.1.2). Quadrat 299 fell on the boundary to granitic Landscape 2, but the field layer does not show the sodic and duplex character associated with such granitic bottomlands.

3.7 Relatively non-sodic doloritic bottomlands

Doloritic bottomlands with relatively little granitic presence are seemingly also relatively non-sodic. These bottomlands are represented best by Releve 284 (Ass. 7.2, Table 5, Ch. IV) from an Arcadia rydalvale Soil, i.e. a dark, non-calcareous, vertisol with self-mulching or weakly crusting surface. The A11 horizon in Releve 284 had 39 per cent clay, a pH of 6,1 and conductivity of 440 micro mhos. Corresponding data for the A12 horizon was 45 per cent clay, pH of 7,2 and conductivity of 530 micro mhos.

3.8 Doloritic bottomlands that are sodic with strong granitic influence

High concentrations of granite-derived sodium occur in some doloritic bottomlands, usually in the contact zone between granite and dolorite. These sodic soils are of: the Escourt Form, i.e. an orthic A horizon over an E horizon and a prismacutanic B horizon, e.g. Releves 135, 282 & 287 (Ass. 4, Table 3, Ch. IV); and the Sterkspruit Form, i.e. an orthic A horizon over a prismacutanic B horizon, e.g. Releves 137 & 291 (Ass. 4, Table 3, Ch. IV). The A horizons are loose loamy sand and sandy loam with 10-11 per cent clay, whereas the B horizons are hard and impenetrable owing to 29-37 per cent clay that has been deflocculated by sodium (see Ch. IV). Because of the poor internal drainage these soils may be seasonally waterlogged.

3.9 Vertic drainage beds

Narrow drainage beds with vertisols occur in some doloritic bottomlands.

Vegetation pattern

3.1 Outcrop vegetation

The major part of Krugertabletkop is a good Central District example of a low doloritic hill. The hot and dry north-western aspect is dominated by _Acacia nigrescens_ and _Combretum apiculatum_ trees and _C. mossambicense_ shrubs. On the cool, mesic, south-eastern side the dominant woody species is _Pterocarpus rotundifolius_, mostly as a brush. _Panicum maximum_ is generally the dominant grass, with _Themeda triandra_ forming locally dominant patches.

The following species were also recorded on the doloritic part of the hill:-

Woody _Aloe marlothii, Ficus soldanella_ (associated with a rare example of large bouldery broken outcrop), _Ximenia caffra, Maerua parvifolia, Dichrostachys cinerea_ subsp. _africana_ var. _setulosa, Cassia abbreviata, Dalbergia melanoxylon, Lonchocarpus capassa, Balanites maughamii, Securinega virosa, Spirostachys africana, Sclerocarya caffra, Lannea stuhlmannii, Ozoroa paniculosa, Maytenus heterophylla, Cassina transvaalensis, Hippocratea longipetiolata, Ziziphus mucronata, Grewia subspathulata, Sterculia rogersii, Combretum hereroense, C. zeyheri, Euclea divinorum, E. natalensis, Diospyros mespiliformis, Strychnos madagascariensis, Ehretia rigida, Gardenis spatulifolia, Vangueria infausta._

Grasses _Heteropogon contortus, Digitaria erianthia, Brachiaria nigropedata, Enneapogon scoparius_ and others.

Forbs _Asparagus falcatus, A. minutiflorus, Jatropha variifolia, Cissus rotundifolia, Hibiscus micranthus_ and others.

3.2 *Lannea stuhlmannii* - *Pterocarpus rotundifolius* - *Themeda triandra* - dominated sprasely shrubby, sparse brushveld or sparse treeveld of level doloritic plateaux with relatively clayey A or deep clay B horizons

The vegetation of this landscape unit belongs to Association 7.1.3 (e.g. Releves 193 & 288, Table 5, Ch. IV) and 7.2 (e.g. Releve 289, Table 5, Ch. IV). Trees are scattered to sparse with *Sclerocarya caffra* and/or *Lannea stuhlmannii* dominant (Appendix 1). *Pterocarpus rotundifolius* is commonly among the dominants in a sparse to scattered brush and shrub stand (Table 5, Ch. IV, Appendix 1). *Combretum hereroense* and *Dichrostachys cinerea* subsp. *africana* may also be among the brush and shrub level dominants. *Themeda triandra* and *Digitaria eriantha* are constantly dominant grasses. *Panicum maximum, P. coloratum* and *Urochloa mossambicense* are occasionally codominant.

3.3 *Acacia nigrescens* - various spp. - *Themeda triandra* - dominated shrubby, brushy, treeveld of doloritic crests and middleslopes with sandy clay loam and sandy clay B horizons

Crests and middleslopes with comparatively good internal drainage have vegetation typically belonging to Ass. 7.1 (e.g. Releves 136, 202, 204, 208, 212, 214, 218, 224 & 285, Table 5, Ch. IV). Releve 283 (Fig. 6, Appendix 5) is an unusual example from Association 7.2 (Table 5, Ch. IV). The tree layer is sparse to dense and dominated by *Acacia nigrescens,* often with *Sclerocarya caffra* subdominant (Appendix 1, Table 5). Brush and shrub levels are also sparse and dominants here may include either of: *Combretum hereroense, C. apiculatum, Dichrostachys cinerea* subsp. *africana, Acacia nigrescens, Peltophorum africanum, Grewia bicolor* and *Ziziphus mucronata*. The grass *Themeda triandra* is a consistent field layer dominant or subdominant. Common codominants or subdominants of the field layer include *Digitaria eriantha*, *Panicum maximum*, *Aristida congesta* subsp. *barbicollis*, *Urochloa mossambicense* and *Cymbopogon plurinodis* (Table 5, Ch. IV)

3.4 *Combretum apiculatum* or *C. zeyheri* - dominated shrubby brushveld and shrubby, brushy treeveld of enclaves of granitic crests on predominantly doloritic plains

On granitic summit enclaves the vegetation belongs to Association 5 (Table 4, Ch. IV). Its structure is sparsely to moderately shrubby, sparsely to moderately brushy, brushveld or treeveld. *Sclerocarya caffra* and *Combretum apiculatum* are the dominant trees. The dominant brush and shrub species on relatively deep soils of the Hutton, Clovelly and Glenrosa Forms is *Combretum zeyheri*, as in Quadrats 209, 222 & 290 (Appendix 1). On shallow Glenrosa Form soils, such as in Quadrat 184, the dominant woody species is *Combretum apiculatum*. Field layer dominants and codominants here include *Digitaria eriantha*, *Aristida* spp., *Panicum maximum*, *Sporobolus fimbriatus*, *Setaria flabellata*, and *Schmidtia pappophoroides*.

3.5 *Acacia nigrescens* - *Combretum apiculatum* - *Digitaria eriantha* - *Aristida* spp. - (*Sporobolus fimbriatus* and *Panicum maximum*) or (*Bothriochloa radicans*) - dominated shrubby, brushy treeveld of crests and middleslopes on doloritic plains with strong granitic influence

The vegetation of relatively sandy examples, where the granitic influence is most strong, belongs to Association 5 (e.g. Releves 220, 270, 281 & 292, Table 4, Ch. IV). The vegetation of relatively clayey examples, owing to proportionately greater doloritic influence, belongs to Association 7.1 (e.g. Releves 185 & 207, Table 5, Ch. IV).

The structure is sparsely to moderately shrubby, sparsely to moderately brushy, sparse to moderate treeveld. Acacia nigrescens, Sclerocarya caffra and Lannea stuhlmannii are the dominant trees (Table 4, Appendix 1). Combretum apiculatum, C. zeyheri and Acacia nigrescens dominate the brush and shrub layers. Acacia gerardii dominates these levels in Releve 185, which is from a gleyed soil with poor internal drainage. Field layer dominants typically include Digitaria eriantha, Aristida spp., Panicum maximum, and either a number of species that are associated with sandy soil, e.g. Sporobolus fimbriatus, Pogonarthria squarrosa, Tricholaena monachme and Trichoneura grandiglumis, or species that are associated with a clayey soil, such as Bothriocloa radicans.

3.6 Moderately shrubby to scrubby, shrubveld, scrub, brushveld or treeveld of doloritic footslopes

Non-sodic doloritic footslopes without marked granitic influence have vegetation belonging to Association 7.1 (e.g. Releves 134, 138, 179, 192 & 293, (Table 5, Ch. IV) and Association 7.3 (e.g. Releve 299, Table 5, Ch. IV). Trees are absent to a moderate layer and include Acacia nigrescens, Sclerocarya caffra and Combretum imberbe (Appendix 1). Brush and/or shrub layers are usually at least moderately dense and dominant species here may be Combretum hereroense, Pterocarpus rotundifolius, Dichrostachys cinerea subsp. africana, Albizia harveyi or Peltophorum africanum (Appendix 1). Themeda triandra is constantly clearly dominant, with Digitaria eriantha subdominant, in the field layer. Panicum maximum is also occasionally subdominant, in addition to D. eriantha (Table 5, Ch. IV).

3.7 _Themeda triandra - Panicum coloratum - Digitaria eriantha_ - dominated grassveld of relatively non-sodic doloritic bottomlands

Releve 284 (Ass. 7.2, Table 5, Ch. IV) best represents this landscape unit. Additional field notes supplemented its description.

The structure is grassveld with scattered shrub and brush and _Themeda triandra, Panicum coloratum_ and _Digitaria eriantha_ are the typical field layer dominants in a combination that may also include _Panicum maximum_ or _Bothriochloa radicans_. Prominent species among the scattered shrub and brush, may include _Euclea divinorum, Acacia gerrardii, Combretum hereroense, Acacia nilotica, Ziziphus mucronata_ and others (e.g. Releve 284). Releve 299 (Ass. 7.3, Table 5, Ch. IV), from the boundary with granitic Landscape 2, has a similar field layer but is _Albizia harveyi_ - dominated shrubby brushveld on a duplex soil transitional to that of sodic granitic bottomlands.

A physiographically, phytosociologically and physiognomically similar landscape unit is found in Non-vertic Tropical Semi-arid Basaltic Lowveld (see Landscape Unit 6.11).

3.8 _Dactyloctenium aegypteum_ - characterized grassveld and shrubveld of doloritic bottomlands that are sodic with strong granitic influence

The vegetation of this landscape unit belongs to Association 4.1 (e.g. Releves 135, 137, 282, 287 & 291, Table 3, Ch. IV). Trees are commonly absent but may occur scattered or form a sparse layer and include _Combretum imberbe_ and _Acacia nigrescens_. The vegetation is mostly grassveld with scattered shrub, brush and trees or sparse shrubveld with scattered taller plants (Appendix 1). Brush and shrub species commonly include _Euclea divinorum_ and _Albizia harveyi_. Field layers are usually dominated by a mixture of four out of the following five grasses: _Dactyloctenium aegypteum, Digitaria eriantha, D._

agyrograpta, *Panicum coloratum* and *Aristida congesta* subsp. *barbicollis* (Table 3, Ch. IV).

3.9 *Spruit complex*

Drainage beds with vertic soils are dominated by the grass *Setaria woodii*. This landscape unit has not been formally sampled. The vegetation is of Association 11, which is presented in Table 8 (Ch. IV).

Fauna

Axis 1 of the Second Correspondence Analysis (Ch. VI) shows a strong association of impala with this landscape. This is owing to high concentrations of impala in Landscape Unit 3.5 near the Sabie and Ripape rivers where granitic influence on vegetation structure and composition is strong. Average impala density for the entire landscape is 6,4 per km^2 (Table 11, Ch. VI).

Kudu bulls and sable breeding herds have some preference for this landscape but their densities are nevertheless low, i.e. 0,1 per km^2 for each of these species (Table 11, Ch. VI). Densities for other species are: 1,0 per km^2 for zebra; 0,5 per km^2 for giraffe; 0,3 per km^2 for blue wildebeest as well as for kudu breeding herds; and 0,2 per km^2 for warthog.

4. Tropical Semi-arid Karoo Sediment Lowveld

Introduction

This is a low, flat and level, densely woody landscape. It is associated with the Karoo Sediments and occurs as a long and narrow, continuous zone down the centre of the southern third of the Park. The Karoo Sediments separate the granitic and basaltic regions (Ch. II). Although these sediments and associated physiography continue northwards, the microphyllous species peculiar to this landscape are restricted to the greater than 500mm rainfall zone in the south. This zone starts at the Timbavati River and continues southwards through the Central and Southern districts. In the arid climate to the north, the dominant vegetation on Karoo Sediments is broad-sclerophyll *Colophospermum mopane* Woodland (Ch. II).

The Karoo Sediments of this landscape include shale, mudstone, sandstone, grit, marl and coal. The sandstone occasionally forms hills and low ridges with characteristic outcrop-associated vegetation, or leached loose sandy uplands with broad-leaved *Terminalia sericea* or *Combretum zeyheri* - dominated brushy bushveld that closely resembles that of deep, leached soils of granitic upland sites. The major part of this landscape, however, has little relief with soils and vegetation ranging: (a) from slightly elevated sandy areas with massive A- and/or B horizons and *Dichrostachys cinerea* subsp. *africana* - dominated brushveld and thicket; (b) to massive (cemented) sandy areas and duplex soils with *Albizia petersiana* - dominated brushveld, thicket and treeveld, lower down the gentle slopes; and (c) extensive flat botomlands with sodic clayey duplex soils and *Acacia welwitschii* - dominated treeveld.

This landscape supports a top ranking diversity and biomass of medium to large herbivores (Joubert, unpubl.). The extensive Karoo Sediment plains are inhabited by moderate to high densities of impala, warthog and rhino, which are probably attracted by the short field layers and grass and forb composition peculiar to some of the sodic bottomlands. Giraffe, which occur here in moderate densities, are presumably favoured mainly by the abundant browse. Buffalo bulls are also relatively common. Blue wildebeest, zebra, kudu and elephant bulls also occur in significant, albeit comparatively low densities (Table 11).

On the Marheya-Kumana plateau, which is part of the divide between the Sweni and Nwaswitsontso rivers, sandstone and dolorite form an extensive mosaic. The influence of both formations on the soils and vegetation may be apparent and the region is treated as a separate landscape (Landscape 5).

Physiographic pattern

4.1 Sandstone outcrop

Low ridges and hills of bouldery sandstone outcrop are rare in the study area. The largest examles are the ridges near the Ngabeni Waterhole, Sandsteenkoppies and the outcrop in the Marheya-Kumana region.

An outstanding sandstone hill, Matikiti occurs immediately north of the western half of the study area and was included in this survey. This ecotope was not included in the phytosociological study but was inspected casually.

4.2-3 Single grain structureless soils of upland sandstone sites

The major region of loose sand and sandy loam on sandstone occurs associated with the occasional outcrop on upland sites of the Marheya Region. The soils here are typically of the Mispah, Hutton and Clovelly Forms (e.g. Releve 167, Ass. 5.2, Table 4, Ch. IV and Venter,[3] pers. comm.).

4.4-6 Massive structureless soils and duplex soils

Lower down, on the middleslopes and footslopes, the loamy sand and sandy loam Mispah, Hutton and Clovelly soils, although still structureless, become massive, i.e. their primary soil particles become coherent (MacVicar et al., 1977). This happens first in B horizons (e.g. Releves 165 & 169, Ass. 2.2, Table 3, Ch. IV) and ultimately, lower down slopes, in A horizons as well (e.g. Releves 246, 300, 304 & 306, Ass. 1 & 2, Table 3, Ch. IV).

The next stage of this catena is represented by soils of the Pinedene Form (e.g. Releves 198, 200, 245 & 254, Ass. 1 & 2, Table 3, Ch. IV). Here a coarse sandy clay, gleycutanic B22 horizon, indicative of prolonged seasonal waterlogging, appears beneath the yellow-brown, apedal, B21 horizon and orthic A horizon that are shared with soils of the Clovelly Form. The latter two upper horizons may still be either single grain or massive, as in the case of the soils of the Clovelly Form. The Pinedene soils are usually of the Pinedene klerksdorp Series, i.e. with 15-35 per cent clay in eutrophic B21 horizons. The B22 horizons are more clayey, e.g. 39-42 per cent for Releves 200, 245 & 254.

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3. Mr F.J. Venter, Research Intitute, Private Bag X402, Skukuza 1350, South Africa.

The penultimate stage, typical of the flat and level bottomlands has orthic A horizon sand sodic, sandy clay loam, prismacutanic B horizons. The soils are of the Sterkspruit Form, usually the Sterkspruit grootfontein Series, or else with slightly more clay in A horizons and then of the Sterkspruit sterkspruit Series (cf. Releves 141, 142, 166, 195, 206, 217, 219, 226 & 303, Ass. 1 & 2, Table 3, Ch. IV). The structureless A horizons are sandy loam and massive with approximately 11-19 per cent clay, or loamy sand and single grain with 9-11 per cent clay (Table 3). The clay content of B horizons are typically between 20 and 35 per cent (Table 3). B horizons, being sodic and deflocculated, are hard, compact and impenetrable when dry, with poor internal drainage and poor aeration when wet (Ch. IV).

4.7 Floodplains

Releve 211 (Ass. 1.2 Table 3, Ch. IV) represents a floodplain with deep sandy soil of the Clovelly blinkklip Series.

4.8 Drainage lines

Drainage channels are commonly shallow with soils on the banks belonging to the Sterkspruit From, similar to adjoining bottomlands of the former ecotope.

Vegetation pattern

4.1 Sandstone outcrop vegetation

The following species list is almost complete for woody species but includes only a few prominent and typical grasses and forbs. The list is from the shrubby to scrubby, brushy and thicketed vegetation of the Ngabeni Ridge, Sandsteenkoppies and Matikiti Hill:-

Woody *Ficus soldanella, F. stuhlmannii, Ximenia caffra, Hexalobus monopetalus, Maerua parvifolia, Albizia brevifolia, A. forbesii, A. petersiana, Acacia nigrescens, Dichrostachys cinerea* subsp. *africana* var. *africana, D. cinerea* subsp. *africana* var. *setulosa, Schotia brachypetala, Cassia abbreviata, Peltophorum africanum, Dalbergia melanoxylon, Erythrina humeana, Balanites maughamii, Commiphora neglecta, Ptaeroxylon obliquum, Securinega virosa, Bridelia cathartica, Croton gratissimus, Spirostachys africana, Euphorbia confinalis, Sclerocarya caffra, Lannea stuhlmannii, Rhus queinzii, Maytenus heterophylla, Cassine aethiopica, Hippocratea longipetiolata, Pappea capensis, Ziziphus mucronata, Grewia bicolor, G. flavescens, G. subspathulata, Sterculia rogersii, Ochna natalitia, O. pretoriensis, Garcinia livingstonei, Combretum apiculatum, C. zeyheri, Terminalia sericea, Manilkara mochisia, Euclea natalensis, Diospyros mespiliformis, Schrebera alata, Strychnos madagascariensis, S. spinosa, Ehretia amoena, E. rigida, Vanqueria infausta, Pavetta assimilis,*

Grasses *Dihetoropogon amplectens*, *Digitaria eriantha*, *Panicum deustum*, *Panicum maximum*.

Forbs *Aloe chabaudii* (succulent), *Sansevieria hyacinthoides*, *Asparagus falcatus, A. minutiflorus, Dioscorea cotinifolia, Achyranthes aspera, Abrus precatorius, Cissus rotundifolia, Abutilon ramosum, Hibiscus micranthus, Jasminum fluminense, Landolphia kirkii, Pachypodium saundersii* (succulent).

4.2 *Terminalia sericea* - dominated brushveld on single grain structureless soils of upland sandstone sites

Terminalia sericea - dominated brushveld on loose sandy upland soils of the Mispah, Hutton and Clovelly forms belongs to Association 5 (e.g. Releve 167, Table 4, Ch. IV.). The representative Quadrat 167, is moderately shrubby, dense brushveld with scattered trees (Appendix 1). *Terminalia sericea* is the dominant brush and shrub. The field layer is dominated by the general grass *Digitaria eriantha* and sand-associated grasses such as *Brachiaria nigropedata*, *Perotis patens* and *Pogonarthria squarrosa*, as well as the sand-associated forb, *Indigofera sanguinea*.

4.3 *Combretum zeyheri* - dominated brushveld and treeveld on transitionally massive structureless soils of near-upper slopes

This landscape unit occupies a catenal position between *Terminalia sericea* - dominated brushveld of upland sites and *Dichrostachys cinerea* - dominated slope vegetation as may be seen along a long, representative slope containing all landscape units. The only example, Releve 307 (Table 3, Ch. IV) was classified as Association 2.1.2, which is transitional to Association 5. Examples of this unit belonging to Association 5 may also be expected to be encountered. The soil of Releve 307 was marginally classified as the Sterkspruit Form. The vegetation structure in this example is moderately shrubby, moderately brushy, sparse treeveld, with *Combretum zeyheri* dominant at all woody levels. Field layer dominants were the general grasses *Digitaria eriantha* and *Panicum maximum*, as well as the psammophyllous *Sporobolus fimbriatus* and *Pogonarthria squarrosa*.

4.4 Dichrostachys cinerea - dominated brushveld, thicket and treeveld, on Clovelly Form soils with massive, structureless A- and/or B horizons and on some soils of the Pinedene and Sterkspruit forms

The Clovelly Form soils with some degree of coherence of the primary soil particles carry this distinct plant commmunity (e.g. Releve 246, Ass. 2.1, Table 3, Ch. IV). The community also extends onto parts of the next catenary stages, i.e. onto some soils of the Pinedene Form (e.g. Releve 198, Ass. 2.2, Table 3, Ch. IV) and of the Sterkspruit Form (e.g. Releve 226, Fig. 7, Appendix 5, Ass. 2.2, Table 3, Ch. IV).

The structure is typically densely shrubby to scrubby, dense brushveld or thicket, or similarly shrubby and brushy, sparse treeveld (Appendix 1). Dichrostachys cinerea subsp. africana is the dominant brush and shrub whereas trees, where present, are mostly Acacia welwitschii and Albizia petersiana (multistemmed, i.e. "giant shrub" growth form). The grass Panicum maximum is the usual field layer dominant, with Digitaria eriantha and Eragrostis rigidior as regular subdominants. Occasional subdominants include Urochloa mossambicense, Sporobolus fimbriatus and Panicum coloratum (Table 3, Ch. IV).

4.5 Albizia petersiana - dominated brushveld, thicket and treeveld on Mispah and Hutton Form soils with massive, structureless A and/or B horizons and on some soils of the Pinedene and Sterkspruit forms

This catenal stage is phytosociologically closely related to the former and both belong to Association 2 (Table 3, Ch. IV). Their habitats are also similar. However, on a slope that contains all units of this landscape, the Albizia petersiana - dominated unit occurs below the Dichrostachys cinerea - dominated unit. The representative releves also suggest that the Albizia petersiana - dominated unit, on the one hand, is largely restricted to soils with impeded drainage such as the Sterkspruit Form (e.g. Releves 142 and 303, Ass. 2, Table 3, Ch. IV), the Pinedene Form (e.g. Releves 245 & 254, Ass. 2, Table 3, Ch. IV) and massive soils of the Mispah Form (e.g. Releves 300 & 306, Ass. 2, Table 3, Ch. IV). Releve 169 (Ass. 2.2, Table 3, Ch. IV) which also represents the latter unit, is exceptional and from a Hutton Form soil with a particularly hard, massive B horizon, on level terrain. The Dichrostachys cinerea - dominated unit, on the other hand, extends onto the higher lying Clovelly Form soils, which are generally better drained.

Woody structure in the Albizia petersiana - dominated unit is typically sparsely shrubby to scrubby, moderate brushveld to thicket and similarly shrubby and brushy moderate treeveld. Multistemmed A. petersiana is usually dominant at all levels, including the tree level (Appendix 1). Field layers are typically dominated by the general grasses (cf. Table 2, Ch. IV) Digitaria eriantha and Panicum maximum. Occasional subdominants include the sand-associated grasses Brachiaria nigropedata, Sporobolus fimbriatus, Eragrostis rigidior and Pogonathria squarrosa and the clay-associated grasses Themeda triandra and Panicum coloratum (Table 3, Ch. IV).

4.6 Acacia welwitschii - dominated treeveld on level bottomland duplex soils

Acacia welwitschii is typically the dominant tree on level or virtually level bottomland plains with soils of the Sterkspruit Form (e.g. Releves 141, 166, 195, 206, 217, 219, 221, 225 & 305, Ass. 1, Table 3, Ch. IV). Examples were also occasionally recorded on soils of the Pinedene and Mispah Forms (e.g. Releves 200 & 304, Ass. 1, Table 3, Ch. IV and Releve 196, Ass. 5,3, Table 4, Ch. IV) Releve 196 is, however, also phytosociologically atypical of this Landscape Unit. Structure and composition correlates with detailed classification:-

(a) Brushy treeveld with sparse understory and short grass

Association 1.1 (Ch. IV) occurs on soils of the Sterkspruit Form that have dark, massive A horizons. The vegetation of the variation with seemingly relatively high B horizon clay content and conductivity (Ass. 1.1.1) has a distinctly open woody understorey and short field layers with characteristic composition. The structure is sparsely shrubby, moderately brushy, moderate treeveld, with *Acacia welwitschii* trees and brushes dominating all woody levels (e.g. Releve 225, Fig. 8, Appendix 5 & Releve 305, Ass. 1.1, Table 3, Ch. IV, Appendix 1). Field layer dominants include the short grasses of sodic soils, *Sporobolus nitens* and *Dactyloctaenium aegypteum*, the general grasses *Panicum maximum* and *Urochloa mossambicense* and various forbs, including *Achyranthes aspera, Portulaca quadrifida, Cyathula crispa, Ruellia patula, Cyphocarpa angustifolia, Blepharis integrifolia* and *Acanthospermum hispidum* (Table 3, Ch. IV).

(b) Densely shrubby to scrubby, brushy to thicketed treeveld with *Euclea divinorum* - dominated understorey

Association 1.1.2 also occurs on soils of the Sterkspruit Form, but with seemingly relatively lower clay content and conductivity than Association 1.1.1 (cf. Table 3, Ch. IV). The structure in Association 1.1.2 is densely shrubby to scrubby, densely brushy to thicketed, sparse to moderate treeveld (e.g. Releves 206, 217, 219 & 221, Fig. 9, Appendix 5, Table 3, Ch. IV, Appendix 1). *Acacia welwitschii*, and occasionally *Spirostachys africana*, are the dominant trees. The densely woody understoreys are dominated by *Euclea divinorum*, occasionally including also high cover of *Maytenus tennuispina* and *Cassine aethiopica*. The woody *Pappea capensis* and *Carissa bispinosa* are also characteristically present (Ch. IV, Table 3, Appendix 1). The general grasses *Panicum maximum* and *Urochloa mosambicense* dominate the field layer, which is luxurious during a wet rainfall cycle such as during sampling, but may be less rank with drought and trampling.

(c) Shrubby, brushy, treeveld with _Dichrostachys cinerea_ or _Acacia welwitschii_ - dominated understoreys and relatively long grass

Association 1.2 (Ch. IV) also commonly has densely vegetated understoreys, but is either transitional to _Dichrostachys cinerea_ - dominated vegetation or else _Acacia welwitschii_ is dominant at all woody levels (e.g. Releves 141, 166, 195, 200 & 304, Table 3, Ch. IV, Appendix 1). Phytosociologically atypical Releve 196 (Ass. 5.3, Table 4, Ch. IV) also belongs here. The soils here are either yellower, or redder, or less aggregated, or sandier than those of the Association 1.1 and belong to the Mispah, Pinedene and Sterkspruit forms. The structure is variable but often has dense to scrubby or thicketed understoreys. Tree cover varies from scattered to dense. A mixture of field layer dominants commonly includes _Panicum maximum_, _Urochloa mossambicense_, _Chloris virgata_, _Dactyloctaenium aegypteum_, _Panicum coloratum_ and _Digitaria eriantha_.

4.7 _Acacia welwitschii_ - _Spirostachys africana_ - _Euclea divinorum_ - dominated floodplain vegetation

Releve 211, which represents a mature floodplain, was classified with Association 1.2, where it is distinctively unique (Table 3, Ch. IV). The vegetation of Releve 211 is densely shrubby, densely brushy, dense treeveld. Dominant woody species include _Acacia welwitschii_ (particularly at the tree level, Appendix 1); _Spirostachys africana_; _Ziziphus mucronata_ and _Euclea divinorum_ (particularly at the brush and shrub levels; Appendix 1). Subdominant brush and shrub species include _Maytenus senegalensis_, _Strychnos spinosa_, _Euclea natalensis_ and _Grewia flavescens_, which are also common and characteristic species of bouldery outcrop (Table 3, Ch. IV). Field layer grasses included _Digitaria eriantha_ and _Perotis patens_ as dominants, as well as _Panicum maximum_ (subdominant), _Pogonarthria squarrosa_, _Eragrostis rigidior_, _Sporobolus_ *fimbriatus* and *Sacciolepis curvata*, a typical combination for sandy habitats (Tables 2 & 3, Ch. IV).

4.8 *Spruit complex*

(a) *Vlei*

A seasonally wet vlei had grassveld dominated by the grasses *Dicanthium papillosum* and *Eriochloa meyerana*.

(b) *Levees*

The following list of trees, brushes, shrubs and grasses was recorded on the levee along a short section of the Nwaswitsontso Spruit in this landscape. The spruit is seasonal and is large here, with well-developed levees and a broad sandy bed:-

Trees *Albizia forbesii, Acacia robusta, A. welwitschii, Schotia brachypetala, Lonchocarpus capassa, Trichilia emetica, Spirostachys africana, Combretum imberbe, Kigelia africana*.

Shrubs & brushes *Phoenix reclinata, Acacia ataxacantha, Dichrostachys cinerea* subsp. *africana*, *Schotia brachypetala, Ormocarpum trichocarpum, Ekebergia capensis, Acalypha glabrata, Spirostachys africana, Rhus queinzii, Maytenus senegalensis, Cassine aethiopica, Flacourtia indica, Euclea divinorum*.

Grasses (List incomplete for sampled area) - *Panicum maximum*.

Fauna

The medium- to large- herbivore biomass per unit area of this landscape is among the highest in the Central District (Joubert, unpubl.). This distinctively high biomass is concentrated largely in the _Acacia welwitschii_ - dominated treeveld unit with sparse woody undergrowth and a short field layer rich in forbs; and which occurs on Sterkspruit Form soils with dark massive A horizon and relatively high B horizon clay content and conductivity. Herbivores that are strongly attracted, presumably by these latter conditions, are impala (Axis 1, 2nd Correspondence Analysis, Ch. VI) with density of 11,4 individuals per km^2 (Table 11, Ch. VI); blue wildebeest (Axis 2, 2nd Correspondence Analysis) with 0,8 per km^2 (but concentrated in the shortgrass, open understorey unit); and warthog and white rhino (Axis 2, Detrended Correspondence Analysis, Ch. VI) with 0,2 and 0,1 per km^2 respectively (also concentrated largely, however, in the short-grass unit).

Other common species include giraffe (0,7 per km^2) and kudu (0,4 per km^2). Both species are presumably sustained at these densities by the abundant browse and kudu probably also by the forbaceous field layers of the sparsely shrubby _Acacia welwitschii_ - dominated treeveld. Also significant are zebra (0,5 per km^2), buffalo bulls (0,2 per km^2) and elephant bulls (0,1 per km^2, Table 11, Ch. VI).

5. Tropical Semi-arid Lowveld on Karoo Sediment Anticline with Dolorite

Introduction

An area of mixed geology occurs along part of the boundary between the Karoo Sediment and basalt zones (Fig. 6). This area extends southwards from the Sweni River and includes the upper parts of the Marheya, Mrunzuluku and Guweni catchments. Also included, is the combined watershed along the western boundary of these catchments, i.e. the Marheya-Kumana Divide. The average annual rainfall of this landscape is 500-600mm (Gertenbach, 1980).

It seems that basalt has weathered away, exposing a Karoo Sediment anticline with swarms of the basalt's doloritic feeders (cf. Venter,[4] pers. comm.). On the Marheya Divide and in the Marheya Catchment, Karoo sandstone outcrop is relatively common in comparison with the southern portion of this landscape. Sodic soil plant indicators are also comparatively rare on the Marheya Divide and in the Marheya and upper Mrunzuluku catchments. Sandstone outcrop is less common and sodic soil indicators comparatively prominent on the Kumana Divide and along drainage lines in the connected upper Guweni Catchment. These drainage line-associated, sodic soil plant indicators, along the Guweni upper reaches, extend well into the adjacent basaltic region below.

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The typical pattern of this landscape is: (1) Sandstone outcrop with characteristic outcrop-associated vegetation; (2) _Grewia bicolor_ - _Acacia tortilis_ - _Schmidtia pappophoroides_ - dominated shrubveld and brushveld near outcrop on a sandy type of soil that is presumably arid, shallow and underlain by unbroken sandstone and found mainly in the Marheya Catchment; (3) _Dichrostachys cinerea_ - dominated shrubveld and brushveld, mainly in the Mrunzuluku and Guweni Catchments, on relatively sandy soils away from outcrop, and alternating with (4) _Combretum hereoense_ - _Dichrostachys cinerea_ - _Panicum maximum_ - _Digitaria eriantha_ - dominated shrubveld and with (5) _Grewia bicolor_ - _Acacia tortilis_ - _Digitaria eriantha_ - _Themeda triandra_ - _Bothriochloa radicans_ - dominated shrubveld and grassveld of relatively clayey soils, presumably with doloritic influence; (6) grassveld on broad, flat, clayey drainage belts that alternate with the shallow sandy slopes of the Marheya Catchment; (7 & 8) flat, level areas on upland sites, mainly on the Guweni Divide and along upper Guweni drainage lines, where _Acacia welwitschii_ is dominant, presumably owing to sodic influence from fine textured Karoo Sediments; and (9) the less sodic Mrunzuluku, Marheya and Sweni spruits. Seasonal pans are typical of flat, level, sodic upland sites, which are common on the Kumana Divide.

During the winter 1979 survey, water was common in the seasonal pans of the Kumana Divide. Sodic areas here, then attracted high densities of rhino and warthog. Elephant breeding herds were also common here and were probably attracted by the lush woody growth and drinking water. Impala had a high preference for the relatively sandy Marheya Catchment. Other animal species included blue wildebeest, zebra, kudu, giraffe and buffalo bulls.

Physiographic pattern

5.1 Sandstone outcrop

Bouldery sandstone outcrop occurs as small ridges and an occasional low hill, in the northern, Marheya, section of this landscape.

5.2 Relatively shallow and -sandy soils

This ecotope is predominant on the Marheya Watershed and in the Marheya Catchment. The latter catchment comprises several drainage lines and broad drainage beds that are separated by convex minor watersheds of this ecotope. Occasional bouldery sandstone hills and small ridges together with frequent sheetlike sandstone outcrop are characteristic of this region. Such features indicate that the soils are mostly relatively sandy, shallow and underlain by unbroken rock. The sandy soils would, therefore, be quick-drying and arid during long intervals between showers. Rainfall, on the other hand, would be spunged up and readily relinquished to plants because of the loose sandy texture.

Releves 101 (Ass. 9.4, Table 7, Ch. IV) and 170 (Ass. 5.1, Table 4, Ch. IV) are representative. These releves are from soils of the Mispah mispah Series and Glenrosa williamson Series respectively, underlain by sandstone. A horizons contain 13-15 per cent clay, pH was 5,8-6,0 and depth 300-400mm. Less than 0,5m high outcrop covered 1-9 per cent of Quadrat 101.

5.3 Relatively deep and -sandy soils

This is one of the two major components of the slopes comprising the upper Guweni catchment. The ecotope is also common in the lower section of that part of the Mrunzuluku Catchment that falls within the landscape. The soils are relatively sandy, presumably owing to sandstone influence. Sandstone outcrop occurs occasionally but is distinctly less common in the previous landscape unit. A horizons are typically loose but B horizons may be massive, structureless, owing to sodic influence from fine-textured Karoo Sediments. The present and following landscape units occur in mosaic-type association and grade into one another.

Formal examples of the present ecotope include Releve 146 (Ass. 9.3, Table 7, Ch. IV), Releve 165 (Ass. 2.2, Table 3, Ch. IV) and Releve 143 (Ass. 3.2, Table 3, Ch. IV). Releve 146 is from a 400mm deep soil of the Glenrosa Form, with doloritic saprolite, but terminating abruptly on sandstone. Releve 165 is from a soil of the Clovelly blinkklip Series, which is deeper than 700mm and has a massive structureless B horizon with 31 per cent clay. Releve 143 is from a Swartland rosehill Soil, which is deeper than 1000mm and has 33 per cent clay in its B horizon. Clay content of the A horizons in these three quadrats was 13-15 per cent and pH was 5,2-6,0.

5.4-5 Relatively clayey slopes

Two other major landscape units occur on relatively clayey soils. These units, together with the former, more sandy unit, form the mosaic that comprises most of the slopes of the Upper Guweni catchment and the lower part of the Upper Mrunzuluku Catchment. The relatively clayey but non-sodic component is presumably associated with doloritic influence. This influence may be colluvial, as in Releve 104, where A horizon clay content is 35 per cent but the A horizon ends abruptly on sandstone. The soil in Quadrat 104 is of the Mispah Form, with pH of 6,2 and 400mm depth (Ass. 9.3, Table 7, Ch. IV). Another example, Releve 144 (Ass. 9.3, Table 7, Ch. IV), is from a 400mm deep soil of the Glenrosa trevanian Series, where clay content was 17 per cent and 25 per cent for A and B horizons respectively and pH 5,9 and 5,6 respectively.

5.6 Broad, flat, relatively clayey drainage beds, presumably on doloritic dykes

These drainage beds typically separate the relatively shallow and sandy soils on slopes of Landscape Unit 5.2. The two landscape units form a mosaic.

5.7 Flat, level upland sites with sodic influence

Such areas are common on the Kumana Watershed. Although these areas have not been formally sampled the influence of fine-textured Karoo Sediments is apparent from:

(a) the occasional sandstone outcrop on adjoining lower eastern slopes and scarcity of sandstone or other outcrop on this watershed;

(b) the distinctly low vegetation cover and typical species composition of Karoo Sediment duplex soils, along drainage lines and in this landscape unit (cf. Ass. 1, Table 3, Ch. IV); and

(c) the pans that are characteristic of the present landscape unit and that typically also develop elsewhere on flat and level Karoo Sediment plains with duplex soils.

5.8 Sodic drainage lines of the upper Guweni Spruit

The southern, Kumana-Guweni section of this landscape has gentle relief. The section is drained by the upper Guweni Spruit, which has a gentle gradient with broad flat bottomlands on its banks. These have duplex soils and the typical vegetation of Karoo Sediment bottomlands (cf. Ass. 1, Table 3, Ch. IV).

5.9 Drainage line complexes of the Mrunzuluku, Marheya and Sweni spruits

These are the spruits that drain the northern, relatively shallow sandy, Marheya section of this landscape. The section of the Sweni spruit that runs through this landscape is mature, with a gentle gradient and broad banks. The Marheya and upper Mrunzuluku spruits drain local small catchments and are young and steep. Sodic geomorphologic and vegetation characteristics are considerably less common in all these spruits than in the upper Guweni Spruit. Releve 102, which was not incorporated in the phytosociological tables of Chapter IV, represents a levee in this landscape. Similarly unclassified Releve 103 represents a flat, level, sodic bottomland.

Vegetation pattern

5.1 Sandstone outcrop vegetation

The following is a combined list of plants recorded on the frequent small bouldery ridges of the Marheya Divide and on low sandstone hills of the Marheya Catchment near the Sweni River:-

Woody Ficus soldanella, Ximenia americana, Thilachium africanum, Albizia forbesii, A. harveyi, Acacia welwitschii, Dichrostachys cinerea subsp. africana var. pubescens, Schotia brachypetala, Cassia abbreviata, Peltophorum africanum, Erythroxylum emarginatum, Phyllanthus reticulatus, Bridelia cathartica, Spirostachys africana, Lannea stuhlmannii, Maytenus heterophylla, Hippocratea longipetiolata, Pappea capensis, Grewia bicolor, G. flavescens, Combretum apiculatum, Manilkara mochisia, Euclea natalensis, E. undulata, Diospyros mespiliformis.

Grasses *Heteropogon contortus, Digitaria eriantha, Panicum maximum, Rhynchelytrum repens, Enteropogon macrostachyus, Pogonarthria squarrosa*.

Forbs *Sansevieria hyacinthoides, Asparagus falcatus, A. minutiflorus, Sarcostemma viminale*.

5.2 *Grewia bicolor* - *Acacia tortilis* - *Schmidtia pappophoroides* - dominated shrubveld and brushveld of relatively shallow and sandy soils

The vegetation here has phytosociological affinities with vegetation on both arid and sandy habitats. Examples include Releves 101 and 147 (Ass. 9.4, Table 7, Ch. IV) and Releve 170 (Ass. 5.1, Table 4, Ch. IV). The following description is not merely based on these three releves but on extensive subsequent notes made on hikes through this unit.

Shrub cover is usually sparse to moderate and occasionally scattered or dense. Brush and trees are typically absent to sparse. *Grewia bicolor* and *Acacia tortilis* are the dominant shrub and brush species. *Peltophorum africanum* is often also among the dominant woody species and in one locality a sparse stand of *Balanites maughamii* comprises the shrub layer. Other occasionally subdominant or codominant woody species are those shown by Releves 101, 147 and 170 and include, e.g. *Combretum apiculatum, Grewia monticola, G. flavescens* and *G. hexamita*. The field layer is short, usually less than 10cm tall, with the grass *Schmidtia pappophoroides* contributing most of the cover. Subdominants here included *Digitaria eriantha, Pogonarthria squarrosa, Panicum maximum, P. coloratum, Urochloa mossambicense* and *Heteropogon contorus*.

5.3 Dichrostachys cinerea - Digitaria eriantha - Sporobolus fimbriatus - Panicum maximum - Eragrostis rigidior - dominated brushveld and shrubveld of relatively deep and sandy soils

Three releves are representative of this landscape unit. Releve 146 (Fig. 10, Appendix 5) belongs to the arid Association 9.3 (Table 7, Ch. IV), whereas Releves 143 and 165 belong to the Deflocculated Soil Alliance (Table 3, Ch. IV). Releve 143 belongs to Association 3.2 and Releve 165 to Association 2.2. Additional field notes support the following description:-

The shrub layer may be sparse to dense, the brush layer absent to dense, and trees are usually absent to sparse. Dichrostachys cinerea subsp. africana is typically the dominant shrub and brush and Acacia nigrescens the dominant tree. Digitaria eriantha and Panicum maximum are the typically dominant grasses in a rank field layer. Other common grasses include Sporobolus fimbriatus and Eragrostis rigidior, which are indicative of relatively sandy soils (Species Groups 4 & 5, Table 2, Ch. IV).

5.4 Combretum hereroense - Dichrostachys cinerea - Panicum maximum - Digitaria eriantha - dominated shrubveld of relatively clayey soils

Releve 243 (Ass. 5.4.2, Table 4, Ch. IV) is an example of this vegetation and was supplemented by less formal descriptions.

The structure of this vegetation is sparse to moderate shrubveld with scattered brush and trees. Sclerocarya caffra and Lannea stuhlmannii are the dominant trees. Combretum hereroense and Dichrostachys cinerea subsp. africana var. africana are the dominant shrub and brush species and the grasses Panicum maximum and Digitaria eriantha are the field layer dominants.

Other species noted in examples of this landscape unit are: the woody Albizia harveyi, Acacia exuvialis, Dichrostachys cinerea subsp. africana var. setulosa, Peltophorum africanum, Dalbergia melanoxylon, Lonchocarpus capassa, Ziziphus mucronata, Cissus cornifolia and Combretum apiculatum; and the grasses Bothriochloa radicans, Heteropogon contortus, Themeda triandra, Urochloa mossambicense, Sporobolus fimbriatus, Eragrostis rigidior, Pogonarthria squarrosa and Schmidtia pappophoroides.

5.5 Grewia bicolor - Acacia tortilis - Panicum maximum - Digitaria eriantha - Themeda triandra - Bothriochloa radicans - dominated shrubveld of relatively clayey soils

Releves 104 and 144, wich represent this landscape unit, belong to Association 9.3 (Table 7, Ch. IV).

These releves plus field notes indicate that the structure is typically sparse to dense shrubveld with scattered brush. Grewia bicolor and Acacia tortilis are mostly the dominant shrub species. Other notably common species include Grewia monticola, G. hexamita, Acacia nigrescens and Dichrostachys cinerea subsp. africana. The field layer is dominated by the widespread Digitaria eriantha and Panicum maximum (Species Group 17, Table 2, Ch. IV) together with species that are indicative of relatively clayey soils, i.e. Themeda triandra, Panicum coloratum and Bothriochloa radicans (Species Groups 7 & 8, Table 2, Ch. IV). Other grass species include Urochloa mossambicense and Heteropogon contortus.

5.6 Grassveld of broad, flat, relatively clayey drainage beds, presumably on doloritic dykes

Field layer composition and habitat in these relatively clayey drainage beds is similar to that of the aforegoing landscape unit, but the drainage is presumably poorer and the woody vegetation is sparser. The vegetation is grassveld with scattered shrub and brush. The shrub and brush species usually include *Acacia tortilis* and *Grewia bicolor*, and occasionally *Combretum hereroense*, *Maytenus senegalense*, *Grewia hexamita*, *G. monticola*, *Ximenia caffra* and *Acacia nigrescens*. The grass *Bothriochloa radicans* is the most common field layer dominant. Other common and occasionally codominant grasses include *Themeda triandra*, *Heteropogon contortus*, *Digitaria eriantha*, *Eragrostis superba* and *E. rigidior*. In a similar drainage bed next to a low sandstone hill, where the soil is presumably relatively sandy, the dominant grass was an *Aristida* sp.

5.7 *Acacia welwitschii* - dominated treeveld and scattered trees of flat, level upland sites with sodic influence

Such areas are common on the Kumana Divide. The commonly low grass cover and the species composition are indicative of sodic, duplex soils derived from Karoo Sediment:-

The structure is usually grass/forb veld with scattered shrub, brush and trees to sparse treeveld with scattered shrub and brush. *Acacia welwitschii* is the typical tree species. Shrub and brush include: *Boscia mossambicensis*, *Grewia subspathulata*, *Manilkara mochisia* and *Carissa bispinosa*, which were recorded next to a brackish depression, as well as *Thilachium africanum*, *Acacia tortilis*, *Dichrostachys cinerea* subsp. *africana*, *Securinega virosa*, *Grewia bicolor*, *G. monticola* and *Euclea divinorum*. Field layers were commonly trampled, short, forbaceous, with extensive patches of bare soil. *Cyathula crispa* and *Trianthema triquetra* were among these forbs. Commonly dominant species in the relatively rank grass patches included *Digitaria eriantha*, *Panicum coloratum*, *Bothriochloa radicans*, *Aristida* spp. and *Panicum maximum*; with the latter clustering under shrub and brush. Other species in the field layers include *Themeda triandra* and *Schmidtia pappophoroides*.

5.8 *Spirostachys africana* - *Acacia welwitschii* - dominated treeveld and bush along the sodic drainage lines of the upper Guweni Spruit and parts of the Shituntweni-Nwatinungu Spruit complex

Spirostachys africana and *Acacia welwitschii* are the dominant trees in the treeveld and bush on the sodic banks of the upper Guweni Spruit. *Boscia mossambicensis* is commonly the dominant shrub in a sparse to scattered shrub and brush cover. Other shrub and brush species recorded in a typical stand included *Capparis tomentosa*, *Lonchocarpus capassa*, *Spirostachys africana*, *Grewia bicolor*, *G. flavescens* and *Euclea undulata*. Common grasses included *Panicum maximum*, *Sporobolus nitens* and *Eragrostis rigidior*. The forb *Asparagus minutiflorus* is also typical.

5.9 Drainage line complexes of the Mrunzuluku, Marheya and Sweni spruits and parts of the Shituntweni-Nwatinungu Spruit system

The following are common components of the mosaic associated with these drainage lines:-

(a) (*Hyphaene natalensis* or *Acacia tortilis* or *Euclea divinorum*) - (*Sporobolus nitens* or *S. smutsii* or *Dactyloctaenium aegypteum* or *Schmidtia pappophoroides* or *Chloris virgata*) - dominated vegetation of floodplains

Flat areas with vegetation dominated by various combinations of the aforementioned species, are common on spruit banks. Unclassified Releve 103, which is *Chloris virgata* - *Dactyloctaenium aegypteum* - dominated grassveld with scattered *Acacia tortilis*, is an example. These banks seem to be relatively sodic.

(b) Trees associated with spruits

Combretum imberbe and *Lonchocarpus capassa* are the dominant trees of the relatively mature section of the Sweni Spruit that flows through this landscape. These trees also occurred in the relatively younger upper reaches of the Marheya and Mrunzuluku spruits. *Ficus sycomorus*, *Diospyros mespiliformis* and *Kigelia africana* trees were recorded along the older Marheya and Sweni spruits sections, whereas *Acacia nigrescens* and *Spirostachys africana* trees seem to select the young upper reaches. Other spruit-associated trees recorded were *Acacia xanthophloea*, *Schotia brachypetala*, *Xanthocercis zambesiaca*, *Sclerocarya caffra* and *Lannea stuhlmannii*.

(c) Shrub and brush associated with spruits

The following shrub and brush species were recorded:- *Phoenix reclinata*, *Hyphaene natalensis*, *Ximenia caffra*, *Capparis tomentosa*, *Acacia robusta*, *A. tortilis*, *A. xanthophloea*, *Dichrostachys cinerea* subsp. *africana* var. *pubescens*, *D. cinerea* subsp. *africana* var. *setulosa*, *Schotia brachypetala*, *Dalbergia melanoxylon*, *Lonchocarpus capassa*, *Phyllanthus reticulatus*, *Lannea stuhlmannii*, *Maytenus senegalensis*, *Cassine aethiopica*, *Ziziphus mucronata*, *Flacourtia indica*, *Combretum hereroense*, *C. imberbe*, *C. mossambicense*, *C. paniculatum* subsp. *microphyllum*, *Euclea divinorum*, *E. natalensis* and *Diospyros mespiliformis*.

In young, sharply incised sections of the Marheya Spruit, *Combretum hereroense*, *Maytenus senegalensis* and *Acacia nigrescens* were among the most abundant shrub and brush species. *Spirostachys africana* also becomes common in the younger section of the Marheya Spruit. In upper reaches the woody species from the adjoining *Grewia bicolor* - *Acacia tortilis* - *Schmidtia pappophoides* - dominated shrubveld and brushveld and other landscape units, also become part of the drainage line vegetation.

(d) Sedges, grasses and forbs of levees, vleis and streambeds

The grasses *Panicum maximum*, *Urochloa mossambicense* and *Schmidtia pappophoroides* are among the most common field layer plants on levees here. Examples of other levee species are *Cenchrus ciliaris*, *Achyranthes aspera*, *Abutilon ramosum*, *Sida dregei*, *Convolvulus farinosus*, *Solanum panduraeforme*, *Cucumis africanus* and *Coccinia rehmannii* (e.g. unclassified Releve 102).

The most common species of wet habitats in streambeds and spruit-associated vleis, are the grasses *Eriochloa meyerana*, *Panicum maximum*, *Setaria woodii* and *Sporobolus consimilis* and the sedge *Cyperus sexangularis*. Each of these are commonly dominant in patches. The forb *Sesbania sesban* also occurs scattered throughout in such habitats. Occasional other species in these wet areas include *Ischaemum brachyaterum* and *Cynodon dactylon*.

A large seasonal pan and vlei with rank grassveld, on the watershed east of the Shituntweni Spruit, was dominated by the grasses *Sporobolus pyramidalis*, *Eragrostis lapula*, *Eriochloa meyerana* and the forb *Sesbania sesban*. Wet patches were dominated by *Eriochloa meyerana* and *Cyperus sexangularis*.

Fauna

Animals with some preference for the landscape include (cf. Tables 11 & 16, Ch. VI), impala (9,6 per km^2; Axis 1, 2nd Correspondence Analysis), elephant (1,1 per km^2; Axis 4, 1st Correspondence Analysis) warthog (0,3 per km^2; Axis 2, 2nd Correspondence Analysis) and white rhino (0,1 per km^2; Axis 2, Detrended Correspondence Analysis).

Impala were particularly dense in the Marheya Catchment, where Landscape Units 5.2/6/9 are predominant, but were nevertheless also significantly common on the Kumana Divide (Joubert, unpubl.). Low relative densities of blue wildebeest (0,8 per km^2), zebra (0,7 per km^2), and giraffe (0,2 per km^2) in this landscape were also largely in the Marheya Catchment.

The white rhino of this landscape occurred in the Mrunzuluku and Guweni catchments. Warthog were at the pans in the shortgrass Landscape Unit 5.7 of the Kumana Divide. Elephant were associated with Landscape Units 5.3/7 of the Kumana Divide and were probably attracted by the abundant brush and tree canopy together with water from the pans. White rhino, warthog and elephant which occurred abudantly in the southern part of the landscape, were relatively rare here during the winter 1980 survey, when the pans on the Kumana Divide had dried up owing to the markedly lower rainfall (Joubert, unpubl.).

6. Nonvertic Tropical Semi-arid Basaltic Lowveld

Introduction

This landscape continues southwards of the former, across the Sabie and Crocodile rivers and beyond. The average annual rainfall varies from 500mm in the north to 650mm in the south.

The internal pattern is complex. Vegetation composition and structure varies in relation to climate, relief unit, slope angle, soil type and other associated characters such as soil depth, texture, colour, pH and conductivity, as well as in relation to grazing impact. The gross landscape pattern is coarse and all major components can only be encompassed in particularly large areas. Some such components recur only twice in the entire Central District section of this landscape.

In general the landscape is gently undulating and clayey, with relatively open woody structure and a variety of field layers. Internal drainage is relatively poor and spruits retain surface water well into the dry season. All of the 14 major medium- to large- herbivore species of the Central District occur here with high relative densities. Only three of the 18 such herbivore species of the Kruger National Park are absent or relatively poorly represented on these plains. The latter are roan antelope, eland and nyala.

Physiographic and grazing pattern

Topography -

Topography has a major influence on the patterns of grazing, soil and vegetation. This part of the basaltic plains is drained by four major river systems. These are, from north to south:-

(a) the well-branched Nwanedzi-Gudzane-Mavumbye System;

(b) the well-branched Sweni-Makongolweni-Guweni-Nungwini System;

(c) the Nwaswitsontso System; and

(d) the Sabie-Mlondozi System.

The Sweni River joins the Nwanedzi River just below the basaltic region. The narrow watersheds of the basaltic terrain separating these rivers and their various tributaries has comparatively strong relief. On the other hand, the Sweni River and its tributaries are much further separated from the Nwaswitsontso River by the low relief Lindanda Plains, which form a plateau divide. Similarly, a low relief watershed, the Rietpan Plains, occurs between the well-separated Nwaswitsontso and Sabie-Mlondozi rivers.

Grazing regions -

The concentration of medium- to large- herbivore biomass on these basaltic plains is high (Table 11, Ch. VI). Therefore the direct effect of uniform grazing and trampling on the vegetation pattern, as well as the indirect influence on vegetation through the trampling of soils, is considerable.

Each of the major river systems on the semi-arid basaltic plains has its associated area of concentrated grazing and trampling by medium and large herbivores. Those of the lower Nwanedzi-Gudzane-Mavumbye and the nearby Sweni-Makongolweni-Guweni-Nungwini systems form an almost continuous region, which extends onto the Lindanda Plains. A more isolated area of concentrated grazing occurs at the Nwaswitsontso River, around Tshokwane. Another major grazing region occurs along the Sabie and Mlondozi rivers.

These grazing regions are not subject to even grazing pressure throughout the year. Seasonal and longer term fluctuations in natural water supplies, seasonal migration patterns, artificial water supplies and burning determine the grazing pressure in each of these areas at any particular time (cf. Joubert, unpubl; Whyte,[5] pers. comm.).

Soils -

The soils of this landscape are largely non-calcareous with 15-35 per cent clay in A horizons. The A horizons may be orthic or melanic. B horizon clay content is usually in the 25-55 per cent range. Soil depth varies from shallow, with lithocutanic B horizons to deeper with pedocutanic B horizons. Total depth is commonly 300-600mm, but occasionally up to 1000mm and more. Most of these soils are of the Mayo, Glenrosa, Bonheim and Swartland forms (Ass. 3, 7.2, 7.3, 8.1, 8.2, 9.2, 9.3, 9.4, Tables 3 & 5-7, Ch. IV).

The soil depth typically varies continuously. Over large areas poorly developed soils of the Mayo and Glenrosa forms alternate with better developed soils of the Bonheim and Swartland forms. Such recurring changes commonly take place at intervals of ones or tens of metres (cf. Coetzee & Venter, unpubl.). There are, however, also some regions where shallow, poorly developed soils with lithocutanic B horizons predominate. Particularly extensive examples of the latter occur in well-dissected convex terrain, with strong water runoff, near major rivers, e.g. towards Nwanedzi where several spruits converge and

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along parts of the Nwanedzi, Sweni, Nwaswitsontso and Sabie rivers. Deeper soils, on the other hand, seem to be relatively common in flat to concave bottomlands and on the southernmost Central District basaltic plains from the Rietpan Plateau to the Sabie River.

The Bonheim Form is particularly common in bottomlands. In some bottomlands the Bonheim Form grades into the vertic Arcadia Form. Other soil forms found immediately along drainage lines include the Oakleaf Form, which has a neocutanic B horizon, the Willowbrook and Tambankulu forms, with high watertables, and the solonetzic Sterkspruit Form (Harmse, unpubl.).

In the severely grazed areas near the major river systems, the vegetation on these various soils have arid types of species composition and structure. This is presumably caused partly by the effect that trampling must have on the soils. Such soils may become deflocculated through puddling and therefore relatively dry because of increased water runoff (cf. Ass. 3, Ch. IV).

Ecotopes -

The following ecotopes were recognized as the net effect of topography, soil patterns, vegetation and related grazing patterns:

6.1 Wide plateau divides

The lightly grazed, Nkongwana Spruit region of the Lindanda Plains and the basaltic, Klein-Mlondozi Spruit region of the Rietpan Plains, belong to this ecotope. The terrain is level to gently (less than 1^{o}) sloping.

The soils of the Rietpan Plains example are typically of the Mayo mayo Series, i.e. a melanic A horizon with 15-35 per cent clay and a non-calcareous lithocutanic B horizon (e.g. Releves 252, 262, 271 & 272, Ass. 7.2 & 7.3, Table 5, Ch. IV). Recorded A horizon pH ranges from 5,7 to 6,2. Releve 251, which is transitional to the adjoining Karoo Sediment landscape (Landscape 4) and Releve 253, which is transitional to the adjoining ecotope (6.2) of the present landscape, are of the Glenrosa and Bonheim forms respectively (Ass. 7.2, Table 5, Ch. IV). The melanic A horizons of the typical plateau-associated soils of this southern divide, are distinct from the orthic A horizons of the next ecotope on surrounding slopes, where soils are typically of the Glenrosa and Swartland forms. Soil A horizons of the divide are also distinctly clayey, with approximately 30 per cent clay.

Soils of the northern example, on the Nkongwana Plains are of the Mayo mayo Series (e.g. Releve 162, Ass. 8.2, Table 6, Ch. IV), as above; and of the Glenrosa williamson and Glenrosa robmore Series (e.g. Releves 232 and 234, Ass. 8.2, Table 6, Ch. IV), i.e. with 15-35 per cent clay and fine to coarse sand in orthic A horizons and with non-calcareous B horizons. Recorded pH values for A horizons here, are 5,7 and 5,8.

6.2-6 Relatively lightly grazed undulating terrain

Sclerocarya caffra - dominated treeveld characterizes five closely related ecotopes. These are slopes and summits of undulating terrain that is relatively lightly grazed. Their Central District distribution is from the Gudzane-Mbatsane region in the north to the Sabie River in the south. Major interruptions are in the two chief grazing regions associated with the Nwanedzi-Sweni River System and Nwaswitsontso River Systems (Landscape 6.9) and at the flat *Acacia gerrardii* - dominated plateaux (Landsape 6.1). The five ecotopes differ in respect of terrain form, rainfall and sandstone influence and associated differences in soil moisture and leaching:-

6.2 Lightly grazed, gently undulating basaltic terrain with comparatively low pH and -low conductivity soils, in the relatively high rainfall region south of Tshokwane

In the lightly grazed undulating and gently (0-2°) sloping terrain south of Tshokwane, where the mean annual rainfall is approximately 600-650mm, the soils are largely non-margalitic and with distinctly lower pH and conductivity than in similar terrain of the lower rainfall region north of Tshokwane. The soils in the south are typically of the Glenrosa robmore Series, i.e. an orthic A horizon with 15-35 per cent clay and coarse sand and a non-calcareous B horizon (e.g. Releves 250, 264, 265 & 276, Ass. 7.2, Table 5, Ch. IV); and of the non-calcareous series of the Swartland Form, i.e. an orthic A horizon and a pedocutanic B horizon on saprolite (e.g. Releves 249, 263 & 269, Ass. 7.2, Table 5, Ch. IV). Releve 275 of the margalitic Mayo Form (Ass. 7.2, Table 5, Ch. IV) is an exception.

Soil A- and B horizon pH in this ecotope are typically less than 6,0. A horizon conductivity is typically less than 250 micro mhos and B horizon conductivity less than 400 micro mhos.

6.3 Lightly grazed, gently undulating basaltic terrain, with comparatively high pH and - high conductivity soils and A horizon clay content exceeding 20 per cent, in the relatively low rainfall region north of Tshokwane

The average annual rainfall north of Tshokwane is less than 600mm and decreases to approximately 500mm in the Gudzane-Mbatsane area. Soils of the lightly grazed, gently undulating and gently sloping (0-1°) terrain in this region are commonly margalitic. The margalitic soils are of:
(a) the Bonheim dumasi Series (e.g. Releves 71, 73, 74 & 163, Ass. 8.2, Table 6, Ch. IV), i.e. a melanic A horizon with 15-35

per cent clay and a non-calcareous, non-red, pedocutanic B horizon; (b) the Mayo mayo Series (e.g. Releves 69 & 84, Ass. 8.2, Table 6, Ch. IV), i.e. a melanic A horizon with 15-35 per cent clay and a non-calcareous lithocutanic B horizon; and (c) the Milkwood dansland Series (e.g. Releve 164, Ass. 8.2, Table 6, Ch. IV), i.e. a non-calcareous, melanic A horizon with 15-35 per cent clay, on hard rock. Non-margalitic soils are, however, also common in this ecotope. These are of: (a) the Glenrosa williamson, Glenrosa trevanian and Glenrosa robmore series (e.g. Releves 82, 85, 94, 148 & 255, Ass. 8.2, Table 6, Ch. IV), i.e. an orthic A horizon with 15-35 per cent clay, and a non-calcareous B horizon; and (b) the Swartland Form (e.g. Releve 83, Ass. 8.2, Table 6, Ch. IV), i.e. an orthic A horizon, pedocutanic B horizon and saprolite.

Soil A- and/or B horizon pH here exceed 6,0; and either A horizon conductivity exceeds 250 micro mhos, or B horizon conductivity exceeds 300 micro mhos or both. This is in contrast with soils of similar terrain in the higher rainfall region south of Tshokwane.

6.4.5 Lightly grazed, gently undulating terrain with sandstone influence and less than 20 per cent clay in A horizon

Sandstone influence is often present in the predominantly basaltic region, near the boundaries of the latter with Karoo Sediment Landscapes 4 and 5. This influence is noticeable as comparatively low soil clay content, high percentage medium to fine sand and relatively low percentages coarse sand, and in some examples sandstone is actually present as stones in the soil profile or as bedrock.

Releve 227 (Ass. 5.4.2, Table 4, Ch. IV), where the sandstone influence is particularly strong, represents a Mispah mispah Soil, with an orthic A horizon containing less than 15 per cent clay, on sandstone.

Releves 168, 236 and 244 (Ass. 8.2.2, Table 6, Ch. IV) and Releve 155 (Ass. 8.3, Table 6, Ch. IV), represent areas where the sandstone influence is moderately strong. A horizon clay content here is approximately 20 per cent. Typically basaltic Releves that are phytosociologially similarly classified (Ass. 8.2), chacteristically have 21-30 per cent clay in A horizons and belong to Landscape Unit 6.3. Other comparisons between typical examples of these two units are, e.g. 64-70 per cent sand in A horizons with sandstone influence (an extreme value excluded) as against 40-60 per cent without sandstone influence; 43-44 per cent A horizon fine sand with- and 24-39 per cent without sandstone influence; and 21, 21, 29 and 37 per cent B horizon clay with- and 35-45 per cent (an extreme value excluded) without sandstone influence. Aforementioned Releves 168, 236 and 244 are of the Glenrosa williamson Series (orthic A horizon with fine sand and 15-35 per cent clay, and non-calcareous lithocutanic B horizon). Releve 155 is of the Swartland reveillie Series, which is similar but with a pedocutanic B horizon.

6.6 Relatively strongly undulating, non-rocky, basaltic terrain

A fifth *Sclerocarya caffra* - characterised ecotope occurs mainly in the relatively strongly undulating terrain between the upper reaches of the Nwanedzi River, i.e. around Satara. The soils of this ecotope belong to: (a) the Mayo mayo Series (e.g. Releves 70, 77 & 81, Ass. 9.2, Table 7, Ch. IV), i.e. a melanic A horizon with 15-35 per cent clay, over a non-calcareous lithocutanic B horizon; and (b) the Glenrosa williamson Series (e.g. Releves 51 & 79, Ass. 9.2, Table 7, Ch. IV), i.e. an orthic A horizon with 15-35 per cent clay and fine sand, over a non-calcareous, lithocutanic B horizon. In most of the cited releves the A horizon pH was 6,0. B horizon pH varied from 6,1 to 6,8.

Releve 248 is physiographically similar to Releves 236, 244 and 168 of Ecotope 6.5 and is from a Glenrosa williamson Soil with 21 per cent clay and 73 per cent sand, including 58 per cent medium sand owing to sandstone influence. Presumably this is why Releve 248 is of the phytosociologically relatively mesic Association 7.1.1 (Table 5, Ch. IV) and this Releve is regarded as transitional to Landscape Units 6.4/5 with sandstone influence.

6.7 Extremely shallow soils where sheet outcrop is common, and strongly undulating terrain

This ecotope is common between the upper reaches of the Nwanedzi River in the Satara vicinity and in welldrained parts of the Nwanedzi vicinity, where the Nwanedzi-Gudzane and the Sweni-Makongolweni drainage lines converge. The vegetation indicates an aridness of habitat that must be largely ascribed to quick drying of the shallow soils as well as to high water runoff in the strongly undulating terrain with its numerous abrupt incisions by drainage lines.

Soils are of: (a) the Mayo mayo Series (e.g. Releves 50, 72, 80 & 106, Ass. 9.4, Table 7, Ch. IV), i.e. a melanic A horizon with 15-35 per cent clay over a non-calcareous lithocutanic B horizon; (b) the Glenrosa williamson and Glenrosa robmore series (e.g. Releves 78, 99, 105 & 149, Ass. 9.4, Table 7, Ch. IV), i.e. an orthic A horizon with 15-35 per cent clay, over a non-calcareous B horizon; (c) the Milkwood dansland Series (e.g. Releves 88 and 90, Ass. 9.4, Table 7, Ch. IV), i.e. a non-calcareous, melanic A horizon with 15-35 per cent clay, over hard rock; and (d) the Mispah mispah Series, (e.g. Releve 100, Ass. 9.4, Table 7, Ch. IV), which is similar but with an orthic A horizon. Soil conductivities of the examples varied from 300-790 micro mhos and pH of A and/or B horizons were between 6,0 and 6,9.

6.8 Heavily grazed upland sites

The heavily grazed section of the Lindanda Plains has soils belonging to: (a) the Glenrosa robmore Series (e.g. Releve 156, Ass. 8.1, Table 6, Ch. IV), i.e. an orthic A horizon with 15-35 per cent clay and coarse-grained sand over a non-calcareous lithocutanic B horizon; (b) the Mayo mayo Series (e.g. Releve 235, Ass. 8.1, Table 6, Ch. IV), i.e. a melanic A horizon with 15-35 per cent clay over a non-calcareous lithocutanic B horizon; and (c) the Bonheim dumasi and Bonheim glengazi series (e.g. Releves 158 & 161, Ass. 8.1, Table 6, Ch. IV), i.e. melanic A horizons with more than 15 per cent clay, over non-calcareous, non-red, pedocutanic B horizons. In all these Releves A horizons had more than 25 per cent clay and B horizons more than 40 per cent clay. A horizon pH ranged from 5,8 to 6,0 and B horizon pH from 5,3 to 7,2. Conductivities ranged from 460-720 micro mhos. Slopes range from 0-1°.

This ecotope, represented by tne aforementioned releves, occurs on the same soil forms as the adjoining *Acacia gerrardii* - dominated brushveld represented by Releves 162, 232 and 234 (Landscape 6.1). Clay percentages and soil depths are essentially similar also. However, the conductivities of the soils, particularly of the B horizons, are significantly higher on the heavily grazed parts as shown by the representative releves mentioned ($P = 0,05$ i.r.o. A horizons and $P = 0,02$ i.r.o. B horizons, $N1 = 3$, $N2 = 5$, Two-tailed Mann-Whitney U tests using normal approximation with tie correction; Table 6, Ch. IV). B horizon conductivity of the severely grazed representatives range from 500-870 micro mhos and that of the representatives from the adjoining area, from 260 to 350 micro mhos (Table 6, Ch. IV).

The unresolved question is: to what extent are the high conductivities primarily the cause or effect of the initial heavy game concentrations? Animal impact made a major contribution to the present state of the vegetation, either directly or through compaction of the soil and concomitant increased runoff, or through manuring, or otherwise. The primary reason for this presence might have been the extension of the major grazing region associated with the Sweni-Makongolweni-Guweni-Nungwini river system, with the soil peculiarities a subsequent phenomenon.

On the other hand, the Lindanda Plains are a "saddle" shaped plateau between the higher rhyolitic area closeby towards the east and the higher Kumana area with abundant Karoo Sediment presence, towards the north-west (Landscape 5). The rhyolite and some of the Karoo Sediments are relatively rich in sodium and the sodic areas characteristically have relatively high conductivities (cf. Table 3, Ch. IV). Colluvial influence from elevated, relatively sodium-rich areas or mixed geology, might thus have enhanced the nutrient status and raised the conductivities of the Lindanda Plains soils, rendering the vegetation more attractive to medium and large herbivores. The effect of game may then be secondary. The direct effect of rhyolites on soils and vegetation are apparent on the Lindanda Plains bordering on the ryolitic area. Here, including part of the burning experimental plots, distinct soil differences and the presence of sodic indicators such as Acacia welwitschii (cf. Table 2, Ch. IV) are ascribed to rhyolitic influence (Coetzee & Venter, unpubl.)

6.9 Heavily grazed bottomlands

This ecotope occurs in the heavily grazed low areas of the major river systems. The most extensive examples are in the Sweni-Makongolweni-Guweni-Nungwini area, in the Tshokwane region of the Nwaswitsontso River and in the immediate vicinity of the Sabie River. Prominent patches also occur near Gudzane Dam and along the lower Nwanedzi River. Slope angles vary from 0-2^{o}. A horizon clay content of 23-35 per cent is similar to that of some of the surrounding less intensively grazed basaltic areas, but A horizon pH of 6,1-6,6 is comparitively high. Exceptions with lower A horizon pH occur in areas such as along the Nkhelenga Spruit where the granophyric Nkumbe Hill has a colluvial influence and in presumably alluvial soil of the Oakleaf Form (e.g. Releve 96, Ass. 3, Table 3, Ch. IV), at Gudzane Dam. Releve 145 (Ass. 8.2, Table 6, Ch. IV) and Releve 160 (Ass. 8.1, Table 6, Ch. IV), which are phytosociologically transitional to heavily grazed upland sites also have lower pH. Conductivities of A and B horizons are variable, ranging from 210-900 micro mhos. Soils of the examples belonging to Association 3 (Table 3, Ch. IV) are presumably puddled owing to sodic influence from adjoining rhyolite, granophyre and Karoo Sediments, or to trampling or to both factors.

The soils are typically of: (a) the Bonheim kiora and Bonheim dumasi series (15-35 per cent clay in melanic A horizon and non-calcareous B horizon; e.g. Releve 317, Ass. 9.3, Table 7 & Releve 258, Ass. 3, Table 3, Ch. IV); (b) The Mayo mayo Series (15-35 per cent clay in melanic A horizon and non-calcareous B horizon; e.g. Releves 127, 150 & 152, Ass. 9.3, Table 7, Releves 145 & 160, Ass. 8.2 & 8.1, Table 6, & Releve 239, Ass. 3, Table 3, Ch. IV); (c) the Swartland reveillie and Swartland broekspruit series (orthic A horizon and 15 per cent clay in non-calcareous and calcareous red B horizons; e.g. Releve 151, Ass. 9.3, Table 7 & Releves 241 & 257, Ass. 3, Table 3, Ch. IV); and (d) the Glenrosa williamson, Glenrosa trevanian and Glenrosa robmore series (orthic A horizons with 15-35 per cent clay and non-calcareous B horizons; e.g. Releves 52, 153 & 238, Ass. 9.3, Table 7 & Releve 268, Ass. 3.2, Table 3, Ch. IV).

6.10 Lightly grazed non-vertic non-sodic, bottomlands that are moderately dry with relatively high soil conductivity and relatively low pH

These bottomlands are represented by Releves 112, 113, 114 and 115 (Ass. 8.2, Table 6, Ch. IV), which are from the low basaltic plains along the upper reaches of the Mbatsane and Shinkelengane spruits, against the Lebombo Mountains. The plains here are gently to moderately sloping. Soil A horizons in the sample had 24-35 per cent clay, pH of 5,1-6,4 and conductivity of 550-900 micro mhos (e.g. aforementioned Releves

112, 114, 115). B horizon figures, available only for Releves 114 and 115, are 46 per cent and 49 per cent clay, pH of 5,1 and 5,5 and conductivity of 270 micro mhos and 640 micro mhos. Conductivities seem to be higher and pH lower than for the next ecotope where neither A horizon nor B horizon conductivities exceed 500 micro mhos and where pH values exceed 5,5. These differences are probably owing to rhyolitic influence from the Lebombo Mountains in the present ecotope. Releve 113 is from an unusually shallow soil of less than 100mm depth.

6.11 Lightly grazed non-vertic non-sodic bottomlands that are mesic with relatively low soil conductivity and relatively high pH

Releves of this ecotope are from lightly grazed bottomland plains south and west of the Lindanda Plains and typically belong to Association 7.2 and 7.3 (e.g. Releves 247, 256, 260, 266, 267 & 331, Table 5, Ch. IV). Releve 233, which belongs here, is phytosociologically similar to the former ecotope, being classified as Association 8.2.1 (Table 6, Ch. IV) and Releve 228 is classified with Association 2.2 (Table 3, Ch. IV) where it is atypical. The latter releve does not include soil data. For the rest A horizons have 25-43 per cent clay, pH of 5,5-6,3 and conductivities of 250-490 micro mhos. B horizons have 33-56 per cent clay (mostly 44-56 per cent), pH of 5,7-8,0 (mostly 6,1-8,0) and conductivities of 170-630 micro mhos (cf. Ecotope 6.10). The soils in typical quadrats are of the non-calcareous Bonheim kiora Series (Releve 247), Bonheim dumasi Series (Releves 256 & 260), Mayo mayo Series (Releve 331), Swartland skilderkrans Series (Releve 267), Swartland breidbach Series (Releve 266) and Glenrosa robmore Series (Releve 233).

6.12-14 Vertic bottomlands, sodic bottomlands and vlei, spruit and river complex

Vertisols of the Arcadia Form are typical of bottomlands in all Central District basaltic landscapes. These vertisols grade via near-vertic soils of the Bonheim Form into adjoining ecotopes. Vleis and drainage lines were excluded from the phytosociological survey and are not represented by formal releves. Adjoining Acacia nigrescens - dominated shrubveld and brushveld on vertisols or near-vertisols, were formally sampled and occurred on soils of: (a) the Bonheim dumasi and Bonheim weenen series (e.g. Releves 86 and 87, Ass. 9.2, Table 7, Ch. IV), i.e. a melanic A horizon with 15-35 per cent clay, over a calcareous or non-calcareous, non-red, pedocutanic B horizon; and (b) the Arcadia rooidraai and Arcadia eenzaam series (e.g. Releves 76 & 97, Ass. 11.2, Table 8, Ch. IV), i.e. a calcareous or non-calcareous, red vertic A horizon with a self-mulching or weakly crusting surface.

Various other plant communities occur on similar vertic soils of vleis and drainage areas. Where adjoining slopes are rhyolytic or granophyric the vegetation indicates strong sodic influence.

Releve 157, which was not phytosociologically classified, was from a particularly calcareous and presumably sodic Oakleaf limpopo Soil along a tributary of the upper Guweni Spruit. The sodic character is inferred from the vegetation and attributed to the influence from the adjoining higher, fine textured Karoo Sediments of Landscape 5.

Vegetation pattern

6.1 *Acacia gerrardii* - dominated brushveld of wide plateau divides

The vegetation of the southern, relatively high rainfall example, i.e. the Klein Mlondozi Spruit part of the Rietpan Plains belongs to Association 7.2 & 7.3 (Table 5, Ch. IV) where it is represented by Releves 251, 252, 253, 262, 271 and 272 (Fig. 11, Appendix 5). The northern example, on the Nkonwane Spruit region of the Lindanda Plains, belongs to Association 8.2 and is represented by Releves 162, 232 and 234 (Table 6, Ch. IV).

The structure on these flat plains is typically sparse to moderate brushveld with scattered to sparse shrub cover (Appendix 1). *Acacia gerrardii* is the dominant brush and often also the dominant shrub species. Occasionally prominent woody species, particularly of the shrub level, include *Acacia nigrescens*, *Dichrostachys cinerea*, *Pterocarpus rotundifolius* and *Albizia harveyi*. Trees of *Sclerocarya caffra* are characteristically absent. The most common dominants and subdominants of the field layer are *Themeda triandra*, *Digitaria eriantha* and *Panicum coloratum* (Tables 5 & 6, Ch. IV). *Heteropogon contortus* is often also among the subdominants.

6.2 Sclerocarya caffra - (Dichrostachys cinerea or Pterocarpus rotundifolius) - Themeda triandra - dominated treeveld, with relatively mesic indicator species (e.g. Albizia harveyi, Acacia gerrardii, Maytenus heterophylla, Ximenia caffra, Heteropogon contortus, Vernonia oligocephala, Rhynchosia minima, Chascanum hederaceum), of lightly grazed, gently undulating basaltic terrain with comparatively low pH and low conductivity soils, in the relatively high rainfall region south of Tshokwane

The S. caffra - dominated treeveld of the relatively high rainfall region, south of Tshokwane, belongs to Association 7.2 (Table 5, Ch. IV) and is represented by Releves 249, 250, 263, 264, 265, 269 and 275. The relatively mesic indicator species listed, help distinguish this landscape unit from Landscape Unit 6.5, which may have similar dominants and structure.

The structure here is sparsely to moderately shrubby sparse treeveld and similar shrubveld and brushveld with scattered trees. Sclerocarya caffra is the dominant tree. Shrub and brush levels are dominated by either Dichrostachys cinerea subsp. africana or by Pterocarpus rotundifolius subsp. antunesii (Appendix 1). The field layer is usually completely dominated by the grass Themeda triandra and occasionally by Digitaria eriantha. The latter as well as Panicum coloratum, Heteropogon contortus and Urochloa mossambicense are the most common subdominants (Table 5, Ch. IV).

6.3 *Sclerocarya caffra* - *Acacia nigrescens* - *Themeda triandra* - *Bothriochloa radicans* - dominated treeveld of lightly grazed, gently undulating basaltic terrain with comparatively high pH and -high conductivity soils and A horizon clay content exceeding 20 per cent, in the relatively low rainfall region north of Tshokwane

The *S. caffra* - dominated treeveld here typically belongs to Association 8.2 (Table 6, Ch. IV). The structure is typically sparse treeveld with scattered to moderate shrub cover and scattered to sparse brush cover. *S. caffra* is the dominant tree (Appendix 1). *Acacia nigrescens* is the dominant shrub and brush species in the most characteristic examples of this landscape unit (e.g. Releves 69, 71, 73, 74, 83, 84, 85, 92, 94 & 255, Ass. 8.2, Table 6, Ch. IV). Dominant shrub and brush species in transitional situations include: *Grewia bicolor* in dry situations, e.g. towards the heavily grazed areas (Releves 148, Fig. 12, Appendix 5 & Releve & 154, Ass. 8.2, Table 6, Ch. IV); *Acacia gerrardii* on areas that are presumably relatively poorly drained, e.g. towards the flat Nkongwana plateau or in low level areas (e.g. Releve 163, Ass. 8.2, Table 6, Ch. IV, representing a mottled B horizon and manganese concretions, owing to a periodically high watertable); and *Albizia harveyi*, in presumably relatively mesic situations, that resemble (a) mesic *Sclerocarya caffra* - dominated treeveld on the basaltic plains south of Tshokwane, where *Albizia harveyi* is highly constant and (b) *Albizia harveyi* - *Dichrostachys cinerea* - *Themeda triandra* - dominated shrubveld and brushveld of nonvertic, non-sodic bottomlands that are also mesic (e.g. Releve 164, Ass. 8.2, Table 6, Ch. IV, from shallow, relatively sandy bottomland soil, and Releve 82, Ass. 8.2, Table 6, Ch. IV).

The grasses *Themeda triandra* and *Bothriochloa radicans* are usually either dominant or subdominant in the field layer (Table 6, Ch. IV). *B. radicans* is thus characteristically more abundant in this moderately dry landscape unit than in the mesic landscpe unit in similar terrain south of Tshokwane. Within the moderately dry unit, _E. radicans_ is moreover characteristically dominant in the driest situations, e.g.: towards the heavily grazed parts of the Sweni-Makongolweni-Guweni-Mungwini System (Releves 148 & 154, Ass. 8.2, Table 6, Ch. IV) or similar areas, e.g. near Gudzane Dam (Releve 92, Ass. 8.2, Table 6, Ch. IV); and towards the well-dissected terrain of the upper Mwanedzi River tributaries, where external drainage is relatively strong (Releves 69 & 85, Ass. 8.2, Table 6, Ch. IV). Other regularly prominent but subdominant grasses include _Digitaria eriantha_ and _Panicum coloratum._

6.4 _Sclerocarya caffra_ - _Acacia nigrescens_ - _Combretum hereroense_ - _Digitaria eriantha_ - _Panicum maximum_ - _Sporobolus fimbriatus_ - dominated shrubby, brushy, treeveld of lightly grazed, gently undulating terrain with strong sandstone influence and less than 15 per cent clay in A horizon

Releve 227 (Ass. 5.4.2, Table 4, Ch. IV) represents _Sclerocarya caffra_ - dominated treeveld with a field layer that is determined mainly by a sandstone influence. The structure in this example is sparsely shrubby, moderately brushy, moderate treeveld (Appendix 1). Woody dominants are _Sclerocarya caffra_ at the tree level, _Acacia nigrescens_ trees at the brush level and _Combretum hereroense_ brushes at the shrub level. _Digitaria eriantha_, _Panicum maximum_ and _Sporobolus fimbriatus_ are the field layer dominants.

6.5 *Sclerocarya caffra* - *Dichrostachys cinerea* - dominated shrubby, brushy treeveld and grassveld with scattered *Dichrostachys cinerea* - dominated shrub and brush; with *Themeda triandra* - *Panicum coloratum* - *Bothriochloa radicans* - *Digitaria eriantha* - dominated field layers; and with relatively xeric indicator species (e.g. *Acacia nigrescens*, *A. tortilis*, *Securinega virosa*, *Chloris virgata*, *Heliotropium steudneri* and *Boerhavia diffusa*); of lightly grazed, gently undulating terrain with moderate sandstone influence and 15-20 per cent clay in A horizon

Releves 168, 236 and 244 (Ass. 8.2.2, Table 6, Ch. IV) and Releve 155 (Ass. 8.3, Table 6, Ch. IV) represent this landscape type. The relatively xeric indicator species listed, help to distinguish this landscape unit from Landscape units 6.2/11, which may have similar dominants and structure.

The structure here is grassveld with scattered shrub and brush, as in aforementioned Releves 155 and 244, or sparsely to moderately shrubby, sparsely brushy, sparse treeveld. *Sclerocarya caffra* is the dominant tree and *Dichrostachys cinerea* the dominant brush and/or shrub. Field layer dominants include the grasses *Themeda triandra*, *Panicum coloratum*, *Bothriochloa radicans* and *Digitaria eriantha*.

6.6 *Sclerocarya caffra* - *Acacia nigrescens* - (*Combretum apiculatum* or *Acacia exuvialis*) - *Bothriochloa radicans* - *Themeda triandra* - dominated treeveld of relatively strongly undulating, non-rocky, basaltic terrain

This vegetation belongs to Association 9.2 and is represented by Releves 51, 70, 77, 79 and 81 (Table 7, Ch. IV). Releve 248 (Ass. 7.1.1, Table 5, Ch. IV), which is transitional to Landscape Unit 6.4 belongs here physiognomically. The structure is sparse to moderate treeveld with scattered to sparse shrub and brush. *Sclerocarya caffra* is the dominant tree and _Acacia nigrescens_ the dominant shrub and brush. _Combretum apiculatum_ and/or _Acacia exuvialis_ shrubs and brushes are typically present (Appendix 1, Table 7, Ch. IV). Occasionally, at relatively low clay percentage (less than 20 per cent in A horizon), _C. apiculatum_ may be the dominant shrub and brush (e.g. aforementioned Releves 81 and 248). Transitional Releve 248 also has abundant _Combretum hereroense_ as in Landscape Unit 6.4. _Bothriochloa radicans_ and _Themeda triandra_ are the dominant grasses. Common subdominant grasses include _Digitaria eriantha_ and _Panicum coloratum_.

6.7 _Acacia nigrescens_ - _Grewia bicolor_ - _Terminalia prunioides_ - _Combretum apiculatum_ - dominated brushveld associated with extremely shallow soils where sheet outcrop is common and with strongly undulating terrain

The vegetation of this landscape unit belongs to Association 9.4, which is transitional to the vegetation of the more arid Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8). Releves 50, 72, 78, 80, 88, 90, 99, 100, 105, 106 and 149 are representative (Ass. 9.4, Table 7, Ch. IV; Appendix 1).

The structure of the vegetation is sparsely to moderately shrubby, scattered to sparsely brushy, shrubveld and brushveld, dominated mainly by various combinations of _Acacia nigrescens_, _Grewia bicolor_, _Combretum apiculatum_ and _Terminalia prunioides_. The latter two species are particularly abundant near outcrop (e.g. aforementioned Releves 72 & 80).

The grass Bothriochloa radicans is usually dominant in the field layer, but may be subdominant to Aristida spp., incuding A. congesta subsp. barbicollis, in heavily grazed or physiographically particularly arid sites. Such Aristida spp. - dominated sites are represented by Releve 99 (Ass. 9.4, Table 7, Ch. IV), which is from near the well-utilized (Ackerman,[6] pers. comm.) Dumbana Waterhole and therefore, quite likely heavily grazed and trampled; and Releve 100 (Ass. 9.4, Table 7, Ch. IV), which is from a 6^{o} slope with extremely shallow soil of the Mispah Form and therefore with high water runoff and quick-drying substrate. Panicum maximum is regularly prominent, clustering under brush and shrub. Occasionally subdominant grasses include Enneapogon cenchroides, particularly in arid sites, Digitaria eriantha and Panicum coloratum (Table 7, Ch. IV).

6.8 Dichrostachys cinerea - Acacia tortilis - dominated shrubveld and brushveld of heavily grazed upland sites

The heavily grazed and trampled Lindanda Plains contribute most to this distinct landscape unit. The vegetation, represented by Releves 156, 158, 161 and 235 (Ass. 8.1, Table 6, Ch. IV; Apendix 1) belongs to the same association as the adjoining less heavily grazed Acacia gerrardii - dominated brushveld represented by Releves 162, 232 and 234 (Ass. 8.2, Table 6, Ch. IV). They do, however, differ floristically at subcommunity level.

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The vegetation structure on the heavily grazed Lindanda Plains is sparsely to moderately shrubby, sparse brushveld and sparse shrubveld with scattered brush. The dominant woody species are Dichrostachys cinerea subsp. africana and Acacia tortilis subsp. heteracantha (Appendix 1). Both these species become relatively abundant with heavy grazing (cf. Ass. 8.1, Ch. IV).

A combination of Bothriochloa radicans, Panicum coloratum and Aristida congesta subsp. barbicollis is usually dominant in the field layer. This bears testimony to the dry (B. radicans), nutrient-rich (P. coloratum) and heavily grazed and trampled (A. congesta subsp. barbicollis) habitat conditions (cf. Tables 2-9 & Ass. 8.1; Coetzee & Venter, unpubl.) Themeda triandra is dominant in the field layer and Acacia gerrardii is a prominent woody species in Releve 161 (Ass. 8.1, Table 6, Ch. IV), which is from the edge of the heavily grazed plains and transitional to the adjoining, lightly grazed Acacia gerrardii - dominated plains (Table 6, Ch. IV). Other prominent grasses of the heavily grazed plains include Panicum maximum, which clusters under shrubs and brushes, Urochloa mossambicense, which is a pioneer grass, and Digitaria eriantha (Table 6, Ch. IV).

6.9 Grewia bicolor - Acacia tortilis - A. nigrescens - dominated brushveld of heavily grazed bottomlands

Much of the vegetation belongs to two associations that grade into one another and presumably represent different degrees of grazing and trampling impact. Part of this landscape unit, particularly in the Sweni-Makongolweni-Guweni-Nungwini area, belongs to Association 9.3 (e.g. Releves 52, 127, 150, 151, 152, 153, 238 & 317, Ass. 9.3, Table 7, Ch. IV). Other areas, particularly around Tshokwane and along the Sabie River, where surface soil compaction has presumably progressed further, belong to both subcommunities of the Pupalio lapaceae - Acacietum nigrescentis (i.e. Ass. 3, Ch. IV; e.g. Releves 96, 237, 239, 240, 241, 257, 258 and 268). Representative Releves 145 and 160 (Ass. 8.1 & 8.2, Table 6, Ch. IV) are phytosociologically transitional to heavily grazed upland sites, i.e. to Landscape Unit 6.8. The structure is typically sparsely to moderately shrubby, sparse brushveld, occasionally with scattered Acacia nigrescens trees. The shrub and brush layers are dominated by Acacia tortilis and an admixture of A. nigrescens, Grewia bicolor and Dichrostachys cinerea subsp. africana (Appendix 1). Of these A. nigrescens and G. bicolor are particularly frequently among the dominants. D. cinerea becomes abundant on the soils with relatively deep, low pH A horizons and vegetation belonging to Association 3 (Table 3, Ch. IV).

Field layer dominants vary according to plant community. Urochloa mossambicense and Aristida spp. are dominant and Bothriochloa radicans may be codominant or subdominant in Association 3.1 (Table 3, Ch. IV). Panicum maximum and P. coloratum are dominant in Association 3.2 (Table 3, Ch. IV). Other prominent grasses here may include Urochloa mossambicense, Bothriochloa radicans, Digitaria eriantha and Themeda triandra (Table 3, Ch. IV). The rest of the vegetation of this landscape unit belongs to the Bothriochloa radicans - dominated Variation of Association 9.3.1 (Table 7, Ch. IV). Other prominent grasses in the latter variation include Panicum coloratum, Aristida spp., Urochloa mossambicense and Panicum maximum.

6.10 Dalbergia melanoxylon - Combretum imberbe - Lannea stuhlmannii - dominated treeveld, brushveld and shrubveld of lightly grazed, non-vertic, non-sodic, bottomlands that are moderately dry with relatively high soil conductivity and relatively low pH

The vegetation here belongs to Association 8.2 as represented by Releves 112, 113, 114 and 115 (Table 6, Ch. IV. Appendix 1). The structure may be sparse shrubveld, shrubby, sparse brushveld, or sparsely shrubby, sparsely brushy treeveld. One or more of Dalbergia melanoxylon, Combretum imberbe and Lannea stuhlmannii are characteristically among the dominant woody plants (Apendix 1 & Table 6, Ch. IV). Albizia harveyi and

Dichrostachys cinerea, which are typically dominant in Landscape Unit 6.11, may be subdominant here. *Combretum apiculatum* is a dominant in a typical Releve 113 from extremely shallow soil. The field layer is dominated by a combination of the grasses *Themeda triandra*, *Bothriochloa radicans*, *Digitaria eriantha* and *Panicum coloratum*.

6.11 *Themeda triandra* - *Panicum coloratum* - dominated grassveld with scattered *Albizia harveyi* shrubs, and *Albizia harveyi* - *Dichrostachys cinerea* - *Themeda triandra* - dominated shrubveld and brushveld of lightly grazed, non-vertic, non-sodic, bottomlands that are mesic with relatively low soil conductivity and relatively high pH

Releves of this unit belong to Association 7.2 and 7.3 (Releves 247, 256, 260, 266, 267 and 331, Table 5, Ch. IV) and Association 8.2.1 (Releve 233, Table 6, Ch. IV). Releve 228 of Association 2.2 is unusual. The vegetation structure may be grassveld as in Releves 228, 260, 266 and 331, or sparse shrubveld as in Releve 233 and 256, or sparsely shrubby, sparse brushveld as in Releve 247. *Albizia harveyi* and/or *Dichrostachys cinerea* are the typical dominant woody species in the shrubveld and brushveld or amongst the scattered shrub and brush of the grassveld. In Landscape Unit 6.10 these woody species are absent or subdominant. The grasses *Themeda triandra* and *Panicum coloratum* are the typical dominant, codominant and subdominant field layer species. *Digitaria eriantha* may also be prominant.

6.12 *Acacia nigrescens* - dominated brushveld of vertic and near-vertic bottomlands

This landscape unit occurs patchily on lower slopes along rivers and in other low areas and is particularly common in the lower Nwanedzi-Gudzane Catchment. Comparatively large patches also occur near Tsokwane in the Nwaswitsontso Catchment. Typical *Acacia nigrescens* - dominated brushveld on soils of the

Bonheim Form belongs to Association 9.2 (Releves 86 & 87, Table 7, Ch. IV). Examples on soils of the Arcadia Form belong to Association 11.2 (Releves 76 and 97, Table 8, Ch. IV). The *Acacia nigrescens* - dominated landscape unit grades: (a) via transitional stages such as represented by Releves 75 and 93 (Ass. 8.2, Table 6, Ch. IV) into *Sclerocarya caffra* - dominated treeveld of higher terrain; and (b) via stages such as represented by Releves 98, 159 and 318 (Ass. 9.3, Table 7, Ch. IV) into *Grewia bicolor* - *Acacia tortilis* - *Acacia nigrescens* - dominated brushveld of heavily grazed bottomlands.

The structure of typical *Acacia nigrescens* - dominated brushveld is sparsely to moderately shrubby, sparse to moderate brushveld, with or without scattered trees. All woody levels are dominated by *Acacia nigrescens* (Releves 76, 86, 87 and 97, Ass. 9 & 11, Appendix 1). Field layer dominants in the recorded examples were either *Bothriochloa radicans* or *Panicum maximum*. The grasses *Digitaria eriantha*, *Panicum coloratum* and *Themeda triandra* were sporadically subdominant (Tables 7 & 8, Ch. IV).

6.13 *Euclea divinorum* - *Sporobolus smutsii* - *Trianthema triquetra* - dominated vegetation of sodic bottomlands

A distinct sodic influence is indicated by patches of vegetation in bottomlands that are adjoined by granophyric or rhyolitic slopes. *Euclea divinorum* - dominated shrub and brush are typical of relatively large patches. *E. divinorum* may thus occur scattered, or as brushveld and shrubveld, or form scrubby thicketclumps. Occasional woody species in such shrubby and brushy sodic areas include *Euclea undulata*, *Carissa bispinosa* and *Rhus queinzii*.

The grass *Sporobulus smutsii* is a common field layer dominant in the shrubby and brushy areas or in local patches of grassveld. *S. smutsii* then typically forms mats, alternating with bare patches of soil or with areas dominated by the forb *Trianthema triquetra*. Occasional grasses on these sodic plains include *Sporobolus nitens* and the vertisol indicator *Setaria woodii*.

Unclassified Releve 157, is from grassveld dominated by *Sporobolus smutsii, Bothriochloa radicans* and *Chloris roxburghiana*. The latter grass seems to be associated with the particularly calcareous soils, whereas *Sporobolus smutsii* presumably indicates a sodic influence from the nearby Landscape 5 on Karoo Sediments.

6.14 Vlei, spruit and river complex

The following are common components of the mosaic associated with drainage lines:-

(a) *Setaria woodii* or *Ischaemum afrum* or *Dicanthium papillosum* or *Sporobolus consimilis* - dominated grassveld of vertic vleis

The aforementioned grasses may each form pure stands or occur in combination to dominate the tall dense grassveld commonly found in vertic vleis and bottomlands. Other species occurring scattered in such grassveld include *Panicum maximum, Eriochloa meyerana, Chloris roxburghiana, Cymbopogon plurinodis* and *Sesbania sesban.* Small waterhole depressions fringed by the grasses *Bothriochloa radicans* and *Sporobolus consimilis* were recorded in these bottomlands.

(b) *Maytenus senegalensis* - other spp. - dominated shrub and brush of drainage line slopes and - shoulders

Maytenus senegalensis is a typically dominant, or among the dominants, at the shrub and brush levels on slopes and shoulders of drainage lines. Other shrubs and brushes of this landscape unit include *Phoenix reclinata, Maclura africana, Ximenia caffra, Acacia robusta, A. tortilis, A. xanthophloea, Dichrostachys cinerea* subsp. *africana, Cassia abbreviata, Dalbergia melanoxylon, Lonchocarpus capassa, Securinega virosa,*

<u>Phyllanthus reticulatus</u>, <u>Lannea stuhlmannii</u>, <u>Rhus queinzii</u>, <u>Combretum hereroense</u>, <u>C. imberbe</u>, <u>C. mossambicense</u>, <u>Euclea divinorum</u>, <u>Diospyros mespiliformis</u> and <u>Ehretia rigida</u>. Field layers are varied and may include various species from adjoining ecotopes. <u>Themeda triandra</u> is typically dominant or among the dominants, with <u>Panicum maximum</u> dominant under shrubs, brushes and trees.

(c) <u>Hyphaene crinita</u> - scrubclumps and -thicketclumps on floodplains

<u>H. crinita</u> - scrubclumps and thicketclumps are particularly common along the southern side of the Sweni River and along the Mrunzuluku Spruit. The occurrence of these clumps is possibly associated with some Karoo Sediment influence from the adjoining slopes of Tropical Semi-arid Lowveld on Karoo Sediment Anticline with Dolorite (Landscape 5). Karoo Sediment influence here is also indicated by the occasional presence of <u>Acacia welwitschii</u>, which is typical of sodic Karoo Sediment bottomlands (cf. Landscapes 4 and 5) and <u>Euclea divinorum</u> and <u>Sporobolus nitens</u>, which are general sodic indicators (Table 2, Ch. IV). <u>A. wellwitschii</u> and <u>Euclea divinorum</u> are common along the southern bank of the Sweni River and <u>S. nitens</u> is occasionally the dominant grass inbetween the <u>Hyphaene crinita</u> clumps. Other dominant grasses recorded inbetween these clumps include <u>Schmidtia pappophoroides</u>, which is also particularly common in the adjoining Landscape 5 with Karoo Sediment influence, and <u>Panicum coloratum</u>. The dominant grass within the clumps is <u>P. maximum</u>.

(d) Trees associated with spruits and rivers

The basaltic region lacks the consistent levees with which the typical riparian bush in the granitic region is associated. River-associated trees are therefore less common in the basaltic region and occur as irregularly scattered individuals of fragmentary stands of riparian bush. Species recorded include <u>Nuxia oppositifolia</u> and <u>Breonadia microcephala</u>, which occur next to perennial water, as well as the following more general trees of rivers as well as seasonal spruits:

> *Ficus sycomorus*, *Acacia robusta*, *A. xanthophloea*, *Lonchocarpus capassa*, *Ekebergia capensis*, *Combretum imberbe*, *Diospyros mespiliformis* and *Kigelia africana*.

(e) Shrub and brush associated with stream beds, banks and islands

Species recorded here include those mentioned under Landscape units b-d, above, as well as the following additional species recorded on a rocky floodplain: *Albizia forbesii*, *Grewia subspathulata*, *G. villosa*, *Euclea natalensis* and *Strychnos spinosa*.

(f) Sedges, reeds, grases and forbs of seasonal streambeds

The most typical species occurring as dominants in various types of seasonal streambeds are: *Typha latifolia*, *Ischaemum afrum*, *Dicanthium papillosum*, *Eriochloa meyerana*, *Panicum maximum*, *Setaria woodii*, *Phragmites australis*, *Sporobolus africanus*, *S. consimilis*, *Cynodon dactylon*, *Eragrostis heteromera* and *Cyperus sexangularis*.

Other stream-bed species recorded in these communities were: the semi-shrub *Sesbania sesban*; the grasses *Hemarthria altissima*, *Bothriochloa radicans*, *Hyperthelia dissoluta*, *Heteropogon contortus*, *Themeda triandra*, *Chloris roxburghiana* and *Eragrostis uniglumis*; and the forb *Pluchea dioscorides*.

Fauna

6.1/13 In *Acacia gerrardii* - dominated brushveld of wide plateau divides (6.1) and adjoining *Euclea divinorum* - *Sporobolus smutsii* - *Trianthema triquetra* - dominated vegetation of sodic bottomlands (6.13)

The *Acacia gerrardii* - dominated brushveld with rank, mesic, grass, is favoured ostrich and tsessebe habitat (Axes 1 & 2, 2nd Correspondence Analysis, Ch. VI). Their densities in Landscape Unit 6.1 and the adjoining Landscape Unit 6.13, combined, are 0,1 individuals per km^2 for ostrich and 0,2 per km^2, for tsessebe (Table 11, Ch. VI). The southern *Acacia gerrardii* - dominated brushveld of the Rietpan Plains, forms a major part of the home range of a small herd of tsessebe. This is one of only three similar herds in the Central District.

Zebra, blue wildebeest and warthog showed a special preference for the *Euclea divinorum* - *Sporobolus smutsii* - *Trianthema triquetra* - dominated short-grass vegetation of sodic bottomlands along the upper Mlondozi streams (Axes 1 & 2, 2nd Correspondence Analysis, Ch. VI). Their densities for Landscape Unit 6.13 and adjoining 6.1 combined were 6,9 per km^2 for zebra, 8,1 per km^2 for blue wildebeest, and 0,6 per km^2 for warthog (Table 11, Ch. VI). The Sabie-Mlondozi region with its perennial water supply is the traditional winter grazing area for high densities of blue wildebeest and zebra. In dry rainfall cycles these populations probably also utilize the mesic, *Sclerocarya caffra* - (*Dichrostachys cinerea* or *Pterocarpus rotundifolius*) - dominated treeveld (Landscape 6.2) in this region. However, it seems that in wet cycles, such as during this survey, the grass growth in the latter landscape unit tends to be too rank and rapid to be maintained favourably short through grazing and trampling. The blue wildebeest and zebra are then restricted to the physiographically arid components in this reqion, i.e. the sodic bottomlands along the Mlondozi River.

Other relatively common species for Landscape units 6.1/13, are kudu breeding herds (0,7 kudu per km^2), giraffe (0,7 per km^2), impala (0,5 per /km^2), sable (0,1 per km^2) and elephant bulls (0,1 per km^2).

6.2-6 In Sclerocarya caffra - dominated treeveld

According to the second axis of the first Correspondence Analysis, buffalo breeding herds have a marked preference for these landscape units (Ch. VI). This is probably owing to the abundant natural water supply and long grass in the relatively mesic basaltic areas during the winter of a wet rainfall cycle. Buffalo density in these three units combined was 2,4 per km^2. Kudu breeding herds at 0,6 kudu per km^2, also showed some preference for these relatively mesic basaltic landscape units (Table 11, Ch. VI; Axis 1, 2nd Correspondence Analysis; Axis 2, Detrended Correspondence Analysis).

The other common species here, are impala (2,7 per km^2), zebra (2,1 per km^2), blue wildebeest (1,5 per km^2), giraffe (0,5 per km^2), waterbuck (0,3 per km^2), warthog (0,2 per km^2), and ostrich, kudu bulls, elephant bulls and buffalo bulls, at 0,1 per km^2 each (Table 11, Ch. VI).

6.7-14 In the landscape units with relatively arid vegetation, and waterholding spruits

Impala, which prefer short arid field layers that are rich in forbs, in relatively shrubby and brushy areas, are particularly fond of these habitats (Axis 1, 2nd Correspondence Analysis, Ch. VI). Their distribution in the Nonvertic, Tropical Semi-arid, Basaltic Lowveld coincides closely with relatively arid units of this landscape and they occur here with moderate to high relative densities (average: 9,6 per km^2, Table 11, Ch. VI).

Waterbuck, which stay close to the abundant supply of water characteristic of the basaltic area, also associate with these landscape units, where they have an average density of 0,5 per km^2 (Table 11; Axis 3, 2nd Correspondence Analysis; Axis 2, Detrended Correspondence Anaysis; Ch. VI). They are highly restricted to three areas where surface water in streams and artificial dams is abundant: (a) the lower Nwanedzi-Sweni River at Nwanedzi; (b) the Nwaswitsonso River near Tsokwane; and (c) the Sabie-Mlondozi River. Other notably common species, at the time of survey, were blue wildebeest (1,0 per km^2), zebra (0,9 per km^2), giraffe (0,7 per km^2), kudu breeding herds (0,5 kudu per km^2), warthog (0,2 per km^2); and kudu bulls, sable, elephant bulls and buffalo bulls at 0,1 per km^2 each (Table 11, Ch. VI).

These landscape units are of major importance to migratory blue wildebeest and zebra:- Blue wildebeest and zebra utilizing the Tropical Arid Basaltic Lowveld of the Olifants River Valley (Landscape 8) in winter, may in summer migrate to the seasonal streams and adjoining relatively arid landscape units of the Nwanedzi-Gudzane-Mavumbye grazing region in Nonvertic Tropical Semi-arid Basaltic Lowveld (Landscape 6). The seasonal streams and adjacent arid units of the Sweni-Makongolweni-Guweni-Nungwini region allow similar summer grazing for moderate to high densities of migratory blue wildebeest and zebra from the Sabie-Mlondozi region. During summers of wet cycles these latter herds are largely restricted to the _Grewia bicolor_ - _Acacia tortilis_ - _A. nigrescens_ - dominated brushveld of heavily grazed bottomlands (Landscape 6.9). They have, however, extended onto the adjoining heavily grazed and trampled _Dichrostachys cinerea_ - _Acacia tortilis_ - dominated shrubveld and brushveld on the Lindanda Plains divide. This extension onto higher terrain was possibly an overflow in dry cycles, when their numbers were large; and the extension was possibly assisted by artificially created surface water of gravel pits.

The distinctively arid _Grewia bicolor_ - _Acacia tortilis_ - _A. nigrescens_ - dominated brushveld (Landscape 6.9) near the Nwaswitsontso River in the Tshokwane area, also has moderate to high densities of blue wildebeest and zebra.

7. Vertic Tropical Semi-arid Basaltic Lowveld

Introduction

The gently undulating basaltic plateau that comprises the upper and southern part of the divide between the Olifants and Mwanedzi rivers seems to be rich in amygdal and olivine basalt that typically produce vertic soils on slopes and in bottomlands (Venter,[7] pers. comm.). The average annual rainfall here is between 500mm and 550mm (Gertenbach, 1980).

Within a range of high clay content, neutral to alkaline, high conductivity soils a catena of increasing clay, pH, conductivity and vertic characterististics, towards bottomlands, exists. Grassveld occurs on non-vertic plateaux and in poorly drained, vertic bottomlands, whereas *Acacia nigrescens* - dominated shrubby brushveld occupies the relatively well-drained vertic slopes. The typical soil and vegetation pattern is:

(1) *Themeda triandra* - *Bothriochloa radicans* - *Digitaria eriantha* - dominated grassveld and shrubveld in high terrain with non-vertic non-calcareous soils of the Swartland, Mayo and Bonheim Forms;

(2) *Acacia nigrescens* - *Themeda triandra* - *Bothriochloa radicans* - *Panicum coloratum* - *Diigitaria eriantha* - dominated shrubby brushveld of upper middleslope terrain with non-vertic, non-calcareous soils of the Glenrosa, Mayo and Bonheim forms;

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(3) *Acacia nigrescens* - *Panicum maximum* - *Setaria woodii* - *Ischaemum brachyaterum* - *Digitaria eriantha* - dominated shrubby brushveld of lower middleslope terrain with non-calcareous to calcareous vertisols of the Arcadia Form;

(4) *Panicum maximum* - *Setaria woodii* - dominated grassveld of moderately poorly drained low terrain with calcareous vertisols of the Arcadia Form;

(5) *Tetrapogon mossambicensis* - dominated grassveld with *Acacia borleae* - scrubclumps in poorly drained broad, level, bottomlands with vertisols of the Arcadia Form;

(6) *Lonchocarpus capassa* - dominated treeveld of levees; and

(7) *Sporobolus consimilis* - dominated grassveld of seasonally wet vleis.

Surface water is particularly rare. Biomass per unit area for medium to large herbivores is relatively low, but the landscape attracts high densities of kudu and sable antelope, relative to other landscapes. Abundant shrub and brush browse and long grass are probably salient factors favouring kudu and sable antelope respectively. Other notable medium to large herbivores include zebra, impala and giraffe.

	STRIGA ASIATICA	29	[illegible]
	5-AVOID MESIC TO MODERATELY DRY, DEEP, CLAYEY SOILS		
W	COMBRETUM APICULATUM	148	+42 2 +4455555 3* * 54+45+ 3
W	CISSUS CORNIFOLIA	116	22 25345242342+ + 222222
G	SCHMIDTIA PAPPOPHOROIDES	102	+ 32+3 4543322+ *34+343 +
F	EVOLVULUS ALSINOIDES	92	+5522 444444 *2*+ *2 2+23
W	COMBRETUM HEREROENSE	91	25+ 234 2+2 2++2 2++224+ 2
F	TRAGIA DIOICA	88	34+ + 3222+5453* + +3+2+2 *
W	ACACIA EXUVIALIS	84	3 23 2+244+2223 + +3+233
	6-RAINFALL > 550MM BUT EXCLUDING SAND & LOAMY SAND A HORIZONS & SODIC SOILS		
W	PELTOPHORUM AFRICANUM	58	222+ 2+*+*432232 *+ **+
F	CRABBEA HIRSUTA	46	+ +* 22 +5232
G	CYMBOPOGON PLURINODIS	36	++ +* +3222 * + +
F	THESIUM GRACILARIOIDES	32	+ *+32322 *
	7-EXCLUDING NON-SODIC SOILS WITH SAND & LOAMY SAND PROFILES		
G	THEMEDA TRIANDRA	194	+32232 +25555555545545 5
G	PANICUM COLORATUM	172	3534553 2+ 432455 4+5442445
F	IPOMOEA SINENSIS	134	+ 234 +* 2254244454 3 2543*2 + 2
F	PHYLLANTHUS PENTANDRUS	106	+3 ++ + +*32+3322+32343334 2
F	SEDDERA SUFFRUTICOSA	78	++ 23 + *2 +4** 2+3+2454
F	SIDA RHOMBIFOLIA	48	+ +4 22 * 3+2*++2 +2+*
F	DYSCHORISTE ROGERSII	41	3 *4 22* 42+ +22 *
	8-EXCLUDING NON-SODIC SOILS WITH SAND, LOAMY SAND & SANDY LOAM PROFILES		
W	ACACIA NIGRESCENS	186	+4+54+2 2+3 3 34+ 544555555 5
G	BOTHRIOCHLOA RADICANS	152	54+ * +334455+55554 23
W	SECURINEGA VIROSA	105	+5323++ ++ + +*223344 3323224+
W	COMBRETUM IMBERBE	89	+ 2 24 * *33+33+432++ 3
W	ORMOCARPUM TRICHOCARPUM	77	2 444+* +3 *+3233+ 332 +
	MOISTURE REGIME-		
	9-MESIC AREAS-RELATIVELY SANDY &/OR > 550MM RAINFALL BUT EXCLUDING SODIC SOILS		
W	MAYTENUS HETEROPHYLLA	93	+ 2+ 2333+54344+ + 4 *+ 3*
F	IPOMOEA CRASSIPES	85	3+ 4+ 322 3+355 2 2
W	PTEROCARPUS ROTUNDIFOLIUS	52	42* 35223
W	XIMENIA CAFFRA	52	+ +2 ++3+*2322+ ++*++ +
G	EUSTACHYS MUTICA	37	+22* 43+23
F	VIGNA UNGUICULATA	28	++ 2* * 3++*22 *+ 5
F	ACALYPHA PETIOLARIS	8	*+ +2+**
	10-EXCLUDING ARID AREAS, SUCH AS SODIC WITH THIN, MASSIVE A HORIZON OR VERTIC OR RAINFALL < 500MM		
G	HETEROPOGON CONTORTUS	157	22 +24444534454 32 324+2 2
F	CASSIA MIMOSOIDES	155	++2+2+455335 333433353 422* * 3
W	SCLEROCARYA CAFFRA	153	+ 3++2 +4434 534453+423522* +
G	ERAGROSTIS SUPERBA	135	3333334+ 42 34344224 423+ *
W	DALBERGIA MELANOXYLON	111	+4++2++2452 533352+3++3*+
W	ALBIZIA HARVEYI	109	32 2452+3+2353345+2+3 ** +
W	LANNEA STUHLMANNII	101	+422 25344+ 2+34+ 322 ++*+ *2
W	LONCHOCARPUS CAPASSA	95	+2+2 +2333+ 3+234+3+2+++ 2
W	ACACIA GERRARDII	89	+2++323+ * 242444+22+ * *
F	BLEPHARIS INTEGRIFOLIA	84	2+33+4422+++5234233 ++ +*2+
F	COMMELINA AFRICANA	76	++43 332+ +22532225++2 +
W	GREWIA MONTICOLA	70	+2+ 32+23 33 3222+ 2++5 *22+
F	HIBISCUS PUSILLUS	67	++ 2++ + ++23433+22++** 2
F	SIDA CHRYSANTHA	64	+3 ++233+22+22+ 2+ 32+*
F	CUCUMIS HIRSUTUS	50	3+ 2 3*2* 22222 2 + 2 2
F	OCIMUM URTICIFOLIUM	36	3++4+ 2+2 *2+ * 2+ *
	11-DRY AREAS SUCH AS SODIC, PUDDLED, VERTIC OR CLAYEY WITH 500-550MM RAINF.		
W	ACACIA TORTILIS	86	232455 + * * +5342+53*+42
G	CHLORIS VIRGATA	86	4323554 2+ +2 + 53+ 44* +
F	CROTALARIA SPHAEROCARPA	58	2+22322+ ++2 2 * 2+2 342*+
G	ERAGROSTIS CILIANENSIS	55	2 +42+ * + 5+2 +44++
W	GREWIA FLAVESCENS	37	52 23+ +3 ** 2 32*
F	ASYSTASIA SUBBIFLORA	18	22 + * +* + 22 *
F	POLYGALA ERIOPTERA	16	* + 3++ *
	12-EXCLUDING THE MOST MESIC SOILS AT > 550MM RAINFALL		
W	GREWIA BICOLOR	146	343355+22* 24 32 ++22545555 242
W	EHRETIA RIGIDA	113	53+24222 + 22225432543*232
F	HIBISCUS MICRANTHUS	103	2+4253 2* 5+2 +++ +++4+2454 4
	13-NON-SODIC DRY TO ARID AREAS: PUDDLED SOILS OR RAINFALL < 550MM		
F	HELIOTROPIUM STEUDNERI	139	+43 + 2 +2*2445535 44525
G	BRACHIARIA XANTHOLEUCA	104	2 + +2 +2+ 3* 3343455 2225
G	ENNEAPOGON CENCHROIDES	80	+ 4 + + 2 2* +2224455 42
F	BOERHAVIA DIFFUSA	80	+ 54 + +* 33323432 3 2
G	TRAGUS BERTERONIANUS	79	2 + 4 4 +2 ++* +2 23345 2 5
W	COMMIPHORA AFRICANA	76	+ 2+ +2 +2 2 ** +3223434 33 + 4
F	PAVONIA BURCHELLII	73	+2+2+4 +* + +* 3+2+34334 *
F	EUPHORBIA CHAMAESYCE	67	2 + 3 +* 332 334*42*
F	JATROPHA SP.	36	* * * 22 3*+ + 53
G	CENCHRUS CILIARIS	37	2 * +2* +24 ++2 2
F	COMMELINA ERECTA	34	+ + *++ 3 * ++2 2*2 2 2
W	MAERUA PARVIFOLIA	35	+ + +2 * * *2 2+2+23 * 2
F	SERICOREMA SERICEA	23	22 2++ 2 *
F	SIDA DREGEI	20	+ + +* * 2+*+* +
W	CORDIA SINENSIS	16	*3 +*+52
	14-NON-VERTIC ARID AREAS: SODIC OR PUDDLED OR RAINFALL < 500MM		
F	ABUTILON AUSTRO-AFRICANUM	70	54224332 * 4 2 + * ++*32 2
F	COMMELINA BENGHALENSIS	49	4424+ 3* 2 ** * + +22 54
F	BECIUM KNYANUM	41	242335 * + * 2 +*22 3
F	OCIMUM CANUM	39	33++4 32 * *+ * 2+22 2
F	DICOMA TOMENTOSA	32	22++3 *2+ ++24
W	ZANTHOXYLUM HUMILIS	11	2+ * * 22
	15-ARID AREAS WITH RAINFALL < 500MM		
F	CERATOTHECA TRILOBA	63	++ 2*++2 2* *++434325 3
W	COMBRETUM MOSSAMBICENSE	43	2 + *+2322333 32
F	HYBANTHUS ENNEASPERMUS	39	* *+ +2 5+32 *
W	COMMIPHORA GLANDULOSA	34	+ + + + +*3343* 2
W	TERMINALIA PRUNIOIDES	33	+ 444
F	MELHANIA REHMANNII	33	++2+ * 345
F	LIMEUM FENESTRATUM	19	* +222+ *
W	GREWIA VILLOSA	22	2 * + + 23+3
	16-ASSOCIATION SPECIFIC -		
F	ACHYRANTHUS ASPERA	55	552223 ++ 2 2 +* * * 4+*2+ *43
W	ACACIA WELWITSCHII	16	45 + * + *
F	SOLANUM COCCINEUM	34	45 ++ + 2+ ++* * 3+ * 2
F	ACHYROPSIS LEPTOSTACHYA	20	4522 + * *
F	INDIGOFERA SCHIMPERI	20	43+ 2 * ++ +22
F	BARLERIA ELEGANS	10	42 * 2
W	DINOCANTHIUM HYSTRIX	7	42
G	ERAGROSTIS CYLINDRIFLORA	9	23 + * *
F	ASPARAGUS SETACEUS	22	32 + * **++3 52
G	SPOROBOLUS NITENS	24	52 4 + * + 3
W	MAYTENUS TENUISPINA	12	5++ * +
W	PAPPEA CAPENSIS	13	4+ + * 4 *
SU	KALANCHOE LANCEOLATA	17	4 + 2 +++ * 2
F	AMARANTHUS THUNBERGII	17	4 + * * * + + 2*
W	ACACIA GRANDICORNUTA	7	4+ *
G	ENTEROPOGON MACROSTACHYUS	9	4 + * 2
W	SPIROSTACHYS AFRICANA	8	4+ + +
W	CAPPARIS TOMENTOSA	4	3
F	BLEPHARIS TRANSVAALENSIS	7	3 + ++
F	RHINACANTHUS SP.	12	3+ * + * +
F	CYATHULA CRISPA	9	3 + +*2
W	CARISSA BISPINOSA	6	3++
SU	PORTULACA QUADRIFIDA	3	2
W	ADENIUM OBESUM	3	2
F	PHARNACEUM ELONGATUM	3	2
W	ALBIZIA ANTHELMINTICA	3	2 +
W	LYCIUM SHAWII	2	2
W	BOSCIA FOETIDA	4	2 +
F	ALTERNANTHERA PUNGENS	5	2 + +
F	SELAGINELLA DREGEI	3	2 2
SU	PORTULACA KERMESINA	5	2 * + *
W	HIPPOCRATEA LONGIPETIOLATA	5	2 + 2
W	CASSINE AETHIOPICA	3	2+
W	BOSCIA MOSSAMBICENSIS	2	2
F	ASPARAGUS FALCATUS	5	2 + 4
W	PAVETTA CATOPHYLLA	8	+3 * 22
F	ABUTILON FRUTICOSUM	4	+2 *
W	ALBIZIA PETERSIANA	25	+453 + +* ** * *
F	SIDA OVATA	11	22+2 * + +*
	[illegible]		
F	INDIGOFERA HETEROTRICHA	26	+ *4 22** +2+ *
F	DALECHAMPIA GALPINII	21	+ 223**+ 3+ +
F	RUELLIA CORDATA	15	+ * *+32+*+ + *
F	HERMANNIA QUARTINIANA	14	2 *3 2+ ++ +
F	VERNONIA POSKEANA	8	+ +32+
G	ARISTIDA SP.	6	+ 32+
F	CROSSANDRA MUCRONATA	7	+ + 2 2
W	MUNDULEA SERICEA	7	52 *
F	LEUCAS SEXDENTATA	14	2 5 + **+ 2
F	SENECIO TRANSVAALENSIS	6	+ 2 + *
G	PANICUM DEUSTUM	6	+ 5 2
F	ASPARAGUS SP.	16	2 * 5+ + 3
W	GALPINIA TRANSVAALICA	6	+ 4 +
F	PELLAEA VIRIDIS	19	2 +* 4 + ++ * 54
W	ACACIA BURKEI	13	++ 22+ * 3 *
W	ACACIA CAFFRA	4	32
F	RHOICISSUS TRIDENTATA	4	+ 3 *
F	URGINEA EPIGEA	6	3 **+ *
W	DOMBEYA ROTUNDIFOLIA	9	+ * * 3 *
F	BIDENS BITERNATA	9	+ + 3 + *
F	HELICHRYSUM NUDIFOLIUM	11	* 3**
W	GREWIA MONTICOLA	8	+ + *+ 2*
G	ANDROPOGON GAYANUS	16	2 4 *
G	BRACHIARIA SERRATA	11	3* *
F	IPOMOEA OBSCURA	19	4 + 2* *+ + 2 *
F	VERNONIA OLIGOCEPHALA	29	2 * 2 +234
F	BARLERIA OXYPHYLLA	29	++3 * 223 + *
F	RHYNCHOSIA MINIMA	36	2 +*24+ ++ *+ 3*
F	CYPHOSTEMMA HUMILE	12	+ * ++2 *
W	BOLUSANTHUS SPECIOSUS	12	2* *
G	UROCHLOA BRACHYURA	18	2* 3 * 2
F	CHASCANUM HEDERACEUM	27	2++ 24 +
F	DECORSEA GALPINII	8	+ *2+
F	CHLOROPHYTUM SPP.	6	22
F	BARLERIA PRIONITIS	10	** 5*+
G	CHLORIS ROXBURGHIANA	9	** 3 ***
W	BOSCIA ALBITRUNCA	18	2 33 52
F	APTOSIMUM LINEARE	32	+ 223+ + *33
F	GISEKIA AFRICANA	32	+2+ 22+* * * +*322+
G	ARISTIDA CURVATA	18	2+ + * * 23
F	SANSEVIERIA HYACINTHOIDES	12	+ 32 2
F	LIMEUM VISCOSUM	19	+ 22++ + 22
F	COMMICARPUS AFRICANUS	9	* 22
F	MERREMIA KENTROCAULOS	8	* ++ *++
F	TRIBULUS TERRESTRIS	26	+ * 2+42 +
F	HERMANNIA GLANDULIGERA	14	+ * + * 3
F	JUSTICIA PROTRACTA	15	*+ * + +3 *
F	TRICLISERAS GLANDULIFERA	10	+3+
F	MARISCUS REHMANNIANUS	26	+ + +++ +*2 + * + 3+ * 2
F	CORBICHONIA DECUMBENS	19	+ +* ++ 2 *+2+
W	RHIGOZUM ZAMBESIACUM	7	* 2+
W	ACACIA SENEGAL ROSTRATA	14	2 3 * * + * 2
F	ELYTRARIA ACAULIS	7	2 *2
F	PRIVA AFRICANA	12	*+4 +
F	KOHAUTIA OMAHEKENSIS	8	* * *3
F	CHASCANUM PINNATIFIDUM	14	+ + ++ +3 +
G	ARISTIDA SCABRIVALVIS	7	+ + **2
F	IPOMOEA MAGNUSIANA	12	+ +* 2 + 2 2
F	BARLERIA TRANSVAALENSIS	5	+2
F	DIPCADI GLAUCUM	8	** + +2 *
G	SETARIA WOODII	29	*++ *+ 2*2 55
F	IPOMOEA COSCINOSPERMA	17	+ + 45
G	BRACHIARIA ERUCIFORMIS	12	* + 53
F	COCCINIA REHMANNII	34	2* *** +2+2++**+53
F	PHYLLANTHUS SP.	12	* * + 43
F	TRAGIA INCISIFOLIA	12	+ *+ + 33
G	ISCHAEMUM AFRUM	4	22
F	ANEILEMA DREGEANUM	7	* 5+
F	COMMELINA FORSKAOLAEI	8	+ 3 + + 4*
W	ANDROSTACHYS JOHNSONII	7	55
F	CRABBEA VELUTINA	27	++ +2 2 * * 2 *2 53
F	BIDENS PILOSA	4	43
W	ACALYPHA GLABRATA	5	+ * 42
F	ADENIA DIGITATA	5	* * 42
W	HYMENOCARDIA PARVIFOLIUM	3	5
SU	MONADENIUM LUGARDAE	4	52
F	SANSEVIERIA SP.	3	5
W	EUPHORBIA CONFINALIS	3	5
SU	CISSUS ROTUNDIFOLIA	5	++ 5
W	CAPPARIS SEPIARIA	4	++ 4
W	HOLMSKIOLDIA TETTENSIS	2	4
F	JATROPHA VARIIFOLIA	3	2 4
F	LEDEBOURIA SP.	2	4
F	PAEDERIA FOETENS	2	4
W	RHOICISSUS REVOILII	2	4
W	STRYCHNOS DECUSSATA	2	4
F	STRIGA GESNERIOIDES	6	+ * * *4
F	KEDROSTIS SP.	3	+ 4
F	CLEOME MACULATA	5	+ 2 4
F	ENDOSTEMON TERETICAULIS	5	+ 4
G	SETARIA PALLIDE-FUSCA	3	4
G	ARISTIDA TRANSVAALENSIS	3	* 3
W	CRYPTOLEPIS OBTUSA	2	3
G	CYMBOSETARIA SAGITTIFOLIA	2	3
	17-GENERAL DISTRIBUTION, > 30% OVERALL PRESENCE		
G	PANICUM MAXIMUM	278	5555455255555555555442554533 5542
G	DIGITARIA ERIANTHA	276	45535555555555555455545 2+5522
W	DICHROSTACHYS CINEREA	245	455555+3343452555545433545 44 322
G	ARISTIDA CONGESTA BARBIC...	215	3453445433555255 33+544 25555 2
G	UROCHLOA MOSAMBICENSIS	190	435555333++23 32555444 3533523
F	CUCUMIS AFRICANUS	150	554545++223422+23+242222434 32223
F	SOLANUM PANDURAEFORME	145	235354+232 3+2+ 3442434343 22 +
F	INDIGOFERA VICIOIDES	136	2+3+3 332233353 3322+3+332322 3 4
F	PHYLLANTHUS ASPERULATUS	127	++32 2 42+3 4222* 23443455 4444
F	LANTANA RUGOSA	125	+232442+ 223 3+ 54222 43+234 *4
F	TEPHROSIA BURCHELLII	123	+3+33 23253 33 23* +232323 5423 4
	18-INFREQUENT, 10-30% OVERALL PRESENCE		
F	RHYNCHOSIA TOTTA	102	+3 2 243325 35222 ++5++2+4 4
F	CORCHORUS ASPLENIFOLIUS	99	+++2243 232 +2*2 3+ 33443 + 3
F	VERNONIA FASTIGIATA	72	+ 2+ ++2 +23 3+ 332++24 2
F	ACALYPHA INDICA	72	22 ++ +++ 4 4 *+ 3 253*34+23 2
F	HERMANNIA BORAGINIFLORA	68	2+2 +3+3 +22* ++++++35
W	ZIZIPHUS MUCRONATA	66	+3 +22 2+2+3232+2++ +232+*+ *
F	SOLANUM INCANUM	62	++ + +2+22+2+32+2 +22+*++ *24
F	TALINUM CAFFRUM	57	+ ++ 3222 *** 24+2+2*232 2
W	GREWIA HEXAMITA	56	+2242+ + +22 2+*++* 5 222 2
F	CUCUMIS HIRSUTUS	50	3+ 2 3*2* 22222 2 + 2 2
F	LEUCAS GLABRATA	44	+33+23 +3+222 * +* +2 *+ * 2
F	LEUCAS NEUFLIZEANA	39	++2233+2 +3+ + * +2
W	CASSIA ABBREVIATA	37	++ 3*+* 2 *2 +*+++ +22 4
W	EHRETIA AMOENA	36	+3++432 23+ 3 *22 +
F	LEDEBOURIA SPP.	34	+ 23* ++* 22 2*+* 5 2

Physiographic pattern

7.1-2 High terrain with non-vertic, non-calcareous soils of the Glenrosa, Swartland, Mayo and Bonheim forms

Non-vertic, non-calcareous soils in this landscape occur in high terrain, usually on flat and level plateaux with less than 1^{o} slopes. Sampled soil A horizons typically have sandy loam to clay textures with 19-38 per cent clay, pH of 5,6 - 6,8 and conductivities ranging from 460 to 1260 micro mhos. Corresponding B horizons have clayloam to clay textures, 31-65 per cent clay, pH of 6,1-7,7 and conductivities of 510-1200 micro mhos. A horizons are orthic and melanic and B horizons lithocutanic and pedocutanic. Examples typically belong to Association 8.3 (Table 6, Ch. IV), e.g.: Releve 63 of the clayey, non-calcareous non-red Swartland hogsback Series; Releves 44, 45 and 54 of the non-calcareous Mayo mayo and Mayo msinsini series; and Releves 56 and 59 of the non-calcareous, non-red Bonheim dumasi Series. Releve 67 (Bonheim dumasi series, Ass. 11.2, Table 8, Ch. IV) is transitional to Ecotope 7.3, while Releve 42 (Mayo mayo Series, Ass. 9.4, Table 7, Ch. IV) Releves 62 and 65 (Bonheim dumasi Series, Ass. 8.2 Table 6, Ch. IV) and Releve 61 (with stoneline, Ass. 8.2.2, Table 6, Ch. IV) are floristically transitional to adjoining landscapes. Releve 48 (Glenrosa robmore Series, Ass. 9.4, Table 7, Ch. IV) is from a stoney soil with typical conductivity for the present landscape, but with unusually low clay content and pH.

7.3 Lower middleslope terrain with non-calcareous to calcareous vertisols of the Arcadia Form

Vertisols with self-mulching or weakly crusting surfaces, of the Arcadia Form, are typical of middleslope and bottomland terrain. The terrain is gently undulating and even middleslopes are mostly less than 1^{o}. Releves typically have clayey A11 horizons, with 37-57 per cent clay, pH of 6,4-7,7 and conductivities of 850-1200 micro mhos. Corresponding data for A12 horizons are 55-60 per cent clay, pH of 6,1-8,0 and conductivities of 800-1700 micro mhos. Examples are: Releves 64, 66 and 91 of the non-calcareous, non-red Arcadia rydalvale and Arcadia rooidraai series and Releves 49 and 60 of the calcareous, non-red Arcadia arcadia and Arcadia wanstead series (Ass. 11, Table 8, Ch. IV).

7.4 Moderately poorly drained low terrain with calcareous vertisols of the Arcadia Form

Moderately poorly drained low areas typically have dark calcareous vertisols of the Arcadia arcadia Series, which also have self-mulching to weakly crusting surfaces (e.g. Releves 46, 47, 53 & 68, Ass. 11, Table 8, Ch. IV). Releve 43 (Ass. 11, Ch. IV), also of this ecotope, is of the clayey, calcareous Mayo pafurie Series.

7.5 Broad, level, poorly drained, broad level bottomlands with vertisols of the Arcadia Form

Such broad, poorly drained flat bottomlands are not represented by formal releves. The soils are vertic nonred with self-mulching to weakly crusting surfaces and presumably calcareous and therefore of the Arcadia arcadia or Arcadia wanstead series (representative augering revealed deep, e.g. 1200mm, A horizons on saprolite).

7.6-7 Levees and vertic vleis

These distinct and prominent ecotopes were not included in the phytosociological sample. The vleis in this landscape are only seasonally waterlogged.

Vegetation pattern

7.1 *Themeda triandra* - *Botriochloa radicans* - *Digitaria eriantha* - dominated grassveld in high terrain with non-vertic, non-calcareous soils of the Swartland, Mayo and Bonheim forms (Fig. 13, Appendix 5)

The grassveld plateaux with field layers dominated by *Themeda triandra*, *Bothriochloa radicans* and *Digitaria eriantha* are represented by Releves 44, 54, 56, 59 and 63 (Ass. 8.3, Table 6, Ch. IV, Appendix 1), Releves 62 and 65 (Ass. 8.2, Table 6, Ch. IV) and an atypical Releve 42 (Ass. 9.4, Table 7, Ch. IV). Occasional subdominants include the grasses *Panicum coloratum*, *P. maximum*, *Urochloa mossambicense* and *Aristida* spp. *Cenchrus ciliaris* may be locally dominant. Scattered shrub and brush may be present and, amongst several others, include *Ehretia rigida*, *Acacia nigrescens*, *Cordia sinensis*, *Ormocarpum trichocarpum*, *Securinega virosa*, *Acacia tortilis*, *Dichrostachys cinerea* subsp. *africana* and *Ziziphus mucronata*.

7.2 *Acacia nigrescens* - *Themeda triandra* - *Bothriochloa radicans* - *Panicum coloratum* - *Digitaria eriantha* - dominated shrubby bushveld of upper middleslope terrain with non-vertic, non-calcareous soils of the Glenrosa, Mayo and Bonheim forms (Fig. 14, Appendix 5)

This landscape unit of upper middleslopes has soils and a field layer similar to that of the aforementioned summit grassveld (Landscape 7.1) and a woody component similar to that of the following lower middleslope terrain (Landscape 7.3). The vegetation belongs to Associations 8.2 (e.g. Releve 61, Table 6, Ch. IV), 8.3 (e.g. Releves 45, Table 6, Ch. IV), 9.4 (e.g. Releve 48, Table 7, Ch. IV) and 11.2 (e.g. Releve 67, Table 8, Ch. IV).

The structure is moderately to densely shrubby, moderate to dense brushveld. Both woody levels are dominated by _Acacia nigrescens_ brushes. Field layer dominants here are usually a combination of the grasses _Themeda triandra_, _Bothriochloa radicans_, _Panicum coloratum_ and _Digitaria eriantha_.

7.3 _Acacia nigrescens_ - _Panicum maximum_ - _Setaria woodii_ - _Ischaemum brachyaterum_ - _Digitaria eriantha_ - dominated shrubby brushveld of lower middleslope terrain with non-calcareous to calcareous vertisols of the Arcadia Form (Fig. 14, Appendix 5)

The shrubby brushveld of middleslope vertisols belongs to Association 11.1 (e.g. Releves 49 and 60, of calcareous vertisols, Table 8, Ch. IV) and Association 11.2 (e.g. Releves 64, 66, 91 & 95, of non-calcareous vertisols, Table 8, Ch. IV). Woody structure here is sparsely to densely shrubby, sparse -, or occasionally moderate, brushveld (Appendix 1). Scattered trees may be present. _Acacia nigrescens_ is dominant at all woody levels. Releve 95 represents sparsely brushy, sparse treeveld, with scattered shrub and with _Acacia nigrescens_ dominating all woody levels.

Field layers are rank and are typically dominated by a combination of the grasses _Panicum maximum_, _Setaria woodii_, _Ischaemum brachyaterum_ and _Digitaria eriantha_ (Table 8, Ch. IV).

7.4 _Panicum maximum_ - _Setaria woodii_ - dominated grassveld of moderately poorly drained low terrain with calcareous vertisols of the Arcadia Form

This grassveld belongs to Association 11.1 (Releves 47 & 53 Table 8, Ch. IV) and Association 11.2 (Releves 43, 46 & 68, Table 8, Ch. IV). The grass _Panicum maximum_ is usually dominant with _Setaria woodii_ codominant or subdominant. _Brachiaria eruciformis_ and _Digitaria eriantha_ are common subdominants. Occasional scattered shrub and brush include _Acacia nigrescens_, _A. tortilis_, _Cordia ovalis_, _Commiphora glandulosa_ and _Securinega virosa_ (Table 8, Ch. IV).

7.5 *Tetrapogon mossambicensis* - dominated grassveld, with *Acacia borleae* scrubclumps, of poorly drained broad level bottomlands with vertisols of the Arcadia Form

This component is characteristic of Vertic Tropical Semi-arid Basaltic Lowveld, where it is typical of the occasional broad, flat and almost level, bottomlands. The vegetation was not sampled for inclusion in the phytosociological tables of Chapter IV.

The dense scrubclumps are 1,5-2m high, several metres in diameter and formed by *Acacia borleae* with an intertwining undergrowth of the rank grass *Panicum maximum*. These clumps are sparsely to densely scattered in a matrix of *Tetrapogon mossambicense* - dominated grassveld. The grassveld phase also includes local patches dominated by either *Brachiaria eruciformis, Setaria woodii* or *Sporobolus consimilis*.

Less prominent species include:

(a) The woody *Azima tetracantha, Cadaba natalensis, Maerua parvifolia, Capparis tomentosa, Boscia mossambicensis* and *Cordia ovalis*;

(b) the grasses *Cenchrus ciliaris* and *Sporobolus smutsii*; and

(c) the forbs *Sansevieria hyacinthoides, Cyathula crispa, Neuracanthus africanus, Asparagus minutiflorus, Abutilon guineense* and *Cienfuegosia hildebrandtii.*

7.6 *Lonchocarpus capassa* - dominated treeveld of levees

Levees along drainage lines and around vleis are characterized by stands of trees dominated by *Lonchocarpus capassa* and including also other riparian species such as *Acacia xanthophloea*, *A robusta* and *Combretum imberbe*. The community is not represented in the phytosociological tables (Ch. 1V).

7.7 Sporobolus consimilis - dominated grassveld of vertic vleis

Between 1,5 and 2m tall grassveld of Sporobolus consimilis is typical of vertic, seasonally wet vleis commonly found in broad flat portions of drainage channels. The vegetation is not represented in the phytosociological tables (Ch. 1V).

Fauna

Kudu showed a distinct preference for this landscape during the 1979 aerial survey when their density here was 1,0 per km2 for breeding herds (Table 11 and Axes 1 & 2, 2nd Correspondence Analysis; Axis 2, Detrended Correspondence Analysis; Ch. V1). Sable, at 0,1 per km2, also had an almost peak density in this landscape (Table 11, Ch. V1). Kudu were probably attracted by the abundant Acacia nigrescens browse and sable by the rank grass stratum (cf. Ch. 1V; Joubert, 1976; Joubert, unpubl.). Joubert (unpubl.) recorded autumn foliage on the woody plants and a dry field layer of 50-100cm length and 70-90 per cent projected canopy cover, at the time of survey.

Other notably common species included: zebra, with a relatively moderate density of 2,8 per km2; impala with a density of 1,7 per km2, which is particularly low as compared with their densities in other landscapes; blue wildebeest (1,3 per km2); giraffe (a relatively moderate, 0,4 per km2); waterbuck (0,2 per km2); and warthog (0,1 per km2).

8. Tropical Arid Basaltic Lowveld of the Olifants River Valley

Introduction

In the Central District the gently to strongly undulating terrain of the Olifants River Valley starts at the northern edge of the Shitsalaleni Watershed of Landscape 7. The climate is hot and arid, with an average annual rainfall of between 450mm and 500mm (Gertenbach, 1980). Strong external drainage by numerous drainage lines enhances the soil aridity.

The arid climate and physiography and the perennial water of the Olifants River, is expressed by the vegetation and fauna. The vegetation of the landscape is Spiny Arid Bushveld (cf. Chapter 11) belonging largely to both subcommunities of the *Boscio albitruncae - Terminalietum prunioides* (Ass. 10, Table 7, Ch. 1V). The structure is shrubby brushveld. Shrub, brush and field layers are aridity-adapted.

The upper slopes of the valley form a major landscape unit, which is less strongly weathered and dissected by drainage lines than the lower slopes, which comprise another major unit. This pattern is also manifested in the soils, vegetation and animal life. The upper slopes are dominated by *Acacia nigrescens* and *Grewia bicolor* brush and shrub with a *Urochloa mossambicense, Aristida congesta* subsp. *barbicollis* and *Bothriochloa radicans* - dominated field layer, and appeared to be selected by buffalo. The lower slopes are dominated by *Terminalia prunioides, Combretum apiculatum, Acacia nigrescens* and *A. exuvialis* brush and shrub with an *Aristida congesta* subsp. *barbicollis* - dominated field layer and are favoured impala and giraffe habitat. Outcrop-associated species occur occasionally on the strongly undulating lower slopes.

A continuous broad alluvial plain forms a distinct landscape unit on the banks of the Olifants River. The soils are deep yellowish alluvium and the vegetation Spiny Arid Bushveld with woody species such as *Terminalia prunioides*, *Boscia* spp., *Gardenia resiniflua*, *Acacia tortilis* and others and a field layer commonly dominated by *Schmidtia pappophoroides*. The river- and spruit-associated species composition is strongly related to those in other landscapes. Waterbuck occur with high density along the Olifants River.

Animal species occuring in low to moderate relative densities in this landscape include elephant, zebra, blue wildebeest, kudu and warthog.

Physiographic pattern

8.1 Non-rocky, non-stoney, gently undulating areas with Mayo and Glenrosa Form soils

The moderately weathered upper slopes of the southern side of the Olifants River Valley are drained by the upper Ngotsa and Bangu tributary systems of the Olifants River. Slopes here are predominantly non-rocky and non-stoney. Such slopes, as well as similar bottomland sites of the strongly undulating lower parts of the valley, belong to this landscape unit. The soils are those of vegetation Association 10.2, for which data is presented in Table 7, Chapter 1V. They are of the Mayo and Glenrosa Forms, i.e. with melanic or orthic A horizons respectively and with lithocutanic B horizons. Soil depth is commonly approximately 300mm. A horizons have 15-25 per cent clay, with pH usually between 6,5 and 7,5 and B horizons are frequently calcareous. The Mayo Form is represented by Releves 29, 36, 37, and 39 Ass. 10.2, Table 7, Ch. 1V) of the calcareous Mayo tsipise Series and Releves 58 (Ass. 9.3, Table 7, Ch. 1V) and 40 (Ass. 10.2, Table 7, Ch. 1V) of the non-calcareous Mayo mayo Series. The Glenrosa Form is represented by Releves 38 and 55 of the non-calcareous Glenrosa robmore and Glenrosa williamson series, respectively and by Releve 57 of the calcareous Glenrosa lekfontein Series. Releve 15 is of the Mispah mispah Series.

8.2 Outcrop of strongly undulating areas

Low basalt outcrop is frequent in the strongly eroded terrain close to the Olifants River, particularly where minor tributaries of this River become numerous. Occasionally this outcrop is extensive enough and/or broken enough to accommodate a special outcrop-associated vegetation. Such outcrop is not represented by formal releves.

8.3 Strongly undulating areas with stoney Mispah Form soils and low outcrop

The lower slopes of the Olifants River Valley are strongly undulating with increased density of drainage lines. The Shitsongwane, Wadrif and Bangwanene spruits, which flow independently into the Olifants River, occur here in addition to the Ngotso and Bangu Systems, which drain the upper parts. The area is rocky and stoney, with rocks of less than 50cm height (sometimes up to 1m tall) usually present and covering less than 10 per cent of the quadrats. The soils belong to the non-calcareous, Mispah mispah Series, i.e. an orthic A horizon on hard rock (Releves 14, 17, 18, 19, 20 & 35, Ass. 10.1, Table 7, Ch. 1V). Clay content is 15-25 per cent and pH between 6,2 and 6,6.

8.4 Undulating alluvial banks of the Olifants River

These are the high broad Olifants River banks that are not seasonally flooded. The terrain is strongly undulating and drained by numerous small tributaries cutting into the Olifants River banks. The soils are relatively deep, yellow and alluvial. The only representative, Releve 13, is from a soil probably of the Glenrosa Form, which had 19 per cent clay, a pH of 6,5 and conductivity of 260 micro mhos in a 400mm deep, orthic A horizon overlying stoney calcareous material.

8.5 Sodic bottomlands

Seemingly sodic, flat bottomlands are common on the banks of the Bangu and tributary Hlahleni spruits. The sodium could be transported from the upper reaches of the Bangu Spruit, as these are in the nearby rhyolitic Lebombo Mountains.

Calcareous concretions are frequent to abundant on the surface and the soils commonly have vertic tendencies such as self-mulching surface. Unvegetated patches of "schaumboden" (cf. Volk & Geyger, 1970), i.e. porous topsoils that crunch under foottred, are characteristic and common.

8.6 Spruit and river complexes

Young spruits in gently undulating terrain have broad vertisol drainage beds, e.g. Releve 16 (Ass. 11.2, Table 8, Ch. 1V). The soil in Quadrat 16 is a vertisol with self-mulching surface, presumably of the non-calcareous Arcadia rydalvale Series.

Deep spruits with steep gradients and steep, occasionally rocky, sides, cut through the strongly undulating alluvial banks of the Olifants River, i.e. through Landscape Unit 8.4. Dry season seepages and damp soils were common at the regularly exposed contact zone between the yellowish alluvium and the rock. Seasonal and perennial pools occur in the streambeds.

Old spruit sections with gentle gradients, through the gently undulating Landscape Unit 8.1, e.g. the lower Hlahleni and Bangu spruits, are shallow, with sharply incised stream-beds and well-defined banks. The sodic bottomlands, i.e. Landscape Unit 8.5 attach to these spruits. The spruits are seasonal with semi-perennial sections and water retaining pools.

The Olifants River is perennial, with seasonally exposed sandy and gravelly streambeds and a low seasonal floodplain terrace. The high banks belong to Landscape Unit 8.4.

Vegetation pattern

8.1 *Acacia nigrescens* - *Grewia bicolor* - dominated brushveld of non-rocky, non-stoney, gently undulating areas with Mayo and Glenrosa Form soils

This brushveld belongs to Association 10.2 and is represented by Releves 15, 29, 36, 37, 38, 39, 40, 55 and 57 (Fig. 15, Appendix 5, Table 7, Ch. 1V; Appendix 1). Releves 41 and 42 also of this landscape belong to Association 9.4 which is transitional to Association 10.2; and transitional Releve 58 belongs to Association 9.3, (Table 7, Ch. 1V). The structure is sparsely to moderately shrubby, sparse brushveld or similar shrubveld with scattered brush. *Acacia nigrescens* is typically the dominant brush species and *Grewia bicolor* the dominant shrub. The usual dominant grasses are *Urochloa mossambicense* at A horizon conductivities exceeding 600 micro mhos, and *Aristida congesta* subsp. *barbicollis* at lower conductivities (Ch. 1V, Ass. 10.2). Occasionally prominent grasses also include *Bothriochloa radicans*, *Brachiaria xantholeuca* and *Enneapogon cenchroides*. The forb *Heliotropium steudneri* is particularly abundant.

8.2 Outcrop-associated vegetation of strongly undulating areas

Woody plants found associated with low outcrop, were *Boscia albitrunca*, *Commiphora glandulosa*, *Ptaeroxylon obliquum*, *Hippocratea longipetiolata*, *Sterculia rogersii*, *Combretum apiculatum*, *C. mossambicense* and *Sesamothamnus lugardii*. This last species is typically dominant in association with weathered basaltic sheet outcrop. Forbs noted in rocky habitats include the desiccation-tolerant fern *Selaginalla dregei*, *Sansevieria* hyacinthoides and the lianes Cissus quadrangularis, C. rotundifolius and Sarcostemma viminale.

8.3 Terminalia prunioides - Combretum apiculatum - Acacia nigrescens - A. exuvialis - dominated brushveld of strongly undulating areas with stoney Mispah Form soils and low outcrop

This vegetation represents the basaltic phase of Association 10.1, which belongs largely to Association 10.1.1. Releves 10, 14, 17, 18, 19, 20 and 35 are representative (Table 7, Ch. 1V; Appendix 1).

The structure is typically densely shrubby, moderate to dense brushveld but can also be slighly less dense. Terminalia prunioides, Combretum apiculatum, Acacia nigrescens and A. exuvialis are the usual dominant and subdominant woody plants. Grewia bicolor is regularly also among the prominent subdominants. Aristida congesta subsp. barbicollis is usually the dominant grass. Occasional other dominants include Bothriochloa radicans, Schmidtia pappophoroides and Enneapagon cenchroides.

8.4 Terminalia prunioides - Schmidtia pappophoroides - dominated brushveld of the undulating alluvial banks of the Olifants River

Releve 13 of Association 10.1.1 (Table 7, Ch. 1V; Appendix 1), is the only formal example of this landscape unit. Data from this releve is supplemented by additional field notes. The structure is typically sparsely shrubby, sparse brushveld with a short, well-grazed grass stratum. The following species were recorded:-

Woody Capparis tomentosa, Boscia albitrunca, B. foetida, Maerua maschonica, M. parvifolia, Acacia nigrescens, A. senegal var. rostrata, A. tortilis, Dichrostachys cinerea subsp. africana var. setulosa, Cassia abbreviata, Zanthoxylum capense, Vepris carringtonia, *Commiphora glandulosa, Pappea capensis, Cissus cornifolia, Grewia bicolor, G. villosa, Sterculia rogersii, Combretum hereroense, C. imberbe, C. mossambicense, Terminalia prunioides, Adenium obeseum* var. *multiflorum, Cordia ovalis, C. sinensis, Rhigozum zambesicacum, Sesamothamnus lugardii, Gardenia resiniflua, G. spatulifolia*.

Grasses The dominant grass is typically *Schmidtia pappophoroides*. Other grasses include: *Bothriochloa radicans, Panicum maximum* (under shrub and brush), *Aristida adscensionis, Tragus berteronianus, Sporobolus smutsii, Chloris virgata, Enneapogon cenchroides*.

Forbs Recorded forbs include those of Releve 13 (Ass. 10.1.1, Table 7, Ch, 1V) plus *Aloe vandermerwei, Crotolaria sphaerocarpa, Impomoea albivenia, Geigeria burkei, Senecio longiflorus*.

8.5 *Sporobolus smutsii* - dominated grassveld of sodic bottomlands

The vegetation on these calcareous sodic duplex soils is typically grassveld with or without scattered shrub, brush and trees. Examples of scattered woody plants are *Capparis tomentosa, Boscia albitrunca, Acacia nigrescens, A. tortilis, Lonchocarpus capassa, Grewia bicolor* and *Combretum imberbe*. Occasional tall dead individuals of *C. imberbe* were noted. *Sporobolus smutsii* is typically the dominant grass and patches of the forb *Trianthema triquetra* may alternate with areas dominated by *S. smutsii*. Bare patches on "schaumbodem" are also characteristic. *Sanseviera hyacinthoides* is conspicuous and typical.

8.6 Spruit and river complex

The following major components of this complex were noted:-

(a) Trees associated with the river and spruits

Trees along the river and spruits in this landscape occur as scattered individuals and scattered groups. Of these, Ficus sycomorus, Breonadia microcephala and Trichilia emetica are common along the Olifants River but rare, if present, along spruits. Combretum imberbe, Lonchocarpus capassa and Diospyros mespiliformis seem to be the most common trees along spruits and occur along the river as well. Other trees recorded for the river and spruits in this landscape include Acacia nigrescens, A. robusta, A. senegal var. leiorrachis, A. xanthophloea, Schotia brachypetala, Xanthocercis zambesiaca and Croton megalobotrys; and, on the steep banks of small but deeply incised spruits at the Olifants River, Berchemia discolor and Galpinia transvaalica were added to the list.

(b) Shrub, brush and field layers associated with the seasonal Olifants River floodplain and riparian bush

Shrub and brush of the seasonal floodplain also occur as scattered individuals and clumps. Acacia xanthophloea here is often bent, broken and stunted and are seemingly maintained thus by the occasional floods. Maytenus senegalensis and Combretum paniculatum subsp. microphyllum are the most commonly dominant shrubs and brushes. Other shrub and brush species recorded here are: Maclura africana, Maerua maschonica, Croton megalobotrys, Combretum imberbe, Acokanthera oppositifolia, Cordia ovalis, C. sinensis, Nicotiana glauca (neophyte), Breonadia microcephala, Gardenia spatulifolia; and, recorded at outcrop with alluvium: Lonchocarpus capassa, Combretum mossambicense and Manilkara mochisia.

Additional shrub and brush recorded in riparian bush included *Capparis tomentosa*, *Acacia tortilis*, *Securinega virosa*, *Grewia bicolor*, *G. villosa*, *Combretum hereroense* and *Diospyros mespiliformis*.

The dominant grasses on the seasonal floodplain are commonly *Sporobolus smutsii* and *Schmidtia pappophoroides* and occasionally *Cynodon dactylon*. *Panicum maximum* is the dominant grass in shrub- and brushclumps.

(c) *Maytenus senegalensis* - dominated thicket and Phragmites australis - dominated reed of sandy and pebbly streambeds of the Olifants River.

Seasonally exposed streambeds in the Olifants River commonly have dense stands of these two species.

(d) *Shrub and brush asociated with spruits*

The following shrub and brush species were noted for relatively mature sections of the Bangu and Hlahleni spruits, which are two of the major spruits of this landscape: *Maclura africana*, *Capparis tomentosa*, *Acacia nigrescens*, *A. xanthophloea*, *Dichrostachys cinerea* subsp. *africana* var. *pubescens*, *D. cineria* subsp. *africana* var. *setulosa*, *Lonchocarpus capassa*, *Securinega virosa*, *Phyllanthus reticulatus*, *Maytenus senegalensis*, *Combretum hereroense*, *C. imberbe*, *C. mossambicense*, *Euclea divinorum*, *Diospyros mespiliformis*, *Cordia ovalis* and *C. sinensis*.

A number of species that are common and typical also for bouldery outcrop, were added to the aforementioned list in the deep spruits with steep, commonly rocky, sides and seepages, and which cut through Landscape Unit 8.4. These species are: *Ptaeroxylon obliquum*, *Spirostachys africana*, *Rhus queinzii* *Cassine transvaalensis*, *Hippocratea longipetiolata*, *Pappea capensis*, *Grewia flavescens*, *Manilkara mochisia*, *Strychnos decussata* and *Iboza riparia*. Other species added to the list here, were Dichrostachys cinerea subsp. africana var. africana, which is the most mesic variety of the subspecies, Lannea stuhlmannii and, from the adjoining arid landscape unit, the xeric Gardenia resiniflua.

(e) Sedges, grasses and forbs of levees, vleis and streambeds

The typically dominant grasses in broad, flat, vertic drainage beds of young drainage lines in gently undulating terrain are: Setaria woodii, Ischaemum brachyaterum and Dicanthium papillosum. The sedge Cyperus sexangularis dominates the wettest areas such as the lowest drainage channels. Releve 16, from a similar site, belongs to Association 11.2 (Table 8, Ch. IV).

The aforementioned grasses and sedges occur commonly in the stream beds of all spruits and are often dominant in patches. Other species of seasonal stream beds and vleis include the grasses Sorghum verticilliflorum, Eriochloa meyerana, Sporobolus consimilis and Cynodon dactylon and the semiwoody forb Sesbania sesban. The grass Panicum maximum is the most typical dominant in the field layer of levees. Panicum deustum also occurred in the deep drainage lines with steep, mesic sides, through the alluvial banks of the Olifants River.

Fauna

8.1/8.5 & 8.6 In Acacia nigrescens - Grewia bicolor - dominated brushveld of non-rocky, non-stoney, gently undulating areas with Mayo- and Glenrosa Form soils (8.1), in associated Sporobolus smutsii - dominated grassveld of sodic bottomlands (8.5) and - spruit complex (8.6)

Buffalo breeding herds at 2,4 individuals per km^2 (Table 11 Ch. VI), seemed to have a preference for this part of the landscape (Axis 2, first Correspondence Analysis, Ch. VI). Moderate densities of impala (6,8 per km^2) and warthog (0,2 per

km^2) occurred mainly along the Bangu Spruit and on sodic areas associated with spruits. Other species for this area were zebra (1,8 per km^2) giraffe (0,6 per km^2), blue wildebeest (0,5 per km2), elephant breeding herds (0,3 individuals per km2) and elephant bulls and buffalo bulls at 0,1 per km^2 each.

8.2-4 & 8.6 In _Terminalia prunioides_ - _Combretum apiculatum_ - _Acacia nigrescens_ - _A. exuvialis_ - dominated brushveld of strongly undulating areas with stoney Mispah Form soils and low outcrop (8.2 & 8.3); in adjoining _Terminalia prunioides_ - _Schmidtia pappophoroides_ - dominated brushveld of undulating alluvial banks of the Olifants River (8.4); and associated spruit and river complex (8.6)

These areas were among the most favoured impala and waterbuck habitats in the Central District (Axes 1 & 3, second Correspondence Analysis; Axis 2, Detrended Corespondence Analysis; Ch. VI). Impala density was 22,8 per km^2 and waterbuck, which were concentrated close to the Olifants River (Joubert, unpubl.) had an average density of 0,4 per km^2 for the region (Table 11, Ch. VI). Giraffe had their highest Central District density of 1,4 per km^2 in this area. Animals with moderate to low relative densities here, included zebra (1,9 per km^2), blue wildebeest (0,8 per km^2), kudu breeding herds (0,5 per km2) and kudu bulls, warthog, elephant bulls and buffalo bulls at 0,1 per km^2 each.

9. Tropical Semi-arid Rhyolitic and Granophyric Lowveld

Introduction

The average annual rainfall of this landscape is approximately 600mm (Gertenbach, 1980). The major portion comprises the rhyolitic Lebombo Mountains south of the Pumbepan region. This low mountain range forms the eastern boundary of the Kruger National Park. The less extensive granophyric examples of this landscape form a long and narrow, broken range of small isolated hills, i.e. Nwamuriwane, Nwamuriwa, Nkumbe and Muntshe, which run parallel to the Lebombo Mountains (Fig. 1). The section of the Lebombo Mountains belonging to this landscape is traversed by the major valleys of the Nwanedzi, Nwaswitsontso and Sabie rivers. These have several large tributaries in the Lebombo Mountains.

The Lebombo Mountains as well as the granophyric hills dip eastward. These ranges therefore comprise largely summits and north-facing slopes with shallow litholitic soils and outcrop. However, steep west-facing pediment slopes with deep litholitic soils also occur along some sections. Soil rconductivity increases considerably from summits to footslopes.

Summit soils are generally loose, stoney and shallow, with sandy loam or loamy texture and low conductivity. The vegetation is typically shrubby and brushy with sparse to scattered trees and *Combretum apiculatum* as dominant, or codominant together with *Pterocarpus rotundifolius*. The grasses *Themeda triandra* and *Digitaria eriantha* are usually among the field layer dominants. Some summits and terraces are flat with hard panlike surfaces and shallow soils on unbroken rock or hardpan. The woody vegetation here is also shrubby and dominated by *Combretum apiculatum*, but is distinctly stunted. *Aristida* spp. usually dominate the field layer.

Combretum apiculatum is also dominant in the shrubby brushveld and shrubby, brushy, treeveld of moderately steep to steep, low conductivity middleslopes. Field layers here are, however, dominated by *Panicum maximum* and *P. deustum* or by the latter two species plus *Digitaria eriantha*.

Relatively steep middleslopes and footslopes with stoney high conductivity soils have moderately to densely shrubby, brushveld and thicket, dominated by *Combretum zeyheri* and the grasses *Themeda triandra, Digitaria eriantha* and others. *Acacia nigrescens* is codominant on relatively clayey soils.

Gentler, non-stoney, high conductivity footslopes that have relatively clayey topsoils, have *Acacia nigrescens* - dominated treeveld with scattered shrub and brush and a *Panicum maximum* - dominated field layer. Similar footslopes with sandier topsoils, high conductivities and presumably high sodium content, have densely shrubby to scrubby, dense brushveld and thicket, dominated by *Acacia gerrardii* and *Panicum maximum.*

Level sodic bottomlands with *Euclea divinorum* and *Sporobolus smutsii* are common. Spruits and rivers have the usual distinct species combination for these habitats.

Kudu, giraffe, buffalo bulls and waterbuck showed a marked preference for this landscape. Kudu occurred throughout, giraffe and buffalo bulls selected the northern, relatively dry section and waterbuck were concentrated at the major river valleys. Relatively high concentrations of impala also occurred near the valleys. The mesic, southern section of this landscape contained a high proportion of the few reedbuck recorded in the Central District. Species with notable but low to moderate relative densities in this landscape were zebra, blue wildebeest, elephant breeding herds and warthog.

Physiographic pattern

9.1 Broken bouldery outcrop

Prominent broken bouldery outcrop is particularly abundant along the major river valleys that cut through the Lebombo Mountains. Such outcrop also occurs scattered elsewere along these various ranges, e.g. as the scarps of west-facing slopes and on relatively steep north-facing slopes. Releve 126 (see "Vegetation pattern") is representative of outcrop.

9.2 Summits and gentle to moderate upper slopes with litholitic soils and intermittant, vertically inclined, amygdaloid low rhyolitic outcrop

An area of distinct arid species composition occurs in a western part of the Lebombo Mountains that forms the upper Makongolweni Catchment, and further west on the nearby rhyolitic ridges that run parallel to the Lebombo Mountains in the Nwanedzi region. The rhyolite of this area is distinctly more amygdaloid than that of the adjoining rhyolitic landscape unit. On the Lebombo Mountains the boundaries between the two vegetation types and their associated geological formations are sharp. Both regions are gently undulating with litholitic soils and have intermittant low outcrop. However, the amygdaloid rhyolitic outcrop characteristically projects upwards whereas the adjoining rhyolitic outcrop is horizontally bedded. Releve 89 (Ass. 10.1.2, Table 7, Ch. IV) and Releve 319 (Ass. 2.2.2, Table 3, Ch. IV) represent the amygdaloid ecotope. The soils in Quadrats 89 and 319 were of the Mispah mispah series, i.e. a non-calcareous, orthic A horizon on hard rock. Clay contents were 11 and 13 per cent respectively, pH 5,9 and 6,2 and conductivity 140 and 160 micro mhos. The pH of this amygdaloid ecotope seems to be comparatively high.

9.3 <u>Summits and gentle to moderate upper slopes with extremely shallow litholitic soils and intermittent horizontally bedded, non-amygdaloid low rhyolitic outcrop</u>

This ecotope is represented by Releves 121, 122, 124 and 125 (Ass. 6.4.2, Table 4, Ch. IV). The slopes are usually less than 6 degrees and the soil surfaces hard and stoney. Soils here are of the Mispah mispah Series, i.e. a non-calcareous A horizon on hard rock. Clay content of sampled areas varied from 11-15 per cent, pH from 4,9 to 5,8 and conductivity from 110 to 210 micro mhos (Table 4, Ch. IV).

9.4 <u>Summits and gentle to moderate upper slopes with loose litholitic soils and intermittent, horizontally bedded non-amygdaloid low rhyolitic outcrop</u>

The soils of this ecotope seem to be somewhat deeper and the surface less hard than the previous ecotope or following ecotope. Releves 118, 216, 274, 310, 311, 312, 313, 314, 315, 316, 323, 324, 325, 326 and 329 (Ass. 6.3 & 6.4.1, Table 4, Ch. IV) are representative. The slopes are gentle to moderate, i.e. from 0-6°, usually up to three degrees and the surface sparsely to moderately stoney. As shown in Table 4 (Ch. IV), the soils may be of the Mispah mispah Series, i.e. a non-calcareous, orthic A horizon on hard rock, or the Milkwood dansland Series, i.e. a non-calcareous, melanic A horizon with 15-35 per cent clay, on hard rock. A horizon texture is loam to sandy loam and recorded clay contents vary from 11 to 19 per cent. The pH is usually 5,0-6,0 and non-extreme conductivities range from 100 to 460 micro mhos.

9.5 <u>Small plateaux and terraces, with hard panlike surfaces, litholitic soils, and intermittant horizontally bedded non-amygdaloid low rhyolitic outcrop</u>

On some small flat to concave, plateaux and terraces, areas with panlike geomorphology and hard soil surfaces occur. The soils are also of the non-calcareous Mispah and Milkwood forms, with extremely shallow A horizons, stones and occasional low outcrop. A horizons have sandy loam texture with approximately 15 per cent clay, pH of 5,0-6,5 and conductivities ranging from 100 to 180 micro mhos (e.g. Releves 320, 321, 322, 327 and 330, Ass. 6.1, Table 4, Ch. IV)

9.6 <u>Moderate to steep middleslopes with scattered low broken outcrop</u>

Middleslopes with scattered low outcrop are represented by Releves 229, 230, 273 and 277 (Ass. 6.2, Table 4, Ch. IV). Clay content, pH and conductivity varies considerably and the species composition seems to be determined largely by factors associated with the scattered outcrop (Table 4, Ch. IV).

9.7 <u>Steep granophyric middleslopes with relatively high pH, low conductivity, deep litholitic soils</u>

Releves 231, 242 and 259 (Ass. 9.1.1, Table 7, Ch. IV) represent this ecotope. These releves are from 23-30° granophyric middleslopes with deep litholitic soils (i.e. without outcrop) that have pH values ranging from 6,2 to 7,0, conductivities from 250 to 390 micro mhos and clay content of 10-16 per cent. It seems that the granophyric pediment slopes have higher pH and lower conductivity than similar rhyolitic slopes (cf. Ecotopes 9.8-10). Releve 328 from an upper slope of the rhyolitic Lebombo Mountains (4° slope, pH 6,0, conductivity 200 micro mhos, clay 16 per cent; Ass. 6.4.2, Table 4, Ch. IV) marginally belongs to this landscape unit and is transitional to Landscape Unit 9.3, with which it is phytosociologically classified.

9.8 <u>Moderately steep to steep, stoney rhyolitic middleslopes and footslopes with relatively low pH, high conductivity, deep litholitic soils</u>

These middleslopes are represented by Releves 107, 111 and 116 (Ass. 6.4.1, Table 4, Ch. IV). Slopes here vary from 8 to 15°, clay content from 11 to 19 per cent, pH from 5,4 to 5,6 and conductivity from 760 to 1510 micro mhos. Releve 123 (Ass. 6.4.2, Table 4, Ch. IV), which is from a similar ecotope and plant association, but with a moderate 4° slope, is transitional to Ecotope 9.10.

9.9 <u>Moderate, non-stoney footslopes with relatively low pH, moderately high conductivity, sandy clay loam soils</u>

Footslopes with relatively high clay content are represented by Releve 119 (Ass. 8.3, Table 6, Ch. IV). The slope here was four degrees, clay content 27 per cent, pH 5,5 and conductivity 670 micro mhos.

9.10 <u>Moderate to moderately steep, non-stoney footslopes with relatively low pH, high conductivity, sandy loam and silty loam soils</u>

Footslopes with relatively low clay content and distinctly high conductivities are represented by Releves 108 and 120 (Ass. 7.1.1, Table 5, Ch. IV). Their slope angles are ten and four degrees, clay contents 17 and 14 per cent, pH 5,5 and 4,7 and conductivities 3100 and 1050 micro mhos. Releve 123 (Ass. 6.4, Table 4, Ch. IV) is transitional to the similarly low pH, high conductivity soils but steeper slopes of Ecotope 9.8 and is floristically classified with the latter ecotope. This transitional releve is from a four degrees slope with 14 per cent clay, pH of 5,8 and conductivity of 770 micro mhos.

9.11 Level sodic bottomlands

Bare patches of "schaumboden" and sodic-soil-associated species are characteristic of level, sodic bottomlands on the banks of drainage lines. This ecotope is not represented by formal releves.

9.12 Spruit and river complex

Young spruits with steep gradients and narrow, occasionally rocky, beds form steepsided kloofs in the Lebombo Mountains. Older spruits, with broad beds, occasionally occur in relatively open valleys with gently-sloping sides. The granitic and basaltic landscapes to the west are drained via the major gorges where the Nwaswitsontso and Sabie rivers cut through the Lebombo Mountains in this landscape. These gorges have steep, rocky sides with abundant outcrop-associated vegetation. Older spruits commonly have semi-permanent pools and the Sabie River is perennial.

Vegetation pattern

9.1 Outcrop vegetation

The characteristic vegetation of broken bouldery outcrop was recorded mainly: in Releve 126 near Nwanedzi; on the steep rocky slopes of the Sabie River gorge and on Muntshe Hill, with additional notes from small enclaves of outcrop elsewhere in this landscape. All woody species encountered were recorded but grass and forb records are only from Releve 126 plus a few unsystematically included examples. The following species were noted:-

Woody *Maclura africana*, *Ficus ingens*, *F. soldanella*, *F. sycomorus*, *Pouzolzia hypoleuca*, *Olax dissitiflora*, *Ximenia caffra*, *Portulacaria afra*, *Monodora junodii*, *Boscia albitrunca*, *Maerua rosmarinoides*, *Thilachium africanum*, *Albizia brevifolia*, *Acacia burkei*, *A. exuvialis*, *A. schweinfurthii*, *Dichrostachys cinerea* subsp. *africana*, *Schotia brachypetala*, *Afzelia quanzensis*, *Cassia abbreviata*, *Mundulea sericea*, *Erythroxylum emarginatum*, *Vepris reflexa*, *Kirkia acuminata*, *Commiphora harveyi*, *C. mollis*, *Ptaeroxylon obliquum*, *Securinega virosa*, *Bridelia micrantha*, *Croton gratissimus*, *Euphorbia confinalis*, *E. cooperi*, *E. tirucalli*, *Lannea stuhlmannii*, *Ozoroa engleri*, *Rhus queinzii*, *Maytenus heterophylla*, *Putterlickia pyracantha*, *Cassine transvaalensis*, *Hippocratea longipetiolata*, *Ziziphus mucronata*, *Berchemia zeyheri*, *Rhoicissus revoilii*, *Grewia bicolor*, *G. flavescens*, *G. subspathulata*, *G. villosa*, *Dombeya cymosa*, *Sterculia rogersii*, *Ochna natalitia*, *O. pretoriensis*, *cf. Dovyalis sp.* *Galpinia transvaalica*, *Combretum apiculatum*, *C. zeyheri*, *Terminalia phanerophlebia*, *Pappea capensis*, *Mimusops zeyheri*, *Manilkara mochisia*, *Euclea divinorum*, *E. schimperi*, *Diospyros mespiliformis*, *Jasminum multipartitum* *Strychnos decussata*, *S. madagascariensis*, *Cordia ovalis*, *Barleria affinis*, *Hymenodictyon parvifolium*, *Xeromphis rudis*, *Tricalysia allenii*, *Kraussia floribunda*, *Vangueria infausta*, *Pavetta catophylla*.

Grasses *Brachiaria xantholeuca*, *Panicum maximum*, *Enneapogon cenchroides*.

Forbs *Pellaea calomelanos*, *P. viridis*, *Mariscus dregeanus*, *Kyllinga alba*, *Commelina africana*, *C. benghalensis*, *Aloe chabaudii*, *A. sessiliflora*, *Sansevieria hyacinthoides*, *S. dessertii*, *Asparagus falcatus*, *A. minutiflorus*, *Dioscorya sylvatica*, *Pupalia lappacea*, *Achyranthes aspera*, *Kalanchoe rotundifolia*, *Indigofera vicioides*, *Acalypha indica*, *Jatropha variifolia*, *Cissus rotundifolia*, *C. quadrangularis*, *Cyphostemma subciliatum*, *Abutilon angulatum*, *A. ramosum*, *Hibiscus lunariifolius H. micranthus*, *Adenia hastata*, *Sarcostemma viminale*, *Ipomoea albivenia*, *Paederia foetens*, *Coccinia rehmannii*, *Bidens ternata*.

9.2 *Acacia erubescens* - *Combretum apiculatum* - dominated brushveld of summits and gentle to moderate upper slopes with litholitic soils and intermittant, vertically inclined amygdaloid low rhyolitic outcrop

Releve 319 (Ass. 2.2.2, Table 3, Ch. IV) and Releve 89 (Ass. 10.1.2, Table 3, Ch. IV), which are typical of this landscape unit, record sparsely to moderately, shrubby, sparse to moderate brushveld, dominated by *Acacia erubescens* brushes (Releve 319) or *A. erubescens* and *Combretum apiculatum* (Releve 89). Field layer dominants include the grasses *Aristida congesta* subsp. *congesta*, *A. congesta* subsp. *barbicollis*, an *Aristida* sp., cf. *A. curvata*, *Pogonarthria squarrosa* and *Enneapogon cenchroides*.

9.3 *Combretum apiculatum* - *Themeda triandra* - *Digitaria eriantha* - *Andropogon gayanus* - dominated dense brushveld and thicket of summits and gentle to moderate upper slopes with extremely shallow litholitic soils and intermittant horizontally bedded, non-amygdaloid low rhyolitic outcrop

The vegetation here is represented by Releves 121, 122, 124, and 125 of Association 6.4.2 (Table 4, Ch. IV; Appendix 1). The woody structure is moderately to densely shrubby, moderate brushveld and thicket. Combretum apiculatum brushes are dominant at both these levels and scattered C. apiculatum trees may occur. Most of the field layer cover, or a considerable proportion thereof, is made up by a combination of the grasses Themeda triandra, Digitaria eriantha and Andropogon gayanus.

9.4 Combretum apiculatum - Pterocarpus rotundifolius - Themeda triandra - Digitaria eriantha - Brachiaria nigropedata - dominated sparse to moderate shrubveld and brushveld of summits and gentle to moderate upper slopes with loose litholitic soils and intermittant, horizontally bedded, non-amygdaloid low rhyolitic outcrop

This landscape unit belongs to Association 6.3 and 6.4 and is represented by Releves 118, 261, 274, 310, 311, 312, 313, 314, 315, 316, 323, 324, 325, 326 and 329 (Fig. 16, Appendix 5, Table 4, Ch. IV; Appendix 1).

Woody structure here is sparse to moderate shrubveld with scattered brush or similarly shrubby, sparse to moderate brushveld, occasionally with scattered trees. Shrub cover comprises mainly Pterocarpus rotundifolius shrubs, or the lower parts of Ozoroa engleri or Combretum apiculatum brush canopies. Where Pterocarpus rotundifolius dominates the shrub level, the dominant brush is commonly Combretum zeyheri. Otherwise the brush level dominant is C. apiculatum. The latter species is almost always among the dominants or subdominants. Scattered trees recorded were Albizia haveyi, Sclerocarya caffra and Combretum apiculatum.

The grasses Themeda triandra, Digitaria eriantha and Brachiaria nigropedata usually contribute most of the field layer cover. Panicum maximum is commonly also codominant.

9.5 _Combretum apiculatum_ - _Aristida_ spp.- dominated sparse shrubveld and sparse bushveld with _Mundulea sericea_, of small plateaux and terraces with hard, panlike surfaces, litholitic soils, and intermittent horizontally bedded non-amygdaloid low rhyolitic outcrop

These panlike areas have a sparse and stunted woody vegetation belonging to Association 6.1 and represented by Releves 320, 321, 322, 327 and 330 (Table 4, Ch. 1V; Appendix 1).

The vegetation is typicaly sparse shrubveld or sparsely shrubby, sparse brushveld, without any trees. _Combretum apiculatum_ is usually the dominant brush and shrub. Other dominants include _Ozoroa engleri and Alibizia harveyi._ The following woody species were occasionally subdominant: _Mundulea sericea, Peltophorum africanum, Ximenia caffra, Dichrostachys cinerea_ and _Grewia bicolor._

Field layers were typically dominated by _Aristida congesta_ subsp. _barbicollis_ and another _Aristida_ sp.

9.6 _Combretum apiculatum_ - _Digitaria eriantha_ - _Panicum maximum_ - _P. deustum_ - dominated moderate to dense brushveld and shrubby brushy, sparse treeveld of moderate to steep middleslopes with scattered, low, broken outcrop

Middleslopes with scattered low outcrop have vegetation belonging to Association 6.2 and are represented by Releves 229, 230, 273 and 277 (Table 4, Ch 1V; Appendix 1). This sample shows moderately shrubby, moderate to dense brushveld with scattered trees and sparsely shrubby, moderately brushy, sparse treeveld. _Combretum apiculatum_ or _C. molle_ are the dominant trees and brushes. The shrub level is dominated by the lower parts of the canopies of _Combretum apiculatum_ or _C. zeyheri_ brushes. The grasses _Digitaria eriantha, Panicum maximum_ and _P. deustum_ are usually codominant in the field layer.

9.7 Acacia nigrescens - Sclerocarya caffra - Combretum apiculatum - Panicum maximum - dominated shrubby, densely brushy, sparse to moderate treeveld of steep granophyric middleslopes with relatively high pH, low conductivity, deep litholitic soils

The vegetation of these steep, nonrocky granophyric slopes are represented by Releves 231, 242 and 259 of Association 9.1.1 (Fig. 17, Appendix 5, Table 7, Ch. 1V; Appendix 1). Transitional Releve 328 (Ass. 6.4.2, Table 4, Ch. 1V) is similar but less typical.

Woody structure in this landscape unit is sparsely shrubby, densely brushy, sparse to moderate treeveld. Acacia nigrescens and/or Combretum apiculatum are the dominant trees. Trees and brushes of the same species dominate the brush level, and shrub level dominants include Combretum apiculatum and C. zeyheri brushes. Panicum maximum is typically clearly dominant in the field layer.

9.8 Combretum zeyheri- Themeda triandra - Digitaria eriantha - Andropogon gyanus - Brachiaria serrata - dominated dense brushveld, thicket and shrubby, brushy treeveld of moderately steep to steep, stoney rhyolitic middleslopes and footslopes with relatively low pH, high conductivity, deep litholitic soils

Stoney high conductivity slopes are represented by Releves 107, 111 and 116, which have vegetation belonging to Association 6.4.1 (Table 4, Ch. 1V; Appendix 1), and by transitional Releve 123, which belongs to Association 6.4.2 (Table 4, Ch. 1V; Appendix 1). The latter releve is from a moderate four degrees slope and its dominant woody species is Acacia gerrardii as in Landscape Unit 9.10 from similar, but non-stoney, footslopes.

The structure is moderately to densely shrubby, dense brushveld or thicket, with or without scattered trees, and similarly shrubby and brushy sparse treeveld. Combretum zeyheri is the dominant woody plant and typical dominant at the shrub and brush levels. The brush level may also be dominated by C. apiculatum. Where present, trees were Acacia nigrescens and Lonchocarpus capassa. A combination of the grasses Themeda triandra, Digitaria eriantha, Andropogon gayanus and Brachiaria serrata and in one example also Panicum maximum and Diheteropogon amplectens, were dominant in the field layer.

9.9 Acacia nigrescens - Panicum maximum - dominated treeveld with scattered shrub and brush, of moderate, non-stoney footslopes with relatively low pH, moderately high conductivity, sandy clay loam soils

On relatively clayey, non-stoney footslopes the vegetation as represented by Releve 119, belongs to Association 8.3 (Table 6, Ch. 1V; Appendix 1). The woody understorey is relatively open and in this example the structure was moderate treeveld with scattered shrub and brush. Acacia nigrescens is the dominant tree and Panicum maximum the dominant grass.

9.10 Acacia gerrardii - Panicum maximum - dominated dense brushveld and thicket of moderate to moderately steep, non-stoney footslopes with relatively low pH, high conductivity, sandy loam and silty loam soils

Releves 108 and 120, which represent this vegetation belong to Association 7.1.1 (Table 5, Ch. 1V; Appendix 1). The structure is densely shrubby to scrubby, dense brushveld and thicket. Acacia gerrardii is dominant at both woody levels. Panicum maximum is the dominant grass and Themeda triandra or Bothriohloa radicans the subdominant grasses in the field layer.

9.11 Euclea divinorum - Sporobolus smutsii - dominated grassveld, shrubveld and brushveld of level sodic bottomlands

Sporobolus smutsii is the most typical dominant in the field layers of this vegetation and Euclea divinorum is the most prominant and characteristic shrub. Scattered individuals of Combretum imberbe are also typical. The grass cover is irregular and is interrupted by bare patches of "schaumboden".

9.12 Spruit and river complex

The spruit and river species for this landscape were recorded mainly in the Mlondozi Spruit and its tributaries near the Ntente and Nwamgondzo waterholes, and along the Sabie River between Mlondozi Picket and the Tinxikweni Spruit (Fig. 1).

(a) Trees of the spruit and river complex

Breondia microcephala and Syzygium guineense trees are associated with the Sabie River banks and islands, where both these species are common. Trees of the following species were recorded along spruit sections with dry parts and occasional pools: Ficus sycomorus; Acacia robusta; A xanthophloea; Schotia brachypetala; Longchocarpus capassa; Combretum imberbe and Diospyros mespiliformis.

(b) Shrub and brush of the spruit and river complex

A number of the shrubs and brushes recorded along the Sabie River are typical of the perennial river rather than the seasonal spruits. These include Salix woodii, Myrica serrata, Ficus capreaefolia, Syzygium guineense, Nuxia oppositifolia and Breonadia microcephala. The following additional species were recorded, either along the Sabie River, or along spruits, or in both habitats: Phoenix reclinata, Maclura africana, Ximenia caffra, *Acacia robusta, A. xanthopholcea, Peltophorum africanum, Dalbergia melanoxylon, Lonchocarpus capassa, Turraea obtusifolia, Securinega virosa, Phyllanthus reticulatus, Antidesma venosum, Bridelia micrantha, Rhus queinzii, Maytenus senegalensis, Ziziphus mucronata, Berchemia zeyheri, Grewia flavescens, G.hexamita, Garcinea livingstonei, Combretum hereroense, C. imberbe, C. paniculatum* subsp. *microphyllum, Terminalia phanerophlebia, Sideroxylon inerme, Euclea divinorum, E. natalensis, E. schimperi, Diospyros mespiliformis, Jasminum stenolobum, Ehretia amoena, E. rigida, Lippia javanica, Vitex haveyana, Gardenia spatulifolia, Kraussia floribunda* and *Pluchea dioscorides*.

(c) *Grasses and sedges of river and spruit stream-beds*

Phragmites australis reed stands are large and particularly common in the seasonally exposed stream-beds of the Sabie River. Smaller stands of this reed do, however, also occur in spruit-beds of this landscape. Other commonly dominant species of occasionally flooded stream-beds are the grasses *Ischaemum brachyaterum, Bothriochloa radicans, Eriochloa meyerana, Setaria woodii, Sporobolus africanus, S. consimilis* and *Cynodon dactylon,* and the sedge *Cyperus sexangularis*.

Fauna

Kudu breeding herds had a marked preference for the northern and southern part of this landscape and the densities for such kudu in both parts were 1,0 individuals per km^2 (Table 11, Axis 2, second Correspondence Analysis & Axis 2, Detrended Correspondence Analysis, Ch. VI). Kudu bulls had a distinct preference for the southern part of this landscape, where their density was 0,1 per km^2 (Table 11, Axis 2, second Correspondence Analysis).

Reedbuck are rare in the Central District and have a preference for the part of this landscape south of Nwanedzi, despite their density of less than 0,1 per km^2 here (Table 11, Axis 2, Detrended Correspondence Analysis, Ch. VI). Giraffe at 1,0 km2 and buffalo bulls at 0,3 per km2, had high preferences for the northern part of this landscape (Table 11, Axis 4, second correspondence Analysis. The respective densities of giraffe and buffalo bulls in the part south of Nwanedzi were 0,4 and 0,1 per km^2.

Waterbuck, which concentrate along the Nwanedzi, Nwaswitsontso and Sabie rivers, also had a preference for this landscape where their average density was 0,3 per km^2 (Table 11, Axes 2 & 3, second Correspondence Analysis & Axis 2, Detrended Correspondence Analysis, Ch. VI). Impala had moderately high relative densities of 8,3 and 9,0 per km^2 in the northern and southern parts of this landscape, respectively. Impala also concentrated in the strongly rolling portions of the Lebombo Mountains of the aforementioned river valleys. The salient factors here seem to be relatively arid substrate and -vegetation, coupled with perennial drinking water.

The following species had low to moderate densities, which are given for the northern and southern portion of this landscape respectively: zebra (1,4 & 2,4 per km^2); blue wildebeest (0,1 & 0,6 per km^2); and elephant bulls (0,1 & 0,1 per km^2). Elephant bulls occurred with a density of 0,4 per km^2 and warthog at 0,1 per km^2 in the southern section.

Buffalo breeding herds were largely absent from both parts of this landscape (cf. Axis 2, first Correspondence Analysis, Ch. VI) and elephant breeding herds seemed to avoid the northern section (Axis 4, first Correspondence Analysis, Ch. VI).

10. Zonal Tropical Arid Rhyolitic Lowveld

Introduction

The rhyolitic Lebombo Mountains between Pumbe and the Olifants River valley have an arid type of climate and vegetation. The average annual rainfall here is approximately 500mm (Gertenbach, 1980). The landscape comprises high terrain with a broad summit region, young erosional valleys and a small west-facing escarpment. The summit region has plateaux and waxing slopes with extremely shallow litholitic soils of the Mispah Form. Outcrop and talus slopes predominate in the young valleys. Talus slopes and pediment slopes with deep litholitic soils occur on the west-facing escarpment. Soil conductivity increases consideraly down these pediment slopes.

Combretum apiculatum - dominated dense brusveld predominates on the shallow stoney soils of the summits as well as on the particularly stoney talus slopes. Pediment slopes are dominated by *Acacia nigrescens*. The upper and middle pediment slopes of the valleys and escarpment are covered by *Acacia nigrescens - Panicum maximum* - dominated shrubby brushy, treeveld. *A. nigrescens - Grewia bicolor - Bothriochloa radicans* - dominated brushveld occurs on lower pediment slopes with particularly high soil conductivity.

The medium- to large- herbivore community of this landscape seems to be determined mainly by aridity, sparse field layers and abundant suitable browse. The major species are impala and zebra, with small numbers of kudu, giraffe and waterbuck.

Physiographic pattern

10.1 Summits and waxing slopes

The litholitic soils of summits and talus slopes are usually extremely shallow and stoney and belong to the Mispah Form. The texture varies from sandy loam to clay loam. The pH values are also variable and for the sampling units range from 5,1 to 7,0. Soil conductivity ranges from 200 micro mhos to 700 micro mhos.

Releves 27 and 30 (Ass. 10.1.1, Table 7, Ch. IV) represent plateau soils with a level panlike surface that has an alluvial character. Stones are frequent on these surfaces but extremely abundant immediately below the surface.

Waxing summits with abundant surface stones are represented by Releves 5 and 12 (Ass. 10.1.2, Table 7, Ch. IV). Releve 26 (Ass. 10.1.2, Table 7, Ch. IV) represents a similar, abundantly stoney, convex slope of a poorly developed part of the escarpment.

10.2 Bouldery outcrop

Releve 28, from a small tributary of the Ntsumaneni Spruit, represents a steep slope with 0,75m tall, bouldery outcrop that covered approximately 10 per cent of the quadrat. The rest of the surface was talus. This releve is unique and was not taken up in the phytosociological tables. Releve 11 (Ass. 10.1.2, Table 7, Ch. IV) is from low rhyolitic outcrop on a gentle slope.

10.3-4 Upper to middle pediment slopes

This relief unit is represented by Releves 23, 31 and 32 (Ass. 9.1.2, Table 7, Ch. IV) and Releve 9 (Ass. 10.1.2, Table 7, Ch. IV) Soil pH is approximately 5,7-6,0 and texture is sandy loam to sandy clay loam with 18-26 per cent clay. Soil conductivity is variable. The soil conductivity on the relatively steep (25°) slope of Quadrat 31 is 450 micro mhos, which is rather similar to conductivities on the summit. Quadrat 9, on an eleven degrees slope, also had a relatively low soil conductivity of 390 micro mhos. However, the moderately steep 12-15°, slopes of Quadrats 23 and 31 had soil conductivities of respectively 1290 and 1780 micro mhos, which are consideraly higher than on the summits and steeper pediment slopes (Table 7, Ch. IV).

10.5 Lower pediment slopes

Releve 24 (Ass. 10.1.1, Table 7, Ch. IV) is the only representative of this ecotope. The soil clay content of 21 per cent is close to that of higher pediment slopes but the pH of 4,9 is low and the conductivity of 2400 micro mhos is exeedingly high. Releve 24 is from a gentle, three degrees, slope.

10.6 Spruit complex

This landscape is drained towards Landscape 8 by the Ntsumaneni Spruit and the upper reaches of the Msizwane and Mpangweni spruits. The spruit-beds are commonly narrow and the lower Ntsumaneni Spruit has cut a narow, deep, steep-sided valley in the Lebombo Mountains. Shallow valleys with broad drainage beds also occur.

Vegetation pattern

10.1 *Combretum apiculatum* - dominated densely shrubby, dense brushveld of summits and waxing slopes

The summit and waxing slope vegetation belongs to both variations of Association 10.1 (Table 7, Ch. IV).

One variation (Ass. 10.1.1, Table 7, Ch. IV), is predominantly basaltic, but also includes the present landscape's illuvial rhyolitic habitats, i.e. panlike plateau surfaces (e.g. Releves 27 Fig. 18, Appendix 5 & Releve 30) and lower pediment slopes (see Releve 24 under Landscape Unit 10.5). The other, predominantly rhyolitic, variation (Ass. 10.1.2, Tale 7, Ch. IV), includes the waxing slope vegetation, represented by Releves 5, 12 and 26.

The summit vegetation, in general, has a homogeneous structure and physiognomy. The structure is typically densely shrubby, dense brushveld. Combretum apiculatum is dominant at both woody levels (Appendix 1). Dominant and subdominant grasses include Brachiaria xantholeuca, Bothriochloa radicans, Aristida spp., Enneapogon cenchroides, Urochloa mossambicense, Schmidtia pappophoroides and Pogonarthria squarrosa (Table 7, Ch. IV).

10.2 Bouldery outcrop vegetation

The following species were recorded in unclassified Releve 28, in Releve 11 (Ass. 10.1.2, Table 7, Ch. IV) and in supplementary field notes from outcrop in the deep valley of the lower Ntsumanene Spruit:-

Woody Maclura africana, Ficus ingens, F. soldanella, Portulacaria afra, Tinospora fragosum, Capparis tomentosa, Boscia albitrunca, Maerua parvifolia, Thilachium africanum, Albizia brevifolia, A. forbesii, Acacia eruhescens, A. nigrescens, A. senegal var. rostrata, Schotia brachypetala, Acacia nigrescens, Dichrostachys cinerea subsp. africana, Cassia abbreviata, Xanthocercis zambesiaca, Erythroxylum emarginatum, Verpris caringtonia, V. refelexa, Kirkia acuminata, Commiphora glandulosa, Ptaeroxylon obiquum, Drypetes gerrardii, Cleistanhus schlechteri, Bridelia cathartica, Androstachys johnsonii, Croton gratissimus, C. steenkapiana, Euphorbia confinalis, E. cooperi, E. tirucalli, Ozoroa engleri, Hippocratea africana, H. longipetiolata, Atalaya alata, Ziziphus mucronata, Rhoicissus revoilii, Grewia bicolor, G. flavescens, Sterculia, rogersii, Ochna pretoriensis, Combretum apiculatum, C. hereroense, C. molle, Terminalia phanerophlebia, T. prunioides, Steganotaenia araliacea, Manilkara mochisia, Strychnos decussata, Cordia ovalis, Ehretia rigida, Iboza riparia, Rhigosum zambesiacum, Ruspolia hypocrateriformis, Hymenodictyon parvifolium, Gardenia resiniflua, Tricalysia allenii, Brachylaena huillensis.

Grasses Bothriochloa radicans, Digitaria pentzii, Brachiaria xantholeuca, Panicum maximum, Aristida congesta subsp. barbicollis, Enteropogon macrostachyus, Enneapogon cenchroides, Schmidtia pappophoroides.

Forbs Mariscus rehmannianus, Stylochiton natalense, Commelina erecta, Aloe sessiliflora, Sansevieria dessertii, S. hyacinthoides, Asparagus falcatus, A. minutiflorus, Ansellia gigantea, Eulophia sp., Boerhavia diffusa, Tinospora fragosa, Indigofera vicioides, Tephrosia burchellii, T. longipes, Abrus laevigatus, Monadenium lugardae, Phyllanthus asperulatus, P. incurvus, Aclypha indica, Euphorbia neopolycnemoides, Cissus quadrangularis, C. rotundifolia, Hibiscus engleri, H. micranthus, Melhania acuminata, Adenium obesum var. multiflorum, Sarcostemma viminale, Convolvulus farinosus, Heliotropium steudneri, Kedrostis foetidissima, Calostephane divaricata.

The tree Newtonia hildebrandtii, which has a relatively restricted distrubution in the Kruger National Park, and large specimens of Adansonia digitata also occur on litholitic slopes with frequent outcrop.

10.3 Acacia nigrescens - Panicum maximum - dominated treeveld of upper and middle pediment slopes

The vegetation of upper and middle pediment slopes belongs to Association 9.1.2 (e.g. Releves 23, 31 and 32, Table 7, Ch. 1V) and Association 10.1.2 (e.g. Releve 9, Table 7, Ch 1V).

The structure is moderately to densely shrubby, moderately brushy to thicketed, sparse treeveld to bush. *Acacia nigrescens* is the dominant tree and occasionally also the dominant brush and shrub species. Other dominant brush and shrub species include *Combretum apiculatum* and *Grewia monticola* (Appendix 1). *Panicum maximum* is the typical dominant grass, occasionally with *Themeda triandra* codominant. *Digitaria eriantha* is often subdominant (Table 7, Ch. 1V).

10.4 *Colophospermum mopane* - dominated shrubveld and shrubby, brushy treeveld of upper to middle pediment slopes

Well-established stands of *Colophospermum mopane* including trees, brushes and shrubs, occur on the slopes in this landscape; these stands are the southernmost individuals of *C. mopane* on the Lebombo Mountains (Gertenbach,[8] pers. comm).

10.5 *Acacia nigrescens* - *Grewia bicolor* - *Bothriochloa radicans* - dominated brushveld of lower pediment slopes

The vegetation on these particularly high conductivity, lower pediment slopes is represented by Releve 24 (Ass. 10.1.1, Table 7, Ch. 1V).

The structure of Releve 24 is moderately shrubby, sparse brushveld, with scattered trees. *Acacia nigrescens* is the dominant tree and brush, *Grewia bicolor* is the dominant shrub and *Bothriochloa radicans* is the dominant grass (Appendix 1, Table 7, Ch. 1V).

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10.6 Spruit complex

The following species were recorded along the lower Mtsumaneni Spruit in the Lebombo Mountains:-

Trees *Acacia robusta, A. welwitschii, Schotia brachypetala, Spirostachys africanus, Diospyros mespiliformis*.

Shrubs and brushes *Maclura africana, Dichrostachys cinerea* subsp. *africana* var. *setulosa, Colophospermum mopane, Peltophorum africanum, Lonchocarpus capassa, Phyllanthus reticulatus, Acalypha pubiflora, Lannea stuhlmannii, Hippocratea crenata, Stadmannia oppositifolia, Berchemia zeyheri, Dombeya cymosa, D. rotundifolia, Scolopia* sp. cf. *S. mundii, Combretum imberbe, Terminalia phanerophlebia, Diospyros mespiliformis, Jasminum fluminense, Xeromphis rudis, Gardenia spatulifolia, Pluchea dioscorides*.

Grasses and forbs (list relatively imcomplete) *Sorghum verticilliflorum, Eriochloa meyerana, Panicum deustum, Tricholaena monachme, Cenchrus ciliarus, Loudetia filifolia, Sporobolus consimilis, Eragrostis* spp., *Cynodon dactylon, Cyperus sexangularis* (sedge) *Sesbania sesban, Epaltes gariepina,*

Fauna

Medium and large herbivores recorded here include impala (10,8 per km2), zebra (3,5 per km2), blue wildebeest (0,5 per km2), giraffe (0,5 per km2) kudu breeding herds (0,5 individuals per km2) kudu bull groups (0,1 individuals per km2) and elephant (0,1 km2, Table 11, Ch. V1). The impala and zebra densities are moderately high as compared with their densities elsewhere in the Central District and favoured arid types of field layers in combination with favoured or tollerated shrubby, brushy woody layers are presumable among the key factors selecting for this faunal community. Moreover, *Combretum apiculatum*, which is favoured impala browse (cf. Dayton, 1979), is a dominant woody species of this landscape.

11. Tropical Arid Rhyolitic Lowveld of the Olifants River Valley

Introduction

The densely woody, strongly rolling, arid mountainous terrain at the Olifants River gorge through the rhyolitic Lebombo Mountains, belongs to this landscape. The rainfall is less than 500mm per annum (Gertenbach, 1980) and the vegetation is a peculiar arid type of bush and thicket. It is argued in Chapter IV (Ass. 12, Table 9) that the arid climate and physiography, in conjunction with the frequent heavy winter fog that is associated with major river valleys, may be the crucial ecological factors determining the nature of this vegetation.

The terrain is strongly dissected by the Olifants River and a number of its primary tributary systems, including the Eight Miles, Kunguveni and Bangu spruits. Summits with sheet outcrop and waxing summit slopes have shallow litholitic soils with *Androstachys johnsonii* - dominated brushveld and thicket. Steep talus slopes with deep litholitic soils and broken bouldery outcrop are covered with dense *A. johnsonii* - dominated bush. The talus slopes have considerably higher soil conductivities that the summit region. Open grassy patches and spruit-associated vegetation occur in valley bottoms. The large Bangu Spruit, which has a number of semi-permanent pools, is an abundant supply of surface water.

Kudu and buffalo bulls had moderately high relative densities in this landscape. Other species included low densities of impala, zebra, warthog and waterbuck.

Physiographic pattern

11.1 Summit divides with sheet outcrop

The gently sloping, less than 3°, upper summit areas typically have abundant low sheet outcrop. Releve 3 (Ass. 12.2, Table 9, Ch. IV) is representative. The shallow Mispah Form soil of this quadrat is yellow, has 17 per cent clay, a pH of 5,1 and conductivity of 90 micro mhos.

11.2-3 Moderate waxing summit slopes

Towards the edges of the summit region the convex slopes are a moderate 2-7°, as represented by Releves 4, 6 and 8 (Ass. 12.2, Table 9, Ch. IV) and Releves 24, 27 and 30 (Ass. 10.1.1, Table 7, Ch. IV). The soils here are slightly deeper than on the divides and of the Mispah Form, with occasional low outcrop. Sampling units have 7-27 per cent clay, a pH of 4,9-6,3 and conductivities of 110-2400 micro mhos.

11.4 Bouldery outcrop of steep slopes

Bouldery outcrop on a very steep, 35° slope is represented in Releve 7 (Ass. 12.1, Table 9, Ch. IV). Such outcrop is common in the steep-sided valleys of this landscape.

11.5 Steep talus slopes with deep litholitic soil

Steep, 26-30°, talus slopes with deep litholitic soils are represented by Releves 1 and 2 (Ass. 12.1, Table 9). Surface stones are frequent, percentage clay between 16 and 18, pH values recorded as 5,2 and 6,0; and the conductivities of 1310 and 1900 micro mhos were considerably higher than on summits.

11.6 Spruit and river complex

The Spruit and river complex includes the Olifants River gorge through the Lebombo Mountains, the large Bangu Spruit and several small tributaries. The Olifants River gorge is narrow, with steep sides. In some places the cliffs extend down to the perennial stream. Elsewhere the streambank may consist of vegetated rocky alluvial floodplains or vegetated, strongly undulating, yellowish alluvium or unvegetated deep white sandbanks.

Broad, flat, brackish areas occur along the Bangu Spruit in the open valley where the spruit enters the Lebombo Mountains. Further downstream, these areas are replaced by the steep valley sides and the stream bed is broad with marshy islands and sides. Rapids and potholes near the mouth at the Olifants River contribute considerably to the particularly pleasant scenery here. The Lebombo Mountains section of the Bangu Spruit is perennial during high rainfall years and retains perennial pools throughout dry cycles.

Smaller spruits are narrow drainage lines in steepsided valleys.

Vegetation pattern

11.1 *Androstachys johnsonii* - dominated brushveld on summit divides with sheet outcrop

This rocky summit vegetation is represented by Releve 3, which belongs to Association 12.2 (Table 9, Ch. IV; Appendix 1). The structure is densely shrubby, sparse brushveld and *A. johnsonii* is virtually the only woody species. The field layer is dominated by *Aristida* spp., the desiccation-tolerant fern *Selaginella dregei* and the sedge *Cyperus rupestris*.

11.2 Androstachys johnsonii - dominated densely shrubby to scrubby thicket, and densely shrubby to scrubby, thicketed treeveld on moderate waxing summit slopes

The vegetation of non-rocky Mispah Form soils on moderate summit slopes typically belongs to Association 12.2 (Releves 4, 6 and 8, Fig. 19, Appendix 5, Table 9, Ch. IV; Appendix 1). The structure is typically scrubby thicket, dominated entirely by Androstachys johnsonii as in Releves 4 and 8 (Appendix 1). The field layer is mostly dominated by the grass Brachiaria xantholeuca as in Releves 4 and 8 or occasionally by Cymbosetaria sagittifolia as in Releve 6 (Table 9, Ch. IV).

11.3 Combretum apiculatum - dominated brushveld enclaves of summits and waxing slopes

This landscape unit comprises outliers of Association 10.1 (Table 7, Ch. IV) from Landscape Unit 10.1 of the adjoining Landscape 10. There were no obvious differences between the habitat of these Combretum apiculatum - dominated enclaves and that of the surrounding Androstachys johnsonii - dominated Landscape Unit 11.2 (cf. general discussion under Ass. 12, Ch. IV).

The formal rhyolitic releves of Association 10.1.1 were taken within the present landscape (Releves 24, 27 and 30, Table 7, Ch. IV). The vegetation is shrubby brushveld, dominated by Combretum apiculatum and grasses, e.g. Brachiaria xantholeuca, Bothriochloa radicans, Aristida spp., Enneapogon cenchroides, Urochloa mossambicensis, Schmidtia pappophoroides and Pogonarthria squarrosa.

Similar vegetation was recorded from a gentle convex slope with a shallow Mispah mispah Soil near a valley bottom. Woody species found here were Combretum hereroense, Combretum apiculatum, Manilkara mochisia, Terminalia prunioides, Capparis tomentosa, Maytenus heterophylla, Euclea divinorum and Diospyros mespiliformis. The dominant grasses were Bothriochloa radicans, Aristida adscencionis, Heteropogon contortus and Panicum maximum (under shrubs).

11.4 Bouldery outcrop vegetation

The following species list for bouldery outcrop was compiled from Releve 7 (Ass. 12.1 Table 9, Ch. IV) and supplementary notes from outcrops on the steep sides of the valley of the Bangu Spruit:-

Woody *Ficus soldanella, Urera tenax, Pouzolzia hypoleuca, Capparis sepiaria, Boscia albitrunca, Albizia brevifolia, Newtonia hildebrandtii, Vepris reflexa, Androstachys johnsonii, Euphorbia confinalis, E. cooperi, E. tirucalli, Stadmannia oppositifolia, Berchemia discolor, Rhoicissus revoilii, Adansonia digitata, Sterculia rogersii, Combretum mossambicense, C. paniculatum subsp. microphyllum, Diospyros mespiliformis, Strychnos decussata, Clerodendrum myricoides, Holmskioldia tettensis, Iboza riparia, Hymenodictyon parvifolium, Xeromphis rudis.*

Succulents *Alloe chabaudii, A. sessiliflora, Sansevieria dessertii, Monadenium lugardae, Cissus quadrangularis, Cissus rotundifolius, Adenium obesum* var. *multiflorum, A. spinosum, Pachypodium saundersii, Sarcostemma viminale*.

Grasses and forbs - Releve 7, Table 9, Ch. IV, provides an example of these.

11.5 Androstachys johnsonii - dominated scrubby thicketed, bush of steep talus slopes with deep litholitic soil

Vegetation on the steep talus slopes of valleys belongs to Association 12.1 (Releves 1, 2 and 7, Table 9, Ch. IV). The structure is sparsely scrubby, moderately to densely thicketed, dense bush. Androstachys johnsonii is the dominant woody species at all height levels. Subdominant woody species include the conspicuous Euuphorbia confinalis as well as Hymenodictyon parvifolium and Boscia albitrunca (Appendix 1, Table 9). Panicum maximum is the dominant grass.

11.6 Spruit and river complex

The vegetation component of the spruit and river complex includes the following:-

(a) Capparis tomentosa - Acacia tortilis - Sporobolus nitens - dominated sparse brushveld with scattered shrub and trees of broad flat brackish areas in the wide upper rhyolitic valley of the Bangu Spruit

This landscapeu unit occurs close to the bank of the Bangu Spruit. The species combination and typical bare patches of soil as well as the geology and position in the landscape indicate sodic soil. Prominent species, in addition to the dominants mentioned in the heading included Combretum imberbe and Securinega virosa.

(b) Vegetated rocky alluvial floodplains

An example of this unit was described from the Olifants River in the western part of its valley through the Lebombo Mountains. The vegetation here was sparse to dense shrubveld with scattered brush and trees, and included the following species:-

Tree *Adansonia digitata*

Brush and shrub *Maclura africana*, *Ximenia americana*, *Boscia foetida*, *Dichrostachys cinera* subsp. *africana* var. *setulosa*, *Dalbergia melanoxylon*, *Erythroxylum emarginatum*, *Turraea obtusifolia*, *Securinega virosa*, *Lannea stuhlmannii*, *Maytenus senegalensis*, *Grewia bicolor*, *G. flavescens*, *Combretum hereroense*, *Terminalia phanerophlebia*, *T. prunioides*, *Manilkara mochisia*, *Pappea capensis*, *Euclea natalensis*, *Diospyros mespiliformis*.

Grasses and forbs (list for sampling site incomplete) *Heteropogon contortus*, *Panicum maximum*, *Loudetia filifolia*, *Eragrostis trichophora*, *Pogonarthria squarrosa*, *Cissus rotundifolia*.

(c) *Vegetated, strongly undulating, yellowish alluvium*

This landscape unit is relatively rare and where sampled was associated with a spruit estuary in the Olifants River. The vegetation here is shrubby and brushy. Woody species included *Capparis tomentosa*, *Boscia albitrunca*, *Acacia ataxantha*, *Dichrostachys cinerea* subsp. *africana* var. *africana*, *Grewia monticola*, *Terminalia prunioides* and *Cordia sinensis*. The field layer included the grasses *Sporobolus smutsii* and *Urochloa mossambicense*.

(d) *Vegetation of a rocky drainage line in a small kloof*

The following species, of such an ecotope, were recorded in the lower tributary at the Potholes of the Bangu Spruit:

Woody *Maclura africana, Ficus soldanella, Ficus* sp., *Urera tenax, Olax dissitiflora, Phyllanthus reticulatus, Drypetes gerrardi, Stadmannia oppositifolia, Ziziphus mucronata, Grewia flavescens, Dombeya cymosa, Garcinia livingstonei, Diospyros mespiliformis, Holmskioldia tettensis, Xeromphis rudis, Manilkara mochisia.*

Grasses *Panicum deustum, Enteropogon macrostachyus.*

(e) *Other spruit vegetation*

Trees *Acacia robusta, A. xanthophloea, Newtonia hildebrandtii, Lonchocarpus capassa, Ptaeroxylon obliquum, Androstachys johnsonii, Spirostachys africana, Euphorbia confinalis, Lannea stuhlmannii, Berchemia discolor, Combretum imberbe and Diospyros mespiliformis.*

Shrub and brush *Maclura africana, Capparis tomentosa, Acacia xanthophloea, Dichrostachys cinerea subsp. africana var. setulosa, Peltophorum africanum, Lonchocarpus capassa, Securinega virosa, Drypetes gerrardii, Bridelia cathartica, Acalypha glabrata, A. pubiflora, Spirostachys africana, Lannea stuhlmannii, Maytenus heterophylla, M. senegalensis, Cassine transvaelensis, Hippocratea sp., Ziziphus mucronata, Rhoicissus revoilii, Grewia monticola, Dombeya cymosa, Galpinia transvaalica, Combretum hereroense, C. imberbe, C. mossambicense, Manilkara mochisia, Euclea divinorum, E. natalensis, Diospyros mespiliformis, Nuxia oppositifolia, Acokanthera schimperi Ehretia rigida, Holmskioldia tettensis, Iboza riparia, Gardenia spatulifolia.*

Grasses, sedges and forbs *Dichanthium papillosum, Cympopogon sp., Eriochloa meyerana, Panicum deustum, P. maximum, Sporobolus consimilis, Cynodon dactylon, Cyperus sexangularis, Sesbania sesban, Epaltes gariepina* and other less prominent species.

Fauna

Kudu breeding herds showed some preference for this landscape and an average of 0,6 such kudu per km^2, occurred here (Table 11, Axis 2, second Correspondence Anaysis, Ch. VI). Buffalo bulls, at 0,2 per km^2, also had a moderately high relative density here. Impala relative density of 2,0 per km^2 is low and so is 0,1 per km^2 for zebra, warthog and waterbuck (Table 11, Ch. VI).

In addition to the aerial survey data, which owing to the dense brush and tree cover and hilly terrain could be poor, it is known that the area has well-utilized hippopotamus and elephant paths. Sharpe's grysbuck, grey duiker and bushbuck also find their favoured type of shelter in this dense brush and tree cover.

12. Cretaceous plateau with Tertiary aeolian sand, in Tropical Semi-arid Lowveld

Introduction

This landscape occurs in the Pumbe region, where the average annual rainfall is between 500mm and 550mm (Gertenbach, 1980). The landscape comprises a vast flat and level sandy plateau falling almost entirely outside the Kruger National Park in Mocambique. A mere 1500ha cuts across the Park boundary.

The major components of this landscape seem to be: (a) loamy sand and sandy loam soils of varying depth, with broad-leaved treeveld and brushveld, covering the major portion of the plateau; (b) a broad-leaved brushveld fringe on the litholitic soils at the edge of the plateau, where the sand has been stripped off, through weathering exposing a layer of cretaceous pebbles; and (c) small seasonal pans that occur scattered over the plateau.

Representative examples of the sandy and litholitic components occur within the Kruger National Park. One well-developed and complete pan also occurs within the Park on the litholitic fringe. Another pan, which is similarly well-developed but surrounded by the sandy component and different in nature, is situated on the boundary, partly within the park.

The area within the Kruger National Park is too small to be of much significance to medium and large herbivores. However, the seasonal pan on the boundary is inhabited by the fish _Notobranchius rachovii_ (Ahl. 1926), which has a lifespan of one season, with eggs surviving the dry period of the pan. This is the only known occurrence of the species within the Republic of South Africa and recent efforts to introduce the species in other "Sandveld" pans in the Kruger National Park have not yet been proved successful (cf. Pienaar, 1979).

Physiographic pattern

12.1 _Quaternary aeolian sand plateau_

The sandy component is represented by Releves 21, 34, 109, 110 and 117 (Ass. 5.1, Table 4, Ch. IV). The terrain is flat and level and stones are rare to absent. Soils, here, are of the Hutton portsmouth and Hutton shorrocks Series (i.e. orthic A horizons and red apedal B horizons) as well as the Mispah mispah Series (i.e. orthic A horizon on hard rock) with a stone line. A horizon clay content in the five releves varies from 11 per cent to 16 per cent and B horizons, where present, have between 11 per cent and 20 per cent clay (cf. Table 4, Ch. IV).

12.2 Cretaceous pebbly plateau edge

Towards the edge of the plateau the Cretaceous pebble layer appears at the surface and contributes largely to a litholitic soil. This situation is represented by Releves 22 and 33 (Ass. 6.4, Table 4, Ch. IV). The terrain is flat and gently sloping and the soil may have a fine sandy clayloam texture with 24 per cent clay or sandy loam with 16 per cent clay.

12.3 Poorly drained depressions

Releve 25 (Ass. 6.1, Table 4, Ch. IV) represents a poorly drained depression with hardpan and seasonal seepages.

Vegetation pattern

12.1 *Combretum zeyheri* - *C. molle* - *C. apiculatum* - *Terminalia sericea* - dominated treeveld, brushveld and thicket on Quaternary aeolian sand plateau

The vegetation here belongs to Association 5.1 (Table 4, Ch. IV; Appendix 1).

Releve 34 represents deep soil of the Hutton Form (depth exceeds 2m in this instance). The structure here is sparsely shrubby, moderately brushy, sparse treeveld. *Cassia abbreviata* dominates the tree and brush levels and *Terminalia sericea* dominates the shrub level, in the stand sampled (Appendix 1). The grasses *Panicum maximum* and *Digitaria eriantha* dominate the grass layer.

On soils of the Mispah Form and on shallow soils of the Hutton Form, the structure is moderately shrubby, moderate brushveld to scrubby thicket, as represented by Releves 21, 109, 110 and 117 (Fig. 20, Appendix 5, Ass. 5.1, Table 4, Ch. IV; Appendix 1). Dominants at the shrub and brush levels vary and include *Combretum molle*, *C. apiculatum* and *C. zeheri*. The grasses _Panicum maximum_ and _Digitaria eriantha_ are commonly dominant. _Brachiaria nigropedata, Heteropogon contortus_ and _Enneapogon cenchroides_ are also locally prominent (Table 4, Ch. IV).

12.2 _Combretum apiculatum_ - dominated brushveld of the Cretaceous pebbly plateau edge

The litholitic soils of the pebbly plateau edge has vegetation classified with Association 6.4.2, (Table 4, Ch. IV). The structure and physiognomy is densely shrubby, moderate to dense brushveld, dominated entirely by _Combretum apiculatum_, as represented by Releves 22 and 33 (Appendix 1). The dominant grasses in this example are _Eragrostis superba, Digitaria eriantha, Brachiaria nigropedata, Aristida congesta_ subsp. _barbicollis, Cymbopogon plurinodis_ and _Bothriochloa radicans_.

12.3 _Grassveld of moist depressions on the plateau_

This landscape unit is represented by Releve 25 of Association 6.1 (Table 4, Ch. IV, Appendix 1). The structure here is grassveld with scattered shrub. Prominent shrubs in Releve 25 were _Lannea stuhlmannii, Acacia borleae, Dichrostachys cinerea_ and _Combretum apiculatum_. Dominant grasses included _Cymbopogon excavatus Eragrostis superba, Brachiaria nigropedata, Urochloa mossambicense, Schmidtia pappophoroides_ and _Aristida_ spp.

VIII. ON RESEARCH, MANAGEMENT AND EDUCATIONAL APPLICATIONS

The landscapes and semi-detailed vegetation types of the Central District have been identified, their internal structures and asociated conditions described and systems provided for communicating effectively about them.

The functioning of an ecosystem is necessarily dependent on its structure and composition, including its vegetation structure and composition. Observations regarding activity, state and change in ecosystems are therefore rendered considerably more meaningful by merely recording the relevant vegetation compositional and structural types in a consistent manner, using the classification systems presented here.

The present inventory could be improved and the under-utilised computerised data of the present study is available for further analyses, but I would suggest that low priority be awarded to such tasks.

It should rather be considered now that ecosystems also undergo important seasonal and other changes. If vegetation research is to further contribute to a useful understanding of ecosystems in the Kruger National Park, the current priorities for the Central Ditrict would seem to be studies of changes in conservation status owing to losses of natural composition, structure, functioning and diversity of landscapes and vegetation types; of their seasonal and fire-associated rhythms; of changes in these rhythms from wet to dry rainfall cycles; and of medium term fluctuations and long term trends in vegetation structure and composition. Complementary zoological research is advancing mainly in the sphere of medium to large mammal ecology, involving all such animal species over the entire Kruger National Park. It is, therefore, also suggested that the vegetation studies emphasize compositional, structural and phenological variables that are directly experienced as such by medium to large mammals. Projects ought also to be relevant to large areas and many animal species.

The present inventory could directly benefit tourists by introducing them to the four major dimensions of variation in vegetation and to the various landscapes as such. Landscapes could be presented as harmoneous systems, analogous to symhonies and each with characteristic natural composition of climate, geology, topography, soil catena, vegetation pattern, surface water and animal life. Such aquaintance should ideally take place in the veld.

The following sections treat the aforementioned recommendations in somewhat greater detail:-

<u>Recording vegetation composition and structural types</u>

A standard may be recommended for the minimum amount of vegetation data to be included with any Central District observation where vegetation is conerned. The pro-forma proposed in Table 17 allows full use of the present inventory to record the generally essential vegetation data with minimum effort:-

TABLE 17. PRO-FORMA FOR RECORDING ESSENTIAL VEGETATION DATA.

LANDSCAPE NO.__ LANDSCAPE UNIT NO.__

WOODY LAYER PLANT ASS. NO.__.__.__.__

HEIGHT LEVEL (M)	COVER CLASS	DOMINANT HEIGHT CLASSES	DOMINANT SPECIES
1			
2			
3-5			
6+			

FIELD LAYER

INFLO-RES-CENCE HEIGHT	VEGE-TA-TIVE HEIGHT	COVER CLASS	GREEN-NESS*	GROWTH STAGE*	FIRE EF-FECT	UTILI-SA-TION*	LITTER*	DOMI-NANT SPE-CIES

(* After Joubert, unpubl.)

(a) Landscape number is obtained from the map of landscapes (Chapter VII, Fig. 1 in folder), or by matching the combinations of landscape unit headings in the Index of this treatise, with the outdoor pattern, or by a combination of map and Index headings.

(b) Landscape unit number is that of landscape unit headings in the Index and in Chapter VII. These headings serve as a key which may be supplemented, when necessary, by consulting descriptions of landscape units in Chapter VII.

(c) Plant association number is provided by cross references in descriptions of landscape units (Chapter VII). Occasionally, alternative subcommunities or variations of an association may be involved. It is useful, therefore, to identify the correct one from the description of the landscape unit; or else from the phytosociological tables of Chapter IV, starting with the synoptic Table 2.

(d) Woody structure is recorded by providing at least the cover symbol for the canopy regime at each height level. It may be necessary to split the 1-2m level into a 1m level plus a 2m level but retaining a combined cover value for the 1-2m level. The cover classes, symbols, estimating and measuring procedures and structural terminology are discussed in Chapter III. The recorder may optionally wish to record the dominant contributing height class(es) and dominant species for each height level. Coding these is discussed in Chapter III.

(e) Field layer dominants may optionally be noted. Field layer structure and phenology are not dealt with in this inventory but it should be quick and most useful to record height, cover, phenological stages, utilisation and amount of litter using the ecological aerial survey classes of Joubert (unpubl.).

Further exploitation of available data

The present inventory could be refined, e.g. by a bigger sample, more objective sampling and potentially also by more objective numerical processing of data. I doubt, however, that further refinement would be worth the effort considering other management, educational and research priorities. It must be recommended, therefore, that such refinements receive low priority and be left largely to students concerned with academic interest rather than practical priorities. Such studies, particularly numerical correlations of plant species with habitat data, would nevertheless be useful. The data for the present inventory has been considerably under-utilized in this respect and it is suggested that the data, which are on computer discettes, be made available to interested students. Soil samples for most releves have been preserved for possible chemical analyses and correlation of chemical composition with other releve characteristics.

Rational evauation and planning of disturbance by monitoring changes in conservation status, per landscape and plant community

Monitoring losses of natural composition, structure, functioning and diversity per landscape and vegetation type seems essential. Such a record should serve to minimize the adverse effects of inevitable disturbances.

Numerous plants contribute to one plant community and several communities contribute to one landscape. The patterns in which plants and communities thus combine are the essence of the present inventory. It appears that these patterns are the products of thousands, millions and thousands of millions of years' climatic, geological, geomorphological and soil-forming processes and concurrent plant and animal evolution. These various processes culminated in systems where a great variety of plants and animals live and survive, spontaneously, in pre-technological harmony with each other and with their complex environment.

Our indispensable technology rests on the exploitation of a variety of climates, rocks and soils and it is the task of agricultural and mining industrialists to gain access to these. My task is to point out that no virgin landscape can be conserved without its climate, rocks and soils. Nature conservation therefore implies that we should somewhere abstain from feeding technology with everything the earth has to offer. It is no use arguing that we can conserve areas that cannot serve some other purpose. Eventually there will be no such areas. Technological exploitation may nevertheless become truly inevitable, either to provide permanent solutions or, more typically, to temporarily postpone a survival problem. In such instances, as well as in making the Kruger National Park available to tourists, the following considerations apply:-

The natural ecosystems may suffer subtle disturbances of composition, structure and function, owing, e.g. to imperfect simulations of natural fire regimes and animal populations. Some such disturbances are reversible. However, it is also clear from the present and numerous similar inventories that the natural vegetation is highly dependent on soil properties that took hundreds to thousands of years to develop and that many of these crucial properties are irreversibly destroyed by ploughing, earth moving, gravel pits, roads, erosion and other such agents. These sites may be recolonized by indigenous plants, but by distinct and completely different associations that indefinitely show the history of disturbance. Therefore, classes of disturbance ought to be distinguished on the basis of severity of losses in natural composition, structure and functioning.

The loss or replacement of relatively few plants through radical disturbances may not be as serious as the damage done to the pristine character of the community to which they contributed and particularly the landscape. The unspoilt vegetation and faunal composition, structure and functioning of landscapes may be seriously impaired without threatening rare species or particularly beautiful specimens of organisms - and landscapes, as such, are no less part of our conservation heritage than their component communities, species, specimens and abiotic habitats. Of these various levels of biological organization, the landscape, with its pristine character, is the most vulnerable.

A minor catchment, including all landscape units from watershed to watershed, is the basic "building block" of a landscape and as such the smallest complete example of a landscape that may be conserved, appreciated, studied and managed as such. Units of complete landscape are, therefore, relatively large and few and their statusses depend on the status of every component. It should also be borne in mind that an isolated undisturbed minor catchment would have a lower conservation status than each member of a cluster of similar catchments that form a larger unspoilt complex. Moreover, undisturbed specimens and species in an unspoilt community - any of these in an unspoilt landscape - or any of the aforegoing in an unspoilt cluster of landscapes, have higher conservation statusses than if they were in equally good condition but existed in less ideal context.

It may be _per se_ necessary to access a specific example of a landscape and detract from its conservation status. It seems reasonable to suggest, however, that inevitable disturbance, particularly severe disturbance, be limited as far as possible to the most disturbed examples of the most widespread types of landscapes and communities.

Natural diversity must also be taken into account when limiting losses in the event of unavoidable disturbances. The grid system used for recording other phenomena in the park (cf. Ch. V) could be useful in this respect. The number of landscapes present in each 4,9km^2 grid block, i.e. landscape diversity, is obtainable from Fig. 1 and has already been computerised. Aerial photo interpretation and field checking, in conjunction with the present inventory of landscapes, landscape units, associations and accompanying physiography, may identify communities present in each grid block. This gives data on community diversity. Typical species diversity for each of these communities is provided in Tables 3-9 (Ch. IV).

For such planning and management as suggested in the aforegoing paragraphs to be rational and efficient, planners and managers would require regularly updated inventories of various types of disturbance, the catchments, landscapes and communities involved, and the extent, conservation status and diversity of such landscapes and communities. It is apparent that considerable botanical expertise, particularly in aerial photo interpretation, phytosociology and environmental impact assessment, would be required to construct such a system. In addition, generous investment in computer facilities would greatly simplify the task of maintaining the system up to date. Such computer facilities are essential if the information contained in the system is to be quickly and easily retrieved in appropriate form to be useful and efficient in day to day planning and management.

Monitoring fire-associated and seasonal rhythms, medium term cycles and long term trends per landscape and plant community

Rhythms and changes, being manifestations of the functioning of ecosystems are necessarily dependent on ecosystem structure and composition. Each association of each landscape should, therefore, ideally be individually monitored for such changes.

Structure and composition not only affect ecosystem functioning but also monitoring priorities. Monitoring considerations depending on structure and composition include: variables that would be most relevant; frequency of observations; usefulness of monitoring results; degree of accuracy needed; and effort required for a given degree of accuracy. Monitoring priorities and procedures are further governed by season and by the time scales involved. Priorities and procedures must therefore be specially established for each ecosystem as well as for fire-to-fire cycles, for seasonal rhythms, for wet to dry cycle fluctuations and for long term trends.

Data from such a vegetation monitoring programme is urgently needed to complement other rapidly inflowing and forthcoming data on medium to large mammal ecology. To design and optimize such a monitoring programme is a major project requiring the present inventory, as well as professional skills in operations research, data processing and vegetation science. Representative sites, visiting frequencies, pro-forma and survey procedures must be determined to satisfy the various monitoring requirements for each ecosystem. These considerations would have to be contained in a well-documented and routine monitoring survey schedule. The programme would also be ineffective without provision for computerized data storage, retrieval and routine processing.

Introducing tourists to the ecosystems of the Kruger National Park

Chapter II of this inventory may be useful in introducing the public to the major sources of variation and the principal regions of the Kruger National Park by various means (cf. Verhoef, 1980).

Chapter VII could similarly be used to introduce tourists to landscapes as ecosystems. Information sites could, e.g., with the aid of Chapter VII, be selected in representative parts of all Central District landscapes. These sites may be situated along tourist roads in such a manner that the shortest possible bush trail brings the tourist in direct contact with the major units of each landscape. The trail might be restricted to the immediate vicinity and within range of a stationary supervisor.

A small information centre at the parking site could offer the tourist a schematic presentation of the salient features of each landscape, based on Chapter VII and including a synopsis of the interrelationships between climate, rocks, landform, soils, vegetation, water and fauna. Annotated physical examples of the major plant species and soil profiles with bedrock, could be encountered along the trail.

After visiting such a centre, tourists ought to be equipped to recognize and appreciate, from the car, the recurring pattern and many characteristics of the relevant landscape.

IX. CONCLUSIONS

The Braun-Blanquet Approach has again provided an adequate semi-detailed account of floristically defined plant communities. Some novel approaches were necessary to describe vegetation physiognomic structure and vegetation-delineated ecosystems. Together, these traditional and new approaches provide for the special needs of conservation scientists, managers, information officers and public in the Kruger National Park. Compatible formal and informal, general and detailed, communication within and between these groups is facilitated and a broad information base is provided. The methodology presented here could be used for similar inventories in other conservation areas, particularly in Bushveld.

The Braun-Blanquet Approach remains a good first choice for a general inventory of floristic communities and relationships. A contribution to the ongoing process of rationalising the relevant techniques is offered, but much remains to be done in this sphere.

Vegetation physiognomic structure could be easily and adequately classified and discussed in all instances, with the system developed for the present inventory. The technique provided by Coetzee & Gertenbach (1977) for determining quadrat dimensions has served its purpose well. Its principles can also be applied in quick casual estimates. The method, nevertheless, requires additional theoretical clarification. The practise of precisely measuring individual canopies, as in the present study, is not recommended for inventory surveys. This practice is unduly accurate and time consuming where cover values merely serve to assign canopy regime to broad cover classes. Quick estimates, based on number of canopy diameters that separate canopies at the various height levels, should provide the necessary accuracy.

The proposed system for classifying and naming vegetation-delineated ecosystems has also been successful. system efficiently integrates (a) phytosociological description, which emphasises floristic relationships between plant assemblages, on the one hand and (b) landscape ecology, which emphasises spacial interdependence of plant assemblages and of their habitats, on the other hand. These two approaches are highly complementary. The classification of landscapes also successfully integrates the ecologically important biotic and abiotic classification systems of Acocks (1953), Braun-Blanquet (cf. Barkman et al., 1976), Thornthwaite (cf. Schulze & McGee, 1978), King (1963), and MacVicar et al. (1974), as well as geological maps.

Reconnaissance surveys of South Africa could be carried out using the landscape classification system presented here. Maps produced with the various abiotic and biotic classification systems incorporated, cover the Country and could be superimposed to produce a tentative map of landscapes. Rapid fieldwork could refine the map and describe the pattern of landscape units within the mapped landscapes. Salient features of ecotopes as well as vegetation structure and dominants could be recorded.

Correspondence analysis, and the multidiciplіne data bank that is based on a geographic grid system, proved to be most promising facilities for synthesising data on ecological relationships. The ecological aerial survey data from this bank was invaluable.

The phytosociology, vegetation structure and landscapes of the Central District have thus been formally inventorised. I trust that the botanical information, communication systems and integrated approach offered, will serve the best interests of conservation and promote integration of phytosociological and landscape ecology. In particular, it is hoped that the thesis may further an awareness of pre-technological harmony. We humans evolved as part of this ".... vast pulsing harmony ....", which suggests that knowledge thereof should help us understand ourselves, our pleasures and our dilemmas; and that our conservation areas, and the stirrings they provoke, are real and indispensible pillars of survival (quoted phrase from Aldo Leopold, 1947).

X. SUMMARY

PHYTOSOCIOLOGY, VEGETATION STRUCTURE AND LANDSCAPES OF THE CENTRAL DISTRICT, KRUGER NATIONAL PARK

by

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1. INTRODUCTION

Col. James Stevenson-Hamilton had an epic statutory and administrative struggle as first Warden to establish the conservation status of the Kruger National Park. Despite these responsibilities, he was substantially productive in every field of botanical enquiry as yet persued in the Park. Lang, through

Obermeijer (1937) and Codd (1951) provided the earliest subsequent botanical contributions with inventories and descriptions of species, and a general-reconnaissance map. H.P. van der Schijff was the first botanist to be appointed in the Kruger Nationa Park. With judiceous priorities and remarkable productivity, he laid a monumental research foundation in the form of a herbarium with a 4000 specimen collection, floristic and phytogeographic accounts, a reconnaissance survey of all major plant communities, a series of long term burning experiments and notes on the interaction between vegetation and animals. These contributions eminated from a brief appointment of less than four years during 1951-1955.

Numerous subsequent contributions built on these early foundations. In 1971 P. van Wyk, then Chief Research Officer, introduced general vegetation monitoring in the Kruger National Park. He also proceded to semi-detailed vegetation surveys, adopting the Braun-Blanquet approach for this purpose. The same approach was followed for floristic classification in the present study. The present study was initiated at a time when the research division at Skukuza underwent rapid expansion and integrated multidisciplinary surveys with an holistic ecosystem approach gained momentum under the leadership of Chief Research Officer S.C.J. Joubert. This approach, the data yielded by ecological areal surveys and various interdisciplinary cross-fertilisation prompted special attention to vegetation physiognomic structure, and to landscapes as vegetation-delineated ecosystems, in the present study.

A strong tradition of landscape ecology exists with major contributions by, e.g., Van der Schijff (1957), Killick (1963), Edwards (1967) and Scheepers (1977). This tradition has been grossly neglected in recent phytosociologically orientated surveys. The present survey is an acknowledgement of the need to integrate phytosociology and landscape ecology.

2. VEGETATION OF THE KRUGER NATIONAL PARK AND ITS CENTRAL DISTRICT IN BROAD ECOLOGICAL PERSPECTIVE

The climate of the Kruger National Park is semi-arid to arid, subtropical and tropical and the vegetation is deciduous Bushveld. At the broadest level, variation in vegetation is essentially four-dimensional. Twenty principal vegetation regions may be delimited by superimposing these four major types of variation.

The four major dimensions of variation are the following:

(1) Rainfall decreases from a subhumid 700mm and higher near the mountains, in the far north-western and south-eastern corners of the Kruger National Park, to between 400mm and 500mm in the arid low area between the Limpopo and Olifants rivers.

(2) Temperature differences are of phytogeographical importance. A strongly tropical flora, which seems to have migrated along the Limpopo river, occurs on extensive sandy areas in the extreme north of the Kruger National Park. Moist temperate mountain ranges link the north-western and south-western corners, and these two areas share a subhumid to humid, warm-temperate to cool-temperate flora. These temperate areas have affinities with the interior plateau and far-southern African areas.

(3) Geologically controlled topography and substrate have a major influence on the vegetation. Thus distinctive species compositions occur: amongst outcrop; on sandstone soils and aeolian sand deposits; on sandy granitic and rhyolitic upland sites; in clayey, non-solonetzic, granitic bottomlands and doloritic and basaltic plains; and on solonetzic clayey soils of granitic and Karoo Sediment bottomlands.

(4) Azonal riparian vegetation of streams and rivers, is distinct.

Of the twenty resultant major vegetation regions, the following nine occur in the present study area: Riparian; Semi-arid Granitic Plains; Semi-arid Doloritic Plains; Semi-arid Basaltic Plains; Semi-arid Karoo Sediment Plains; Semi-arid Sand Plateau; Semi-arid Hills and Inselberge; Southern Spiny Arid Bushveld; and Arid Rhyolitic Hills.

3. PHYTOSOCIOLOGY AND VEGETATION STRUCTURE (1): METHODS

Floristic vegetation sampling and synthesis was in the Braun-Blanquet Tradition, coupled with detailed, mainly physical, soil analysis. The soil analysis included a soil profile description as used in the official South African Soil Classification System (Mac Vicar et al., 1977). Ranks and names are assigned to associations and, where two or more closely related associations are discussed, to the alliance to which they belong.

The technique used to sample woody structure and composition (Coetzee & Gertenbach, 1977) provides for calculating per species, stem growth- form (number of stems) and height class: (a) canopy regime at different height levels; (b) total canopy regime; and (c) density. Quadrat size is determined independently at each site for each height class of plants, to suit the density and distribution of plants. Low densities and irregular distribution of individuals result in large quadrats, whereas smaller quadrats result from regular spacing and high densities.

Structural classification is based simply on canopy cover regime at three height levels, i.e. the shrub level (0,75-<2,5m), brush level (2,5-<5,5m) and tree level (5,5m+). Trees may contribute at the tree, brush and shrub levels, brushes at the brush and shrub levels and shrubs at the shrub level only. Classification may be on the upper-, on a subordinate- or on all canopy levels and on major or detailed cover classes, depending on emphasis and detail required. Class names indicate the type of classification and level of detail. Thus six primary classes are recognised on the basis of broad canopy regime class of the upper canopy level:

(1) shrubveld (upper level at shrub height, with 1-<25 per cent cover);
(2) scrub (upper level at shrub height, with 25 per cent+ cover);
(3) brushveld (upper level at brush height, with 1-<25 per cent cover);
(4) thicket (upper level at brush height, with 25 per cent+ cover);
(5) treeveld (upper level at tree height, with 1-<25 per cent cover);
(6) bush (upper level at tree height, with 25 per cent+ cover).

If grasses form the upper level, the primary classification is grassveld. The highest level covering one per cent or more is the upper level.

The adjectives "sparse", "moderate" and "dense" denote detailed regime class of the upper level, as subdivided by the Braun-Blanquet cover scale. Dependent clauses describe subordinate canopy levels, which are classified by height and cover in the same manner as upper canopy levels. To form these clauses, the nouns shrubveld, scrub and brushveld become the adjectives shrubby, scrubby and brushy; the noun thicket becomes the verb thicketed; and the adjectives sparse moderate and dense are replaced by the adverbs sparsely, moderately and densely. Height levels with scattered canopies covering 0,1-<1 per cent are indicated by the clauses "with scattered shrub/brush/trees".

Three symbols, each representing a Braun-Blanquet Scale cover value for a different height level, may be obtained by three quick estimates and are sufficient to classify a stand at any of the various levels of detail mentioned. Thus "3b+" represents sparsely scrubby, dense brushveld, with scattered trees (canopy at 1-2m covering >25-50 per cent, at 3-5m covering >12-25 per cent and at 6m+ covering 0,1-<1 per cent); or, more briefly: scrubby dense brushveld; or scrubby brushveld; or brushveld or simply scrubby vegetation, depending on emphasis.

Coding is expanded to show height classes of plants that contribute most at the shrub and brush level and to indicate dominant species at each level, e.g. "3B-DICCIN; bB-DICCIN; +ACANIG" to indicate that Dichrostachys cinerea brushes (3-5m tall) contribute most at the shrub and brush levels and that the scattered emergents are largely Acacia nigrescens trees.

4. PHYTOSOCIOLOGY AND VEGETATION STRUCTURE (2): RESULTS

A Synoptic Table, which groups species on their overall distribution in the study area, shows 16 major differential species groups as well as two groups that occur either too generally or too sporadically to differentiate between plant communities. Two of the differential groups are useful indicators of deflocculated soils, sodic or otherwise. Six differential groups may conveniently be regarded as soil texture indicators. Seven groups are good indicators of moisture regime. Another group of species have narrow ecological amplitudes and are largely exclusive to specific plant associations.

The Synoptic Table also shows 12 communities with the rank of association and their primary subdivision into 32 subcommunities. Species groups and communities are dealt with in more detail on seven detailed phytosociological tables, where species are to some extent re-ordered in the more limited context of particular communities. The re-ordering amplifies some communities established in the Synoptic Table and brings out additional subdivisions.

The <u>Chloride virgatae - Justiceion flavae</u> is an alliance on soils that are deflocculated owing to high sodium content, kneeding of wet soil through trampling, or to both these factors. In keeping with the arid nature of puddled clayey soils and solodized solonetzic B horizons, general aridity and clay indicators are well represented. Conversely, the sandy, often moist A horizons of the solonetz soils also allow indicators of mesic and sandy conditions. Four associations belonging to this alliance are discussed.

The Pogonarthrio squarrosae - Combretion apiculati is an alliance on mesic sand. This alliance occupies soils with sandy, sandy loam and loamy sand texture throughout the profile, in the 500-650mm rainfall region. Such soils of the Granite-Gneiss, Quaternary and Sandstone regions generally belong to the Glenrosa, Hutton and Clovelly forms, whereas the Lebombo Mountain lithosols include talus slopes and soils of the Mispah Form. The two associations discussed are related to these differences.

The Themedo triandrae - Acacietum gerrardii (Association on mesic clay) belongs to an unspecified alliance. This association occurs in the bottom parts of undulating granitic terrain and on doloritic and relatively high rainfall basaltic plains. Mean annual rainfall in these areas is 550-600mm and the soils are more clayey than sandy loam in at least one horizon, particularly the B horizon.

The Acacietum gerrardio-tortilis (Association on moderately dry clay), also of an unspecified alliance, is restricted to the 500-550mm rainfall basaltic plains.

The Acacio nigrescentis - Grewion bicoloris is an alliance of arid habitats. One association occurs as arid enclaves in the 500-550mm rainfall zone. These enclaves are associated with heavy grazing and shallow soils. Another association occupies the arid basaltic and rhyolitic plains adjoining the Olifants River. The rainfall here is less than 500mm.

The Acacio nigrescentis - Setarietum woodii, of unspecified alliance, is an association on vertisols.

The *Androstachyetum*, of unspecified alliance, is an association of arid habitats with heavy winter fog. The dominant woody species, *Androstachys johnsonii*, is evergreen, typically forms dense stands with sharp boundaries and is slow growing. The species is associated with arid climates and arid substrates such as sheet outcrop, where fog, such as coastal fog, river valley winter fog, or low stratus cloud on mountains, occur.

5. LANDSCAPES (1) : CONCEPTS AND METHODS

The landscape classification system proposed comprises three categories of vegetation-delineated ecosystems. Corresponding categories for the entire vegetation and abiotic components of these ecosystems are provided. The classification system fully incorporates the abiotic classification of Land by MacVicar *et al*. (1974), the Braun-Blanquet Phytosociological System and Acocks' (1975) system of Veld Types. The integration of these systems are expressed in the names of the categories of biotic and vegetation components. The lowest of the three categories of ecosystem is the Landscape Unit, incorporating a plant Association in an abiotic ecotype, and with associated fauna. A pattern of landscape units forms a Landscape, with its Association Complex, abiotic Land Type and fauna. Landscapes combined, form and Ecological Province, with its Veld Type, abiotic Land System and fauna. The categories of faunal and microbiological components would vary according to the taxonomic group.

Also integrated into the classification and expressed in the names of landscapes, are:

(a) Thornthwaite's climatic classification system (Schulze & McGee, 1978), which seems most appropriate for explaining major southern African Veld Types;

(b) King's (1963) classification of major Geomorphological Provinces; and

(c) geological formations.

Within one biogeographic region, the major determinants of land type and landscape are macro-climate, terrain form and soil pattern. Terrain form depends largely on macro-climate, geology and Geomorphological Province and soil pattern depends on all these. Landscapes of a biogeographic region may, therefore, conveniently be characterised by, and named after, macro-climate, geology and geomorphologic provinces. Further characterisation on the basis of salient ecological features, may be justified by different patterns of plant associations.

Landscapes are described here with data from the phytosociological survey and with data on medium to large herbivores from the 1979 aerial ecological monitoring surveys by Joubert (unpubl.). Landscapes and the aerial survey data have been inventorised per geographic grid square and incorporated in the computerised ecological data base at Skukuza. The computerised data was used to print grid distribution maps of landscapes and animal density classes and to ordinate landscapes and medium to large herbivore species on the basis of their interrelationships. Ordination was by Correspondence Analysis (Hill, 1973 & 1974).

6. LANDSCAPES (2): RESULTS OF ORDINATION OF HERBIVORES AND LANDSCAPES

Landscapes change with season as well as with burning and medium-term rainfall cycles. Animal preferences for landscapes and the emphasis placed on different habitat factors, may, therefore, vary with season and from one year to the next. Ecological tollerances also vary with species and an occurrence within a landscape at the time of survey may be more or less incidental. As this was not primarily a study of herbivore ecology, these factors could not be taken into account. Neither was the literature on the animals concerned, studied.

Despite these limitations the results of the ordination provided useful information on the habitat and landscape preferences of the following species and groups: buffalo breeding herds, buffalo bulls, elephant breeding herds, elephant bulls, impala, blue wildebeest, ostrich, tsessebe, kudu breeding herds, kudu bulls, ground hornbill, sable breeding herds, sable bulls, warthog, reedbuck, waterbuck, giraffe and to a lesser extent, white rhino.

7. LANDSCAPES (3): DESCRIPTION OF CLIMATE, PHYSIOGRAPHIC AND VEGETATION PATTERNS, AND MEDIUM TO LARGE HERBIVORE FAUNA

The climate, physiographic and vegetation patterns, and medium to large herbivore fauna of twelve landscapes are described:-

(1) Tropical Arid Granitic Lowveld of the Sabie River Valley

Although the climate here is semi-arid, the overall character of this ecosystem is arid owing to the valley-associated physiography and biotic influence. The medium- to large-herbivore community consists largely of forb, shrub and brush browsers, shortgrass grazers and river and bushloving species, i.e. impala, giraffe, kudu, warthog, buffalo bulls and bushbuck.

(2) Tropical Semi-arid Granitic Lowveld

The major determinants of the medium- to large-herbivore community here, seem to be the abundance of trees and brushes, combined with relatively tall grass strata and the scarcity of free surface water. The landscape is extremely favourable to sable antelope but is largely avoided by other species.

(3) Tropical Semi-arid Doloritic Lowveld

This landscape has varying degrees of granitic influence. The vegetation is largely shrubby, brushy treeveld. Purely doloritic areas have rank mesic types of grass cover. Grass cover becomes sparser and arid with granitic influence. Kudu bulls, sable breeding herds and ostriches showed some preference for this landscape, but other species occur here in relatively low densities.

(4) Tropical Semi-arid Karoo Sediment Lowveld

This is a low, flat and densely woody landscape, which supports a top ranking diversity and biomass of medium to large herbivores. Short, forbaceous and arid grass field layers, peculiar to some sodic bottomlands, are probably major attractions to the high densities of impala, warthog and rhino. Giraffe, which occur here with moderate densities are presumably favoured mainly by the abundant browse. Buffalo bulls are relatively common and blue wildebeest, zebra, kudu and elephant bulls occur in significant numbers.

(5) Tropical Semi-arid Lowveld on Karoo Sediment Anticline with Dolorite

The Landscape has a wide range of habitats. During the winter 1979 survey, when water was common in the several seasonal pans, sodic areas attracted high densities of white rhino and warthog. Elephant breeding herds were also common and were probably attracted by the lush woody growth and abundant drinking water. Impala had a high preference for part of the landscape.

(6) Non-vertic Tropical Semi-arid Basaltic Lowveld

In general the landscape is gently undulating and clayey, with relatively open woody structure and a variety of field layers. Internal drainage is poor and spruits retain their surface water well into the dry season. All of the 14 major medium to large herbivore species of the Central District occur here with high relative densities. Only three of the 18 such species of the Kruger National Park are absent or poorly represented. These are roan antelope, eland and nyala.

(7) Vertic Tropical Semi-arid Basaltic Lowveld

The landscape has little surface water. Biomass per unit area for medium to large herbivores is low, but the landscape attracts high densities of kudu and sable antelope, relative to other landscapes. Abundant shrub and brush browse and long grass are probably salient factors favouring these two species respectively.

(8) Tropical Arid Basaltic Lowveld of the Olifants River Valley

The arid climate and physiography and the perennial water of the Olifants River, is expressed by the vegetation and fauna. The vegetation is Spiny Arid Bushveld with shrubby brushveld structure. Waterbuck occur with high density along the Olifants River. Elephant, zebra, blue wildebeest, kudu and warthog occur in low to moderate densities.

(9) Tropical Semi-arid Rhyolitic and Granophyric Lowveld

The major portion of this landscape comprises the rhyolitic Lebombo Mountains south of the Pumbe Pan region, where the rainfall exeeds 600mm. Kudu, giraffe, buffalo bulls and waterbuck were strongly attracted to this landscape. Kudu occured throughout, giraffe and buffalo bulls selected the nothern, relative dry section and waterbuck were concentrated at the major river valleys. Impala are also common in these valleys and several other species occur with low to moderate densities.

(10) Zonal Tropical Arid Rhyolitic Lowveld

This is the Lebombo Mountains between Pumbe and the Olifants River Valley. Its medium- to large- herbivore community seems to be determined mainly by aridity, sparse field layers and abundant suitable browse. The major species are impala and zebra. Kudu, giraffe and waterbuck occur in small numbers.

(11) Tropical Arid Rhyolitic Lowveld of the Olifants River Valley

The arid mountainous terrain here is clad with *Androstachys johnsonii* bush and thicket. Principal medium to large herbivores include kudu breeding herds and buffalo bulls. The area is traversed by well-utilized hippopotamus and elephant paths. Sharpe's grysbuck, grey duiker and bushbuck also find shelter in the bush and thicket.

(12) Cretaceous Plateau with Tertiary Aeolian sand, in Tropical Semi-arid Lowveld

The landscape comprises a vast flat and level sandy plateau with a pebly plateau edge and numerous seasonal pans. A small portion falls within the Kruger National Park. This portion contains a seasonal pan with the only South African occurrence of the fish Notobranchius rachovii (Ahl. 1926). The species has a lifespan of one rainy season.

8. ON RESEARCH, MANAGEMENT AND EDUCATIONAL APPLICATIONS

Ecosystem functioning is dependant on vegetation structure and composition. Observations regarding activity, state and change in ecosystems are therefore rendered considerably more meaningful by merely recording the relevant vegetation compositional and structural types in a consistent manner and in ecosystem context, using the classification systems presented here.

Numerous plants may form one plant community and several communities may contribute to one landscape. The unspoilt vegetation and faunal composition, structure and functioning of landscapes, may be seriously impared without threatening rare species or particularly beautiful specimens of organisms. Moreover, landscapes as such, are no less part of our conservation heritage than their component communites, species, specimens and abiotic habitats. An inventory of these various levels of biological organisation and their conservation statusses is, therefore, essential in order to minimise the adverse effects of inevitable disturbances.

Tourists could be introduced to the four major dimensions of variation in vegetation and to the various landscapes as such. Landscapes could be presented as harmoneous systems, analogous to symphonies and each with characteristic natural composition of climate, geology, topography, soil catena, vegetation pattern, surface water and animal life.

9.CONCLUSIONS

The Braun-Blanquet Approach has provided the required floristic classification. Novel approaches were necessary to describe vegetation physiognomic structure and vegetation delineated ecosystems. The resulting inventory should facilitate compatable formal and informal, general and detailed, within group and between group, communication between scientists, conservation managers, information officers and public. The system is offered as a guide to similar inventories in other conservation areas, particularly in Bushveld.

The main concern of this thesis is the nature and importance of pre-technological harmony. The fact that human evolution has its roots in such harmony suggest that it is relevant to our pleasures and dilemmas and that our conservation areas, and the stirrings they provoke, may be real and indispensable pillars of survival.

XI. CURRICULUM VITAE

The author was born in Nelspruit on the 21st April, 1943. He grew up in Pretoria, where he attended Die Laerskool Rietfontein-Noord and Die Hoërskool Wonderboom. He matriculated from the latter in 1960. In 1961 he completed his military training at the Air Force Gymnasium in Pretoria and during 1962 was a full-time B.Sc. student at the University of Pretoria.

In January, 1963 the author joined the Public Service as a Clerk, later designated Administrative Assistant. In 1966, while serving in this capacity, he again enrolled at the University of Pretoria and in 1968 obtained the B.Sc.-degree with botany and zoology as major subjects. He then did an honours degree in botany in 1969 at the University of Pretoria and was transferred to a post of Professional Officer in the Department of Agricultural Technical Services. During his five years service here as a Professional Officer and Senior Professional Officer, he obtained an M.Sc. degree in plant ecology and was author and co-author of ten professional publications. Published projects included: semi-detailed phytosociological surveys of the Jack Scott Private Nature Reserve, the Rustenburg Nature Reserve, the Nylsvley Nature Reserve and the Augrabies Falls National Park; a west-east vegetation transect through southern Africa; and a number of publications on phytosociological methodology.

In 1975 the author joined the National Parks Board as a Research Officer at Skukuza. During the following six years here as a Research Officer and Senior Research Officer, he was author and co-author of a further eight professional publications. These included a chapter on the vegetation of the Sudano-Zambezian Region in a book on the biogeography and ecology of southern Africa; a semi-detailed phytosociological survey of the Mlilwane Wildlife Sanctuary in Swaziland; a reconnaissance survey of the southern Waterberg Mountains in the Transvaal; vegetation changes and elephant impact in the Kruger National Park; papers on phytosociological methodology; as well as a thesis on the phytosociology, vegetation structure and landscapes of the Central District, Kruger National Park. The latter thesis was submitted towards obtaining the D.Sc. degree in vegetation science at the University of Pretoria.

In January, 1981 the author left the National Parks Board and his carreer as a biologist, to become a Programmer and later Systems Analyst for a Johannesburg private company.

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APPENDIX 1. VEGETATION STRUCTURE AND DOMINANTS

Cover regime, dominant growth form and dominant species at the tree (5,5m+) brush (2,5-<5,5m) and shrub (0,75-<2,5m) levels. Symbols for species are the first three letters of the genus, followed by the first three letters of the specific epitheton (see Tables 2-9, Appendix 3 for full names). Other symbols are:

C = cover class
(Braun-Blanquet Symbol)

G = growth form
T = tree (5,5 m+)
B = brush (2,5-<5,5 m)
S = shrub (0,75-<2,5 m)

Association	Releve			HEIGHT LEVEL Shrub			Brush		Tree
		C	G	Species	C	G	Species	C	Species
1.1.1	333	1	B	Aca gra	a	B	Aca gra	+	Aca gra
	309	1	B	Aca gra	a	B	Aca gra	1	Aca gra
	305	1	T	Aca wel	a	T	Aca wel	a	Aca wel
	225	1	B	Aca wel	a	T	Aca wel	a	Aca wel
1.1.2	217	b	B	Euc div	b	B	Euc div	1	Aca wel
	221	b	B	Euc div	3	B	Euc div	a	Aca wel
	206	3	B	May ten	b	B	Euc div	a	Spi afr
	219	b	S	Cas aet	b	B	Aca wel	a	Aca well

		HEIGHT LEVEL							
Association	Releve	Shrub			Brush			Tree	
		C	G	Species	C	G	Species	C	Species
1.2	200	b	B	Dic cin	b	B	Dic cin	1	Aca wel
	304	a	B	Dic cin	b	B	Aca wel	a	Aca wel
	141	3	B	Aca wel	3	B	Aca wel	a	Aca wel
	195	1	B	Dic cin	+	B	Aca tor	+	Aca wel
	211	b	B	Euc div	b	B	Euc div	b	Aca wel
	166	1	T	Aca wel	1	T	Aca wel	b	Aca wel
2.1.1	301	1	B	Com her	1	B	Com her	0	
	303	a	S	Alb pet	a	T	Alb pet	a	Alb pet
	300	1	B	Alb pet	a	T	Alb pet	a	Alb pet
2.1.2	306	1	B	Alb pet	1	T	Alb pet	1	Alb pet
	307	a	B	Com zey	a	B	Com zey	1	Com zey
	246	b	B	Dic cin	3	B	Dic cin	1	Alb pet
2.2	245	1	B	Alb pet	a	T	Alb pet	a	Alb pet
	169	3	B	Alb pet	3	B	Alb pet	0	
	198	3	B	Dic cin	b	B	Dic cin	+	Aca wel
	142	a	B	Alb pet	b	B	Alb pet	0	
	165	3	B	Dic cin	b	B	Dic cin	+	Lon cap
	319	1	B	Aca eru	1	B	Aca eru	0	
	254	a	B	Alb pet	b	B	Alb har	a	Alb har
	226	b	B	Dic cin	b	B	Dic cin	0	
	228	+	S	Rhu spi	0			0	
3.1	240	a	B	Gre bic	1	B	Aca nig	0	
	239	1	B	Aca tor	1	B	Aca tor	+	Aca nig
	241	a	B	Aca tor	b	B		0	
	237	1	B	Aca nig	1	B	Aca tor	0	
	96	1	B	Aca nig	1	B	Aca nig	+	Aca nig
3.2	258	1	B	Dic cin	1	B	Dic cin	0	
	143	a	B	Dic cin	a	B	Dic cin	1	Aca nig
	257	1	B	Aca nig	1	B	Aca nig	+	Aca nig
	268	1	S	Aca tor	+	B	Aca tor	0	

					HEIGHT LEVEL				
Association	Releve			Shrub			Brush		Tree
		C	G	Species	C	G	Species	C	Species
4.1	287	+	B	Alb har	+	B	Alb har	0	
	297	1	S	Orm tri	+	B	Alb har	0	
	291	1	B	Alb ant	+	B	Alb ant	0	
	282	1	B	Euc div	+	B	Man moc	+	Aca nig
	137	1	B	Euc div	+	B	Euc div	1	Com imb
4.2.1	180	0			0			0	
	173	+	S	Alb har	0			0	
	135	+	S	Alb har	0			0	
	187	+	S	Ter ser	1	B	Pel afr	0	
	171	0			0			0	
	210	1	B	Euc div	1	B	Euc div	0	
4.2.2	131	+	S	Alb har	+	B	Com her	0	
	133	1	B	Com her	1	B	Com her	0	
5.1	34	1	B	Ter ser	a	B	Cas abb	1	Cas abb
	110	3	B	Com mol	3	B	Com mol	0	
	117	a	B	Com zey	a	B	Com zey	0	
	170	b	B	Gre bic	b	B	Gre bic	0	
	21	a	B	Com api	a	B	Com api	0	
	109	3	B	Com zey	b	B	Com zey	0	
5.2.1	177	a	B	Com zey	b	B	Com zey	1	Aca nig
	203	1	B	Com zey	1	B	Com zey	+	Scl caf
	298	a	B	Pte rot	b	B	Pte rot	+	Pte rot
	295	a	B	Com zey	b	B	Com zey	1	Scl caf
	182	a	B	Com zey	a	B	Com zey	1	Scl caf
5.2.2	176	b	S	Pte rot	a	B	Com zey	0	
	174	a	B	Com zey	a	B	Com zey	1	Scl caf
	130	a	B	Ter ser	a	B	Ter ser	0	

Association	Releve	C	G	Shrub Species	C	G	Brush Species	C	Tree Species
							HEIGHT LEVEL		
5.2.3	190	b	B	Com zey	b	B	Com zey	1	Scl caf
	223	a	B	Pte rot	a	B	Com api	1	Scl caf
	290	1	B	Com zey	1	B	Com zey	1	Scl caf
	188	b	B	Pte rot	b	B	Pte rot	1	Scl caf
	292	1	B	Com zey	1	B	Com zey	1	Scl caf
	167	a	B	Ter ser	b	B	Ter ser	+	Com her
5.3	199	b	B	Com zey	b	B	Com api	+	Lon cap
	205	1	B	Com api	a	B	Com api	+	Scl caf
	296	a	B	Pte rot	b	B	Com api	1	Lan stu
	196	a	B	Aca wel	a	B	Aca wel	a	Aca wel
	197	a	B	Com zey	a	B	Com zey	+	Com api
	172	1	B	Com api	a	B	Com api	1	Com api
	215	b	B	Pte rot	b	B	Pte rot	a	Scl caf
5.4.1	279	a	B	Dic cin	a	B	Com api	+	Scl caf
	281	a	B	Com zey	a	B	Com api	1	Lan stu
	278	a	B	Com zey	a	B	Com api	+	Scl caf
	128	b	B	Com zey	3	B	Com api	1	Com api
	308	a	S	Aca exu	a	T	Com api	a	Scl caf
	286	1	B	Com zey	a	B	Com api	1	Scl caf
	280	1	B	Com zey	b	T	Aca nig	a	Aca nig
	129	a	B	Gre mon	a	T	Aca nig	b	Aca nig
	140	b	B	Pte rot	b	B	Com api	b	Scl caf
	270	1	B	Com api	b	B	Com api	b	Scl caf
	332	a	B	Gre fla	a	B	Com api	a	Scl caf
	220	1	B	Com api	1	T	Aca nig	a	Aca nig
5.4.2	222	a	B	Com zey	a	B	Com zey	a	Scl caf
	209	1	B	Com zey	1	B	Com zey	0	
	184	a	B	Com api	a	B	Com api	+	Com api
	191	a	B	Str mad	a	B	Com api	a	Scl caf
	175	a	B	Com api	a	B	Com api	1	Lan stu
	302	1	B	Com zey	a	B	Com zey	1	Scl caf
	243	1	B	Com her	1	B	Com api	+	Lan stu
	227	1	B	Com her	a	T	Aca nig	a	Scl caf

Association	Releve	C	G	Shrub Species	C	G	Brush Species	C	Tree Species
				HEIGHT LEVEL					
6.1	321	a	B	Com api	1	B	Com api	0	
	320	1	B	Com api	1	B	Com api	0	
	330	1	S	Com api	+	B	Com api	0	
	327	1	S	Alb har	1	B	Com api	0	
	322	1	S	Ozo eng	0			0	
	25	+	S	Dic cin	0			0	
6.2	229	a	S	Pte rot	a	B	Com api	+	Com api
	273	1	B	Com api	a	B	Com mol	1	Com mol
	230	1	B	Com api	a	B	Com api	1	Com api
	277	a	B	Com zey	b	B	Com api	+	Com api
6.3	324	1	B	Ozo eng	1	B	Com api	0	
	313	a	B	Ozo eng	a	B	Com zey	0	
	311	1	B	Com api	a	B	Com api	+	Com api
	323	a	S	Pte rot	+	B	Com api	0	
	310	1	S	Pte rot	1	B	Com api	0	
	312	1	B	Pte rot	a	B	Scl caf	+	Scl caf
	261	a	S	Pte rot	1	B	Com zey	+	Alb har
	274	a	B	Com zey	1	B	Com api	0	
	314	a	S	Pte rot	a	B	Com zey	0	
6.4.1	325	a	B	Com api	a	B	Com api	0	
	326	1	B	Com api	1	B	Com api	0	
	118	b	S	Pte rot	a	B	Com api	+	Com api
	316	a	S	Pte rot	a	B	Com zey	+	Dio mes
	315	a	S	Pte rot	1	B	Com api	0	
	329	1	S	Pte rot	+	B	Com api	0	
	111	b	B	Com zey	a	B	Com api	1	Aca nig
	116	a	B	Com zey	b	B	Com zey	+	Lon cap
	107	b	B	Com zey	3	B	Com zey	0	

		HEIGHT LEVEL								
Association	Releve			Shrub			Brush		Tree	
		C	G	Species	C	G	Species	C	Species	
6.4.2	121	a	B	Com api	3	B	Com api	+	Com api	
	122	a	B	Com api	a	B	Com api	0		
	123	1	B	Aca ger	a	B	Aca ger	1	Aca nig	
	124	a	B	Com api	b	B	Com api	0		
	33	b	B	Com api	a	B	Com api	0		
	328	1	B	Com api	a	B	Com api	1	Com api	
	22	b	B	Com api	b	B	Com api	0		
	125	b	B	Com api	b	B	Com api	0		
7.1.1	218	1	S	Dic cin	+	B	Com her	1	Aca nig	
	285	1	B	Com zey	a	B	Com api	b	Aca nig	
	120	3	B	Aca ger	4	B	Aca ger	0		
	248	1	B		a	T		a	Scl caf	
	108	b	B	Aca ger	b	B	Aca ger	0		
	224	1	B	Aca nig	1	B	Pel afr	1	Aca nig	
7.1.2	201	a	B	Dic cin	a	B	Dic cin	1	Aca nig	
	179	1	B	Alb har	1	B	Alb har	0		
	213	a	B	Aca ger	a	B	Aca ger	1	Scl caf	
	139	a	B	Dic cin	a	B	Com api	a	Aca nig	
	183	1	B	Aca ger	1	B	Aca ger	0		
	208	1	B	Com her	1	T	Aca nig	1	Aca nig	
	207	1	B	Com api	a	B	Com api	a	Aca nig	
	185	1	B	Aca ger	a	B	Aca ger	1	Aca nig	
	212	1	B	Com api	1	B	Com api	1	Aca nig	
	214	1	S	Gre bic	1	B	Com api	a	Aca nig	
	216	1	B	Com her	1	B	Com her	1	Scl caf	
	198	3	B	Dic cin	b	B	Dic cin	+	Aca wel	

Association	Releve	C	G	Shrub Species	C	G	Brush Species	C	Tree Species
				HEIGHT LEVEL					
7.1.3	202	1	S	Zic muc	1	B	Com her	1	Aca nig
	192	a	B	Pel afr	a	B	Dic cin	a	Aca nig
	181	a	B	Alb har	b	B	Com her	+	Aca ger
	189	a	S	Pte rot	1	B	Pte rot	1	Scl caf
	178	b	B	Com her	b	B	Com her	0	
	186	a	S	Bol spe	1	B	Pel afr	0	
	136	1	S	Dic cin	+	B	Dic cin	1	Aca nig
	204	1	B	Com her	1	T	Com her	1	Scl caf
	132	b	B	Pte rot	1	B	Com zey	a	Scl caf
	288	1	S	Com her	1	B	Com her	1	Scl caf
	293	a	B	Dic cin	1	B	Com col	1	Scl caf
	138	a	S	Com her	+	B	Com her	+	Com imb
	134	3	B	Pte rot	a	B	Pte rot	0	
	193	1	B	Pte rot	1	B	Pte rot	+	Lan stu
7.2	262	1	B	Pte rot	1	B	Aca ger	0	
	289	1	B	Dic cin	+	T	Lan stu	1	Lan stu
	283	+	S	Dic cin	+	T	Scl caf	a	Aca nig
	276	1	S	Pte rot	+	T	Scl caf	+	Scl caf
	264	1	B	Dic cin	1	B	Dic cin	1	Scl caf
	256	1	S	Alb har	0			0	
	253	1	B	Pte rot	1	B	Dic cin	0	Lon cap
	275	a	S	Pte rot	+	T	Scl caf	1	Scl caf
	269	1	B	Dic cin	1	B	Gre mon	+	Scl caf
	284	+	B	Euc div	+	B	Aca nil	0	
	263	a	B	Dic cin	1	B	Dic cin	+	Scl caf
	294	a	S	Pte rot	1	B	Pte rot	0	
	272	+	B	Aca ger	1	B	Aca ger	0	
	249	a	S	Pte rot	+	B	Pte rot	1	Scl caf
	250	a	S	Pte rot	1	T	Scl caf	1	Scl caf
	265	1	B	Dic cin	1	B	Dic cin	+	Scl caf
	251	1	B	Alb har	a	B	Alb har	0	

					HEIGHT LEVEL					
Association	Releve			Shrub			Brush		Tree	
		C	G	Species	C	G	Species	C	Species	
7.3	331	+	S	Alb har	0			0		
	266	+	S	May sen	0			0		
	252	1	B	Alb har	1	B	Alb har	0		
	271	1	B	Aca ger	a	B	Aca ger	+		
	267	1	B	Dic cin	+	B	Dic cin	0		
	247	1			1	B	Dic cin	0		
	260	0			0			0		
	299	1	B	Alb har	1	B	Alb har	0		
8.1	235	a	S	Dic cin	1	B	Aca tor	0		
	156	1	S	Dic cin	+	B	Aca tor	0		
	160	1	B	Aca nig	1	B	Aca nig	0		
	158	1	S	Dic cin	+	B	Aca tor	0		
	161	1	B	Dic cin	+	B	Dic cin	0		
8.2.1	162	+	B	Dic cin	+	B	Aca ger	0		
	234	a	B	Aca nig	a	B	Aca nig	+	Aca ger	
	233	1	B	Alb har	+	B	Dic cin	0		
	148	1	S	Gre bic	0			1	Scl caf	
	62	1	B	Dic cin	+	B	Alb har	0		
	73	1	B	Aca nig	+	T	Aca nig	+	Scl caf	
	114	1	S	Dal mel	+	B	Aca ger	0		
	74	+	B	Aca nig	+	B	Aca nig	1	Scl caf	
	93	+	B	Aca nig	+	T	Aca ger	1	Aca nig	
	92	+	S	Aca nig	1	T	Scl caf	a	Scl caf	
	65	+	S	Sec vir	0			0		
	75	1	B	Aca nig	+	B	Aca nig	0		
	94	+	S	Aca nig	+	B	Lan stu	0		
	115	a	S	Dal mel	1	B	Lan stu	0		
	71	1	B	Aca nig	1	B	Aca nig	1	Scl caf	

Association	Releve	HEIGHT LEVEL							
				Shrub			Brush		Tree
		C	G	Species	C	G	Species	C	Species
8.2.2	164	1	B	Alb har	+	B	Alb har	a	Scl caf
	168	a	S	Dic cin	1	B	Aca tor	1	Scl caf
	84	a	S	Aca nig	+	T	Scl caf	1	Scl caf
	85	a	S	Aca nig	+	B	Aca nig	1	Scl caf
	244	+	B	Dic cin	+	B	Dic cin	0	
	236	1	B	Aca nig	1	B	Dic cin	1	Scl caf
	82	1	S	Alb har	1	T	Scl caf	1	Scl caf
	145	a	S	Aca nig	+	T	Lan stu	0	
	83	1	S	Aca nig	+	T	Scl caf	1	Scl caf
	154	+	S	Gre bic	0			1	Scl caf
	255	1	S	Aca nig	1	B	Aca ger	1	Scl caf
	113	1	B	Lan stu	1	B	Com api	0	
	61	b	B	Aca nig	a	B	Aca nig	0	
	232	1	B	Aca nig	1	B	Aca ger	0	
	69	1	B	Aca nig	a	B	Aca nig	a	Scl caf
	112	1	B	Com her	1	B	Com imb	1	Com imb
	163	1	S	Aca Ger	1	T	Lan stu	1	Lan stu
8.3	54	+	B	Aca nig	+	B	Aca nig	0	
	45	1	B	Aca nig	1	B	Aca nig	0	
	155	+	S	Dic cin	0			0	
	56	+	S	Aca nig	0			0	
	340	1	S	Aca sen	1	B	Aca tor	0	
	119	+	B	Dal mel	+	T	Aca nig	a	Aca nig
	44	+	S	Cor ova	0			0	
	59	0			0			0	
	63	0			0			0	
9.1.1	231	1	B	Com api	b	T	Aca nig	a	Aca nig
	242	1	B	Com api	b	B	Com api	1	Aca nig
	259	1	B	Com zey	b	T	Com api	a	Com api
9.1.2	23	a	T	Aca nig	3	T	Aca nig	3	Aca nig
	31	a	S	Gre mon	a	B	Aca nig	b	Aca nig
	32	b	B	Com api	b	B	Com api	1	Aca nig

Association	Releve			HEIGHT LEVEL					
				Shrub			Brush		Tree
		C	G	Species	C	G	Species	C	Species
9.2	70	1	B	Aca nig	1	B	Aca nig	a	Scl caf
	81	1	S	Com api	+	B	Com api	1	Scl caf
	86	1	B	Aca nig	1	B	Aca nig		
	51	1	B	Aca nig	1	T	Scl caf	a	Scl caf
	77	1	B	Gre bic	1	T	Aca nig	1	Aca nig
	79	+	B	Aca nig	+	T	Aca nig	1	Scl caf
	87	1	B	Aca nig	+	B	Aca nig		
9.3	151	1	B	Gre bic	+	B	Com her	1	Scl caf
	318	1	B	Aca nig	1	B	Aca nig	0	
	317	1	B	Aca tor	1	B	Aca nig	0	
	150	1	S	Gre bic	0			0	
	152	1	S	Aca tor	+	B	Aca tor	0	
	144	a	S	Dic cin	1	B	Aca tor	1	Aca nig
	146	b	B	Dic cin	1	B	Dic cin	+	Aca nig
	52	0			0			0	
	153	1	S	Gre bic	+	B	Aca tor	0	
	104	a	S	Gre bic	+	B	Gre bic	0	
	339	a	T	Com imb	a	T	Com imb	+	Com imb
	98	1	B	Aca nig	1	B	Aca nig	0	
	238	1	B	Aca tor	1	B	Aca tor	+	Aca nig
	159	1	S	Aca nig	1	B	Aca nig	1	Aca nig
	127	a	B	Gre bic	a	B	Aca tor	1	Aca nig
	58	1	B	Aca nig	1	B	Aca tor	0	

					HEIGHT LEVEL					
Association	Releve			Shrub			Brush		Tree	
		C	G	Species	C	G	Species	C	Species	
9.4	105	a	S	Gre bic	+	B	Gre bic	0		
	99	1	B	Aca nig	1	B	Aca nig	0		
	101	b	S	Gre bic	1	B	Gre bic	+	Com her	
	147	a	B	Gre bic	1	B	Com api	0		
	50	a	S	Dic cin	1	B	Aca nig	0		
	78	a	B	Gre bic	1	B	Gre bic	0		
	80	1	B	Com api	+	B	Com api	+	Aca nig	
	106	a	B	Gre bic	1	B	Ter pru	0		
	88	a	B	Gre bic	1	B	Gre bic	0		
	48	a	B	Aca nig	a	B	Aca nig	0		
	149	a	B	Aca nig	1	B	Aca nig	0		
	72	a	B	Ter pru	1	B	Ter pru	0		
	100	a	B	Gre bic	1	B	Com api	0		
	41		B	Aca nig		B	Aca nig	0		
	90	a	S	Gre bic	1	B	Aca nig	0		
	42	+	B	Aca nig	+	B	Aca nig	0		
	20	b	B	Aca nig	b	B	Aca nig	0		
10.1	18	b	B	Com api	a	B	Com api	0		
	19	b	B	Aca exu	a	B	Ter pru	0		
	24	a	S	Gre bic	1	B	Aca nig	+	Aca nig	
	35	a	S	Gre bic	1	B	Ter pru	0		
	27	b	B	Com api	b	B	Com api	0		
	13	1	S	Gre bic	1	B	Com imb	0		
	30	b	S	Com api	a	B	Com api	0		
	14	b	S	Gre bic	1	B	Ter pru	0		
	12	b	S	Com api	b	B	Com api	0		
	10	b	B	Ter pru	b	B	Ter pru	1	Com imb	
	11	a	S	Ter pru	1	B	Ter pru	+	Pta obl	
	17	a	B	Aca nig	1	B	Aca tor	0		
	9	b	B	Aca nig	3	B	Aca nig	+	Aca nig	
	26	b	B	Com api	b	B	Com api	0		
	89	a	S	Com api	a	B	Com api	0		
	5	b	B	Com api	b	B	Com api	0		

Association	Releve			HEIGHT LEVEL					
				Shrub			Brush		Tree
		C	G	Species	C	G	Species	C	Species
10.2	15	a	S	Gre bic	1	B	Aca nig	0	
	38	a	S	Gre bic	1	B	Aca nig	+	Aca nig
	29	a	S	Gre bic	1	B	Ter pru	0	
	37	1	S	Gre bic	1	B	Aca nig	0	
	39	1	S	Gre bic	1	B	Aca nig	+	Aca nig
	40	1	S	Gre bic	+	B	Aca nig	0	
	55	1	S	Aca exu	+	B	Aca nig	0	
	57	a	B	Aca nig	1	B	Aca nig	0	
	36	a	S	Gre bic	1	B	Aca nig	0	
11.1	53	+	S	Sec vir	0			0	
	49	b	B	Aca nig	a	B	Aca nig	0	
	47	0			+	T	Aca nig	0	
	60	1	B	Aca nig	1	B	Aca nig	+	Aca nig
11.2	95	+	S	Aca nig	1	T	Aca nig	1	Aca nig
	43	+	B	Cor ova	+	B	Aca nig	0	
	64	1	B	Aca nig	1	B	Aca nig	0	
	76	a	B	Aca nig	a	b	Aca nig	0	
	97	1	B	Aca nig	1	B	Aca nig	+	Aca nig
	46	+	S	Com gla	+	B	Aca tor	0	
	91	+	B	Aca nig	1	B	Aca nig	+	Aca nig
	67	1	B	Aca nig	1	B	Aca nig	0	
	68	0			0			0	
	66	1	B	Aca nig	1	B	Aca tor	0	
	16	+	S		0			0	
12.1	2	3	B	And joh	4	T	And joh	5	And joh
	7	3	B	And joh	4	T	And joh	5	And joh
	1	3	B	And joh	5	T	And joh	5	And joh
12.2	3	b	S	And joh	1	B	And joh	0	
	6	b	B	And joh	3	B	And joh	1	And joh
	8	3	B	And joh	4	B	And joh	+	And joh
	4	3	B	And joh	3	B	And joh	0	

(no page 393)

APPENDIX 2. SPECIES WITH LOW PRESENCE AND CONSISTENTLY LOW COVER, TRUNCATED FROM TABLES 3-9

The following species have been omitted from Tables 3-9 because their prescence in these tables was low and their cover never reached one per cent in any quadrat. Releves in which species are present are listed in brackets:-

TABLE 3 SPECIES

Abutilon guineense (211, 228, 239, 241), Acacia burkei (211, 303, 187, 210), Asparagus minutiflorus (225, 301, 240, 282), Barleria oxyphylla (165, 241, 258, 268), Commelina erecta (206, 300, 303, 287), Euphorbia chamaesyce (228, 241, 96, 180), Maerua caffra (206, 211, 300, 297), Mariscus rehmannianus (217, 303, 287, 180), Maytenus heterophylla (217, 306, 307, 228), Pavetta catophylla (219, 304, 141, 211), Sida chrysantha (241, 257, 268, 210), Tragia rupestris (211, 301, 303, 165).

Abutilon fruticosum (221, 141, 211), Acacia robusta (211, 171, 210), Adenium obesum (309, 217, 221), Albizia anthelmintica (333, 305, 291), Asystasia subiflora (239, 96, 143), Balanites maughamii (304, 169, 297), Cassia petersiana (221, 303, 306), Cleome monophylla (303, 165, 241), Cyperus obtusiflorus (211, 307, 96), Cyphostemma subciliatum (221, 141, 143), Diospyros mespiliformis (239, 291, 137), Euphorbia neopolycnemoides (303, 319, 291), Pharnaceum elongatum (305, 225, 217),Phyllanthus niruri (241, 187, 131), Putterlickia pyracantha (195, 165, 137), Pycreus pelophilus (246, 198, 187), Stylosanthus fruticosa (301, 307, 180), Talinum caffrum (305, 307, 169), Teclea pilosa (305, 225, 137), Trichoneura grandiglumis (304, 303, 198), Vernonia fastigiata (142, 143, 291), Zanthoxylum humilis (333, 309, 304).

Asparagus falcatus (221, 219), Asparagus sp. (303, 300), Blepharis maderaspatensis (200, 195), Boscia foetida (309, 305), Boscia mossambicensis (217, 219), Brachiaria dictyoneura (297, 187), Cassia abbreviata (306, 228), C. absus (301, 226), Cenchrus ciliaris (240, 239), Ceratotheca triloba (306, 319), Cissus rotundifolia (225, 304), Commelina africana (305, 268), C. ecklοniana (166, 96), C. forskaolaei (211, 143), Commiphora glandulosa (305, 319), Cordia sinensis (304, 166), Crabbea velutina (301, 254), Eragrostis lehmanniana (282, 180), Gossypium herbaceum (217, 195), Grewia monticola (333, 301), Heliotropium strigosum (319, 173), Hermannia quartiniana (319, 226), Hippocratea longipetiolata (225, 206), Indigofera filipes (211, 301), Justicea anagalloides (173, 171), Justicea protracta (221, 219), Kalanchoe rotundifolia (309, 304), Kedrostis foetidissima (217, 165), Limeum sulcatum (211, 246), Lippia javanica (268, 133), Lycium shawii (305, 225), Monsonia ovata (287, 291), Oropetium capense (221, 301), Orthosiphon australis (141, 254), Pellaea viridis (301, 300), Pergularia daemia (211, 228), Portulaca kermesina (333, 221), Selaginella dregei (309, 221), Sesbania sesban (171, 133), Sida cordifolia (245, 96), Solanum sp. (221, 211), Striga asiatica (165, 173), Vigna decipiens (142, 143), V. unguiculata (301, 254).

Abutilon ramosum (206), Aerva leucura (219), Aizoon glinoides (237), Aptossimum lineare (319), Aristida sp. (319), Asparagus africanus (96), Asystasia gangetica (211), Barleria prionitis (219), Berchemia discolor (245), Buchnera glabrata (301), Cardiospermum corindum (303), Cassia italica (319), Chascanum pinnatifidum (96), Chlorophytum macrosporum (226), Chloris roxburghiana (198), Clerodendrum glabrum (254), Cleome maculata (211), Clerodendrum ternatum (303), Combretum molle (301), Convolvulus farinosus (211), Corbichonia decumbens (219), Crassula expansa (141), Crabbea hirsuta (297), Croton gratissimus (304), Crotolaria podocarpa (257), C. schinzii (254), C. virgulata (142), Cynodon dactylon (291), Cyphostemma humile (307), Cyphostemma sp. (226), Dombeya rotundifolia (307), Ecbolium amplexicaule (305), Enneapogon scoparius (319), Eragrostis aethiopica (319), E. trichophora (305), Euphorbia crotonoides (307), Exacum quinquenervium (133), Gardenia spatulifolia (257), Gloriosa superba (141), Grewia villosa (268), Hibiscus lunariifolius (142), H. sidiformis (300), Hippocratea crenata (219), Hyperthelia dissoluta (187), Ilysanthes dubia (169), Indigofera adenoides (291), I. arrecta (309), Ipomoea bolusiana (246), I. magnusiana (169), Ipomoea sp. (307), Ipomoea sp. (304), Jasminum fluminense (304), Justicea incerta (307), Kalanchoe sp. (305), Kedrostis sp. (221), Ledebouria sp. (171), Limeum viscosum (211), Maerua juncea (268), Mariscus congestus (141), M. indecorus (137), Merremia palmata (304), M. tridentata (307), Murdannia simplex (187), Gisekia africana (211), Oldenlandia caespitosa (291), Orbea maculata (240), Oxygonum sinuatum (169), Ozoroa engleri (307), Panicum deustum (141), Pavonia elegans (169), Pegolettia senegalensis (237), Philyrophyllum schinzii (304), Phyllanthus reticulatus (303), Plectranthus tetensis (221), Portulaca oleracea (225), Pouzolzia hypoleuca (200), Pycreus pumilus (187), Raphionacme flanaganii (303), Rhynchosia minima (268), Ruellia cordata (307), Schkuria pinnata (309), Secamone parvifolia (211), Sida dregei (254), Sporobolus pyramidalis (171), Striga gesnerioides (287), Tephrosia elongata (297), T. plicata (268), T. retusa (239), Thilachium africanum (221), Tricalysia allenii (304), Triumfetta pentandra (211), Turraea obtusifolia (198), Vangueria infausta (307), Vernonia oligocephala (268), Vernonia poskeana (319), Ximenia caffra (228), and eleven unidentified occurrences (221, 221, 187, 135, 169, 169, 141, 225, 304, 187, 301).

TABLE 4 SPECIES

Acalypha petiolaris (290, 296, 330, 277, 261, 116), Anthericum longistylum (177, 203, 176, 205, 209, 243), Aristida meridionalis (203, 298, 295, 190, 290, 128), Asparagus minutiflorus (177, 176, 130, 296, 278, 243), Commelina eckloniana (167, 129, 222, 107, 122, 123), Corbichonia decumbens (172, 279, 311, 118, 123, 125), Crossandra mucronata (330, 118, 316, 315, 122, 22), Dolichos trilobus (110, 199, 205, 172, 286, 107), Euclea divinorum (175, 243, 326, 316, 123, 328), Euphorbia chamaesyce (21, 327, 322, 25, 111, 123), Euphorbia tettensis (110, 298, 182, 176, 174, 296), Hibiscus engleri (21, 298, 279, 175, 302, 230), H. schinzii (279, 140, 320, 277, 328), Lippia javanica (128, 308, 129, 140, 326, 328), Xeromphis obovata (298, 182, 174, 130, 290, 278).

Boerhavia diffusa (279, 280, 220, 111, 124), Cucumis myriocarpus (190, 330, 313, 310, 274), Diospyros mespiliformis (290, 280, 302, 229, 316), Hemizygia petrensis (128, 129, 330, 261, 116), Ipomoea sp. (295, 174, 296, 215, 191), Melhania forbesii (281, 129, 220, 184, 243), Monechma debile (21, 290, 280, 123, 22), Rhus gueinzii (332, 320, 311, 316, 22), Senecio transvaalensis (21, 327, 25, 326, 125), Stylosanthus fruticosa (174, 167, 196, 279, 209), Teramnus labialis (34, 298, 295, 292, 296), Vernonia oligocephala (188, 229, 118, 111, 107).

Acacia caffra (230, 277, 313, 312), Asparagus setaceus (308, 332, 302, 116), Cassia italica (279, 243, 330, 22), Coccinia rehmannii (117, 109, 174, 107), Crotolaria diodgeae (109, 111, 116, 107), Cyperus rupestris (21, 140, 332, 320), Cyphostemma subciliatum (230, 312, 314, 22), Hybanthus enneaspermus (286, 316, 123, 125), Ipomoea magnusiana (34, 167, 320, 327), Ocimum canum (292, 279, 332, 320), Oxygonum sinuatum (34, 199, 197, 322), Piriqueta capensis (21, 25, 33, 125), Sesamum alatum (292, 209, 227, 328).

Acanthospermum hispidum (279, 308, 227), Amaranthus thunbergii (21, 128, 124), Aristida curvata (279, 286, 280), Asparagus africanus (21, 190, 286), Athrixia phylicoides (292, 278, 280), Becium knyanum (129, 332, 227), Calostephane divaricata (124, 328, 125), Cenchrus ciliaris (290, 323, 315), Combretum mossambicense (110, 21, 321), Convolvulus farinosus (110, 229, 123), Crotolaria podocarpa (321, 320, 326), Dicoma macrocephala (128, 308, 140), Eragrostis aspera (286, 280, 332), Fingerhuthia africana (278, 122, 328), Gardenia spatulifolia (215, 332, 227), Indigofera parviflora (21, 121, 22), I. trista (321, 325, 122), I. coptica (170, 196, 184), Kohautia omahekensis (290, 281, 278), Oxalis sp. (117, 140, 243), Pavonia schumanniana (190, 223, 197), Pentarrhinum insipidum (34, 176, 302), Phyllanthus reticulatus (298, 174, 230), Pycreus pelophilus (110, 196, 184), Rhoicissus tridentata (110, 229, 273), Rhynchosia caribaea (203, 292, 199).

Anthericum sp. (295, 281), Aristida sp. (196, 25), Tylosema fassoglensis (330, 261), Borreria scabra (34, 292), Chascanum adenostachyum (107, 124), Combretum imberbe (129, 123), Crinum sp. (34, 191), Cucumis melo (109, 22), Eragrostis aethiopica (321, 322), Eragrostis cilianensis (332, 243), Euclea schimperi (170, 290), Euphorbia crotonoides (176, 175), Hemizygia sp. (290, 188), Hypoxis rooperi (117, 107), Ipomoea bolusiana (199, 302), Jatropha sp. (203, 184), J. zeyheri (295, 279), Lannea discolor (199, 329), Pearsonia uniflora (311, 107), Maerua parvifolia (290, 128), Maetenus tenuispina (129, 332), Monsonia biflora (196, 184), Pavetta catophylla (279, 308), Phyllanthus niruri (196, 243), Portulaca kermesina (308, 261), Rhinacanthus sp. (308, 332), Rhynchosia minima (313, 111), Tephrosia semiglabra (220, 312), Tricalysia allenii (279, 328), Tylosema fassoglensis (330, 261), Urginea epigea (273, 277), Wahlenbergia dinteri (182, 190), Xerophyta sp. (278, 308).

Abutilon fruticosum (290), Acacia borleae (25), A. nilotica (328), A. senegal var. rostrata (302), Acalypha glabrata (196), Achyropsis leptostachya (177), Adenia digitata (295), Albuca sp. (311), Anthericum galpinii (175), Aristida transvaalensis (124), Asclepias burchelli (270), Asparagus falcatus (196), A. virgatus (314), Asystasia subiflora (21), Athrixia sp. (325), Barleria oxyphylla (184), Berchemia discolor (328), Bulbostylis burchellii (124), Bulbostylis collina (298), Caralluma rogersii (328), Cassine transvaalensis (220), Ceropegia sp. (277), Chaetacanthus burchellii (295), Chloris roxburghiana (33), Cleome maculata (230), Commiphora glandulosa (321), Conyza floribunda (190), Corchoris longipedunculatus (118), Crassula alba (107), Crotolaria schinzii (205), Cucumis metuliferus (227), Cussonia natalensis (273), Cyathula crispa (322), Cyanotis speciosa (107), Cyperus denudatus (21), C. margaritaceus (117), Cyperus sp. (118), Cyphostemma humile (302), C. schlechteri (22), C. woodii (273), Cyphostemma sp. (230), Decorsea galpinii (110), Ecbolium amplexicaule (34), Epaltes gariepina (25), Eragrostis gummiflua (196), E. heteromera (270), E. cylindriflora (332), Fimbristylis quinquangularis (118), Fimbristylis sp. (197), Flacourtia indica (290), Geigeria ornativa (129), Gonatopus sp. (21), Gossypium herbaceum (140), Hemizygia sp. (130), Hermannia glanduligera (21), H. modesta (199), H. viscosa (279), Hyparrhenia sp. (190), Indigofera astragalina (281), I. fastigiata (290), I. rhytidocarpa (124), I. schimperi (227), Indigofera sp. (177), Ipomoea coscinosperma (110), Jasminum fluminense (290), J. stenolobum (277), Jatropha variifolia (229), Justicea petiolaris (314), Kalanchoe sp. (273), Lapeirosia erythrantha (25), Leonotis nepetifolia (227), Limeum sulcatum (167), Mariscus aristatus (107), Melhania rehmannii (227), Merremia palmata (327), Mollugo nudicaulis (188), Oxalis semiloba (278), Oxygonum sp. (332), Ozoroa reticulata (177), Pegolettia senegalensis (270), Phyllanthus sp. (116), Raphionacme procumbens (277), Rhynchosia densiflora (34), Rhynchelytrum repens (33), Schotia brachypetala (129), Secamone filiformis (273), Senecio sp. (313), Sida cordifolia (196), S. dregei (274), S. ovata (302), Sida sp. (273), Sporobolus panicoides (332), Striga gesnerioides (128), Strychnos spinosa (167), Sutera micrantha (290), Thunbergia atriplicifolia (33), Tribulus terestris (21), Triumfetta pentandra (332), Vahlia capensis (196), Ximenia americana (321), Zanthoxylum humilis (332), and eleven unidentified occurrences (125, 243, 111, 107, 170, 128, 230, 33, 274, 121, 123).

TABLE 5 SPECIES

Acalypha indica (108, 201, 185, 132), Achyranthus aspera (179, 139, 208, 267), Aristida adscensionis (218, 120, 201, 185), Becium knyanum (201, 139, 214, 247), Cenchrus ciliaris (218, 120, 204, 266), Commiphora africana (218, 248, 207, 247), Cucumis metuliferus (208, 212, 192, 193), Cyperus obtusiflorus (248, 185, 202, 247), Eragrostis cilianensis (248, 201, 207, 185), Euclea schimperi (208, 212, 189, 136), Helichrysum nudifolium (108, 293, 138, 283), Ipomoea bolusiana (285, 248, 183, 272), Kohautia lasiocarpa (179, 213, 183, 181), Leucas neuflizeana (201, 185, 198, 202), Melhania didyma (218, 285, 208, 214), M. forbesii (139, 208, 293, 284), Rhynchosia caribaea (120, 248, 185, 134).

Achyropsis leptostachya (183, 185, 198), Balanites maughamii (192, 189, 253), Barleria prionites (136, 288, 289), Cleome monphylla (120, 108, 185), Commelina benghalensis (201, 198, 132), Combretum molle (285, 108, 139), Crotolaria monteiroi (208, 212, 204), Crotolaria sphaerocarpa (201, 185, 202), Cucumis myriocarpus (288, 275, 272), Cyphocarpa angustifolia (208, 185, 198), Dalechampia galpinii (108, 276, 331), Dombeya rotundifolia (248, 207, 185), Hermannia quartiniana (275, 269, 267), Hibiscus sidiformis (201, 185, 202), Hybanthus enneaspermus (285, 262, 284), Ilysanthes dubia (289, 265, 267), Justicea flava (139, 185, 198), Leucas glabrata (285, 198, 331), Merremia tridentata (120, 108, 262), Phyllanthus niruri (201, 216, 185), Polygala hottentotta (178, 289, 294), Ruellia cordata (178, 283, 276), Seddera suffruticosa (185, 178, 284), Solanum coccineum (139, 178, 192), Sporobolus pectinatus (139, 185, 299), Stylochiton natalense (285, 181, 204), Tephrosia semiglabra (218, 201, 213), Terminalia sericea (208, 181, 283), Tragia rupestris (285, 120, 136), Trichoneura grandiglumis (139, 198, 189), Tricholaena monachme (201, 202, 181), Tricliceras schinzii (202, 134, 289), Urginea epigea (285, 284, 252).

Acacia nilotica (139, 284), A. tortilis (139, 247), Acalypha petiolaris (178, 293), Aristida congesta subsp. congesta (198, 189), Asystasia subbiflora (208, 185), Brachiaria serrata (108, 178), Cassia absus (248, 283), Chloris roxburghiana (208, 198), Coccinia rehmannii (248, 276), Commelina erecta (208, 214), Dactyloctaenium aegypteum (183, 299), Dicoma macrocephala (253, 275), Dipcadi glaucum (285, 283), Enneapogon scoparius (218, 285), Epaltes gariepina (120, 179), Euphorbia neopolycnemoides (285, 120), Fimbristylis hispidula (183, 198), Gardenia spatulifolia (207, 186), Geigeria ornativa (179, 139), Hemizygia sp. (181, 138), Indigofera bainesii (183, 181), I. heterotricha (204, 283), Jatropha sp. (224, 193), Lannea discolor (178, 294), Ledebouria sp. (288, 293), Lippia javanica (139, 178), Maerua parvifolia (208, 198), Ocimum canum (201, 139), Oropetium capense (202, 181), Panicum infestum (189, 186), Phyllanthus maderaspatensis (132, 289), Puppalia lappacea (139, 198), Rhynchelytrum villosum (285, 134), Sida ovata (202, 267), Talinum caffrum (108, 251), Tragus berteronianus (120, 198), Vigna decipiens (208, 207).

Abutilon angulatum (272), Acacia burkei (193), A. robusta (284), A. senegal var. rostrata (139), Acalypha glabrata (201), Alysicarpus vaginalis (284), Anthericum longistylum (181), Aristida curvata (285), A. scabrivalvis (299), Barleria lancifolia (285), Boerhavia diffusa (120), Brachiaria xantholeuca (120), Cassia petersiana (189), Cassine transvaalensis (201), Ceratotheca triloba (185), Chlorophytum macrosporum (224), Commelina eckloniana (108), Convolvulus farinosus (284), Corchorus confusus (120), Crinum sp. (193), Crotolaria dioidgeae (108), Crossandra fruticosa (275), Crotolaria pisicarpa (251), Cucumis melo (207), Cyphostemma congestum (289), Dyschoriste rogersii (120), Enneapogon cenchroides (198), Eragrostis heteromera (299), E. cylindriflora (201), E. leihmanniana (185), Fimbristylis sp. (285), Gisekia africana (198), Gladiolus sp. (294), Gomphrena celosioides (139), Hibiscus engleri (285), Hyperthelia dissoluta (276), Hyparrhenia sp. (186), Hypoxis rooperi (208), Indigofera adenoides (266), I. sanguinea (132), Indigofera sp. (178), Ipomoea obscura (201), Ipomoea sp. (251), Justicea sp. (185), Kalanchoe lanceolata (251), Kalanchoe sp. (299), Maerua juncea (260), Mariscus aristatus (198), Melhania acuminata (108), Monsonia biflora (179), Ozoroa reticulata (276), Pappea capensis (198), Pedistylis galpinii (265), Pellaea calomelanos (285), Polygala erioptera (264), Putterlickia pyracantha (139), Pycreus pelophilus (198), Raphionacme procumbens (178), Rhigosum zambesiacum (139), Rhoicissus tridentata (285), Rhus gueinzii (265), Rhynchosia nitens (331), Schotia brachypetala (201), Senecio sp. (178), Setaria perennis (179), Sporobolus nitens (198), Striga gesnerioides (262), Strychnos madagascariensis (285), Tephrosia purpurea (139), Tragia incisifolia (271), Tricalysia allenii (285), Turraea obtusifolia (198), Tylosema fassoglensis (285), Vigna vexillata (189), Zanthoxylum humilis (139) and six unidentified occurrences (139, 285, 276, 263, 265, 248).

TABLE 6 SPECIES

Acacia nilotica (235, 73, 92, 232), Ammocharis coranica (114, 65, 61, 59), Barleria oxyphylla (244, 236, 255, 232), Cassia abbreviata (235, 84 244, 155), Combretum mossambicense (73, 113, 69, 54), Cyathula crispa (161, 65, 340, 63), Dolichos trilobus (162, 114, 115, 113), Eragrostis rigidior (168, 61, 163, 34), Hermannia odorata (74, 56, 340, 119), Justicea flava (160, 244, 236, 255), Kohautia virgata (164, 45, 56, 63), Maerua parvifolia (168, 154, 340, 59), Maytenus heterophylla (244, 236, 113, 61), Neurotanenia amboensis (235, 62, 114, 44), Peltophorum africanum (233, 92, 236, 155), Tephrosia purpurea (62, 65, 69, 63), Tragia dioica (84, 85, 255, 61).

Aristida bipartita (71, 54, 45), Cassia absus (164, 84, 155), Ceratotheca triloba (73, 75, 119), Commelina eckloniana (114, 115, 59), C. erecta (234, 85, 244), Euclea divinorum (62, 93, 236), Evolvulus alsinoides (163, 340, 59), Galactia tenuiflora (65, 75, 94), Gossypium herbaceum (74, 71, 236), Grewia hexamita (158, 168, 83), Ocimum urticifolium (233, 168, 163), Oropetium capense (148, 164, 84), Phyllanthus niruri (244, 236, 85), Rhus gueinzii (114, 71, 82), Tragia incisifolia (65, 71, 45), Tragia rupestris (156, 160, 119), Urochloa panicoides (65, 75, 71).

Abutilon austro-africanum (244, 255), Abutilon guineense (160, 255), Agathisanthemum bojeri (161, 163), Alysicarpus vaginalis (71, 69), Amaranthus thunbergii (75, 145), Asparagus minutiflorus (234, 145), Asystasia subbiflora (160, 163), Commelina forskaolaei (160, 63), Commiphora glandulosa (158, 54), Cyphostemma congestum (235, 94), Diospyros mespiliformis (233, 119), Gardenia spatulifolia (158, 234), Ipomoea obscura

(112, 119), Justicia protracta (85, 61), Leucas glabrata (156, 154), L. neuflizeana (244, 236), Melhania didyma (236, 113), Monsonia ovata (84, 82), Neuracanthus africanus (59, 63), Pegolettia senegalensis (83, 44), Sida dregei (65, 61), Sorghum versicolor (93, 44), Sporobolus pectinatus (156, 161), Tephrosia plicata (235, 69), Tephrosia retusa (156, 162), Tribulus terrestris (65, 75), Vigna decipiens (74, 113), Vigna unguiculata (163, 45).

Acalypha segetalis (69), Acacia senegal var. rostrata (340), Acacia welwitschii (340), Achyranthus aspera (74), Albizia petersiana (163), Aristida adscensionis (168), Aristida congesta subsp. congesta (56), Aristida scabrivalvis (56), Asystasia subbiflora (75), Balanites maughamii (168), Becium knyanum (255), Blepharis subvolubilis (92), Brachiaria eruciformis (69), B. nigropedata (163), B. serrata (75), Capparis sepiaria (59), Cardiospermum corindum (73), Cassia petersiana (112), Chascanum hederaceum (44), C. pinnatifidum (56), Cleome monophylla (163), Commelina africana (112), C. benghalensis (244), Commiphora glandulosa (160), Convolvulus farinosus (112), Crabbea velutina (61), Crotolaria burkeana (163), C. doidgeae (113), C. virgulata (84), Cucumis myriocarpus (235), Cymbopogon plurinodis (255), Cyphocarpa angustifolia (340), Cyphostemma humile (232), Cyphostemma sp. (83), Dicoma macrocephala (233), Dipcadi glaucum (340), Ehretia amoena (56), Gisekia africana (75), Grewia villosa (156), Hermannia glanduligera (115), Hibiscus trionum (65), Indigofera schimperi (54), Ipomoea wightii (65), Justicea anagalloides (234), J. matammensis (74), J. petiolaris (45), Kyllinga alba (45) Lannea edulis (161), Limeum fenestratum (75), L. viscosum (340), Lippia javanica (156), Maerua juncea (340), Mariscus aristatus (164), M. rehmannianus (61), Merremia kentrocaulos (61), M. tridentata (112), Phyllanthus sp. (71), Polygala sphenoptera (154), Priva cordifolia (232), Ruellia cordata (44), R. patula (340), Senecio longiflorus (75), Sida cordifolia (71), Solanum coccineum (69), S. incanum (45), Tephrosia semiglabra (255), Teramnus labialis (112), Thesium gracilarioides (112), Urochloa brachyura (236), Vigna angustifolia (164), Wahlenbergia dinteri (163), Ximenia americana (235), and one unidentified occurrence (112).

TABLE 7 SPECIES

Calostephane divaricata (99, 18, 35, 27, 14, 15), Cardiospermum halicacabum (105, 99, 88, 72, 29, 40), Cleome monophylla (104, 339, 101, 10, 37, 55), Combretum molle (242, 318, 147, 20, 30, 11), Justicea protracta (70, 58, 48, 72, 100, 90), Kohautia virgata (70, 50, 41, 30, 89, 38), Zanthoxylum humilis (18, 35, 17, 9, 39, 57).

Aristida scabrivalvis (80, 35, 38, 39, 55), Asparagus minutiflorus (144, 153, 238, 147, 17), Barleria transvaalensis (20, 19, 17, 15, 57), Commelina africana (231, 242, 150, 146, 147), Cucumis hirsutus (259, 105, 88, 48, 42), Gossypium herbaceum (23, 31, 52, 98, 36), Indigofera bainesii (70, 72, 35, 17, 39), Polygala sphenoptera (104, 50, 78, 89, 5), Ruellia patula (104, 339, 58, 72, 30), Sporobolus fimbriatus (52, 104, 101, 147, 30).

Brachiaria nigropedata (101, 147, 30, 89), Cordia sinensis (50, 48, 11, 39), Crotolaria podocarpa (144, 105, 106, 149), Dipcadi glaucum (19, 17, 15, 36), Hibiscus pusillus (32, 79, 151, 105), Ipomoea obscura (41, 42, 40, 55), Leucas sexdentata (104, 101, 27, 36), Peliostomum leucorrhizum (99, 20, 18, 19), Tephrosia retusa (151, 318, 238, 159), Ximenia americana (317, 48, 19, 9).

Acacia nilotica (77, 339. 98), Blepharis subvolubilis (100, 41, 42), Commiphora glandulosa (151, 153. 90), Cymbopogon plurinodis (32, 27, 30), Hemizygia petrensis (78, 27, 89), Indigofera schimperi (31, 70, 40), Kohautia lasiocarpa (101, 147, 57), Monsonia ovata (101, 147, 55), Pellaea viridis (231, 81, 50), Rhynchelytrum repens (339, 12, 26), Sida ovata (152, 146, 105), Sterculia rogersii (231, 11, 29), Tetrapogon tenellus (18, 12, 11), Trichoneura grandiglumis (146, 147, 89).

Acacia gerrardii (259, 317), Asystasia subbiflora (150, 149), Bidens biternata (242, 50), Boscia foetida (9,5), Commelina eckloniana (159, 89), Crotolaria virgulata (98, 14), Cucumis myriocarpus (88, 42), Cyperus rupestris (101, 89), Cyphostemma subciliatum (50, 80), Endostemon tenuifolius (14, 11), Enteropogon macrostachyus (242, 100), Euphorbia schinzii (20, 11), Fimbristylis hispidula (104, 101), Geigeria burkei (13, 11), Heliotropium giessii (58, 37), Hibiscus lunariifolius (23, 24), Hibiscus schinzii (11, 89), Hippocratea longipetiolata (14, 11), Hollubia saccata (14, 11), Indigofera parviflora (12, 9), Ipomoea crassipes (77, 79), Limeum sulcatum (339, 35), Maerua caffra (318, 58), Melhania acuminata (100, 26), Monechma debile (77, 78), Orthosiphon australis (31, 32), Ozoroa engleri (259, 80), Rhus gueinzii 23, 127), Rhynchosia caribeae (78, 39), R. densiflora (70, 238), Schotia brachypetala (31, 32), Sesamum alatum (11, 37), Tephrosia purpurea (144, 147).

Abutilon ramosum (259), Acanthospermum hispidum (146), Acacia senegal var. leiorachis (242), A. welwitschii (339), Adenia digitata (9), Alysicarpus vaginalis (50), Ammocharis coranica (152), Andropogon gayanus (89), Aneilema dregeanum (99), Balanites maughamii (242), Barleria crossandriformis (10), B. elegans (78), B. holubii (11), B. obtusa (231), B. oxyphylla (52), Bolusanthus speciosus (238), Brachiaria eruciformis (51), Bulbostylis collina (5), Caralluma rogersii (88), Cassia absus (101), C. italica (90), Cissus quadrangularis (13), Coccinia adoensis (39), Commicarpus pentandrus (151), Commicarpus sp. (100), Convolvulus farinosus (9), Corchorus longipedunculatus (242), Crotolaria australis (80), C. schinzii (101), Cyphostemma woodii (259), Cyphostemma sp. (259), Diospyros mespiliformis (238), Diplachne eleusine (12), Dolichos trilobus (55), Dregea macrantha (11), Eragrostis lehmanniana (11), Euphorbia tettensis (78), Felicia mossamedensis (57), Gardenia resiniflua (13), Gnidia sericocephala (5), Hibiscus calyphyllus (23), H. engleri (42), H. Trionum (70), Hippocratea crenata (32), Indigofera dyeri (5), I. trita (13), Jasminum fluminense (32), Justicea petiolaris (35), Kalanchoe lanceolata (259), K. luciae (231), Kedrostis hirtella (231), Mariscus sp. (13), Maytenus senegalensis (149), M. tenuispina (32), Molugo nudicaulis (11), Mukia maderaspatana (127), Neurautanenia amboensis (51), Neuracanthus africanus (58), Ochna pretoriensis (9), Oropetium capense (30), Pellaea calomelanos (242), Phyllanthus maderaspatensis (77), P. niruri (86), Phyllanthus sp. (77), Portulaca kermesina (13), Putterlickia pyracantha (72), Rhynchosia komatiensis (77), Rhynchelytrum villosum (89), Ruellia cordata (9), Schizobasis intricata (19), Senecio transvaalensis (89), Spirostachys africana (231), Sporobolus stapfianus (27), Strychnos madagascariensis (32), Stylosanthes fruticosa (101), Tephrosia rhodesica (242), Tephrosia semiglabra (88), Tragia incisifolia (87), Triaspis nelsoni (11), Trochomeria macrocarpa (231), Triumfetta pentandra (147), Urochloa panicoides (101), and five unidentified occurrences (30, 30, 30, 72, 11).

TABLE 8 SPECIES

Acalypha segetalis (64, 67), Albizia harveyi (91, 66), Amaranthus thunbergii (60, 76), Cardiospermum halicacabum (53, 47), Chascanum pinnatifidum (43, 46), Chloris virgata (43, 76), Commiphora africana (43, 66), Commelina erecta (91, 67), Euphorbia chamaesyce (53, 97), Hibiscus trionum (64, 68), Indigofera rhytidocarpa (76, 67), Ipomoea sinensis (64, 97), Kohautia virgata (67,66), Maytenus senegalensis (46, 67), Merremia palmata (91, 16), Priva africana (43, 16), Rhynchosia caribaea (43, 16), Schmidtia pappophoroides (43, 46), Sclerocarya caffra (91, 66), Sida dregei (67, 16), Solanum panduraeforme (76, 16), Tribulus terrestris (64, 46), Ximenia caffra (76, 16).

Abutilon guineense (49), Acacia gerrardii (64), Achyranthus aspera (76), Albizia petersiana (64), Alysicarpus vaginalis (66), Aristida bipartita (97), Asparagus minutifloris (46), Asystasia subbiflora (97), Cardiospermum corindum (49), Cassia mimosoides (76), Cephalocroton mollis (49), Coccinia adoensis (76), Commelina eckloniana (68), Corchorus confusus (49), Crotalaria australis (46), Crossandra mucronata (53), Cyperus sp. (49), Dipcadi glaucum (66), Dyschoriste rogersii (64), Eragrostis superba (76), Gossypium herbaceum (64), Hibiscus pusillus (49), Hybanthus enneaspermus (64), Indigofera heterotricha (43), Ipomoea obscura (46), Lantana rugosa (76), Lannea stuhlmannii (95), Leucas glabrata (16), Limeum fenestratum (46), Maerua caffra (64), Maerua parvifolia (67), Mariscus rehmannianus (46), Mollugo nudicaulis (76), Monechma debile (97), Neurotanenia amboensis (95), Hibiscus trionum (49), Pavonia burchellii (16), Polygala erioptera (76), Pycreus polystachyus (49), Rhynchosia komatiensis (16), Sericorema sericea (64), Sesamum alatum (64), Solanum incanum (76), Sorghum versicolor (97), Striga bilabiata (91), Striga gesnerioides (97), Tragia dioica (16), Urginea epigea (64), Urochloa brachyura (60), Waltheria indica (43), Ziziphus mucronata (97) and four unidentified occurrences (53, 49, 64, 64).

TABLE 9 SPECIES

Abutilon austro-africanum (2), Acalypha indica (6), Actinopteris radiata (2), Albizia brevifolia (7), Barleria elegans (7), Cassia absus (3), Cissus quadrangularis (7), Cleome monophylla (4), Commiphora glandulosa (6), Combretum mossambicense (1), Commiphora mollis (8), Convolvulus farinosus (4), Corchorus longipedunculatus (8), Cucumis hirsutus (6), Cyperus obtusiflorus (4), Cyphostemma simulans (1), Dioscorya cotinifolia (8), D. sylvatica (1), Entandophragma caudatum (1), Enteropogon macrostachyus (2), Ficus soldanella (7), Gonatopos sp. (2), Grewia hexamita (8), Hermbstaedtia odorata (4), Hibiscus calophyllus (1), H. engleri (4), H. sidiformis (8), Hippocratea longipetiolata (2), Ipomoea albivenia (7), Ipomoea sinensis (8), Justicea flava (6), Kalanchoe lanceolata (7), Ledebouria sp. (1), Leucas glabrata (6), Leucas sexdentata (8), Macrotyloma axillare (8), Maerua parvifolia (4), Manilkara mochisia (1), Mariscus rehmannianus (6), Melhania didyma (6), Ocimum canum (3), Oropetium capense (6), Phyllanthus incurvis (6), Polygala sphenoptera (6), Pouzolzia hypoleuca (1), Sansevieria hyacinthoides (2), Sarcostemma viminale (7), Senecio longiflorus (7), Talinum caffrum (8), Tinnea rhodesiana (6), Tricalysia allenii (2), Vepris reflexa (7), Vernonia fastigiata (3), Xerophyta retinervis (3) and one unidentified occurrence (1).

APPENDIX 3. LIST OF PLANT SPECIES MENTIONED IN TEXT AND IN TABLES

Families and genera belonging to the Pteridophyta have been arranged after Schelpe (1970).

Arrangements of families and genera of the Spermatophyta follows Dyer (1975, 1976), whose arrangement, except for genera of the Poaceae, is based on the system of De Dalla Torre & Harms (1900-1907). Arrangement of genera within the Poaceae is based on Hubbard's (1934) system.

Species are arranged alphabetically within each genus.

PTERIDOPHYTA

SELAGINELACEAE

Selaginella dregei (C.Presl) Hieron.

ADIANTACEAE

Pellaea calomelanos (Swartz) Link

Pellaea viridis (Forsk.) Prantl var. glauca (Sim) Sim

Actinopteris radiata (Koenig ex Swartz) Link

SPERMATOPHYTA (ANGIOSPERMAE)

MONOCOTYLEDONEAE

TYPHACEAE

Typha latifolia L. subsp. capensis Rohrb.

POACEAE

Ischaemum afrum (J.F.Gmel) Dandy

Hemarthria altissima (Poir) Stapf & C.E.Hubb.

Elionurus muticus (Spreng.) Kunth

Sorghum versicolor Anderss.

Sorghum verticilliflorum (Steud.) Stapf

Bothriochloa radicans (Lehm.) A.Camus

Dichanthium papillosum (Hochst.) Stapf

Andropogon gayanus Kunth var. polycladus (Hack.) W.D. Clayton

Andropogon schirensis Hochst. ex A.Rich. var. angustifolius Stapf

Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy

Cymbopogon plurinodis (Stapf) Stapf ex Burtt Davy

Hyperthelia dissoluta (Nees ex Steud.) W.D. Clayton

Heteropogon contortus (L.) Beauv. ex Roem. & Schult.

Diheteropogon amplectens (Nees) W.D.Clayton

Themeda triandra Forsk.

Digitaria argyrograpta (Nees) Stapf

Digitaria eriantha Steud.

Eriochloa meyerana (Nees) Pil.

Brachiaria dictyoneura (Fig. & de Not.) Stapf

Brachiaria eruciformis (J.E.Smith) Griseb.

Brachiaria nigropedata (Munro ex Fical. & Hiern) Stapf

Brachiaria serrata (Thunb.) Stapf

Brachiaria xantholeuca (Hack.) Stapf

Urochloa brachyura (Hack.) Stapf

Urochloa mosambicensis (Hack.) Dandy

Urochloa panicoides Beauv.

Oplismenus hirtellus (L.) Beauv.

Panicum coloratum L.

Panicum deustum Thunb.

Panicum infestum Anderss. ex Peters

Panicum maximum Jacq.

Cymbosetaria sagittifolia (A.Rich.) Schweick.

Setaria flabellata Stapf

Setaria pallide-fusca (Schumach.) Stapf & C.E.Hubb.

Setaria perennis Hack.

Setaria woodii Hack.

Rhynchelytrum repens (Willd.) C.E. Hubb.

Rhynchelytrum villosum (Parl.) Chiov.

Tricholaena monachne (Trin.) Stapf & C.E.Hubb.

Cenchrus ciliaris L.

Loudetia filifolia Schweick.

Loudetia flavida (Stapf) C.E.Hubb.

Phragmites australis (Cav.) Trin. ex Steud.

Aristida adscensionis L. subsp. guineensis (Trin. & Rupr.) Henr.

Aristida bipartita (Nees) Trin. & Rupr.

Aristida congesta Roem. & Schult. subsp. barbicollis (Trin. & Rupr.) De Wint.

Aristida congesta Roem. & Schult. subsp. congesta

Aristida curvata (Nees) Trin. & Rupr.

Aristida meridionalis Henr.

Aristida scabrivalvis Hack.

Aristida transvaalensis Henr.

Tragus berteronianus Schult.

Perotis patens Gand.

Sporobolus africanus (Poir.) Robyns & Tournay

Sporobolus consimilis Fresen

Sporobolus fimbriatus Nees var. latifolius Stent

Sporobolus nitens Stent

Sporobolus panicoides A.Rich.

Sporobolus pectinatus Hack.

Sporobolus pyramidalis Beauv.

Sporobolus smutsii Stent

Sporobolus stapfianus Gand.

Eragrostis aethiopica Chiov.

Eragrostis aspera (Jacq.) Nees

Eragrostis cilianensis (All.) Lutati

Eragrostis cylindriflora Hochst.

Eragrostis gummiflua Nees

Eragrostis heteromera Stapf

Eragrostis lappula Nees

Eragrostis rigidior Pilg.

Eragrostis superba Peyr.

Eragrostis trichophora Coss. & Dur.

Eragrostis uniglumis Hack.

Cynodon dactylon (L.) Pers.

Enteropogon macrostachyus (Hochst. ex A.Rich.) Munro ex Benth.

Chloris roxburghiana Schult.

Chloris virgata Swartz

Eustachys mutica (L.) Cuf.

Oropetium capense Stapf

Tetrapogon tenellus (Roxb.) Chiov.

Dactyloctenium aegypteum (L.) Willd.

Pogonarthria squarrosa (Licht.) Pilg.

Diplachne eleysine Nees

Trichoneura grandiglumis (Nees) Ekman

Enneapogon cenchroides (Licht.) C.E.Hubb.

Enneapogon scoparius Stapf

Schmidtia pappophoroides Steud.

Fingerhuthia africana Lehm.

CYPERACEAE

Cyperus amabilis Vahl

Cyperus denutanus L.f.

Cyperus margaritaceus Vahl

Cyperus obtusiflorus Vahl var. obstusiflorus

Cyperus rupestris Kunth

Mariscus aristatus Rottb.

Mariscus congestus C.B.Cl.

Mariscus dregeanus Kunth

Mariscus indecorus (Kunth) Podleck

Mariscus rehmannianus C.B.Cl.

Pycreus pelophilus (Ridley) C.B.Cl.

Pycreus polystachyos Beauv.

Pycreus pumilus (L.) Domin

Kyllinga alba Nees

Fuirena pubescens Kunth

Bulbosylis burchellii C.B.Cl.

Bulbostylis collina (Kunth) C.B.Cl.

Fimbristylis hispidula (Vahl) Kunth

Fimbristylis quinquangularis Kunth

PALMAE

Phoenix reclinata Jacq.

Hyphaene natalenis Kunze

ARACEAE

Stylochiton natalense Schott

COMMELINACEAE

Commelina africana L.

Commelina benghalensis L.

Commelina eckloniana Kunth

Commelina erecta L. subsp. livingstonei (C.B.Cl.) Morton

Commelina forskaolaei Vahl

Commmelina subulata Roth

Aneilema dregeanum Kunth

Murdannia simplex (Vahl) Brenan

Cyanotis speciosa (L.f.) Hassk.

LILIACEAE

Gloriosa superba L.

Antherieum galpinii Bak.

Antherieum longistylum Bak.

Chlorophytum macrosporum Bak.

Schizobasis intricata (Bak.) Bak.

Aloe chabaudii Schonl.

Aloe marlothii Berger

Aloe sessiliflora Pole Evans

Tulbaghia leucantha Bak.

Urgomea epigea R.A.Dyer

Dipcadi glaucum Bak.

Sansevieria hyacinthoides (L.) Druce

Asparagus africanus Lam.

Asparagus buchananii Bak.

Asparagus falcatus L.

Asparagus minutiflorus Bak.

Asparagus setaceus (Kunth) Jessop

Asparagus virgatus Bak.

Smilax kraussiana Meisn.

AMARYLLIDACEAE

Ammocharis coranica (Ker-Gawl.) Herb.

HYPOXIDACEAE

Hypoxis rooperi S.Moore

VELLOZIACEAE

Xerophyta retinervis Bak. var. equisetoides (Bak.) Coetzee

DIOSCOREACEAE

Dioscorea cotinifolia Kunth

Dioscorea sylvatica Eckl.

IRIDACEAE

Lapeirousia erythrantha (Klatt) Bak. var. sandersoni (Bak.) Marais

ORCHIDACEAE

Ansellia gigantea Reichb.f.

DICOTYLEDONEAE

SALICACEAE

Salix woodii Seemen

MYRICACEAE

Myrica serrata Lam.

ULMACEAE

Trema orientalis (L.) Blume

MORACEAE

Maclura africana (Bur.) Corner

Ficus carpreifolia Del.

Ficus ingens (Miq.) Miq.

Ficus soldanella Warb.

Ficus stuhlmannii Warb.

URTICACEAE

Urera tenax N.E.Br.

Pouzolzia hypoleuca Wedd.

LORANTHACEAE

Pedistylis galpinii (Shinz ex Sprague) Wiens

SANTALACEAE

Thesium gracilarioides A.W.Hill

OLACACEAE

Olax dissitiflora Oliv.

Ximenia americana L. var. microphylla Welw. ex Oliv.

Ximenia caffra Sond. var. natalensis Sond.

POLYGONACEAE

Oxygonum sinuatum (Hochst. & Steud. ex Meisn.) Damm.

AMARANTHACEAE

Hermbstaedtia odorata (Burch.) T. Cooke

Amaranthus thunbergii Moq.

Sericorema sericea (Schinz) Lopr.

Cyphocarpa angustifolia Lopr.

Cyathula crispa Schinz

Pupalia lappacea (L.) Juss.

Aerva leucura Moq.

Achyranthes aspera L.

Achyropsis leptostachya (E. Mey. ex Meisn.) Hook.f.

Alternanthera pungens H.B.K.

Gomphrena celosioides Mart.

NYCTAGINACEAE

Commicarpus africanus (Lour.) Dandy

Boerhavia diffusa L. var. hirsuta Heimerl

PHYTOLACCACEAE & AIZOACEAE

Limeum fenestratum (Fenzl) Heimerl

Limeum sulcatum (Klotzsch) Hutch.

Limeum viscosum (Gay) Fenzl

Gisekia africana (Lour.) Kuntze

Mollugo nudicaulis Lam.

Pharnaceum elongatum (DC.) Adamson

Corbichonia decumbens (Forsk.) Exell

Trianthema triquetra Willd. subsp. triquetra

Aizon glinoides L.f.

PORTULACACEAE

Talinum caffrum (Thunb.) Eckl. & Zeyh.

Portulacaria afra Jacq.

Poytulaca kermesina N.E.Br.

Poytulaca oleracea L.

Portulaca quadrifida L.

MENISPERMACEAE

Tinospora fragosa (Verdoorn) Verdoorn & Troupin

ANNONACEAE

Hexalobus monopetalus (A.Rich) Engl. & Diels

Monodora junodii Engl. & Diels

CAPPARACEAE

Cleome angustifolia Forsk. subsp. petersiana (Klotzsch ex Sond.) Kers

Cleome hirta (Klotzsch) Oliv.

Cleome maculata (Sond.) Szyszyl.

Cleome monophylla L.

Capparis sepiaria L.

Capparis tomentosa Lam.

Boscia albitrunca (Burch.) Gilg & Ben.

Boscia foetida Schinz subsp. rehmanniana (Pest.) Toelken

Boscia mossambicensis Klotzsch

Cadaba natalensis Sond.

Maerua cafra (DC.) Pax

Maerua juncea Pax subsp. crustata (Wild) Wild

Maerua parvifolia Pax

Maerua rosmarinoides (Sond.) Gilg & Ben.

Thilachium africanum Lour.

CRASSULACEAE

Kalanchoe lanceolata (Forsk.) Pers.

Kalanchoe luciae R.-Hamet

Kalanchoe rotundifolia (Haw.) Haw.

Crassula alba Forsk.

Crassula expansa Dryand. subsp. fragilis (Bak.) Toelken

VAHLIACEAE

Vahlia capensis (L.f.) Thunb.

ROSACEAE

Rubus ridigus Sm.

LEGUMINOSAE (MIMOSOIDEAE)

Albizia anthelmintica (A.Rich.) Brongn.

Albizia brevifolia Schinz

Albizia forbesii Benth.

Albizia harveyi Fourn.

Albizia petersiana (Bolle) Oliv. subsp. evansii (Burtt Davy) Brenan

Acacia ataxacantha DC.

Acacia borleae Burtt Davy

Acacia burkei Benth.

Acacia caffra (Thunb.) Willd.

Acacia erubescens Welw. ex Oliv.

Acacia exuvialis Verdoorn

Acacia gerrardii Benth.

Acacia grandicornuta Gerstn.

Acacia nigrescens Oliv.

Acacia nilotica (L.) Willd. ex Del. subsp. kraussiana (Benth.) Brenan

Acacia robusta Burch. subsp. clavigera (E.Mey.) Brenan

Acacia schweinfurthii Brenan & Exell var. schweinfurthii

Acacia senegal (L.) Willd. var. leiorhachis Brenan

Acacia senegal (L.) Willd. var. rostrata Brenan

Acacia tortilis (Forsk.) Hayne subsp. heteracantha (Burch.) Brenan

Acacia welwitschii Oliv. subsp. delagoensis (Harms) Ross & Brenan

Acacia xanthophloea Benth.

Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummit var. africana

Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummitt var. setulosa

Dichrostachys cinerea (L.) Wight & Arn. subsp. africana Brenan & Brummit var. pubescens

Newtonia hildebrandtii (Vatke) Torre

LEGUMINOSAE (CAESALPINIOIDEAE)

Colophospermum mopane (Kirk ex Benth.) Kirk ex J. Leonard

Schotia brachypetala Sond.

Schotia capitata Bolle

Afzelia quanzensis Welw.

Tylosema fassoglensis (Schweinf.) Torre & Hilk.

Cassia abbreviata Oliv. subsp. beareana (Holmes) Brenan

Cassia absus L.

Cassia didymobotrya Fresen

Cassia italica (Mill.) Lam. ex F.W.Andr.

Cassia mimosoides L.

Cassia petersiana Bolle

Peltophorum africanum Sond.

LEGUMINOSAE (PAPILIONOIDEAE)

Bolusanthus speciosus (H.Bol.) Harms

Pearsonia uniflora (Kensit) Polhill

Crotalaria burkeana Benth.

Crotalaria damarensis Engl.

Crotalaria doidgeae Verdoorn

Crotalaria monteiroi Taub. ex Bak.f. var. galpinii Burtt Davy

Crotalaria pisicarpa Welw. ex Bak.

Crotalaria podocarpa DC.

Crotalaria schinzii Bak.

Crotalaria sphaerocarpa Perr. ex DC.

Crotalaria virgulata Klotzsch

Indigofera adenoides Bak.f.

Indigofera arrecta Hochst. ex A.Rich.

Indigofera astragalina DC.

Indigofera bainesii Bak.

Indigofera dyeri Britten

Indigofera fastigiata E.Mey.

Indigofera filipes Benth. ex Harv.

Indigofera heterotricha DC.

Indigofera parviflora Heyne ex Wight & Arn.

Indigofera rhytidocarpa Benth. ex Harv.

Indigofera sanguinea N.E.Br.

Indigofera schimperi Jaub. & Spach

Indigofera trita L.f. subsp. subulata (Vahl ex Poir.) Ali

Indigofera vicioides Jaub. & Spach var. rogersii (R.E.Fries) J.B.Gillett

Tephrosia burchellii Burtt Davy

Tephrosia elongata E. Mey.

Tephrosia forbesii Bak. subsp. interior Brummitt

Tephrosia plicata Oliv.

Tephrosia purpurea (L.) Pers. subsp. leptostachya (DC.) Brummitt

Tephrosia retusa Burtt Davy

Tephrosia rhodesica Bak.f.

Tephrosia semiglabra Sond.

Mundulea sericea (Willd.) A. Chev.

Sesbania sesban (L.) Merr.

Ormocarpum trichocarpum (Taub.) Harms ex Burtt Davy

Stylosanthes fruticosa (Retz.) Alston

Alysicarpus vaginalis (L.) DC.

Dalbergia melanoxylon Guill. & Perr.

Pterocarpus rotundifolius (Sond.) Druce

Lonchocarpus capassa Rolfe

Xanthocercis zambesiaca (Bak.) Dumaz-le-Grand

Abrus laevigatus E. Mey.

Abrus precatorius L. subsp. africanus Verdc.

Neorautanenia amboensis Schinz

Teramnus labialis (L.f.) Spreng.

Erythrina humeana Spreng.

Galactia tenuifbra (Willd.) Wight & Arn.

Rhynochosia caribaea (Jacq.) DC.

Rhynchosia densiflora (Roth.) DC. subsp. chrysadenia (Taub.) Verdc.

Rhynchosia komatiensis Harms

Rhynchosia minima (L.) DC.

Rhynchosia nitens Benth.

Rhynchosia totta (Thunb.) DC.

Vigna angustifolia Verdc.

Vigna decipiens Harv.

Vigna unguiculata (L.) Walp.

Vigna vexillata (L.) A.Rich.

Decorsea galpinii (Burtt Davy) Verdc.

Dolichos trilobus L. subsp. transvaalicus Verdc.

Macrotyloma axillare (E.Mey.) Verdc.

Macrotyloma maranguense (Taub.) Verdc.

GERANIACEAE

Monsonia biflora DC.

Monsonia ovata Cav.

OXALIDACEAE

Oxalis semiloba Sond

ERYTHROXYLACEAE

Erythroxylum emarginatum Thonn.

ZYGOPHYLLACEAE

Tribulus terrestris L.

BALANITACEAE

Balanites maughamii Sprague

RUTACEAE

Zanthoxylum humilis (E.A.Bruce) Waterm.

Vepris carringtoniana Mendonca

Vepris reflexa Verdoorn

Teclea pilosa (Engl.) Verdoorn

SIMAROUBACEAE

Kirkia acuminata Oliv.

BURSERACEAE

Commiphora africana (A.Rich,) Engl.

Commiphora glandulosa Schinz

Commiphora harveyi (Engl.) Engl.

Commiphora mollis (Oliv.) Engl.

Commiphora neglecta Verdoorn

MELIANTHACEAE, PTAEROXYLACEAE & AITONIAEAE

Ptaeroxylon obliquum (Thunb.) Radlk.

Entandrophragma caudatum (Sprague) Sprague

Turraea obtusifolia Hochst.

Ekebergia capensis Sparrm.

Trichilia emetica Vahl

MALPIGHIACEAE

Triaspis nelsoni Oliv.

Sphedamnocarpus pruriens (A.Juss.) Szyszyl.

POLYGALACEAE

Polygala erioptera DC.

Polygala hottentotta Presl

Polygala sphenoptera Fresen.

EUPHORBIACEAE

Pseudolachnostylis maprouneifolia Pax

Securinega virosa (Willd.) Pax & K. Hoffm.

Phyllanthus asperulatus Hutch.

Phyllanthus incurvus Thunb.

Phyllanthus maderaspatensis L.

Phyllanthus niruri L.

Phyllanthus pentandrus Schumach. & Thonn.

Phyllanthus reticulatus Poir.

Drypetes gerrardi Hutch.

Antidesma venosum E. Mey. ex Tul.

Cleistanthus schlechteri (Pax) Hutch. var. schlechteri

Androstachys johnsonii Prain

Bridelia cathartica Bertol.f.

Bridelia micrantha (Hochst.) Baill.

Croton gratissimus Burch.

Croton megalobotrys Muell. Arg.

Croton steenkampiana Gerstner

Croton sylvaticus Hochst.

Acalypha glabrata Thunb.

Acalypha indica L.

Acalypha petiolaris Hochst.

Acalypha pubiflora Baill.

Acalypha segetalis Muell. Arg.

Tragia dioica Sond.

Tragia incisifolia Prain

Tragia rupestris Sond.

Dalechampia Galpinii Pax

Jatropha variifolia Pax

Jatropha zeyheri Sond.

Cephalocroton mollis Klotzsch

Spirostachys africana Sond.

Euphorbia chamaesyce L.

Euphorbia confinalis R.A.Dyer

Euphorbia cooperi N.E.Br. ex Berger

Euphorbia crotonoides Boiss.

Euphorbia neopolycnemoides Pax & K.Hoffm.

Euphorbia schinzii Pax

Euphorbia tettensis Klotzsch

Euphorbia tirucalli L.

Monadenium lugardae N.E.Br.

ANACARDIACEAE

Sclerocarya caffra Sond.

Lannea discolor (Sond.) Engl.

Lannea edulis (Sond.) Engl.

Lannea stuhlmannii (Engl.)Engl.

Ozoroa engleri R. & A. Fernandes

Ozoroa paniculosa (Sond.) R. & A. Fernandes

Ozoroa reticulata (Bak.f.) R. & A. Fernandes

ANACARDIACEAE

Rhus gueinzii Sond.

CELASTRACEAE

Maytenus heterophylla (Eckl. & Zeyh.) N.Robson

Maytenus senegalensis (Lam.) Exell

Maytenus tenuispina (Sond.) Marais

Putterlickia pyracantha (L.) Szyszyl.

Cassine aethiopica Thunb.

Cassine transvaalensis (Burtt Davy) Codd

Hippocratea africana (Willd.) Loes. var. richardiana
(Cambess.) N.Robson

Hippocratea crenata (Klotzsch) K.Schum. & Loes.

Hippocratea longipetiolata Oliv.

SAPINDACEAE

Cardiospermum corindum L.

Cardiospermum halica cabum L.

Atalaya alata (Sim) H.Forbes

Pappea capensis Eckl. & Zeyh.

Stadmania oppositifolia Poir. subsp. rhodesica Exell

RHAMMACEAE

Ziziphus mucronata Willd.

Berchemia discolor (Klotzsch) Hemsl.

Berchemia zeyheri (Sond.) Grubov

VITACEAE

Rhoicissus revoilii Planch.

Rhoicissus tridentata (L.f.) Wild & Drumm.

Ciccus cornifolia (Bak.) Planch.

Cissus quadrangularis L.

Cissus rotundifolia (Forsk.) Vahl

Cyphostemma congestum (Bak.) Desc. ex Wild & Drumm.

Cyphostemma humile (N.E.Br.) Desc. ex Wild & Drumm.

Cyphostemma schlechteri (Gilg & Brandt) Desc. ex Wild & Drumm.

Cyphostemma simulans (C.A.SM.) Wild & Drumm.

Cyphostemma subciliatum (Bak.) Desc. ex Wild & Drumm.

Cyphostemma woodii (Gilg & Brandt) Desc.

TILIACEAE

Corchorus asplenifolius Burch.

Corchorus confusus Wild

Corchorus longipedunculatus Mast.

Grewia bicolor Juss.

Grewia flavescens Juss.

Grewia hexamita Burret

Grewia monticola Sond.

Grewia subspathulata N.E.Br.

Grewia villosa Willd.

Triumfetta pentandra A.Rich.

MALVACEAE

Abutilon angulatum (Guill. & Perr.) Mast.

Abutilon austro-africanum Hochr.

Abutilon fruticosum Guill. & Perr.

Abutilon guineense (K. Schum.) Bak.f. & Exell.

Abutilon ramosum (Cav.) Guill. & Perr.

Sida chrysantha Ulbr.

Sida cordifolia L.

Sida dregei Burtt Davy

Sida ovata Forsk.

Sida rhombifolia L.

Pavonia burchellii (DC.) R.A.Dyer

Pavonia elegans Garcke

Hibiscus calyphyllus Cav.

Hibiscus engleri K. Schum.

Hibiscus lunarifolius Willd.

Hibiscus micranthus L.f.

Hibiscus pusillus Thunb.

Hibuscus schinzii Guerke

Hibiscus sidiformis Baill.

Hibiscus trionum L.

Cienfuegosia hildebrandtii Garcke

Gossypium herbaceum L. var. africanum (Watt) Hutch. & Ghose

BOMBACACEAE

Adansonia digitata L.

STERCULIACEAE

Melhania acuminata Mast.

Melhania didyma Eckl. & Zeyh.

Melhania forbesii Planch. ex Mast.

Melhania rehmannii Szyszyl.

Dombeya cymosa Harv.

Dombeya rotundifolia (Hochst.) Planch. var. rotundifolia

Hermannia boraginiflora Hook.

Hermannia glanduligera K.Schum.

Hermannia modesta (Ehrenb.) Mast.

Hermannia quartiniana A. Rich.

Hermannia viscosa Hiern

Waltheria indica L.

Sterculia rogersii N.E.Br.

OCHNACEAE

Ochna natalitia (Meisn.) Walp.

Ochna pretoriensis Phill.

GUTTIFERAE

Garcinia livingstonei T. Anders.

VIOLACEAE

Hybanthus enneaspermus (L.) F.Muell.

FLACOURTIACEAE

Flacourtia indica (Burm.f.) Merr.

TURNERACEAE

Tricliceras glanduliferum (Klotzsch) R.Fernandes

Tricliceras schinzii Urb.

Piriqueta capensis (Harv.) Urb.

PASSIFLORACEAE

Adenia digitata (Harv.) Engl.

Adenia hastata (Harv.) Schinz

THYMELAEACEAE

Gnidia sericocephala (Meisn.) Gilg ex Engl.

LYTHRACEAE

Galpinia transvaalica N.E.Br.

COMBRETACEAE

Combretum apiculatum Sond. subsp. apiculatum

Combretum collinum Fresen.

Combretum erythrophyllum (Burch.) Sond.

Combretum hereroense Schinz

Combretum imberbe Wawra

Combretum mossambicense (Klotzsch) Engl.

Combretum molle R.Br. ex G.Don

Combretum paniculatum Vent. subsp. microphyllum (Klotzsch) Wickens

Combretum zeyheri Sond.

Terminalia phanerophlebia Engl. & Diels

Terminalia prunioides Laws.

Terminalia sericea Burch. ex DC.

MYRTACEAE

Syzygium cordatum Hochst.

Syzygium guineense (Willd.) DC.

ARALIACEAE

Cussonia natalensis Sond.

UMBELLIFERAE

Steganotaenia araliacea Hochst.

SAPOTACEAE

Sideroxylon inerme L.

Manilkara mochisia (Bak.) Dubard

Mimusops zeyheri Sond.

EBENACEAE

Euclea divinorum Hiern

Euclea natalensis A.DC.

Euclea schimperi (A.DC.) Dandy

Euclea undulata Thunb.

Diospyros mespiliformis Hochst. ex A.DC.

OLEACEAE

Schrebera alata (Hochst.) Welw.

Jasminum fluminense Vell.

Jasminum multipartitum Hochst.

Jasminum stenolobum Rolfe

SALVADORACEAE

Azima tetracantha Lam.

LOGANIACEAE

Strychnos decussata (Pappe) Gilg

Strychnos madagascariensis Poir.

Strychnos spinosa Lam.

Nuxia oppositifolia (Hochst.) Benth.

GENTIANACEAE

Exacum quinquenervium Griseb.

APOCYNACEAE

Acokanthera oppositifolia (Lam.) Codd

Acokanthera schimperi (A.DC.) Schweinf. var. rotundata Codd

Carissa bispinosa (L.) Desf. ex Brenan

Landolphia kirkii Dyer

Adenium obesum (Forsk.) Roem. & Schult. var. multiflorum (Klotzsch) Codd

Pachypodium saundersii N.E.Br.

PERIPLOCACEAE

Cryptolepis obtusa N.E.Br.

Raphionacme flanaganii Schltr.

Raphionacme procumbens Schltr.

ASCLEPIADACEAE

Asclepias burchellii Schltr.

Pentarrhinum insipidum E.Mey.

Sarcostemma viminale (L.) R.Br.

Secamone filiformis (L.f.) J.H.Ross

Secamone parvifolia (Oliv.) Bullock

Caralluma rogersii (L.Bol.) E.A.bruce & R.A.Dyer

Orbea maculata (N.E.Br.) Leach

Dregea macrantha Kloyzsch

Prthulstis fsrmis (Forsk.) Chiov.

CONVOLVULACEAE

Evolvulus alsinoides (L.) L. var. linifolius (L.) Bak.

Seddera suffruticosa (Schinz) Hallier f.

Convolvulus farinosus L.

Merremia kentrocaulos (C.B. Cl.) Rendle

Merremia palmata Hallier f.

Merremia tridentata (L.) Hallier f. subsp. angustifolia (Jacq.) Ooststr.

Ipomoea albivenia (Lindl.) Sweet

Ipomoea bolusiana Schinz

Ipomoea coptica (L.) Roth ex Roem. & Schult. var. coptica

Ipomoea coscinosperma Hochst. ex Choisy

Ipomoea crassipes Hook.

Ipomoea magnusiana Schinz

Ipomoea obscura (L.) Ker-Gawl. var. fragilis (Choisy) A.Meeuse

Ipomoea sinensis (Desr.) Choisy subsp. blepharosepala (Hochst. ex A.Rich.) Verdc.

Ipomoea wightii (Wall.) Choisy

BORAGINACEAE

Cordia ovalis R.Br. ex DC.

Cordia sinensis Lam.

Ehretia amoena Klotzsch

Ehretia rigida (Thunb.) Druce

Heliotropium giessii M.Friedrich

Heliotropium steudneri Vatke

Heliotropium strigosum Willd.

VERBENACEAE

Lantana camara L.

Lantana rugosa Thunb.

Lippia javanica (Burm.f.) Spreng.

Chascanum adenosta chyum (Schauer) Moldenke

Chascanum hederaceum (Sond.) Moldenke

Chascanum pinnatifidum (L.f.) E.Mey.

Priva africana Moldenke

Priva cordifolia (L.f.) Druce var. abyssinca (Jaub. & Spach Moldenke

Vitex harveyana H. Pearson

Clerodendrum glabrum E.Mey.

Clerodendrum myricoides (Hochst.) Vatke

Clerodendrum ternatum Schinz

Holmskioldia tettensis (Klotzsch) Vatke

LABIATAE

Tinnea rhodesiana S.Moore

Leonotis nepetifolia (L.) Ait.f.

Leucas glabrata (Vahl) R.Br. ex Benth.

Leucas neuflizeana Courb.

Leucas sexdentata Skan

Endostemon tenuiflorus (Benth.) Ashby

Endostemon tereticaulis (Poir.) Ashby

Plectranthus tetensis (Bak.) Agnew

Iboza riparia (Hochst.) N.E.Br.

Hemizygia bracteosa (Benth.) Briq.

Hemizygia petrensis (Hiern) Ashby

Becium knyanum (Vatke) G.Tayl.

Ocimum canum Sims

Ocimum urticifolium Roth

Orthosiphon australis Vatke

SOLANACEAE

Lycium shawii Roem. & Schult.

Solanum coccineum Jacq.

Solanum incanum L.

Solanum panduraeforme E.Mey.

Nicotiana glauca R.A.Graham

SCROPHULARIACEAE

Aptosimum lineare Marloth & Engl.

Peliostomum leucorrhizum E.Mey. ex Benth. var. linearifolium Weber

Sutera micrantha Hiern

Ilysanthes dubia (L.) Bernh.

Buchnera glabrata Benth.

Striga asiatica (L.) Kuntze

Striga bilabiata (Thunb.) Kuntze

Striga gesnerioides (Willd.) Vatke ex Engl.

BIGNONIACEAE

Rhigozum zambesiacum Bak.

Kigelia africana (Lam.) Benth.

PEDALIACEAE

Harpagophytum procumbens (Burch.) DC. ex Meissn.

Holubia saccata Oliv.

Sesamum alatum Thonn.

Ceratotheca triloba (Bernh.) Hook.f.

ACANTHACEAE

Elytraria acaulis (L.f.) Lindau

Thunbergia atriplicifolia Nees

Thunbergia dregeana Nees

Dyschoriste rogersii S. Moore

Chaetacanthus burchellii Nees

Ruellia cordata Thunb.

Ruellia patula Jacq.

Crabbea hirsuta Harv.

Crabbea velutina S. Moore

Barleria affinis C.B.Cl.

Barleria crossandriformis C.B.Cl.

Barleria elegans S. Moore

Barleria holubii C.B.Cl.

Barleria lancifolia R. Anders.

Barleria obtusa Nees

Barleria oxyphylla Lindau

Barleria prionitis L.

Barleria transvaalensis Oberm.

Neuracanthus africanus T. Anders. ex S. Moore

Blepharis integrifolia (L.f.) E. Mey. ex Schinz

Blepharis maderaspatensis (L.) Heyne ex Roth subsp. maderapatensis

Blepharis subvolubilis C.B.Cl.

Blepharis transvaalensis Schinz

Crossandra fruticulosa Lindau

Crossandra mucronata Lindau

Asystasia gangetica (L.) T.Anders.

Asystasia subbiflora C.B. Cl.

Ruspolia hypocrateriformis (Vahl) Milne-Redh. var. australis Milne-Redh.

Ecbolium amplexicaule S.Moore

Ecbolium revolutum (Lindau) C.B. Cl.

Justicia annagalloides T.Anders.

Justicia flava (Vahl) Vahl

Justicia incerta C.B.Cl.

Justicia matammensis (Schweinf.) Oliv.

Justicia petiolgris E.Mey ex C.B.Cl.

Justicia protracta (Nees) T. Anders.

Monechma debile (Forsk.) Nees

RUBIACEAE

Agathisanthemum bojeri Klotzsch subsp. australe Brem. var. australe

Kohautia lasiocarpa Klotzsch

Kohautia omahekensis (Krause) Brem.

Kohautia virgata (Willd.) Brem.

Oldenlandia caespitosa Hiern var. major Brem.

Hymenodictyon parvifolium Oliv.

Breonadia microcephala (Del.) Ridsd.

Xeromphis obovata (Hochst.) Keay

Xeromphis rudis (E. Mey. ex Harv.) Codd

Gardenia resiniflua Hiern

Gardenia spatulifolia Stapf & Hutch.

Kraussia floribunda Harv.

Tricalysia allenii (Stapf) Brenan

Vangueria infausta Burch.

Dinocanthium hystrix Brem.

Pavetta assimilis Sond.

Pavetta catophylla K.Schum.

Paederia foetens (Hiern) K.Schum.

Borreria scabra (Schumach & Thonn.) K.Schum.

CUCURBITACEAE

Mukia maderaspatana (L.) M.J.Roem.

Kedrostis foetidissima (Jacq.) Cogn. subsp. obtusiloba (Sond.) A. Meeuse

Kedrostis hirtelle (Naud.) Cogn.

Cucumis africanus L.f.

Cucumis hirsutus Sond.

Cucumis melo L.

Cucumis metuliferus E. Mey. ex Naud.

Cucumis myriocarpus Naud.

Coccinia adoensis (Hochst. ex A.Rich.) Cogn.

Coccinia rehmannii Cogn.

CAMPANULACEAE

Wahlenbergia dinteri V.Brehm.

ASTERACEAE

Veronia fastigiata Oliv. & Hiern

Veronia natalensis Sch. Bip.

Veronia oligocephala (DC.) Sch. Bip. ex Walp.

Veronia poskeana Vatke & Hildebr.

Felicia mossamedensis (Hiern) Mendonca

Conyza floribunda H.B. & K.

Brachylaena huillensis O.Hoffm.

Pluchea dioscoridis (L.) DC.

Epaltes gariepina (DC.) Steetz

Helichrysum nudifolium (L.) Less var. leiopodium (DC.) Moeser

Athrixia phylicoides DC.

Calostephane divaricata Benth.

Pegolettia senegalensis Cass.

Philyrophyllum schinzii O.Hoffm.

Geigeria burkei Harv. subsp. burkei var. elata Merxm.

Geigeria ornativa O.Hoffm.

Acanthospermum hispidum DC.

Bidens biternata (Lour.) Merr. & Sherff

Bidens pilosa L.

Schkuhria pinnata (Lam.) Cabr.

Senecio longiflorus (DC.) Sch.Bip.

Senecio transvaalensis H.Bol.

Dicoma macrocephala DC.

Dicoma tomentosa Cass.

APPENDIX 4. SCIENTIFIC EQUIVALENTS OF COMMON ANIMAL SPECIES NAMES USED IN TEXT AND IN TABLES

Common name	Scientific name
Blue wildebeest	Connochaetes taurinus (Burchell)
Buffalo	Syncerus caffer (Sparrman)
Bushbuck	Tragelaphus scriptus (Pallas)
Eland	Taurotragus oryx (Pallas)
Elephant	Loxodonta africana (Blumenbach)
Giraffe	Giraffa camelopardalis (L.)
Grey duiker	Sylvicapra grimmia (L.)
Ground hornbill	Bucorvus leadbeateri (Vigors)
Hippopotamus	Hippopotamus amphibius L.
Impala	Aepyceros melampus (Lichtenstein)
Kudu	Tragelaphus strepsiceros (Pallas)
Nyala	Tragelaphus angasi Gray
Ostrich	Struthio camelus L.
Reedbuck	Redunca arundinum (Boddaert)
Roan antelope	Hippotragus equinus (Desmarest)
Sable	Hippotragus niger (Harris)
Sharpe's grysbok	Raphicerus sharpei Thomas
Tsessebe	Damaliscus lunatus (Burchell)
Warthog	Phacochoerus aethiopicus (Pallas)
Waterbuck	Kobus ellipsiprymnus (Ogilby)
White rhinoceros	Ceratotherium simum (Burchell)
Zebra	Equus burchelli Gray

APPENDIX 5. FIGURES 2 - 20

Fig.2. Moderately shrubby, moderately brushy treeveld (aB-GRE FLA; aB-COM API; a-SCL CAF) of Quadrat 332 in Landscape Unit 1.1.

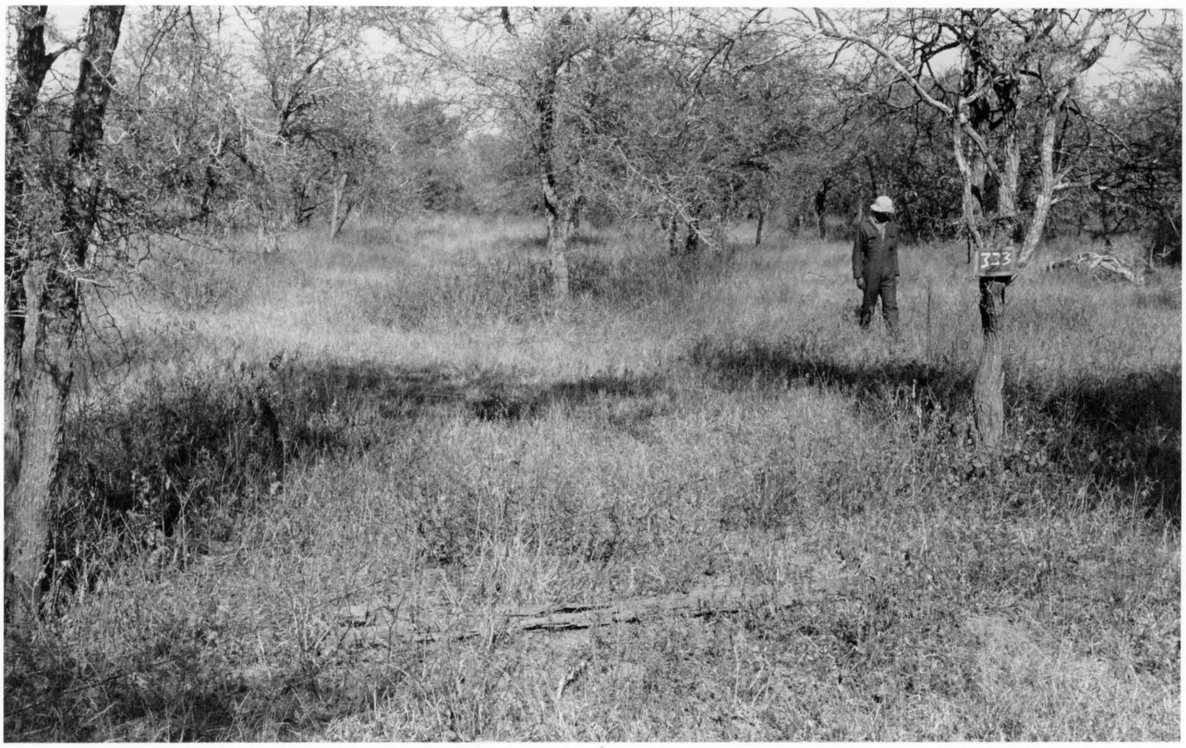

Fig.3. Sparsely shrubby moderate brushveld with scattered trees (lB-ACA GRA; aB-ACA GRA; +- ACA GRA) of Quadrat 333 in Landscape Unit 1.4.

Fig.4. Moderately shrubby, densely brushy, sparse treeveld (aB-COM ZEY; bB-COM ZEY; 1-SCL CAF) of Landscape Unit 2.2.

Fig.5. Grassveld (O-GRASS; O; O) of Landscape Unit 2.4.

Fig.6. Moderate Acacia nigrenscens - Themeda triandra - dominated treeveld with scattered shrub and brush (+S-DIC CIN; +T-SCL CAF; a-ACA NIG) of Landscape Unit 3.3.

Fig.7. Densely shrubby, dense brushveld dominated by Dichrostachys cinerea (bB-DIC CIN; bB-DIC CIN; O) of Landscape Unit 4.4.

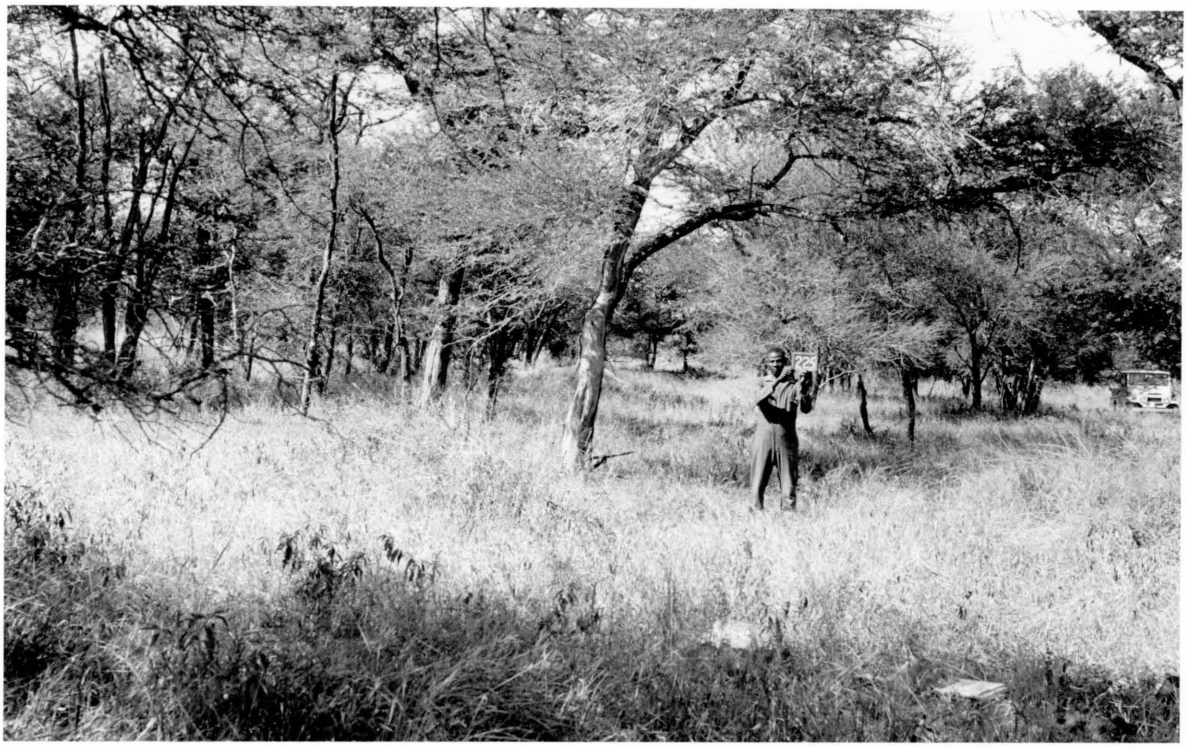

Fig.8. Sparsely shrubby, moderately brushy moderate tree-veld (1B-ACA WEL; aT-ACA WEL; a-ACA WEL) of Landscape Unit 4.6. Acacia welwitschii trees dominate the tree and brush levels.

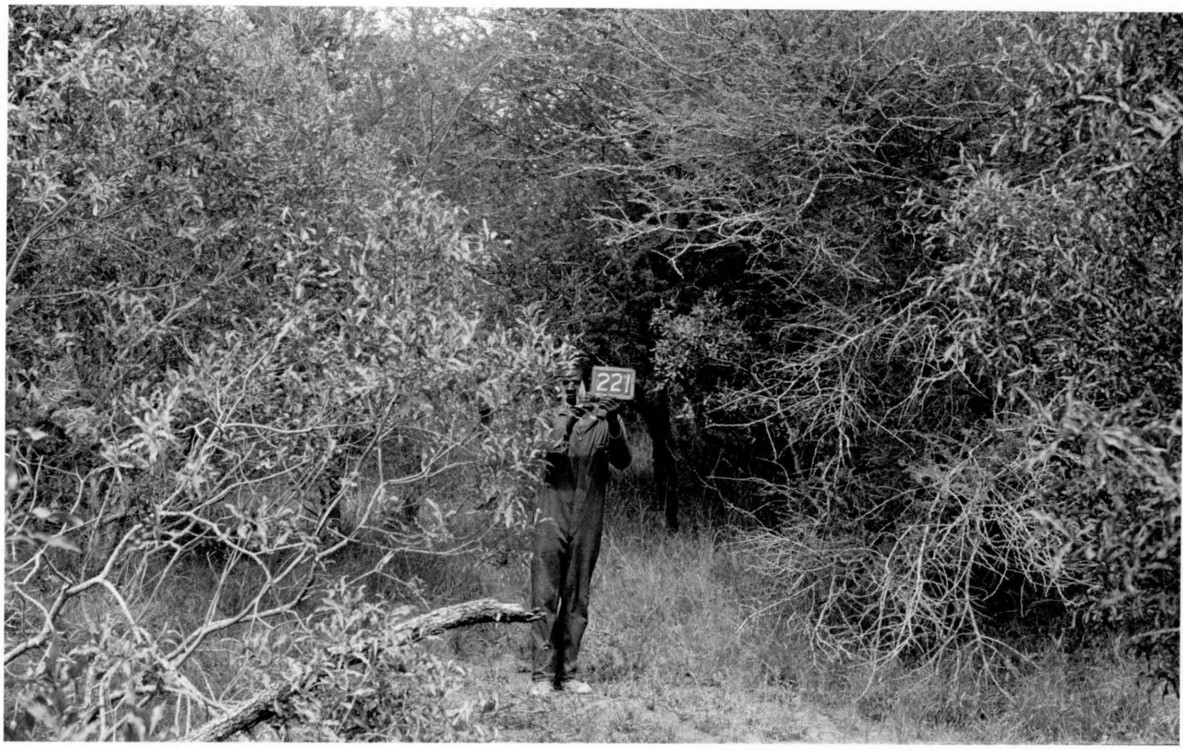

Fig.9. Densely shrubby, thicketed, moderate treeveld (bB-EUC DIV; 3B-EUC DIV; a-ACA WEL) of Landscape Unit 4.6. Acacia welwitschii dominates the tree level, whereas Euclea divinorum brushes dominate the brush and shrub levels.

Fig.10. Densely shrubby, sparse brushveld with scattered trees (bB-DIC CIN; 1B-DIC CIN; +-ACA NIG) of Landscape Unit 5.3. The brush and shrub levels are dominated by Dichrostachys cinerea brushes.

Fig.11. Acacia gerrardii - dominated sparse brushveld with scattered shrub (+B-ACA GER; 1B-ACA GER; 0) of Landscape Unit 6.1.

Fig.12. Sparsely shrubby, sparse treeveld (1S-GRE BIC; O; 1-SCL CAF) of Landscape Unit 6.3.

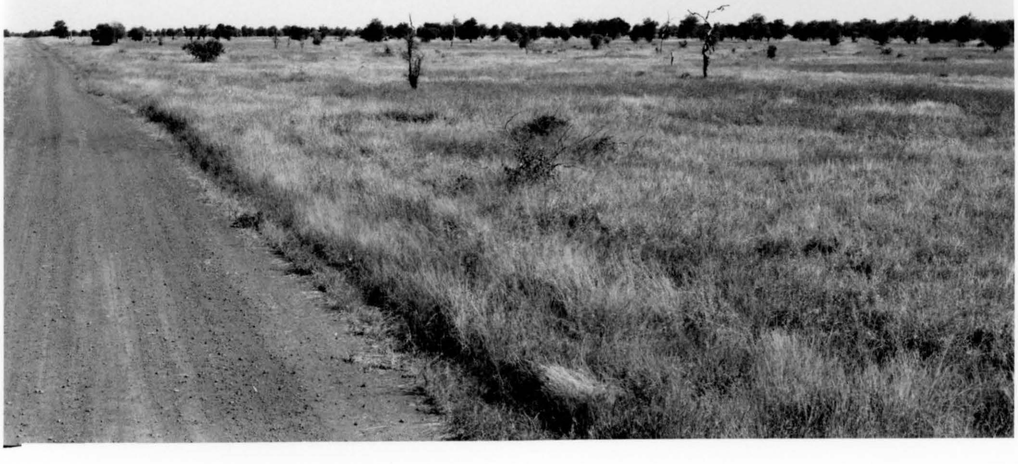

Fig.13. Grassveld with scattered shrub (+-GRASS; O; O) of Landscape Unit 7.1. Shrubby brushveld of Landscape Unit 7.2 is visible in the background (Photograph: S.C.J. Joubert by courtesy National Parks Board).

Fig.14. Acacia nigrenscens - dominated shrubby brushveld 1B-ACA NIG; 1B-ACA NIG; O) of Landscape Units 7.2 and Landscape Unit 7.3. (Photograph: S.C.J. Joubert by courtesy National Parks Board).

Fig.15. Moderately shrubby, sparse brushveld (aS-GRE BIC; 1B-TER PRU; O) of Landscape Unit 8.1.

Fig.16. Sparsely shrubby, moderate brushveld, with scattered trees (1B-COM API; aB-COM API; +-COM API) of Landscape Unit 9.4.

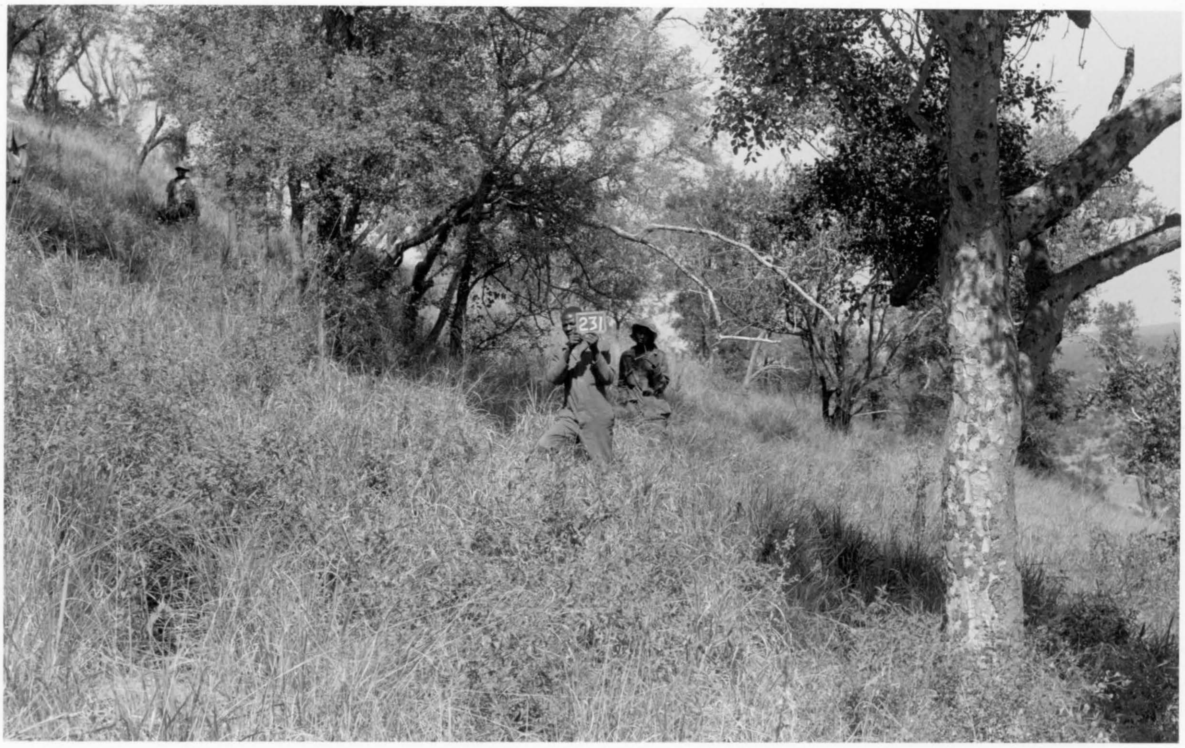

Fig.17. Sparsely shrubby, densely brushy, moderate treeveld (1B-COM API; bT-ACA NIG; a-ACA NIG) of Landscape Unit 9.7. Acacia nigrenscens trees dominate the tree and brush levels.

Fig.18. Densely shrubby, dense brushveld (bB-COM API; bB-COM API; 0) of Landscape Unit 10.1. Combretum apiculatum brushes dominate the brush and shrub levels.

Fig.19. Densely shrubby, thicketed, sparse treeveld (bB-AND JOH; 3B-AND JOH; 1-AND JOH) of Landscape Unit 11.2.

Fig.20. Moderately shrubby moderate brushveld (aB-COM ZEY; aB-COM ZEY; O) of Landscape Unit 12.1. Combretum zeyheri brushes are dominant at the brush and shrub levels.