

A STUDY OF THE VEGETATION OF THE ANDRIES VOSLOO KUDU
RESERVE, CAPE PROVINCE.

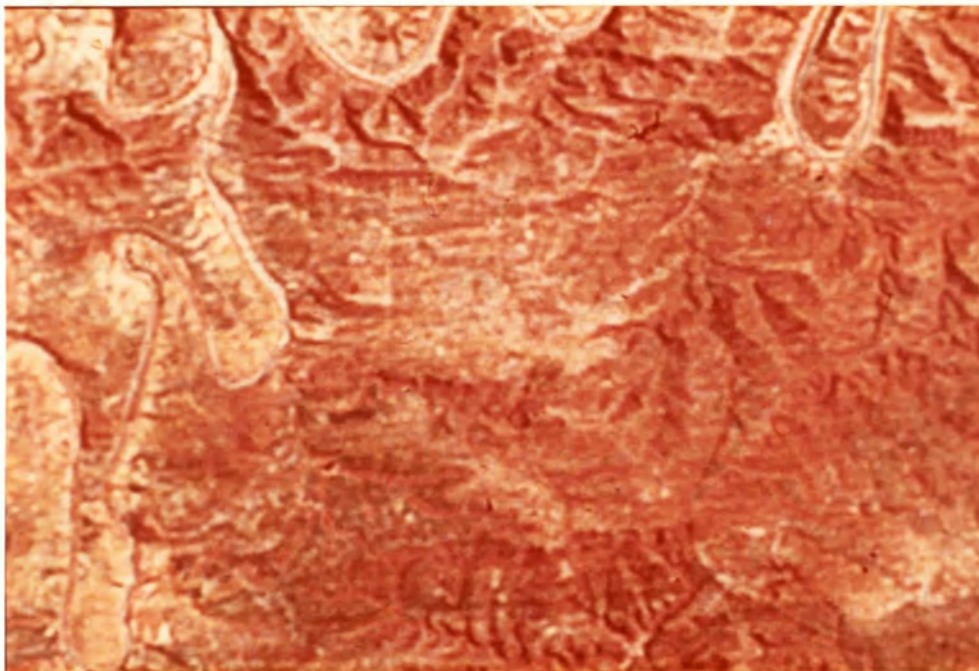
by

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December, 1981.



Frontispiece: A colour positive print of the enlarged LANDSAT 2
image recorded over the Andries Vosloo Kudu
Reserve.

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ABSTRACT

The plant communities of the Andries Vosloo Kudu Reserve (6493 ha.; Acocks's Valley Bushveld) are classified using the Braun-Blanquet phytosociological technique.

A checklist of the flowering plants is presented. The flora of the reserve displays an affinity to five phytochoria (Capensis, Karoo-Namib, Sudano-Zambeziian, Afro-montane and Indian Ocean Coastal Belt), of which the Karoo-Namib and Indian Ocean Coastal Belt are the most extensive. The flora of the Valley Bushveld is regarded as adequately conserved, but a recommendation is made to consolidate the study area with adjacent farms. A small herbarium, containing specimens of all species listed in the checklist, has been established.

The climate of the study area is classified according to the Koppen classification as Cfa. Simultaneous air temperature recording at four separate localities demonstrated that differences exist between localities of marginally different altitude, aspect and slope.

The phenology of 51 plant species, recorded at monthly intervals over a continuous period of 478 days, is presented. These species are classified according to their response to air temperature and rainfall for the initiation of new growth, flowering and fruiting. Species exhibited a spectrum of responses ranging from endogenous to exogenous control over phenological events.

ACKNOWLEDGEMENTS

I would like to extend my sincere appreciation to the following people who have assisted me during the study:

Dr.R.A.Lubke for enthusiastic and constructive supervision;
The Director, Department of Nature and Environmental Conservation, for permission to conduct this study while in his employ;

The under-graduate students from the Department of Plant Sciences who assisted with the early part of the total floristic survey;

Mrs.E.Brink and Miss G.V.Britten of the Albany Museum Herbarium who assisted with many of the plant identifications;

Drs.A.Jacot-Guillarmod and J.P.Jessop for permission to use their unpublished checklists;

Dr.P.Terry and Mr.H.Murrell of the Department of Computer Sciences and the Computer Centre (Rhodes University), for their assistance with the data processing;

Mr.S.Williams for constructing the weather screens;

Mr.P.Burdett and Mr.C.Wels for assistance in the field and for changing the thermohygrograph charts during my periods of absence;

Head of Department, Department of Botany, University of Fort Hare, for the loan of three thermohygrographs;

The Secretary, Commission for Administration, for financial support in the form of a bursary;

Drs.B.J.Coetzee, E.R.Robinson and G.E.Gibbs-Russell who advised on the arrangement of the phytosociological tables;

Mr.O.West and Mr.J.Keulder of the Department of Geography, who gave advice and assistance on cartographic procedures;

all my colleagues in the Regional Office, Grahamstown, who have been an inspiration in the work;

and finally to my wife Carolyn, who has assisted me throughout the study in the field, the herbarium, at the computer, and in the preparation of this manuscript.

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• Poster paper. 1982 AETFAT Congress, Pretoria.

1. INTRODUCTION

The Andries Vosloo Kudu Reserve (AVKR) was established in 1973 in order to conserve a large population of the greater kudu (Tragelaphus strepsiceros Pallas 1766) in the Cape Province (Director of Nature & Environmental Conservation, 1979). In addition, a representative example of the Fish River Scrub variation of the Valley Bushveld (Acocks, 1975) was conserved. After the establishment of the reserve, the effective management of the ecosystem had to be planned. This initial planning necessitated the accumulation of comprehensive natural resource data for the area. This study was initiated to collect data on the fundamental units of a terrestrial ecosystem. These units include the physiognomy, phytosociology, phenology and total floristic composition of the vegetation, as well as a brief description of the geology, soils and climate.

One of the problems encountered in terrestrial ecosystem conservation is the effective management of free range ungulate populations (Mentis & Duke, 1976). Data which quantify some of the physical relationships within the ecosystem may assist in solving this problem. The plant community is the fundamental unit of a terrestrial ecosystem and an understanding of the plant/environment relationship is the basis of any terrestrial ecosystem management policy. Plant community composition and distribution are related directly to environmental

characteristics (Huntley & Birks, 1979), and suitable methods of survey had to be selected before classification and mapping of the communities could be achieved.

Werger (1973) notes that if Braun-Blanquet phytosociological surveys are undertaken in all conservation areas within South Africa, this would result in the classification of plant communities at points distributed over a variety of Acocks's Veld Types. The Department of Plant Sciences (Rhodes University) had initiated a survey of the vegetation of the AVKR using the Braun-Blanquet phytosociological technique, and it was decided to continue and complete the survey during this study.

There are many factors which may be responsible for the distribution of a population of large wild ungulates within a terrestrial ecosystem. Allen-Rowlandson (1980) has discussed the role of intraspecific behaviour in the spatial organization of the greater kudu in the study area. When this present study was initiated no information had been accumulated on the role of the vegetation and macroclimate in determining these ungulate distribution patterns. In order to fill this gap, the following investigations were planned:

- a) an examination of the phenology of the vegetation, which can be regarded as an external indication of its nutritional status; and
- b) an assessment of the macroclimate, which affects both the distribution and physiology of individual plant species.

The phenology (timing of the metabolism and development) of the primary producers in an ecosystem is of fundamental importance to consumers within the ecosystem. This timing may be controlled by environmental circumstances (exogenous control), or it may be determined by the genome of the species (endogenous control) (Lieth, 1974). Huxley & Van Eck (1974) suggest that the phenology of tropical woody perennials is related to both endogenous and exogenous control, whereas Borchert (1980) maintains that growth periodicity of some tropical trees is primarily the manifestation of endogenous periodic processes. In this study the climate and phenology were correlated to assess the degree of endogenous and exogenous control of certain species.

In addition, more detailed information on the phenology of the major plant species in the study area was requested by researchers in the field of ungulate and small mammal biology (Perrin pers. comm.). All the phenological data will benefit these researchers.

Macroclimate may affect the physiology of plant species. Acocks (1975) subjectively attributes the formation of the Fish River scrub variation to the exacting climatic conditions which prevail in the Great Fish river valley. These conditions have apparently resulted in distinguishable differences in the species composition and physiognomy of plant communities in this Veld Type. It was decided to investigate the macro-climate in the context of Acocks's statement.

Plant species display both morphological and physiological adaptations to environment. Variation in leaf structure and size in microphanerophytes is regarded as one form of adaptation (Shimwell, 1971). Description of these morphological characteristics enables discussion of adaptation. Comparisons may also be made with areas where similar edaphic conditions prevail, but where species composition is considerably different.

A controversy surrounds the biogeographical affinity of the Valley Bushveld (Huntley, 1978; Moll & White, 1978; Werger, 1978; Werger & Coetsee, 1978). Floristic data collected in the study area can be compared with data from conserved areas representative of the five phytochoria which meet there.

Plant ecologists tend to regard the Valley Bushveld as adequately conserved (Edwards, 1974; Huntley, 1978). By comparing the results of this study with information published on other conserved areas within the Valley Bushveld, an assessment of the floristic relationships between the areas is made. This, together with information on endemism, provides the background for an assessment of the adequacy of conservation of the flora.

Town and Regional Planners make extensive use of natural resource data in determining optimum land use (Loxton, Hunting & Associates, 1977). Natural resource data has seldom been used in a similar manner in the planning and management of nature reserves in southern Africa. The feasibility of establishing a computer-based natural resource data bank which may facilitate the planning and management of this, and similar nature reserves, is investigated.

1.1 AIMS OF THE STUDY

The purposes of this study were:

- a) to provide a classification of the vegetation into "ecological units correlated with stable and permanent conditions, distinguishing, therefore, areas of uniform potential for management purposes" (Coetzee, 1974);
- b) to prepare an annotated checklist of the flowering plants and establish an herbarium for the reserve;
- c) to describe more accurately the "exact climatic conditions" mentioned by Acocks (1975);
- d) to record the phenological characteristics of some of the plant species which occur abundantly on the reserve and relate these to climatic factors; and
- e) to prepare a computer-based mapping system which will facilitate access to natural resource data.

1.2 STUDY AREA

1.2.1 LOCATION

The Andries Vosloo Kudu Reserve (AVKR) is 6493 hectares in extent (Director of Nature and Environmental Conservation, 1979), and is situated 40 km north east of Grahamstown in the Fish River Scrub variation of Acocks's (1975) Valley Bushveld (Fig. 1).

The AVKR is located between $33^{\circ} 04'$ and $33^{\circ} 09'$ S; and $26^{\circ} 37'$ and $26^{\circ} 49'$ E (SA Topo Series 3326 BA and BB), and is bordered in the north-east and north-west by the Great Fish River. The altitude of the reserve varies from 182 m above sea level at the Great Fish River to 548 m on Graskop II, with the eastern section being traversed by numerous deep riverine valleys (Fig. 2).

The reserve was established in 1973 by the Department of Nature and Environmental Conservation of the Provincial Administration of the Cape of Good Hope on land which had been previously used exclusively for pastoral agriculture.

1.2.2 GEOLOGY

Johnson & Keyser (1976) describe the geology of the study area as predominantly grey and 'red' mudstone, and sandstone, of the Middleton formation (Adelaide Subgroup: Beaufort Group: Karoo Supergroup). The sandstones predominate over the mudstone

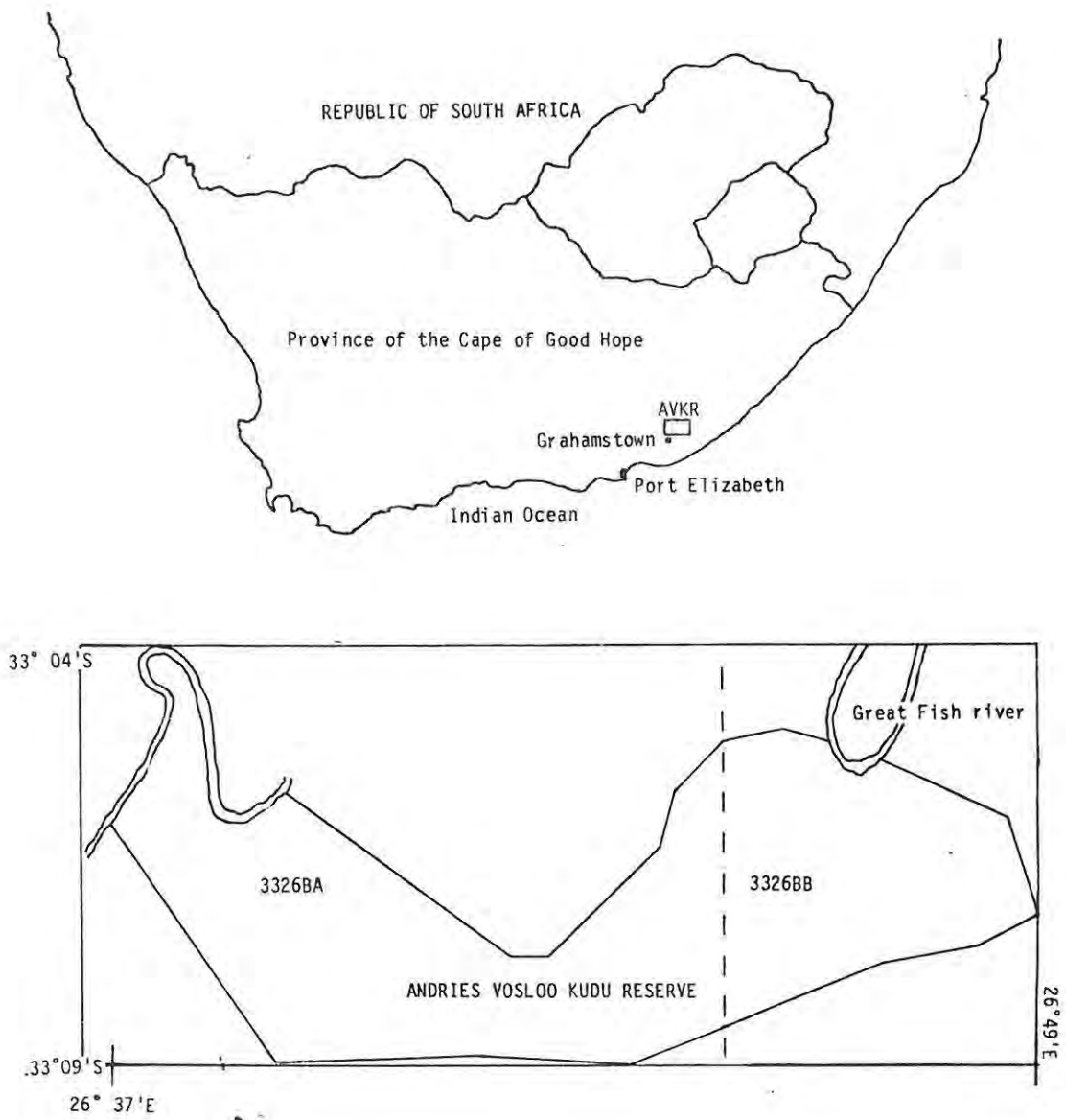


Fig. 1. Location of the study area.

throughout this formation. Isolated dolerite dykes of post-Karoo age exist in the eastern section of the study area (Mountain, 1937). The koppies (Kentucky, Grasslands, Graskop II and Rooikop) are features related to the more resistant rocks of the upper division of the Ecca series (Mountain, 1946). The shales are of varying character, interbedded with blueish sandstone, the beds gently dipping northwards (Mountain, 1937).

1.2.3 GEOMORPHOLOGY AND SOILS

The erosion of the sedimentary beds of the Adelaide subgroup is largely responsible for the geomorphology of the study area. Differential erosion of the sandstones and mudstones has resulted in the formation of flat-topped koppies which may slope gently (soft sandstones and mudstones) or steeply (harder sandstones and dolerites) down to the drainage lines. The basement of the drainage lines is characterised by harder rocks of the formation, which include shales, sandstones and dolerites of post-Karoo age.

The soils of the Adelaide subgroup have been described most recently by Hartmann et al. (1979) for the Kat River basin situated 20 km north of the study area. The soil form in their study area, which also occurs most abundantly on AVKR, was the Mispah form (MacVicar et al., 1977), in which the orthic A-horizon overlies parent rock i.e. shallow soils associated with middle and upper pediment slopes.

1.2.4 EARLY DESCRIPTIVE LITERATURE OF THE VEGETATION

The earliest descriptive botanical work in the Fish River Valley was that of Black (1901) who visited the area in the period 1848 to 1852, and described the vegetation in remarkable detail. In discussing the area between Fort Brown and Committees Drift, in which the study area falls, Black noted that the sides of Graskop were broken by dark kloofs and bushy ridges. The "bush is denser and more tree-like in the kloofs and opener on the more level and elevated grounds". Grass fires were a feature of the hills and often consumed a little of the edges of the bush. Black (1901) mentions the importance of the genera Acacia, Pelargonium, Euphorbia (E. triangularis), Portulacaria, Jasminum, "Amaryllides", Narcissus, Aloe and Salix. He also recognised that the "river bush" was of "different nature to that covering the rest of the country and marks the course of the stream distinctly."

Pole-Evans (1936) described the vegetation of the Fish River as a succulent form of desert scrub. Subsequently, Dyer (1937) described the area as Karroid scrub, particularly that component dominated by the presence of arborescent species of Aloe and Euphorbia. Dyer (1937) recognised that grasslands were a feature of the higher plains between river valleys, and that in the overlap of scrub and grassland, a broken veld developed. These grasslands were "sour", and were dominated by Themeda triandra and Digitaria eriantha.

Acocks (1975) classified the Fish River scrub as a variation of his Valley Bushveld, and maintained that the original vegetation had been opened up by over-utilization by domestic and wild ungulates. He regarded this original vegetation as an extremely dense, semi-succulent scrub, about 2m high. Acocks (1975) considered Euphorbia bothae an invading species, which had been so successful that the present-day vegetation closely resembled Noorsveld, which is restricted to the Jansenville district (Van der Walt, 1968) and in which the dominant species is Euphorbia coerulescens.

Acocks (1975) distinguished four categories of succession in this variation of the Valley Bushveld, all of which are represented in the study area. The categories are:

- a) dense, succulent scrub with some grass (climax);
- b) open, succulent scrub with much grass;
- c) open succulent scrub with thorny shrubs and succulents, and Karoo bushes invading the grassland;
and
- d) succulent thorny scrub with Karoo bush and little grass.

More recently, Martin & Noel (1960) recorded two plant formations in the study area. These were :

- i) low succulent scrub and
- ii) tall sub-succulent woodland (inland).

The tall sub-succulent woodland comprised Euphorbia triangularis, E. tetragona, E. curvirama, Ptaeroxylon obliquum, Schotia latifolia and Cussonia spicata. "The general structure

is an open woodland in which the dominant stratum consists of micro- and mesophanerophytes with the crown of the trees separated by distances greater than the crown diameter" (Martin & Noel, 1960).

The principle alliance of the low succulent scrub formation is Euphorbia bothae-Portulacaria afra. Other species include Euphorbia pentagona, E. burmanii, E. mauritanica, Rhigozum obovatum, Grewia robusta, Cadaba juncea, Putterlickia pyracantha, Capparis oleoides, Pappea capensis and Asparagus striatus. Grasses are rare in this formation, but numerous succulent Aizoaceae are present (Martin & Noel, 1960).

Acocks (1964) suggests that the grassy substratum in the Valley Bushveld has been replaced by a sparse growth of two Karoo species, Pentzia incana and Ruschia parvifolia.

Jessop (unpubl.) subjectively recognised eight communities in the study area and noted the heterogeneous nature of the vegetation. Communities range from "near desert conditions, almost pure grassveld, succulent and non-succulent bush, to non-succulent forest" (Allen-Rowlandson, 1980). Jessop (unpubl.) suggested that the bushclump savanna community is a product of stock management practices and that heavy browsing pressure has "opened up" the bush.

2. CLIMATE

2.1 INTRODUCTION

Acocks (1975) described the climatic conditions prevailing in the Fish River Valley as "exacting", and attributes the development of the vegetation to these conditions. Niedzwiedz et al. (1976) attribute the variation within the vegetation of the Chelmowa National Park (Poland) to micro-climatic differences. Climate does influence the structure, distribution and composition of vegetation, and its fundamental components must be determined in any ecological investigation. The components investigated in this study include precipitation (rainfall and advective fog) and air temperature.

Schultze (1975) proposed that aspect, slope and season all affect solar radiation flux densities in the southern hemisphere. Schultze's (1975) research was stimulated by plant ecologists' desire to account for variation in plant community composition in meso-scale studies on non-horizontal surfaces. His results are based on empirical data within a theoretical framework. As direct solar radiation could not be measured during this study, air temperature was regarded as the closest appropriate factor.

2.2 MATERIALS AND METHODS

Climatic data were recorded at four weather stations (Fig. 2) during mid-summer and mid-winter, and at the Grasslands homestead throughout the duration of the study. Each station was equipped with a specially constructed weather screen (Plate 1) in which the recording instruments were housed. Standard Stevenson screens proved too costly and their use could not be justified. The uniformity in recording conditions essential to compare macroclimate at localities of different slope and aspect, was achieved using these screens.

Recording instruments included three Thies Model 620 Gottingen Thermohygrographs (temperature ranges -10°C to 50°C) and one Thies Model 622 Thermohygrograph (temperature range 0°C to 50°C). Two perspex rain gauges were located at each station. Fog droplet samplers (Fig. 3) were constructed from galvanised iron and 4 mm^2 nylon mesh according to the specifications of R. Fuess, Berlin, and erected at each station above one of the rain gauges. Seely (pers. comm.) had been experimenting with a similar gauge at the Desert Research Station (Gobabeb, Namibia), where advective fog is a major form of precipitation. The Grasslands station was equipped with an 8 inch Casella Natural Siphon Rainfall Recorder (Serial No. 6090).



Plate 1. Specially constructed weather screen used during the study.

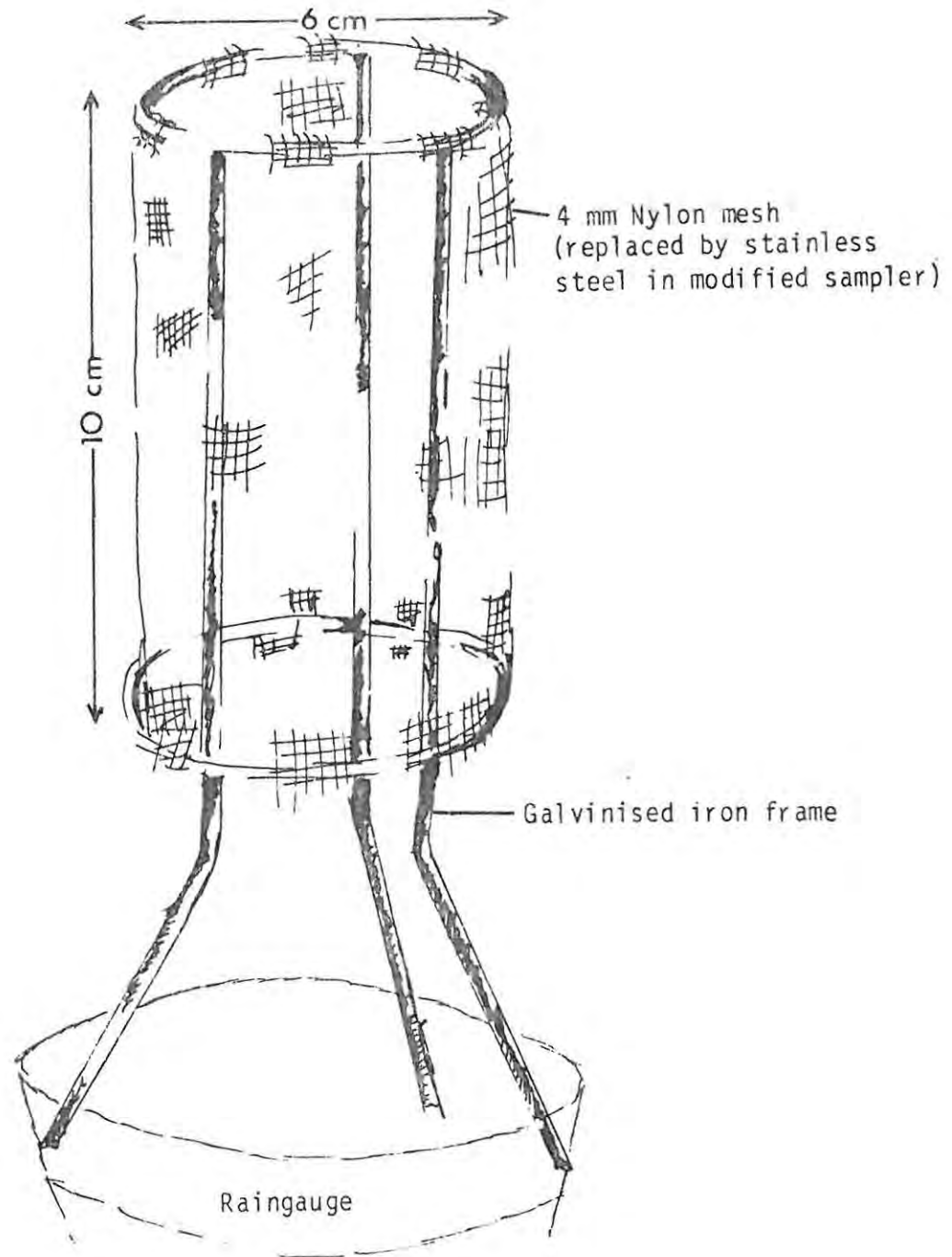


Fig. 3. A fog droplet sampler constructed and used during the study.

All the weather stations were visited at weekly intervals during the period December 1979 to March 1980, and again during the months of June and July 1981. At each visit the following operations were performed:

- i) the recorder charts were changed, ink checked and the thermohygrographs re-activated;
- ii) precipitation in the rain and fog droplet sampler was measured accurately using a glass measuring cylinder;
- iii) wind speed and direction were noted subjectively;
- iv) cloud cover was recorded; and
- v) the presence of dew on the weather screen noted.

The time of day was recorded, and every effort was made to complete the task at all the stations within the shortest possible time (maximum 60 minutes) in order to make results comparable. Recording at the Grasslands station was continued throughout the study.

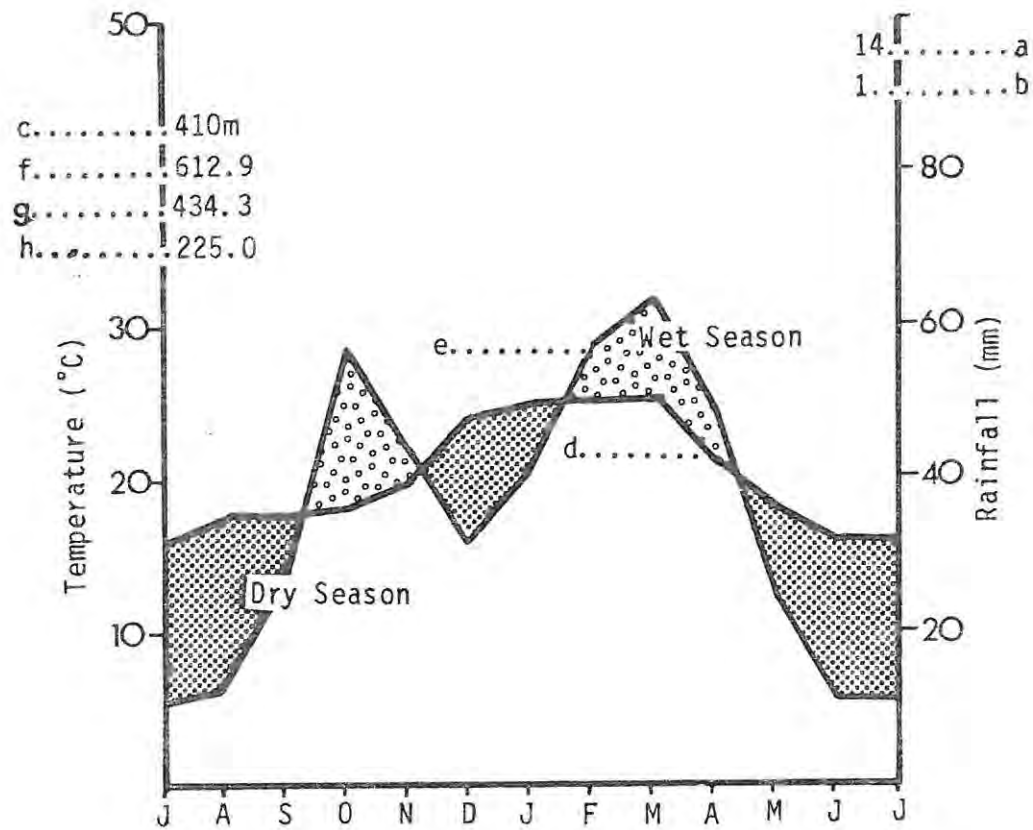
The thermohygrographs were calibrated simultaneously at the end of the study in a controlled environment room against a Macdac mercury thermometer (temperature range 0-150° C). Calibration curves for the four instruments are presented in Appendix 2.

2.3 RESULTS

The climate diagram (Walter & Lieth, 1960) has been used to describe the climate of the study area (Fig. 4). Information on the diagram includes mean, maximum and minimum annual rainfall; periods of recording rainfall and temperature; and altitude. A histogram of the average monthly rainfall for the 12 year period (1937-1949) is presented in Fig. 5, together with a representation of monthly rainfall during the study period.

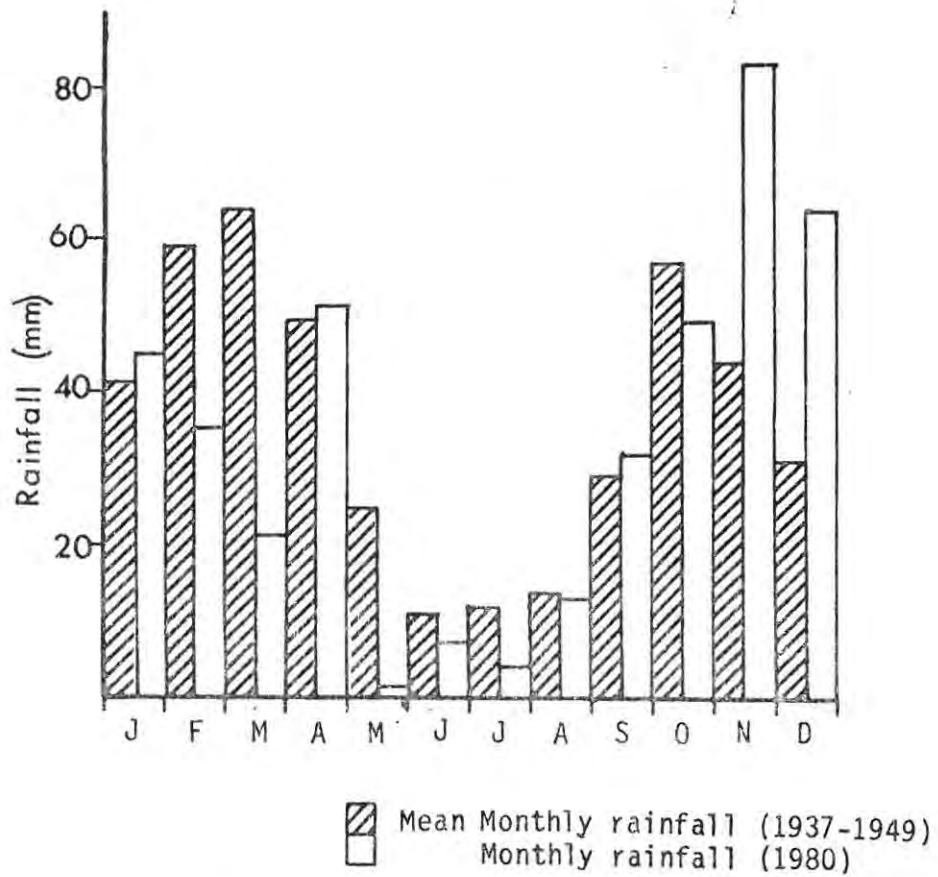
Table 1 shows the date, quantity, duration and rate of rainfall recorded during the study, with rates of fall in mm/hour. This was determined from the recorder charts of the Casella Natural Siphon Rainfall Recorder. Mean rate of fall was $2.05 \text{ mm hour}^{-1}$ ($s = 4, 19$). On 34 occasions (45%) rate of fall was $< 1.0 \text{ mm hr}^{-1}$. Advective fog was subjectively recorded when rate of fall was 0.05 and $0.13 \text{ mm hour}^{-1}$.

The weekly mean maximum, absolute maximum, weekly mean minimum and absolute minimum air temperatures for the duration of the study are presented in Fig. 6. Two periods were chosen during which measurement of temperature, relative humidity and precipitation were made simultaneously at four selected localities (weather stations) within the study area. These periods were chosen during February and June when extreme temperatures were most likely to be experienced. The physical



- a - number of recording years (rainfall)
- b - number of recording years (temperature)
- c - altitude (m)
- d - mean monthly temperature (°C)
- e - mean monthly rainfall (mm)
- f - highest annual rainfall
- g - mean annual rainfall
- h - lowest recorded annual rainfall

Fig. 4. The climate diagram of the study area.



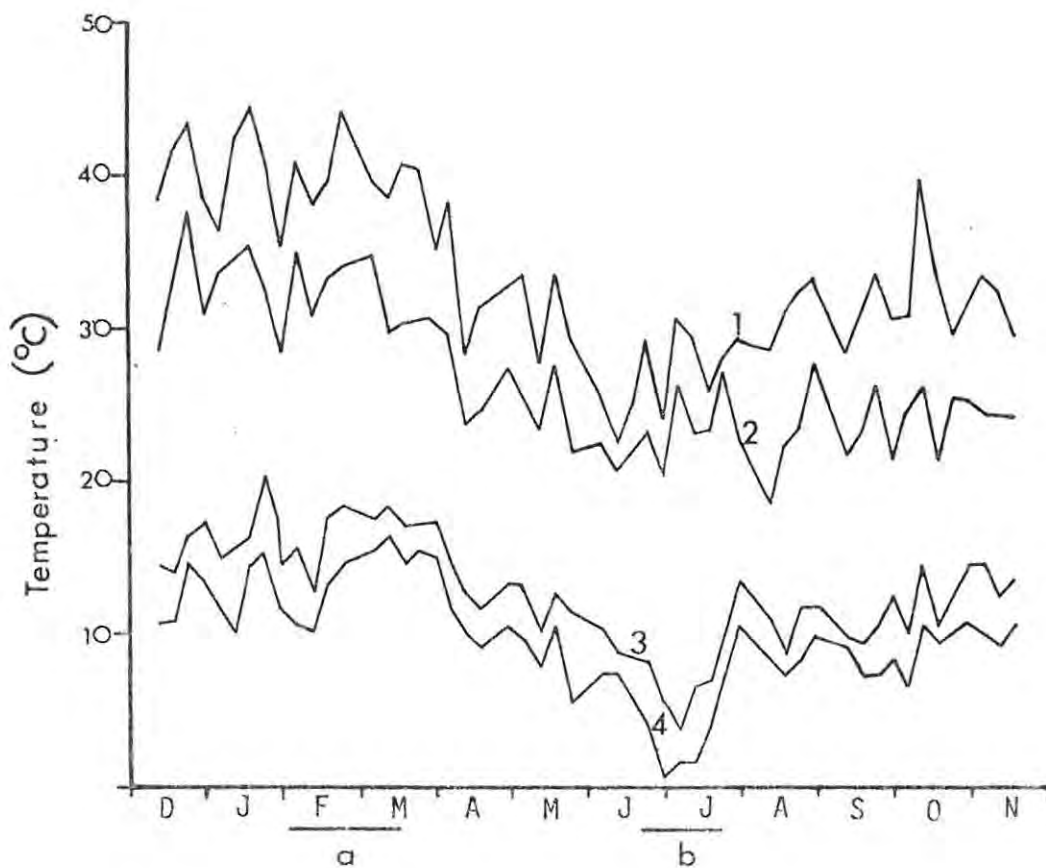
Correlation co-efficient (r) = 0.54
 $p < 0.05$

Fig. 5. Histogram of expected and received monthly rainfall during the study (Weather Bureau, 1954; 1965). Correlation co-efficient for the relationship between expected and received monthly rainfall is given.

DATE	RAINFALL (mm)	DURATION (hrs)	RATE OF FALL (mm hr ⁻¹)	DATE	RAINFALL (mm)	DURATION (hrs)	RATE OF FALL (mm hr ⁻¹)
23.12.79	1,3	0,3	3,94	14.06.80	2,2	-	-
24.12.79	3,6	2,6	1,38	21.06.80	1,17	2,33	0,5
24.12.79	14,2	13,3	1,07	21.06.80	1,33	1,33	1,0
25.12.79	1,4	5,0	0,28	28.06.80	1,5	2,67	0,56
25.12.79	2,6	2,6	0,98	29.06.80	1,58	8,0	0,2
26.12.79	2,6	0,5	5,2	16.07.80	5,5	-	-
21.01.80	0,7	0,66	1,06	23.07.80	2,17	4,67	0,46
21.01.80	3,8	0,66	5,76	08.08.80	0,83	9,67	0,09
21.01.80	2,7	2,0	1,35	09.08.80	4,67	2,00	2,34
21.01.80	0,4	0,66	0,61	09.08.80	2,0	6,67	0,3
23.01.80	26,1	24,7	1,06	10.08.80	2,08	1,67	1,25
25.01.80	1,8	0,66	2,73	10.08.80	1,17	0,67	1,75
28.01.80	9,2	2,66	3,46	13.08.80	0,42	1,33	0,32
03.02.80	0,9	0,17	5,29	17.08.80	0,66	4,0	0,17
06.02.80	1,0	1,66	0,6	19.08.80	0,92	0,67	1,37
07.02.80	0,7	0,5	1,4	26.08.80	1,33	1,0	1,33
07.02.80	1,75	2,5	0,7	01.09.80	0,17	0,33	0,52
08.02.80	6,2	2,5	2,48	06.09.80	7,83	34,0	0,23
16.02.80	4,6	7,66	0,6	17.09.80	0,42	0,33	1,27
18.02.80	0,75	0,66	1,14	20.09.80	0,17	0,33	0,52
22.02.80	4,0	0,66	6,06	22.09.80	12,17	4,67	2,61
24.02.80	1,5	0,66	2,27	25.09.80	0,66	0,67	1,0
26.02.80	2,33	4,0	0,58	26.09.80	9,17	14,0	0,66
26.02.80	6,17	0,66	9,34	27.09.80	3,33	4,0	0,83
27.02.80	2,33	4,0	0,58	28.09.80	2,67	12,0	0,22
27.02.80	4,0	7,33	0,55	16.10.80	16,83	14,67	1,15
05.03.80	3,17	2,0	1,58	17.10.80	2,0	2,67	0,75
06.03.80	9,42	3,33	2,83	18.10.80	24,83	12,67	1,96
13.03.80	8,00	5,0	1,6	28.10.80	2,67	3,33	0,8
15.03.80	0,5	4,0	0,13	31.10.80	3,0	17,33	0,17
20.03.80	1,0	1,67	0,6	03.11.80	1,83	1,0	1,83
03.04.80	34,5	1,0	34,5	06.11.80	0,66	0,67	1,00
04.04.80	1,0	2,67	0,37	07.11.80	3,33	1,0	3,33
09.04.80	1,17	0,17	6,88	13.11.80	3,5	2,67	1,31
09.04.80	8,17	4,0	2,04	23.11.80	6,0	15,33	0,39
10.04.80	5,75	3,0	1,92	24.11.80	19,8	4,67	4,24
11.04.80	0,42	2,0	0,21				
16.04.80	3,25	1,0	3,25	Total	334,88mm	319,45 hrs	
18.04.80	0,17	3,33	0,05		$\bar{x} = 4.34$ *	$\bar{x} = 2.05$ **	
24.04.80	0,83	3,33	0,25		s = 5.83	s = 4.19	
24.05.80	0,33	0,67	0,49		n = 77	n = 75	

Table 1. Daily rainfall (mm), duration (hours) and rate of fall (mm hr⁻¹) from December 1979 to November 1980. Mean rate of fall was 2.05 mm hr⁻¹.

*mm/occasion **mm/hr



'a' and 'b' = periods during which comparative measurement took place

Fig. 6. Air temperatures (1 = absolute maximums; 2 = weekly mean maximum; 3 = weekly mean minimums; 4 = absolute minimum) recorded at Grasslands during the study.

characteristics of each weather station are presented in Table 2. The means, standard deviations, two standard errors and ranges of the air temperatures of each station are presented in the form of Hubbs & Hubbs (1953) dice-diagrams (Fig. 7 & 8). The results of oneway analysis of variance (Nie et al., 1970) using the SPSS software package (Statistical Package for the Social Sciences) on the Rhodes University computer (ICL 1904S), are presented in Tables 3 & 4. Scheffe's, Tukey's and the LSD (least significance difference) multiple range tests were applied.

Data on relative humidity recording, wind speed and direction, dew deposition and cloud cover are not been presented here as these parameters need to be monitored continuously.

Station	TH1	TH2	TH3	TH4
Altitude (m)	401	320	330	380
Aspect (°)	153°	23°	133°	23°
Slope (°)	5	0	5	0
Physiognomic Class of Adjacent Vegetation	Dry forest	Succulent Scrub	Succulent Bushclump Savanna	Succulent Bushclump Savanna
Community Number	3	2.1.1	2.1	2.2.1

Table 2. The physical characteristics of each of the four weather stations in the study area.

Maximums

<u>Oneway Analysis of Variance</u>		
Degrees of freedom	F-ratio	F-probability
3, 105	1.689	0.172
<u>Homogeneity of variance</u>		
Cochrans C test = 0.2955		p = 0.652
Bartlett's Box F = 0.182		p = 0.907
<u>Multiple range tests</u>		
All stations fell within the same homogeneous subset.		

Minimums

<u>Oneway analysis of variance</u>		
Degrees of freedom	F-ratio	F probability
3,105	0.594	0.624
<u>Homogeneity of variance</u>		
Cochrans C = 0.2820		p = 0.853
Bartlett's Box F = 0.124		p = 0.942
<u>Multiple range tests</u>		
All stations fell within the same homogeneous subset.		

Table 3. Oneway analysis of variance, homogeneity of variance and multiple range tests after Nie et al. (1970) for the February maximum and minimum air temperatures.

Maximums

Oneway Analysis of Variance		
Degrees of freedom	F-ratio	F-probability
3, 113	5.231	0.002
(F _{.01} [3,113] = 3.85)		
F _s F _{.01} , ∅ rejected		
Homogeneity of variance		
Cochrans C test = 0.2808		p = 0.854
Bartlett's Box F = 0.104		p = 0.953
Multiple range tests		
Scheffe's (0.01)		
TH1	TH4	TH2

	TH4	TH2

		TH3
Tukey's (0.05)		
TH1		
	TH4	TH2

		TH3
LSD (0.01)		
TH1		
	TH4	TH2

		TH3

Minimums

Oneway analysis of variance		
Degrees of freedom	F-ratio	F probability
3,113	3.993	0.01
Homogeneity of variance		
Cochrans C = 0.2965		p = 0.617
Bartlett's Box F = 0.273		p = 0.846
Multiple range tests		
Scheffe's (0.01) not significant		
Tukey's (0.05)		
	TH3	TH4

		TH2
		TH1
LSD (0.01)		
	TH3	TH4

		TH2
		TH1

Table 4. Oneway analysis of variance, homogeneity of variance and multiple range tests after Nie et al. (1970) for the June maximum and minimum air temperatures.

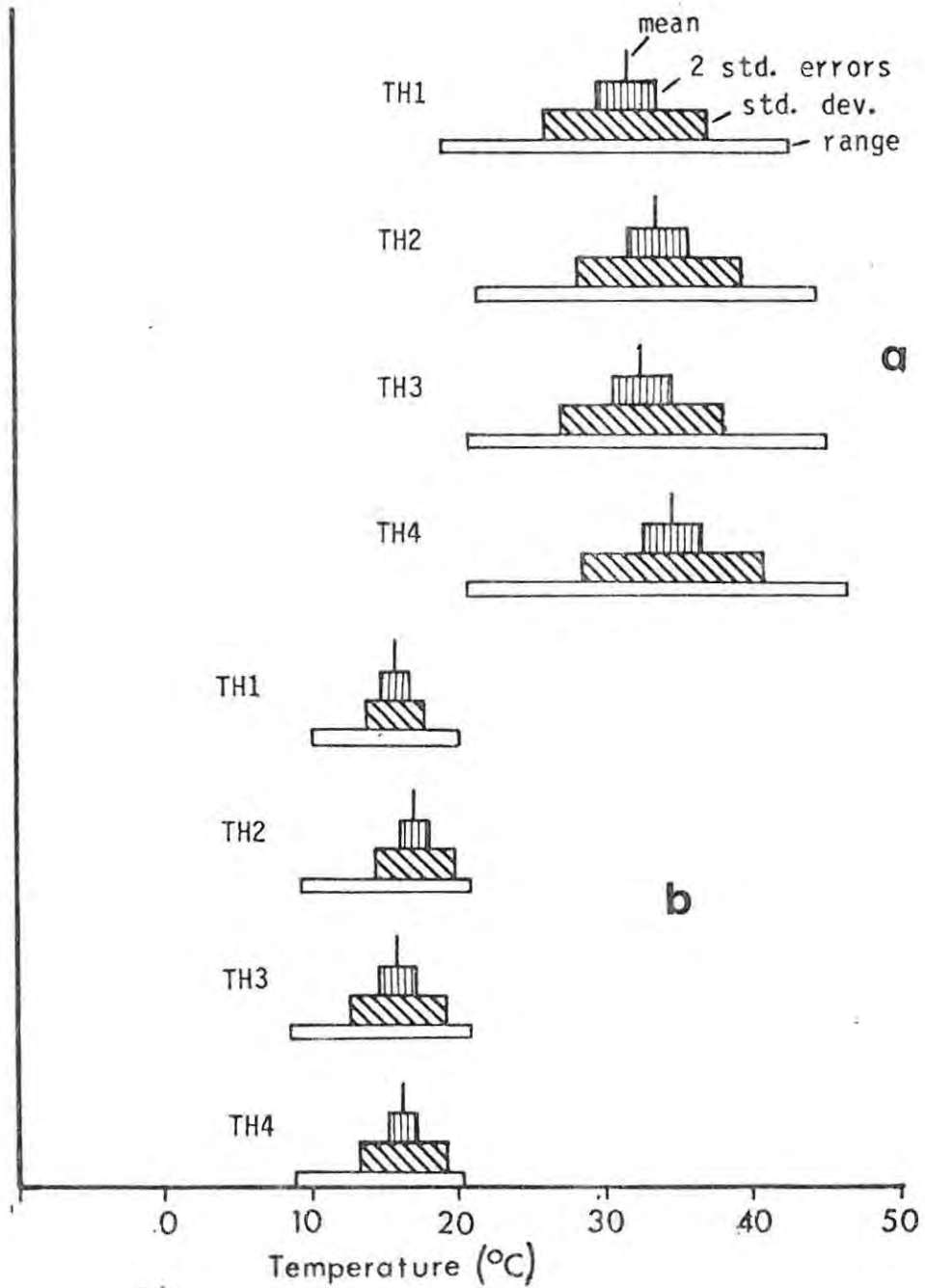


Fig. 7. Hubbs & Hubbs (1953) dice-diagrams for maximum (a) and minimum (b) air temperatures during February 1980 at four weather stations within the study area.

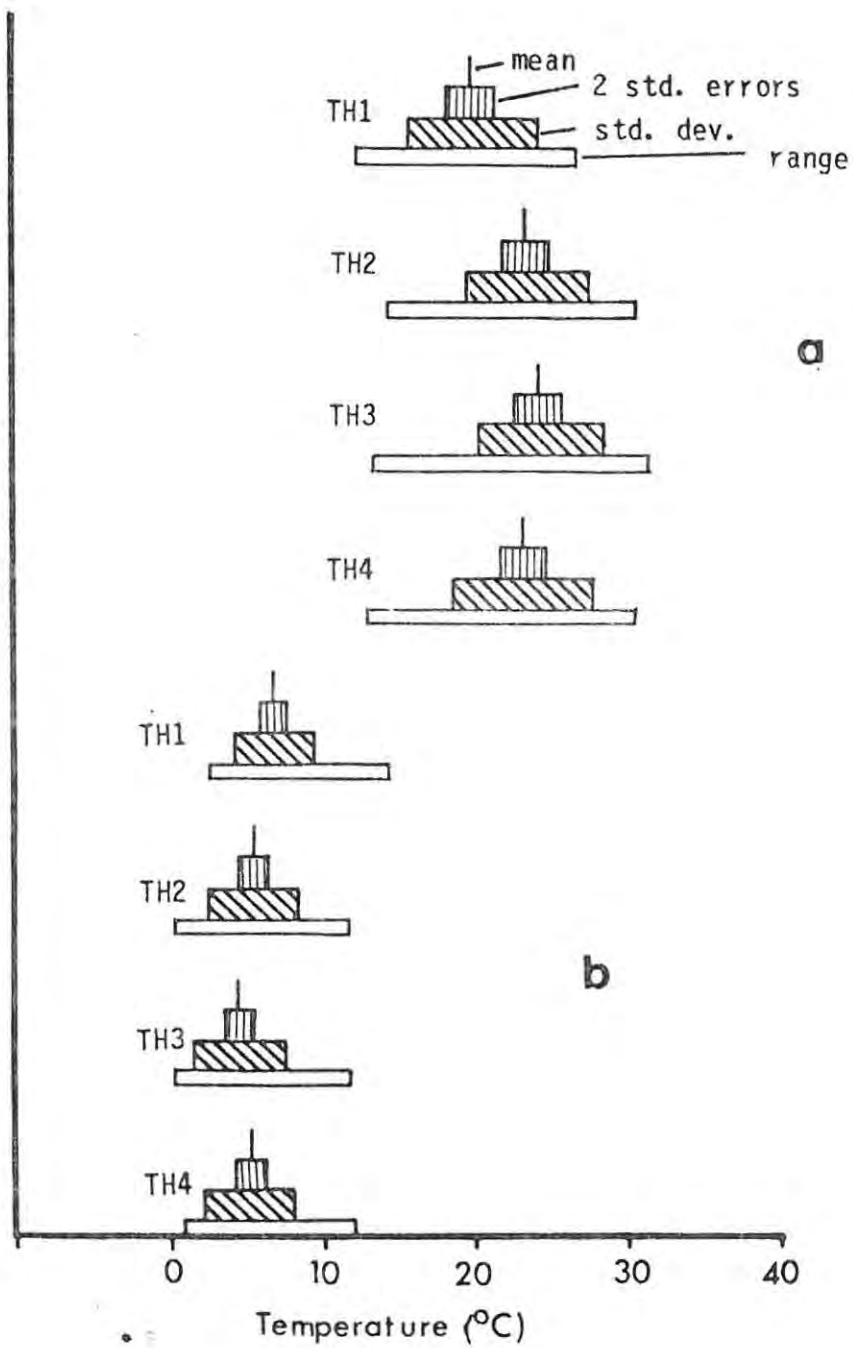


Fig. 8. Hubbs & Hubbs (1953) dice-diagrams for maximum (a) and minimum (b) air temperatures during June/July 1980 at four weather stations within the study area.

2.4 DISCUSSION

2.4.1 GENERAL

According to the Koppen climatic classification (Schultze, 1947), the climate of the area is Cfa (C=warm temperate climate-coldest months 18°C to -3°C ; f=sufficient precipitation during all months; a=warmest month over 22°C).

The year can be divided into four seasons according to the climate diagram. These are

- i) a wet, cool spring (September - November);
- ii) a dry, hot midsummer (December);
- iii) a long hot wet summer/autumn (January to April) when expected rainfall is highest and temperatures may exceed 45°C ; and
- iv) a cool dry winter (May-August).

2.4.2 TEMPERATURE

The results of the simultaneous comparative temperature recording at the four stations (Figs. 7 & 8) confirm that air temperature differences do exist between localities. Tukey's and LSD multiple range tests indicated that TH1 experienced significantly lower maximum temperatures during the winter months. Winter minimum temperatures at TH1 were higher than at the other stations. Neither maximum nor minimum temperatures in the summer showed any statistically significant differences between stations. On the basis of Schultze's (1975) model, the following solar radiation flux densities would be expected for the four stations:

Predicted radiation flux density ($10^6 \text{Jm}^{-2} \text{day}^{-1}$)		
Station	Mid-winter	Mid-summer
TH1	16	32.6
TH2	12.5	32.7
TH3	16.5	32.0
TH4	12.5	32.7

The results obtained in this study affirm these predictions. This winter/summer variation in the macroclimate must be taken into account when determining the habitat preference of wild ungulates.

One of the aims of the study has been to describe more accurately the subjective observation made by Acocks (1953) that the vegetation is a product of the exacting climatic conditions which prevail in the Great Fish River valley. The results of the temperature and precipitation measurements indicate that extreme climatic conditions prevail in the Fish River Valley. These include high maximum summer temperatures (45°C), low winter minimum temperatures (-2°C) associated with extremely dry conditions and wide daily temperature fluctuations.

2.4.3 PRECIPITATION

The historical reliability of total monthly rainfall at the 60% confidence limit has been included in Fig. 9 from the research of Buys et al. (1979). According to these authors there is a

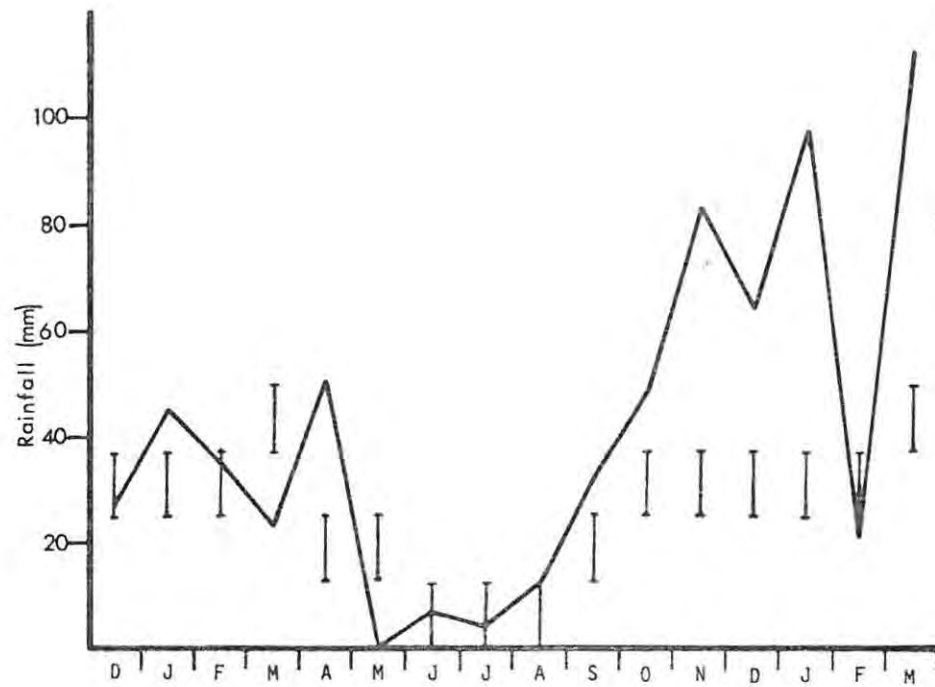


Fig. 9. Total monthly rainfall on AVKR during the study.
 Vertical bars = probability at 60% confidence level
 (Buys *et al.* 1979).

reliable rainfall peak in March and a trough in June, July and August. This is in agreement with the data collected in this study. The year 1980 can be regarded as "normal" for the study area in terms of the amount and distribution of total rainfall. This has particular reference to the section on the phenology of the flowering plants (Section 4).

The mean rate of rainfall during the study was low (2.05 mm hr^{-1}) and the rainfall recorder was sufficiently sensitive to detect extremely light falls (0.13 mm hr^{-1}). This was a common form of precipitation at the Grasslands station (45% of occasions when rate of rainfall was $<1.00 \text{ mm hr}^{-1}$). Light rains of long duration are beneficial to the vegetation and soil, and this may explain the presence of mesic vegetation in an otherwise dry, extreme environment.

Marloth (1903) initiated fog sampling in South Africa on Table Mountain, and his results indicated that advective fog was a major source of precipitation which was not recorded by a conventional raingauge. However, Stewart (1903) showed that Marloth's fog sampling was inaccurate because the effective area of precipitation collection was greater in the sampler than in the conventional raingauge. Marloth (1905) defended his work, but the evidence is inconclusive, as the fog sampler used was extremely crude. A more carefully constructed sampler was used during this study (Fig. 3), however the results remain unconvincing.

Robinson & Seely (1980) have demonstrated that advective fog is a major contributor to precipitation in arid ecosystems, and in the Namib desert the co-efficient of variation of fog is three times less than that of rainfall i.e. "the occurrence of fog in a given month is three times more likely than rainfall". The fog droplet sampler used during this study was not effective in measuring significant quantities of fog, as precipitation from rain was too great. However, advective fog was observed within the study area, indicating that the unreliable rainfall may have less impact on the vegetation than was previously suggested.

A modified fog droplet sampler, constructed from stainless steel wire mesh, is currently being tested in the study area. Preliminary results (Table 5) indicate that this would be more successful in monitoring precipitation from fog. In addition the stainless steel acts as a good condensing surface and does not corrode, as is the case with steel wire.

DATE	RAIN & MIST (mm)	RAIN (mm)	MIST (mm)	% accounted for by mist
22.03.81	32.0	28.6	3.4	12.0
23.03.81	8.5	8.0	0.5	6.25
24.03.81	28.0	18.6	9.4	50.5
25.03.81	58.0	42.4	15.6	36.8
29.03.81	2.8	-	2.8	100
13.04.81	1.5	-	1.5	100
16.04.81	0.8	0.5	0.3	60
22.04.81	2.0	-	2.0	100
26.04.81	7.0	6.2	0.8	12.9
06.05.81	12.0	8.8	3.2	36.3
09.05.81	3.1	2.8	0.3	10.7
11.05.81	4.0	3.6	0.4	11.0
12.05.81	2.8	2.4	0.4	16.6
13.05.81	1.4	1.2	0.2	16.6
28.05.81	14.2	13.8	0.4	2.9
06.06.81	36.0	26.0	10.0	38.0

Table 5. Advective fog records from the study area using the improved fog droplet sampler.

3. VEGETATION SURVEY

3.1 INTRODUCTION

Moore et al. (1970) conclude that the Braun-Blanquet method combines several advantages over other phytosociological techniques, and is most economical in terms of time input and information emerging. Werger (1974), Coetzee & Werger (1975) and Boucher (1977) provide the impetus for the continued use of the Braun-Blanquet phytosociological method of vegetation survey in southern Africa.

Quantitative analysis of the mineral composition and structure of the soils yields valuable insight into the relationship between soil and vegetation (Eyre, 1971). Most ecological studies include information on soil analysis (Coetzee et al., 1976; Van der Merwe, 1976; Huntley & Birks, 1979; Jooste, 1980), but an explanation of the relationship between soil and vegetation is often neglected. The soil of the study area was analysed (Crook, 1981) with a view to interpreting the plant/soil relationships.

A vegetation map provides an invaluable basis for a management programme (Werger, 1977a). Various mapping alternatives were investigated (Werger, 1977a; Webb & Haskins, 1980; Jarman et al., 1981), but a subjective technique was adopted as it would provide a map suitable for management purposes.

3.2. MATERIALS AND METHODS

3.2.1 SAMPLING PROCEDURE

Details concerning the Braun-Blanquet technique are well documented (Poore, 1955a, 1955b, 1956; Moore, 1962; Muller-Dombois & Ellenberg, 1974; Werger, 1974; Van der Maarel, 1975; Westhoff & Van der Maarel, 1978), however a description of particular aspects of the sampling strategy employed in this study is necessary.

Werger (1974) stresses, "the area of investigation must be well known in all its variety before the study is started." A prerequisite to the field sampling was an extended visit to the study area in March 1979. A technique similar to that used by Coetzee (1974) and De Moor et al. (1977) was employed, and the area was traversed extensively both in a vehicle and on foot for a period of two weeks. A preliminary physiognomic map (Fig. 10) of the study area was drawn from monochromatic aerial photographs taken in 1973 (scale 1:50 000). This initial survey established that:

- a) the entire study area is not physiognomically homogeneous. The vegetation comprising the largest area of the reserve is similar to the heterogeneous bushclump savanna described by Martin & Noel (1960).
- b) taller, homogeneous dry forests (Story, 1952; Comins, 1962) are characteristic of the steep drainage lines of the southern slopes.
- c) riparian thicket occurs along the more gently sloping drainage lines, and
- d) succulent karroid scrub vegetation is a feature of the flatter, western area.

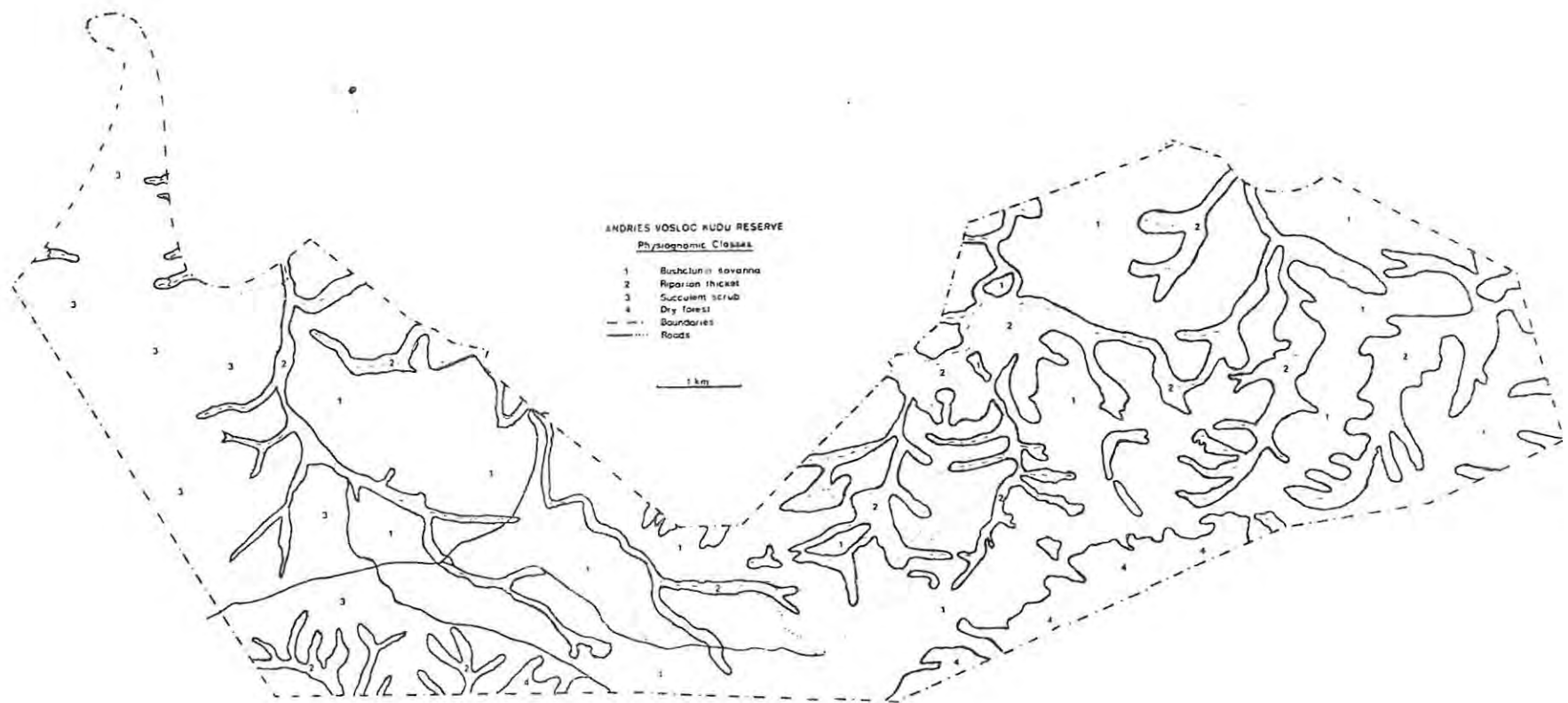


Fig. 10. Map of the physiognomic classes of the vegetation of the study area. Drawn from aerial photographs.

The bushclump savanna, riparian thicket and succulent karroid scrub were the physiognomic classes chosen for investigation in this study, and quadrats were selected within these three classes.

A study of the phytosociology of the riparian thicket was made in March 1977 by Dr. R.A. Lubke and students of the Department of Plant Sciences at Rhodes University. These unprocessed data were checked by re-examining some of the permanent quadrats and plant species identifications were verified. The data were then included in the present study.

Coetzee & Nel (1978) recommend that in a situation where the vegetation is a mosaic of various physiognomic classes, these classes should be surveyed separately. However, in the earlier work, a fixed-area quadrat had been chosen for statistical reasons (Lubke pers. comm.) and its use was continued during this study. Quadrats surveyed using this quadrat size invariably included at least two different structural classes (bushclumps and grasslands).

Quadrats were selected using a representative sampling strategy (Werger, 1977a), and marked at one corner with a steel dropper and a galvanised iron number tag. An accurate compass reading, using a Recta oil floated compass, was taken along one

edge of the quadrat to ensure that subsequent studies would be able to relocate quadrats from the marker. The aspect ($^{\circ}$) of the quadrat was measured using a compass following a subjective assessment of the general direction of slope. A magnetic declination of $23^{\circ} 7'$ (1976.0) was then added to the reading (magnetic north is $23^{\circ} 7'$ west of north). Each quadrat was located accurately on a 1:18 000 topographical map (Fig. 2). Where quadrats were a great distance from easily recognisable landmarks, steel droppers were used as survey point markers (SP), and were located at accessible points. Direction and distance details of the quadrat from the survey point were noted on the data sheet. The slope of the quadrat was measured in degrees using an Abney level (Francis Barker & Son Ltd., Kent). When this instrument was not available, slope was estimated by measuring elevation change along 10 metres of a nylon measuring tape. Height and percentage cover of each stratum of the vegetation was estimated. A special note was also made of any biotic factors which may have been influencing the vegetation within the quadrat.

The ideal quadrat size in Braun-Blanquet surveys has been discussed at length by various authors (Hopkins, 1957; Goodall, 1963; Werger, 1972). Hopkins (1957) defined "minimal area" as the smallest area which can contain an adequate representation of an association. Werger (1972) described the 100 m^2 quadrat as the one which gave "the most favourable balance between information obtained and effort expended" in the savanna of southern Africa. Werger (1977a) noted that in the savanna and

woodland vegetation of Africa a large plot size (10 x 20 m) is required to adequately represent the structure of the vegetation. Although the plot size was not determined by the conventional method (species-area curve) for this study, the 100 m² plot was chosen as it is in agreement with the findings of other researchers in southern Africa (Lubke, pers. comm.).

Plots measuring 10m X 10m (100m²) were demarcated using two 20 metre nylon measuring tapes. A total floristic list was drawn up, and any new or doubtful species were collected and pressed for identification. Cover abundance values (Table 6) were based on the scale of Barkman *et al.* (1964) in which the scale unit 2 is divided into 2m, 2a and 2b. These values have been subsequently used by other workers (Werger, 1974). Sociability was also noted for all species collected, and was recorded on the scale presented in Table 6. The soil of each plot was examined *in situ*, and composition and depth were recorded using the categories of Aircraft Operating Company (A.O.C.) Technical Services (1968). All information was noted on the Field Data Sheet designed by the Botanical Research Institute, Department of Agriculture and Fisheries, Pretoria.

3.2.2 COLLECTION AND ANALYSIS OF SOIL DATA

61 soil samples from 31 relevés were collected in a single operation in August 1981 (Crook, 1981). A sample of 50-100 cm³ was collected from the A-horizon of two representative soil pits within the 30 relevés using a hand-held soil auger. A

BRAUN-BLANQUET COVER ABUNDANCE VALUES

- r = very rare - a single individual (negligible cover)
- + - present but not abundant (cover <1%)
- 1 - numerous but cover <1% or not so abundant but cover 1-5%
- 2m - very numerous, covering <5%
- 2a - 5-12% cover, independent of abundance
- 2b - 13-25%, independent of abundance
- 3 - cover between 26 and 50%
- 4 - cover between 51 and 75%
- 5 - cover between 76 and 100%

SOCIABILITY

- 1 - single individuals
- 2 - grouped or tufted
- 3 - in groups, patches or cushions
- 4 - in small colonies, extensive patches or forming carpets
- 5 - in extensive crowds or pure populations

Table 6. Cover-abundance values and sociability scales used in the Braun-Blanquet phytosociological survey. Cover-abundance values according to Barkman et al. (1964) and sociability scales according to Werger (1974).

further sample was collected from an unclassified quadrat within the dry forest physiognomic class. In quadrats where floristic sampling had been physiognomically heterogeneous, a soil sample was collected from beneath the bushclump and within the grassland. The soil pH was measured in a 1:5 soil:distilled water paste using a Metrohm pH meter Model E280A. The moisture content (%) of the soil was determined by weighing the samples before and after drying at 105°C. Organic content was estimated by measuring loss-in-dry weight upon ignition at 400°C for 8 hours in a muffle furnace (Huntley & Birks, 1980). Conductivity was measured using an Electronics Switchgear conductivity meter Model MC-1, Mark V. Potassium (K), Calcium (Ca), Sodium (Na) and Magnesium (Mg) concentrations were determined using an atomic absorption spectrophotometer (Crook, 1981).

3.2.3 NUMERICAL ANALYSIS OF SOIL DATA

The soil data of the sixty one samples consists of eight variables (moisture content, organic content, conductivity, pH, K, Ca, Na and Mg). Ordination of the plots on the basis of the soil data was carried out using Principal Components Analysis (PCA) of the correlation matrix of the eight variables. The analysis was implemented by the computer program COMP1 written by L. Orloci and translated from ALGOL to FORTRAN by R.A. Lubke. The data points were plotted using the plotting program PHCM written by H.C. Murrell (Appendix 3).

3.2.4 VEGETATION MAPPING

Aerial survey photograph interpretation (1973-scale 1:50 000), did not yield a map which was compatible with the ground control information. A mapping technique had to be developed which would suit both the financial limitations and ecological aims of the project. Jarman *et al.* (1981) developed a suite of computer programmes for mapping the extensive Fynbos Biome using computer compatible tapes of LANDSAT 1 and 2 imagery. The suite applies the principle that each vegetation type has a characteristic spectral reflectance called "chromatic signature". Each "chromatic signature" consists of a combination of colours within the recognisable spectral range of the three recorded wave bands (blue, green and red). In this study, the "chromatic signature" of each community was recognised subjectively after enlarging a colour transparent product of LANDSAT 2.

The plant community map (Fig. 11) was prepared using a colour transparency of the LANDSAT 2 image (Scene 22169-07195 (182-83)) processed at a scale of 1:1 000 000 by the Satellite Remote Sensing Centre of the CSIR. The processed image, recorded on 30 December 1980 at 09h20, was too small for detailed mapping of the study area and was enlarged in a Mod II Mini Cat micro-Fiche reader (Ozalid (Pty) Ltd.). The image projected onto the screen of the micro-Fiche reader at a scale of approximately 1:45 000. Major landmarks (rivers, towns, mountain ranges, cultivated lands and impoundments) were recognised, and the study area was positioned on the micro-Fiche screen. The outline of the Great Fish river was drawn onto Ozotex semi-matt tracing paper.

The outline was placed on the upper surface of a Planvariograph (R. & A. Rost, Wien), and a 1:50 000 SA Topo Series map was adjusted to match the scale of the image outline. There were minimal magnification distortions, and the image and map matched extremely well. Detailed information from the Topo map (fences, roads, spot heights, earth dams, perennial streams) were then included on the overlay. The transparent map prepared in this manner was once again superimposed upon the enlarged image on the micro-Fiche reader. The boundaries of each "chromatic signature" were mapped on the detailed overlay. The relationship between "chromatic signature" and plant community was determined subjectively after examining the distribution of relevés representing each community on the 1:18 000 map. Piper (unpubl.) mentions that this manual method of interpreting LANDSAT imagery may be used when computer processing facilities are not available.

3.2.5 SORTING OF PHYTOSOCIOLOGICAL DATA

Species presence and cover abundance data were sorted on the ICL 1904S computer (192K) at the Rhodes University Computer Centre, using the program prepared by Ceska & Roemer (1971). The data were not suited to the use of this program, and only the rewriting mode, in which both components of the species group and relevé sequence were predetermined, was used. The program was used to assist with the physical rearrangement of

3.3 RESULTS

3.3.1 PHYTOSOCIOLOGY - PHYTOCOENA (Plant communities)

The results of the survey are presented in the form of two phytosociological tables (Table 7 & 8). Each column represents a relevé, and the rows represent species occurring in these stands. Cover abundance symbols (Table 6) for every species represented in each relevé are entered in the matrix. The subdivisions of cover abundance class 2 (Table 6) are not shown in Tables 7 & 8. Species with similar distribution patterns are grouped together, and differentiate groups of relevés. Each group typifies a plant community at a particular level in the hierarchy (Coetzee et al., 1976).

Table 7 presents the floristic details and edaphic characteristics of the drainage line and non-succulent bushclump savanna community. The soil data given in Tables 7 & 8 refers to soil samples collected within the bushclumps. The results of the soil analysis are given to the nearest whole number to facilitate presentation. The floristic details and edaphic conditions prevailing in the succulent bushclump savanna and dry forest communities are presented in Table 8. Tables 7 & 8 are summarised in a Roman table (Table 8a).

Three communities are recognised, based on the presence of differentiating species. These are the:

- a) Walafrida geniculata-Felicia muricata community of the drainage lines and non-succulent bushclump savanna;

- b) Portulacaria afra-Barleria obtusa community of the succulent bushclump savanna and thicket;
- c) Hippobromus pauciflorus-Schotia latifolia community of the dry forests.

The code of phytosociological nomenclature (Barkman et al., 1976) was not adhered to in the naming of communities. Final decisions on nomenclature will only be possible after further co-ordinated research in this field in southern Africa. Communities were named using two species names and a descriptive habitat characteristic. These species names were chosen subjectively, irrespective of constancy within the community. Variation and sub-variation names included a species name from the species group diagnostic of the variation. This conforms with the trend practised by other southern African phytosociologists (Werger, 1973; Coetzee, 1974, 1975; Bredenkamp & Theron, 1976, 1978; Coetzee et al., 1976; Boucher, 1977; Coetzee & Nel, 1978; Jooste, 1980). Constancy values (%), based on the presence of the species within the field of the community, are quoted for some species mentioned in the community description. The "field of the community" is defined as the number of relevés in which the community is recorded.

THE DRAINAGE LINE AND NON-SUCCULENT BUSHCLUMP SAVANNA COMMUNITY

1. Walafrida geniculata-Felicia muricata community of the drainage lines and non-succulent bushclump savanna.

The mesic vegetation of the study area is associated primarily with the numerous drainage lines which traverse the reserve. Soils are generally deep and structureless with the presence of unoxidized shale in the profile, giving the soil a stoney appearance. The basement of the drainage lines consists of resistant mudstones and sandstones, and overlying these are soils of secondary origin. The soil texture is predominantly clayey, but with organic and sand components. The sandy component originates from the erosion of the more resistant sandstone layers within the Ecca series. The pH ranges from 5.4 to 6.6, and there is a trend towards a higher pH in the less mesic relevés of this community (Table 7). Moisture content shows a distinct gradation from high on the left hand side of Table 7 to low on the right hand side.

The most abundant differentiating species of this community is the karroid chamaephyte Helichrysum rosum which occurs in 75% of the relevés within the community. A perennial karroid component, with Walafrida geniculata (54%), Felicia muricata (58%), Chrysocoma tenuifolia (41%) and Pentzia incana (29%) as major representatives, is a conspicuous aspect of this community. Other diagnostic species include Clutia laxa (58%) and the perennial grass Sporobolus fimbriatus (37%), which is adapted to the moist soils. Species diversity within this community is variable, with the number of species per relevé

ranging from 14 (disturbed areas) to 45 (preserved examples). Two pioneer grasses of denuded areas, Eragrostis obtusa and Aristida congesta, are abundant. Both of these species are weak perennials under suitable conditions (Tainton et al. 1976). This abundance is apparently a consequence of earlier management, when domestic livestock (mainly cattle) over-utilized the areas adjacent to water supplies.

The community is represented in 24 relevés, and has been divided into 2 variations and 6 sub-variations based on the presence of differentiating species groups. These are:

1.1 Rhus refracta-Walafrida geniculata variation

The species group which distinguishes this variation from the others in community 1 consists of predominantly woody species. Diagnostic species include Acacia karroo (75%) and Rhus refracta (69%). The variation has a field of 16 relevés and is restricted to the drainage lines of low altitude (270-411 m). Soil erosion cycles have been exaggerated by the utilization of these areas by domestic stock during previous management. Associated woody species include Combretum caffrum

and Buddleia saligna. The vegetation may achieve a height of up to 5 metres in areas where the moisture regime is favourable.

Du Toit (1967) has demonstrated that Acacia karroo is a perennial encroacher which thrives under conditions of over-utilization. The abundance of Acacia karroo in this variation may be an indication of historical mismanagement. Acocks (1975) regarded this invasion as being of such great importance that he established a Veld Type (False Thornveld of the Eastern Province) to describe the vegetation changes which are taking place.

1.1.1a Rhus refracta-Walafrida geniculata sub-variation.

This sub-variation possesses the same differentiating species groups as the parent community. No other differentiating species group was present. The sub-variation has a field of 5 relevés. Pentzia incana had high cover-abundance values within three of the relevés, but cannot be considered differentiating because of its ubiquity.

1.1.1b Mariscus capensis-Rhus refracta-Walafrida geniculata sub-variation

This sub-variation has a field of 5 relevés and is characterised by sedges (Mariscus capensis) and sour grasses

(Hyparrhenia hirta and Schismus inermis). Number of species per relevé ranges from 20 to 33, and total percentage cover varies from 60 to 90%. Moisture content of the soil is high (10.8-15.5%), which may explain the high percentage cover.

1.1.2 Olea africana-Rhus refracta-Walafrida geniculata sub-variation.

This sub-variation of the Rhus refracta-Walafrida geniculata variation has a field of 6 relevés. Diagnostic species are Olea africana (50%) and Lasiocorys capensis (83%). The trend within the community is towards a less mesic environment, and therefore a reduction in the height of the woody component (height range 1.5-2.5 m). Relevés within this variation were of slightly greater altitude, than those of 1.1.1 (410-426 m).

1.2 Eragrostis lehmanniana-Walafrida geniculata variation

This variation of community 1 is characterised by a species group composed of chamaephytes, succulents and grasses of karroid origin. The relevés within the variation are situated predominantly in the non-succulent bushclump savanna. Species diversity remains high (33-45 species per relevé), but

overlap between community 1 and community 2 is evident. The presence of annual and weak perennial species indicates that historical mismanagement may have influenced floristic composition. The fire climax grassland of the study area, a Cymbopogon plurinodis-Themeda triandra association, is present within this variation. Because of the abundance of these grass species in the community 2, they are not regarded as diagnostic of a subvariation.

1.2.1 Becium burchellianum-Eragrostis lehmanniana-Walafrida geniculata sub-variation

A minor variation of 1.2 is characterised by a species group which is diagnostic of more xeric conditions. This variation is restricted to areas of gentle to flat slope and was only recognised in 3 relevés. Becium burchellianum and Polygala leptophylla, the two important differentiating species, were usually associated with extreme xeric environments within the study area e.g. community 2.1.1. (Senecio radicans-Hibiscus pusillus-Barleria obtusa variation).

1.2.2 Rhus incisa-Eragrostis lehmanniana-Walafrida geniculata
sub-variation

This sub-variation is restricted to relevés of higher altitudes (426-430m), with mostly clay soils. The sub-variation represents the non-succulent bushclump savanna (Plate 2). The early geological maps (Mountain, 1946) of the area indicate the presence of rocks of doleritic origin. This may account for some of the differences in species composition of the vegetation. Diagnostic species include Rhus incisa, Scutia myrtina, and Cassine crocea. Relevés are south facing, and the environment is cooler and more mesic (possibly as a result of advective fog). Total % cover is generally high (95%) and the vegetation of the relevés may be up to 3,0 m in height. The sour grass Merxmüllera disticha and a species of Capensis origin, Merxmüllera disticha, are present within this sub-variation. Merxmüllera disticha is usually associated with soils of doleritic origin (Stormberg Series) where Acocks (1975) described the Karroid Merxmüllera Mountain Veld in the eastern Cape midlands.

1.2.3 Anthospermum aethiopicum-Eragrostis lehmanniana-
Walafrida geniculata sub-variation

This sub-variation consists of two relevés, with altitude varying from 407-450 m, and having a northern aspect. Species diversity varies from 35-41 species per relevé. Differential



Plate 2. A photograph of a relevé within the non-succulent bushclump savanna (variation 1.2).

species include Anthospermum aethiopicum, Lotononis pungens and Gazania linearis. The soil sample collected from this variation had low K and Ca concentrations, and had a clayey texture. The differential species of the Eragrostis lehmanniana-Walafrida geniculata variation (1.2) are well represented.

SUCCULENT BUSHCLUMP SAVANNA AND DRY FOREST COMMUNITIES (Table 8)

2. Portulacaria afra-Barleria obtusa Bushclump community

The second phytocoena encountered within the study area is the vegetation of the succulent bushclump savanna formation recognised by Martin & Noel (1960). This is a community of the xeric areas of the reserve, on soils of predominantly mudstone or shale origin. Portulacaria afra (70%) and Barleria obtusa (64%) are the major diagnostic species. P. afra is an important primary producer in the study area and throughout its range in the eastern Cape, it is associated with soils of shale origin. This has been personally noticed in the Noorsveld (near Steytlerville), and Succulent Mountain Veld (near Graaff-Reinet), as well as in the present study. The community has a field of 44 relevés and species diversity within the community is high. Panicum deustum and Panicum maximum are two shade-loving grasses which are strongly associated with the bush clumps. This community is a complex mosaic of two variations and six subvariations.

The general trend within Table 8 is from the xeric variations of the community, situated in the western side of the study area, to the mesic valley bushveld of the eastern side.

2.1 Hibiscus pusillus-Barleria obtusa variation (Plate 3)

This variation of the Portulacaria afra-Barleria obtusa community is found on shallow soils with a clayey texture. The A-horizon of the soil profile has mostly been eroded away, and only examples of the old soil profile are found within the Euphorbia bothae/Rhigozum obovatum clump. The soils are minerally rich with high concentrations of Na and K, but organic and moisture content is low. pH tends to be high ($x = 6.8$; $\text{max} = 7.4$) as a result of high mineral content and the 'young' age of the soils. Hibiscus pusillus (69%), Kalanchoe rotundifolium (77%) and Asparagus striatus (77%) are the important diagnostic species. The variation has a field of 13 relevés and is associated with the gently sloping to flat regions of the study area. A Euphorbia sp./Rhigozum obovatum association has been recorded previously in the drier Noorsveld near Steytlerville (Van der Walt, 1969).

2.1.1 Cymbopogon plurinodis-Hibiscus pusillus-Barleria obtusa subvariation

This variation is characterised by two fire climax grasses of the savanna of southern Africa, Cymbopogon plurinodis and

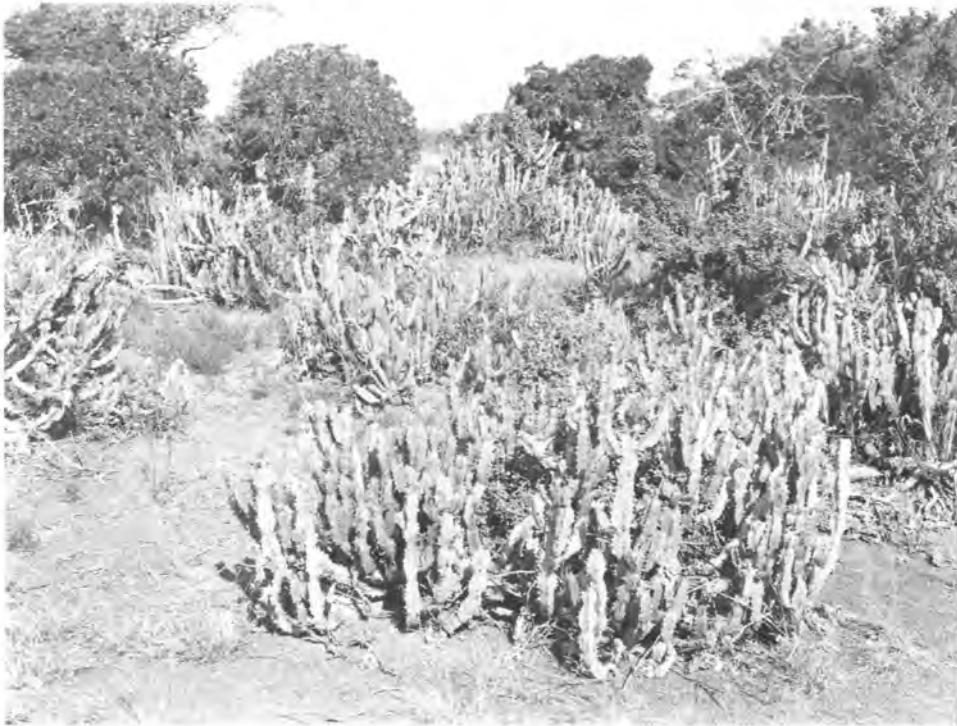


Plate 3. A photograph of the succulent bushclump savanna, showing clumps separated by grasslands and low growing karroid scrub.

Themeda triandra. The soils are deep , and less disturbed, with the A-horizon remaining intact. This subvariation is divisible into two sections, each of which will be discussed separately.

2.1.1a Senecio radicans-Hibiscus pusillus-Barleria obtusa
subvariation

This xeric division of the subvariation is found on the flat to gently sloping, windswept western section of the study area. Succulent species are charactersitically diagnostic. These include Ruschia sp., Pachypodium succulentum

and Gasteria sp. Soils are shallow Mispahs, in which the A-horizon has been eroded, exposing unoxidized shale. Organic and moisture content of the soils is low. In places where the soil profile remains, the A-horizon is a sandy clay and \pm 5 cm deep. This has allowed those diagnostic species of group 21 to remain. Once again this may be regarded as an indicator of the historical composition of the vegetation prior to erosion of the A-horizon. Tragus berteronianus is a pioneer grass species which occurs in this sub-variation.

2.1.1b Cymbopogon plurinodis-Hibiscus pusillus-Barleria obtusa
subvariation

The second division of the subvariation is distinguished by the same species group which is diagnostic of the subvariation. Examples of this sub-variation have usually survived in areas which have been protected from utilization by domestic livestock e.g. long distances from water or growing within a bushclump.

2.2 Phyllanthus verucossus-Barleria obtusa variation.

This is a more mesic variation of the community, with Ptaeroxylon obliquum assuming diagnostic characteristics. The variation has a wide field (31 relevés), and is restricted to soils in which the A-horizon has been derived directly from the shale parent rock. Edaphically, calcium content is high, and the moisture content of the soil sample has increased. The soils tend to be leached (minerally poor) with low Na and K content. The species group diagnostic of this variation does not overlap with the Cymbopogon plurinodis-Hibiscus pusillus-Barleria obtusa sub-variation (2.1.1). This could be explained if Phyllanthus verucossus and Ptaeroxylon obliquum are found to be susceptible to fire damage. P. obliquum has been felled extensively in recent times and used in the production of fence poles. Large numbers of young shoots from coppicing stumps are in evidence, but the destruction has reduced the importance of the species in determining the structure of the community.

2 2.1 Ozoroa mucronata-Phyllanthus verucossus-Barleria obtusa
sub-variation.

Relevés representing this variation were located in more mesic areas. Two abundant succulent species, Crassula perforata and C. spathulata are also diagnostic of this variation. Grewia occidentalis and Asparagus subulatus are found growing inside bush-clumps of diverse species composition. The sub-variation has a field of 23 relevés and the height of the vegetation varies from 2.5 to 4.0 metres. The relevés are flat to gently sloping, with poor drainage, and good water holding potential. This variation is also divisible into two:

2.2.1a Hibiscus pusillus-Phyllanthus verucossus-Barleria obtusa
subvariation.

Overlap between variations 2.1 and 2.2 are recognised in this subvariation, which has a field of 11 relevés, and is characterised by strong representation of three differential species groups. These are the community species group and the two variation species groups. The apparent trend within the subvariation is away from a fire climax grassland component which is found in a warmer, drier environment, towards a thicker, succulent bushveld.

2.2.1b Rhynchosia calvescens-Phyllanthus verucossus-Barleria obtusa sub-variation.

This sub-variation has a field of 9 relevés. Altitude is variable (306-426 m), and soils are predominantly clays and sandy clays. Total percentage cover is between 50 and 90%. This subvariation does not contain an open grassland component, but grass species associated with bushclumps are present.

2.2.1c Ozoroa mucronata-Maytenus heterophylla -Phyllanthus verucossus-Barleria obtusa subvariation.

This subvariation represents the overlap between 2.2.1 and 2.2.2, and has a small field (3 relevés). The soils are sandy clays, and % cover is high (65-100%). This sub-variation characterises the transition between xeric and mesic succulent bushclumps.

2.2.2 Plumbago auriculata-Phyllanthus verucossus-Barleria obtusa sub-variation.

In these relevés, the vegetation becomes more dense, and the valley bushveld, as Acocks (1975) described it, develops. There is no climax grassland component, and the relevés representing this sub-variation may have a southerly aspect. Maytenus heterophylla is a diagnostic species, and the

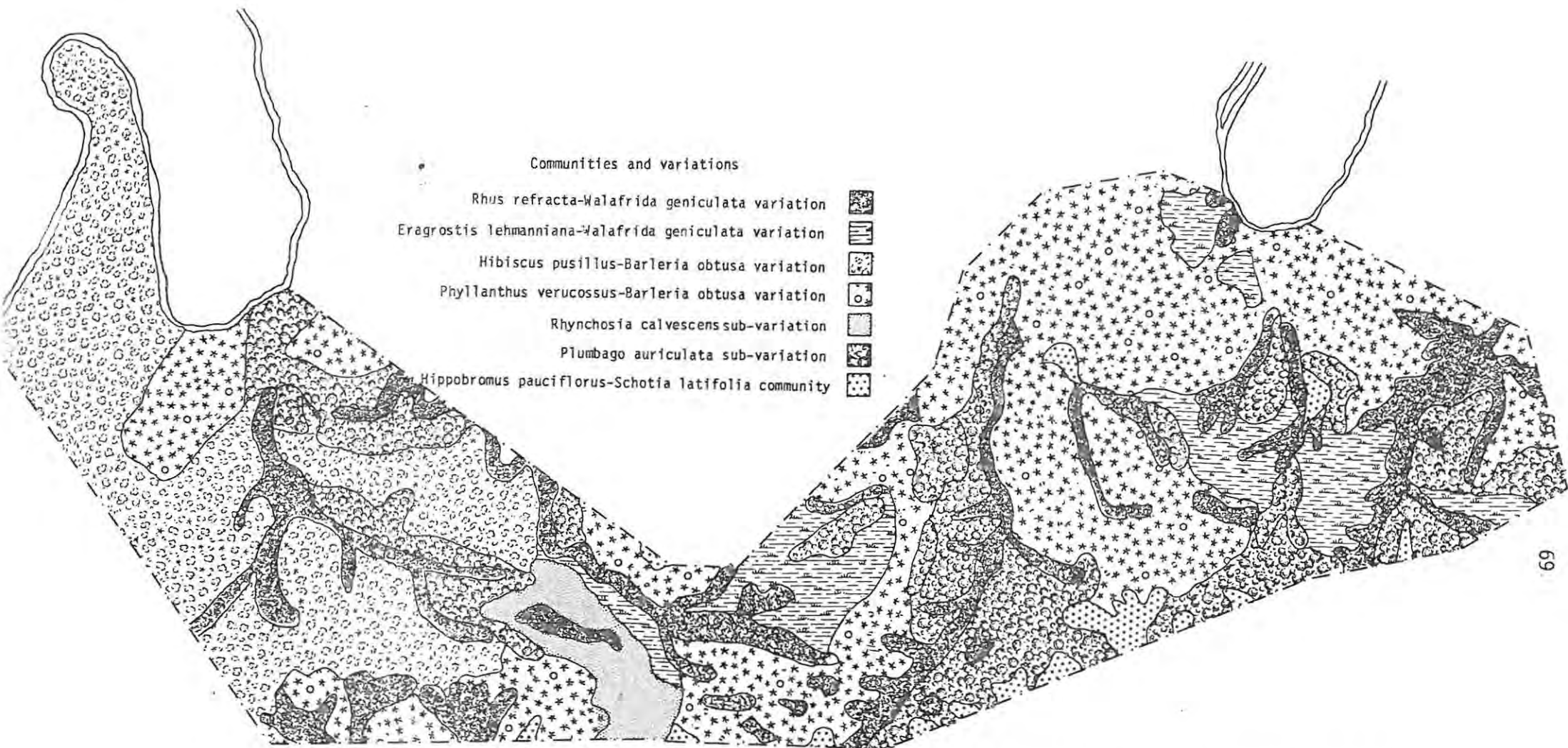


Fig. 11. The plant communities of the Andries Vosloo Kudu Reserve. Drawn after LANDSAT image interpretation.

Community Number	Phytosociologically Defined Vegetation Type	Mapping Unit	Physiognomic Class of diagnostic species
1	Walafrida geniculata-Felicia muricata community	Riparian thicket and non-succulent bushclump savanna	Karroid component of riparian thicket
1.1	Rhus refracta-Walafrida geniculata variation	Riparian thicket	Woody component of riparian thicket
1.1.1	Mariscus capensis-R. refracta-W. geniculata sub-variation	Riparian thicket	"
1.1.2	Olea africana-R. refracta W. geniculata sub-var.	Riparian thicket	"
1.2	Eragrostis lehmanniana-W. geniculata sub-var.	Non-succulent bushclump savanna	Grasslands of bushclump savanna
1.2.2	Rhus incisa-E. lehmanniana-W. geniculata var.	Non-succulent bushclump savanna	Bushclump
1.2.3	Anthospermum aethiopicum-E. lehmanniana-W. geniculata sub-variation	Non-succulent bushclump savanna	Grassland of the bushclump savanna
2.	Portulacaria afra-Barleria obtusa community	Succulent bush-clump savanna	Bushclump savanna
2.1	Hibiscus pusillus-B. obtusa variation	Xeric succulent bushclump savanna	Bushclump savanna
2.1.1a	Senecio radicans-H. pusillus-B. obtusa sub-variation.	Xeric bush-clump savanna	Succulent scrub
2.1.1b	Cymbopogon plurinodis-H. pusillus-B. obtusa sub-variation	Xeric bushclump savanna	Grasslands
2.2	Phyllanthus verucossus-B. obtusa variation	Succulent bush	Succulent bush
2.2.1a	<i>Hibiscus pusillus</i> - P. verucossus-B. obtusa sub-variation	Xeric succulent bush	Succulent bush
2.2.1b	Rhynchosia calvescens-P. verucossus-B. obtusa sub-variation	Succulent bush	Succulent bush
2.2.2	Plumbago auriculata-P. verucossus-B. obtusa sub-variation	Mesic succulent bush	Succulent bush
3.	Hippobromus pauciflorus-Schotia latifolia community	Dry forest	Dry forest

Table 9a. Relationships between phytosociological hierarchy, mapping unit and physiognomic class.

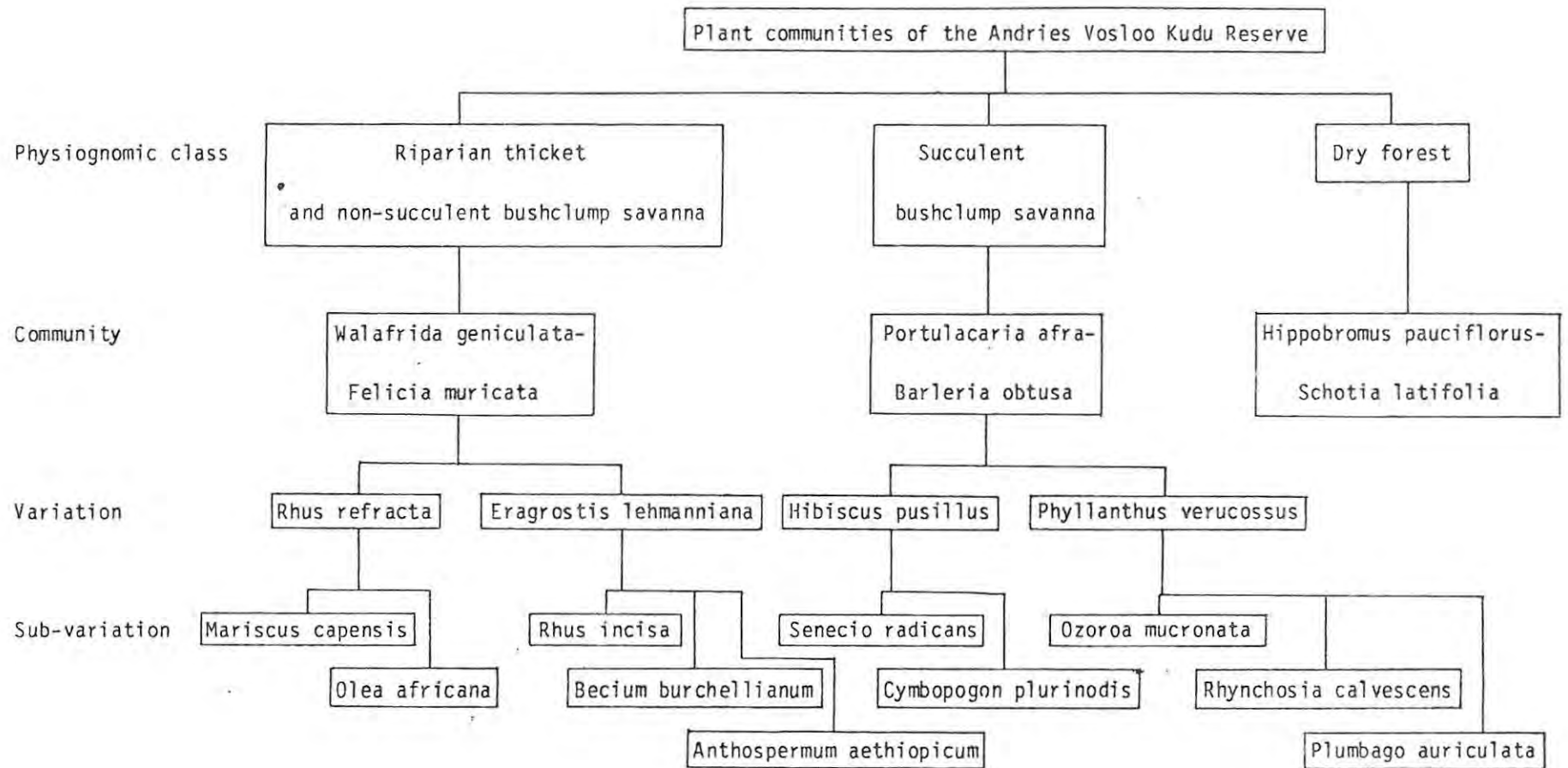


Table 9b. A hierarchical representation of the plant communities of the Andries Vosloo Kudu Reserve.

vegetation may be between 3.0 and 4.0 metres in height. The meadow grass, Cynodon dactylon, is a component in areas where historical disturbance (stock watering and resting points) has occurred. This species is not truly diagnostic of the sub-variation, and has been included to emphasise the presence of a disturbance cycle.

DRY FOREST COMMUNITY

3. Hippobromus pauciflorus-Schotia latifolia Community

This community is restricted to the dry forests which occur on the south facing slopes of the study area, and has a field of four relevés. Further intensive sampling of this community was not carried out as emphasis was placed on the riparian thicket and succulent bushclump savanna in this study. Overlap between this community and subvariations 2.2.2 and 1.1.1 is evident. This parallels the trend from a xeric to a mesic environment. The trees of this community may be up to \pm 8-10 metres high, and the community is associated with areas experiencing the moderate temperatures recorded during the climatic survey. The soils are rich in organic material and moisture content is high, but mineral concentrations are low.

The relationship between phytosociological hierarchy, mapping unit and physiognomic class is outlined in Table 9a. A hierarchical representation of all the communities, variations and subvariations is presented in Table 9b.

Relevés 6,10,11,17 and 19 have been excluded from the final tables, as they could not be relocated in the second survey and composition could not be verified. Quadrats 36,74 and 75 do not exist due to a sequential error.

3.3.2 PRINCIPAL COMPONENT ANALYSIS OF THE SOIL DATA

The first principal component (Table 10) accounts for 46% of the total variance, and has high positive loadings for Ca, moisture, organic content and Mg, and negative loadings for Na, K, pH and conductivity. In edaphic terms, the component is contrasting organic soils which have a high moisture content (e.g. relevés 57,61,70,79) with mineral rich soils of lower pH which are rich in K and Na. In vegetational terms this gradient parallels the physiognomic differentiation between the dry forest and mesic bushclump savanna on the one hand, and the grasslands and xeric bushclump savanna on the other.

The second principal component (19% of total variance) has a high positive loading for K and Na, and low negative loadings for pH, moisture content, organic content and Ca. The component has high negative loadings for Mg and conductivity. In edaphic terms, this component is separating soils of high K and Na from those of low Mg and conductivity. The other variables assume undifferentiating characteristics. This gradient parallels the gradation between dry, organically poor, mineral rich soils of the grasslands and xeric bushclump savanna, and the moist, secondary soils of the drainage lines and forest community.

PRINCIPAL COMPONENT ANALYSIS								
COMPONENT	% OF TOTAL VARIANCE ACCOUNTED FOR BY EACH COMPONENT							
1	46							
2	19							
3	16							
4	8							
5	4							
6	3							
7	2							
8	2							
LOADING OF EACH SOIL FACTOR (%) FOR EACH COMPONENT								
Component	Loading of soil factor (%)							
	Organic content	Moisture content	Mg	Ca	K	Na	pH	conductivity
1	15.7	16.4	15.5	18.0	8.0	7.9	5.7	12.8
2	9.9	9.3	4.0	9.6	30.2	22.2	11.7	3.1
3	5.7	9.4	5.7	2.6	2.7	13.7	35.3	24.9

Table 10. The percentage of total variance accounted for by each principal component, and the loading of each soil factor in the first three principal components.

The subsequent components account for 16%, 7%, 4%, 3%, 2% and 1% of the total variance, and no interpretable patterns were evident within them.

3.3.3 TOTAL FLORISTIC SURVEY

A systematic checklist of 284 of the species of flowering plants of the study area is presented in Appendix 1. Of the 64 families recorded (Table 11), the best represented were Poaceae (34), Compositae (30), Leguminosae (19) and Liliaceae (19). 180 Genera are represented.

The list of species given by Acocks (1975) for this Veld Type are well represented in the study area, with 69 of the 94 species (or 73%) being recorded.

Family	No. of species	No. of genera	Family	No. of species	No. of genera
Polypodiaceae	1	1	Rhamnaceae	2	1
Marsiliaceae	1	1	Vitaceae	2	1
Zamiaceae	1	1	Tiliaceae	2	1
Aponogetonaceae	1	1	Malvaceae	3	3
Poaceae (Graminae)	35	22	Sterculiaceae	3	3
Cyperaceae	5	3	Flacourtiaceae	3	1
Commelinaceae	3	2	Thymelaceae	2	1
Liliaceae	20	9	Combretaceae	1	1
Amaryllidaceae	2	2	Araliaceae	1	1
Iridaceae	5	5	Umbelliferae	1	1
Moraceae	1	1	Plumbaginaceae	1	1
Loranthaceae	2	2	Sapotaceae	1	1
Santalaceae	1	1	Ebenaceae	5	2
Amaranthaceae	1	1	Oleaceae	3	2
Aizoaceae	3	3	Salvadoraceae	1	1
Mesembryanthemaceae	5	3	Loganiaceae	2	1
Portulacaceae	1	1	Apocynaceae	4	3
Ranunculaceae	1	1	Asclepiadaceae	3	3
Cruciferae	2	2	Convolvulaceae	2	2
Capparaceae	3	3	Boraginaceae	1	1
Crassulaceae	16	3	Verbenaceae	3	4
Leguminosae	19	10	Labiatae	8	5
Geraniaceae	4	2	Solanaceae	4	2
Oxalidaceae	1	1	Scrophulariaceae	4	3
Rutaceae	2	2	Selaginaceae	2	2
Burseraceae	1	1	Bigoniaceae	2	2
Ptaeroxylaceae	1	1	Acanthaceae	8	7
Polygalaceae	4	1	Rubiaceae	3	3
Euphorbiaceae	10	4	Cucurbitaceae	1	1
Anacardiaceae	7	3	Campanulaceae	1	1
Celastraceae	9	4	Lobeliaceae	1	1
Sapindaceae	4	4	Compositae	30	18

Table 11. A summary of the checklist of the
Vosloo Kudu Reserve.

plants of the Andries

3.4 DISCUSSION

3.4.1 PHYTOSOCIOLOGY

Earlier descriptions (Pole-Evans, 1936; Dyer, 1937; Martin & Noel, 1960; Acocks, 1975) are unable to adequately explain the vegetation characteristics determined in this study. This is perhaps a measure of the complexity of the vegetation of the region, where researchers have been trying for decades to describe the processes taking place. Martin & Noel (1960) do however describe a bushclump savanna in which "microphanerophytic shrubs form densely interwoven clumps separated by a distance usually greater than the diameter of the clumps, with a more or less continuous grass stratum between the clumps." This definition satisfies the physiognomic characteristics of variation 1.2 and 2.1, although Martin & Noel (1960) did not record this formation within the study area.

In order to assess the validity of the phytosociological classification arrived at in this study, it is necessary to examine the work of other authors in southern Africa.

Werger (1973) described an Acacia karroo-Celtis africana community of the woody riverine vegetation of the Tussen-die-Riviere game farm (22 000 ha; Acocks's False Upper Karoo). Pioneer species found within this community, which have been recorded on AVKR, include Eragrostis lehmanniana, Chrysocoma tenuifolia, Felicia muricata and Asparagus suaveolens. These species have assumed diagnostic, general and infrequent characteristics in the Walafrida geniculata-Felicia muricata community described in this study. This indicates the karroid

affinity of the vegetation within the study area. Werger's (1973) classification corresponds with the Walafrida geniculata-Felicia muricata community, but the diagnostic species Celtis africana is not present within the study area.

No phytosociological descriptions of the flora of the Indian Ocean Coastal Belt could be found, and this description of the Portulacaria afra-Barleria obtusa community must be regarded as original work.

Coetzee (1975) recognised a Hypoestes verticillaris-Mimusops zeyheri forest community on the Rustenberg Nature Reserve (2896 ha.; Acock's Sour Bushveld). Differentiating and infrequent species within this community which have also been recorded in this study include Acocanthera oppositifolia, Rhoicissus tridentata, Acalypha glabrata and Zanthoxylon capensis. These species have assumed diagnostic characteristics in a structurally lower, more xeric formation (succulent bushclump savanna) on the AVKR.

This study has revealed the presence of a relationship between biogeographical affinity and phytosociological classification. Final decisions concerning phytosociological nomenclature in southern Africa should therefore be based on the biogeographical affinity of the floras concerned. The regions defined by Werger (1978), Werger & Coetzee (1978), White (1978) and Moll & White (1978) should be accepted and their centres of endemism recognised. Where floras overlap, the bio-

geographically related components should first be defined before any further classification is undertaken.

3.4.2 HISTORICAL DEVELOPMENT OF THE VEGETATION

Returning to the historical development of this vegetation, Acocks (1975) recognised a formation in which the bushclumps were separated from one another by grassland. He regarded this as an example of the succession in which the bushveld was being opened up by grazers and browsers, and after poor management, was being invaded by karroid vegetation. It is possible that this is not entirely due to recent pastoral agriculture when one considers that elephant inhabited this bush in the last century (Black, 1901). Penzhorn et al. (1974) note that elephants in the Addo Elephant National Park have reduced the standing biomass of the vegetation within the elephant camp by more than 50%.

Black (1901) reports that fires were a feature of the grasslands of the koppies in the area between Fort Brown and Committees Drift, and these occasionally spread into the bush. Burnt stumps have been found within the study area (Burdett, pers. comm.), although no record of recent intentional or accidental fire exists. Trollope (pers. comm.) reports that non-succulent Valley Bushveld is capable of burning during dry months. It is suggested that the bushclump savanna (Plate 2) is a consequence of the opening up of the bush by elephant, buffalo and kudu, followed by winter fires. From Table 8, it is apparent that bushclumps have a variable composition with high

species diversity. Clear differentiation between variations within the community is not readily apparent. This could be explained by the physical factors, namely climatic diversity (high summer rainfall, followed by drought and high winter temperatures) and fire, which have led to bushclump formation. Fire would have resulted in a non-conformity of bushclump composition. The presence of fire climax grasses (Themeda triandra, Cymbopogon plurinodis, Setaria sphacellata, Digitaria eriantha and Heteropogon contortus) is also evidence for fire possibly being responsible for the development of this vegetation.

It seems unlikely that, contrary to the suggestion of Acocks (1975), a vegetation type which shows clear differentiation between variations and communities, would have been caused entirely by human mismanagement. Over-utilization has led to changes, but these are evident in the host of ubiquitous pioneer species which pervade the study area. The vegetation is a product of the climatic, edaphic and biotic factors which prevailed in fairly recent times.

3.4.3 CLIMATIC INFLUENCE

Macro-climatic variation within the study is significant, and may account for variation in community structure and composition. The Hippobromus pauciflorus-Schotia latifolia community is only found on the cooler southern slopes. Extreme and mean maximum air temperatures are lower in the summer (Fig. 7) at the station (TH1) nearest this community, indicating that

the climate is more moderate. Similarly, the winter extreme minimum air temperatures are higher (Fig. 8) . The Senecio radicans-Hibiscus pusillus-Barleria obtusa subvariation is associated with the hotter, drier western areas in which weather station TH2 was situated. The subjective observation by Acocks (1975) that the vegetation is a product of the diverse micro-climate, is confirmed. In addition, the general climatic conditions are sufficiently extreme to account for the magnitude of Fish river scrub endemism (Table 15).

3.4.4 PRINCIPAL COMPONENT ANALYSIS OF THE SOIL DATA

The plot of the first and second principal component axes (Fig. 12 & 13) result in a grouping of samples into grasslands with negative loadings of both components, and a forest-bushclump grouping with positive loadings of the first component.

This grouping reaffirms the phytosociological classification arrived at in this study. The variations of community 1 (1.1 and 1.2) have formed four groups (A,B,C and E). Groups A, B and C consists of those soil samples representative of the grasslands of the non-succulent bushclump savanna. Organic and moisture content is low, with minerally rich soils developing from the parent rock. Group E consists of soil samples from the bushclumps found within these variations. Soils are leached (relatively low mineral content) but have a higher organic and moisture content.

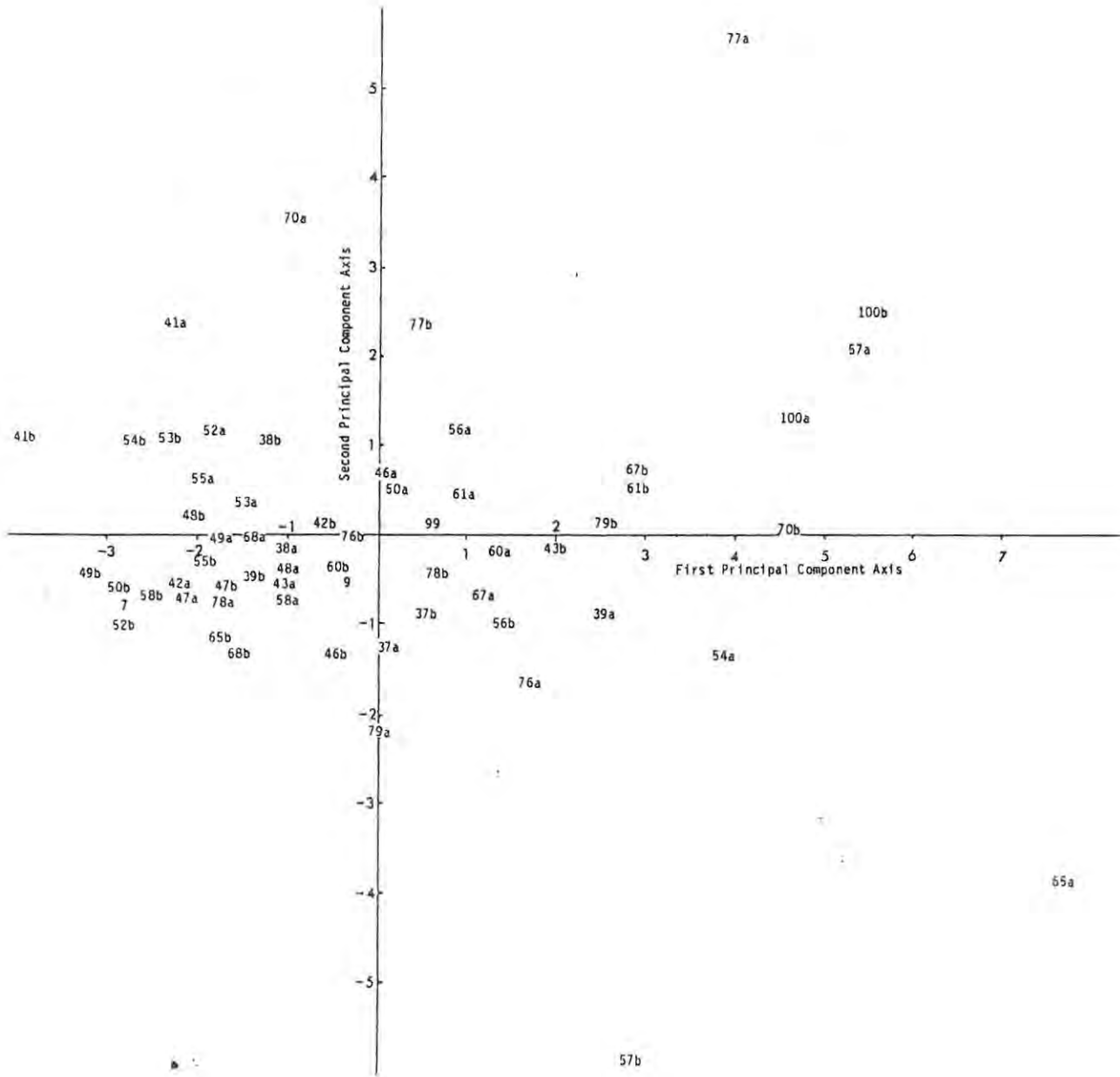


Fig. 12. Plot of the first and second principal component axes following principal component analysis of the soil data. Numbers refer to quadrats, and letters to grassland/bush-clump samples.

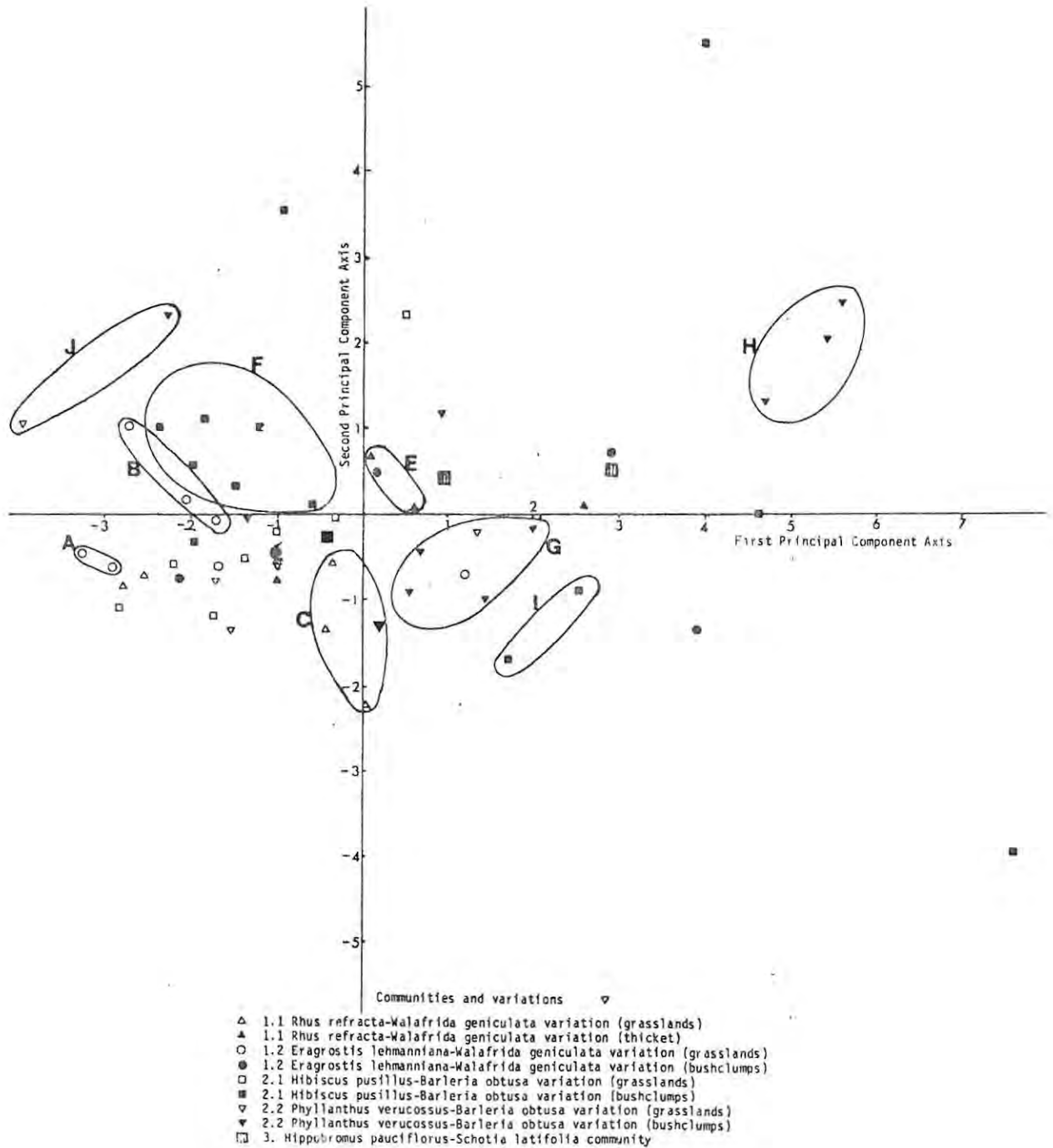


Fig. 13. Plot of the first and second principal component axes following principal component analysis of the soil data. The symbols indicate physiognomic class (bushclump or grassland) and phytosociological classification of the quadrats.

The variations of community 2 have also formed five groups (F,G,H,I and J). Group F consists of soil samples from the bushclumps of relevés of the Hibiscus pusillus-Barleria obtusa variation of the Portulacaria afra-Barleria obtusa community. The soils are minerally rich with high Na, K concentrations and associated high conductivity and pH. Group G consists of soil samples from relevés of the Phyllanthus verucossus-Barleria obtusa variation. Organic and moisture content, as well as Mg concentrations, are high. Group H, which consists of releve 57 and a sample from quadrat 100, is characterised by minerally rich soils (high Ca, Mg, K and Na concentrations) and high moisture and organic content. Quadrat 100, which has not been phytosociologically classified, was situated in the transition between the non-succulent bushclump savanna and the dry forest community. The soils of groups I (relevés 39 & 76) and J (relevé 41) did not correspond with the soils of the phytosociologically related groups (G and H). This is a reflection that community composition is not determined exclusively by soil factors.

The recognition of a hierarchy which is related to the moisture and soils gradients within the plant communities of the study area is important. The relative uniformity of edaphic factors (soil structure, pH and origin; altitude) points to secondary soil development and the availability of water being responsible for distinct vegetation differences. Micro-climatic factors also appear to exert an influence on community composition and structure.

The differences found between the soils of the grassland and bushclump are interesting. Bushclump and forest soils are 'old' in comparison to those of the grassland and karroid areas. This suggests that grasslands have developed subsequent to the other formations. Grassland development has led to utilization by grazers, soil erosion, and a general impoverishment of the soil. The mineral richness and low organic content of the soils of the grasslands is indicative of a 'young' soil still undergoing pedogenesis (Eyre, 1971). Pedogenesis is a lengthy process, and should not be aggravated by excessive utilization of the grasslands or trampling of the inter-bushclump region by browsers.

3.4.5 THE ROLE OF INDIVIDUAL SPECIES

Euphorbia bothae is a diagnostic component of the Hibiscus pusillus-Barleria obtusa variation, and does not appear to be an invading species, as was originally suggested by Acocks (1975). This is deduced from the degree of utilization of this species by browsers (kudu and eland) during the study. Whenever new growth of this species was recorded (see Section 4), heavy utilization was evident. Plants only exceeded 2,0 m in height when they were growing within a bushclump, whereas unprotected specimens were usually browsed to a height of +1,0 metre. Burdett (pers. comm.) reports the presence of large quantities of E. bothae in the rumen of kudu.

While dealing with the status of individual species, it is pertinent to discuss Acacia karroo, which is distributed

throughout Africa, and is posing a threat to the grasslands and savannas of eastern and southern regions of the continent (Comins, 1962). Thornbush encroachment has been the subject of many publications (West, 1947; Story, 1952; Du Toit, 1967; Acocks, 1975; Trollope & Coetzee, 1975; Werger, 1977b). The general opinion is that encroachment and the success of this species is a consequence of the over-utilization of the grass sward and the subsequent germination of the A. karroo seeds under optimum conditions. The re-establishment and maintenance of a good grass sward is the first pre-requisite to the control of A. karroo germination. Trollope (1980) has demonstrated that it is possible to control existing A. karroo growth by a resting/burning/browsing programme. Few saplings were recorded during this study, and further spread of this species appears to have ceased. The implementation of a similar control programme is not necessary. If A. karroo is regarded as a threat to the endemic vegetation outside conservation areas, then prevention of germination is not the only solution and the senescence time of the species must be determined. White (1979) recognises that senescence is "often, if not usually, caused by environmental factors." It is therefore essential to assess the possibility of programmed senescence within this species before specific recommendations can be made.

3.4.6 TOTAL FLORISTIC COMPOSITION

In order to assess the floristic relationship between conserved areas within the Valley Bushveld, the checklist of the study area was compared with those of two other closely related

conservation areas within the same Veld Type, namely the Addo Elephant National Park (AENP) and the Thomas Baines Nature Reserve (TBNR). The checklist of the AENP (Penzhorn & Olivier, 1974) is compared with that of the study area (Table 12). 114 species are common to both areas, dominated by members of the families Graminae (13), Crassulaceae (9) and Compositae (12). The difference in total number collected (AVKR=284, AENP=320) can be accounted for by the large number of species belonging to the family Mesembryanthemaceae(35) in AENP, and that AVKR has been under-collected.

In order to quantify the differences between these two related floras, the "quotient of similarity" (QS) used by Exell & Wild (1961) is introduced. This is a simple calculation based on the work of Sørensen (1948), and is used to demonstrate the similarity between floras in the same Acocks Veld Type.

$$QS = \frac{2 \times X}{A + B} \times 100$$

where QS = quotient of similarity

X = number of common species

A = number of species in one flora

B = number of species in another flora

The quotient of similarity for AENP and AVKR was calculated as 38,72.

Family	No. of species		Common species	Family	No. of species		Common species
	AVKR	AENP			AVKR	AENP	
Graminae	35	32	13	Tiliaceae	2	2	2
Cyperaceae	5	4	1	Malvaceae	3	2	2
Commelinaceae	3	3	3	Sterculiaceae	3	3	1
Liliaceae	20	29	8	Flacourtiaceae	3	0	0
Amaryllidaceae	2	6	0	Thymelaceae	2	2	1
Iridaceae	5	3	1	Combretaceae	1	0	0
Moraceae	1	0	0	Araliaceae	1	0	0
Loranthaceae	2	3	2	Umbelliferae	1	3	0
Santalaceae	1	0	0	Ericaceae	0	2	0
Polygonaceae	0	2	0	Plumbaginaceae	1	1	1
Chenopodiaceae	0	5	0	Sapotaceae	1	1	1
Amaranthaceae	1	0	0	Ebenaceae	5	5	4
Aizoaceae	3	6	3	Oleaceae	3	1	1
Mesembryanthemaceae	5	35	0	Salvadoraceae	1	1	1
Portulacaceae	1	1	1	Loganiaceae	2	0	0
Ranunculaceae	1	0	0	Apocynaceae	4	3	2
Cruciferae	2	3	2	Asclepiadaceae	3	4	1
Capparaceae	3	3	2	Convolvulaceae	2	1	1
Crassulaceae	16	22	9	Boraginaceae	1	1	1
Leguminosae	19	11	4	Verbenaceae	3	2	1
Geraniaceae	4	8	2	Labiatae	8	2	2
Oxalidaceae	1	3	0	Solanaceae	4	5	2
Zygophyllaceae	0	2	0	Scrophulariaceae	4	6	3
Rutaceae	1	3	0	Selaginaceae	2	5	1
Burseraceae	1	0	0	Bigoniaceae	2	1	1
Ptaeroxylaceae	1	1	1	Acanthaceae	8	11	4
Polygalaceae	4	2	1	Rubiaceae	3	2	0
Euphorbiaceae	10	7	3	Dipsacaceae	0	1	0
Anacardiaceae	7	4	4	Cucurbitaceae	1	1	0
Celastraceae	9	8	6	Campanulaceae	1	2	1
Sapindaceae	4	0	0	Lobeliaceae	1	2	1
Rhamnaceae	2	1	1	Compositae	30	40	12
Vitaceae	2	1	0				

Table 12. A comparison of the checklists of the flowering plants of the Andries Vosloo Kudu Reserve (AVKR) and the Addo Elephant National Park (AENP).

Similarly, the checklist of the TBNR (Jessop & Jacot-Guillarmod, 1969) is compared with that of the study area (Table 13). There are 123 common species, dominated by Graminae (14), Liliaceae (10), Compositae (15), Leguminosae (9) and Crassulaceae (8). The quotient of similarity is 38,64.

Acocks (1975) does not expand on his reasons for separating the variations of the Valley Bushveld, but this comparison of three intensively sampled areas gives some idea of the magnitude of these differences, and certainly justifies their existence as conservation areas.

3.4.7 BIOGEOGRAPHICAL AFFINITY

Huntley (1978) defines the Valley Bushveld biome as arid savanna of the Zambezian Domain, and excludes this vegetation type from his list of types meriting conservation attention. Werger & Coetsee (1978) note that in terms of floristic composition, namely the presence of a large endemic group, the inclusion of this vegetation type in the Sudano-Zambezian domain is disputable. Werger (1978) classifies the Valley Bushveld as belonging to the Karoo Domain of the Karoo-Namib biogeographical region, but states that in the eastern Cape, the boundaries of the biogeographical regions are difficult to define.

The assessment of the biogeographical affinity of the study area is an extremely difficult one. In order to facilitate the process, total floristic checklists from a number of

Family	No. of species		Common species	Family	No. of species		Common species
	AVKR	TBNR			AVKR	TBNR	
Graminae	35	35	14	Tiliaceae	2	1	1
Cyperaceae	5	13	1	Malvaceae	3	6	2
Restionaceae	0	2	0	Sterculiaceae	3	3	0
Commelinaceae	3	4	2	Ochnaceae	0	1	0
Juncaceae	0	1	0	Guttiferae	0	1	0
Liliaceae	20	24	10	Flacourtiaceae	3	4	2
Amaryllidaceae	2	6	10	Thymelaceae	2	6	0
Iridaceae	5	10	2	Combretaceae	1	0	0
Orchidaceae	0	1	0	Myrtaceae	0	1	0
Salicaceae	0	1	0	Araliaceae	1	1	1
Moraceae	1	1	1	Umbelliferae	1	2	0
Proteaceae	0	3	0	Cornaceae	0	1	0
Loranthaceae	2	2	1	Ericaceae	0	6	0
Santalaceae	1	4	0	Myrsinaceae	0	1	0
Amaranthaceae	1	1	0	Plumbaginaceae	1	1	1
Aizoaceae	3	2	1	Sapotaceae	1	1	1
Mesembryanthemaceae	5	4	0	Ebenaceae	5	4	2
Portulacaceae	1	0	0	Oleaceae	3	4	2
Ranunculaceae	1	0	0	Salvadoraceae	1	1	1
Cruciferae	2	1	0	Loganiaceae	2	1	1
Capparaceae	3	2	1	Gentianaceae	0	1	0
Crassulaceae	16	13	8	Apocynaceae	4	1	1
Pittosporaceae	0	1	0	Asclepiadaceae	3	8	2
Rosaceae	0	2	0	Convolvulaceae	2	0	0
Leguminosae	19	19	9	Boraginaceae	1	1	1
Geraniaceae	4	4	2	Verbanaceae	3	3	1
Oxalidaceae	1	5	0	Labiatae	8	6	1
Linaceae	0	1	0	Solanaceae	4	2	0
Rutaceae	1	4	1	Scrophulariaceae	4	4	2
Burseraceae	1	0	0	Gesneriaceae	0	1	0
Ptaeroxylaceae	1	2	1	Selaginaceae	2	2	2
Polygalaceae	4	4	1	Bigoniaceae	2	0	0
Euphorbiaceae	10	15	3	Acanthaceae	8	2	2
Anacardiaceae	7	8	5	Rubiaceae	3	12	2
Celastraceae	9	5	3	Dipsacaceae	0	1	0
Icacinaceae	0	1	0	Cucurbitaceae	1	1	0
Sapindaceae	4	3	3	Campanulaceae	1	6	0
Rhamnaceae	2	2	0	Lobeliaceae	1	0	0
Vitaceae	2	3	1	Compositae	30	52	15

Table 13. A comparison of the checklists of the flowering plants of the Andries Vosloo Kudu Reserve (AVKR) and the Thomas Baines Nature Reserve (TBNR).

conservation areas representing the floras of the five phytochoria which meet here (Capensis, Karoo-Namib, Sudano-Zambezian, Afro-montane and Indian Ocean Coastal Belt), were compared with that of the study area. All the species within the study area were listed in a working table, and their presence in the selected areas noted. The result is a table (Table 14) in which the representative species form a mosaic, each with different chorological affinity. This table contains 132 (48%) of the species within the study area, and a large proportion of the remaining species are ubiquitous, endemic to the Fish river scrub variation of the Valley Bushveld (Table 9) or exotic.

Moll & White (1978) regard the study area as being situated in the southern extremes of the Tongaland-Pondoland Regional Mosaic of the Indian Ocean Coastal Belt. White (1978) classifies the study area as Pondoland-Tongaland bushland thicket. These are justifiable conclusions as many of the genera recorded from the study area are endemic to, or have centres of endemism in, the regional mosaic (Encephalartos, Aloe, Diospyros, Euclea, Rhoicissus); or have high concentrations of species in the regional mosaic (Cassine and Cussonia). The dominant bushclump species Euclea undulata, Grewia occidentalis, Scutia myrtina and Portulacaria afra are clearly symptomatic of Pondoland-Tongaland affinity.

The distinct group of endemic species (Table 9), already recognised by Werger & Coetzee (1978), are also diagnostic of

Asparagus crassicladus	Indigofera disticha
A. densiflorus	Lotonotis pungens
Bulbine caulescens	Mestoklema albanicum
Cotyledon velutina	Pachypodium bispinosum
C. campanulata	Polygala hamata
Cyrtanthus spp.	P. microlopha
Delosperma echinatum	Ruschia uncinata
Diospyros scabrida var. cordata	R. dyeri
Dolichos hastaeformis	Scilla rigidifolium
Encephalartos trispinosus	Strelitzia reginae
Eriospermum dyeri	Tritonia securigera
Gasteria beckeri	Thesium flexuosum
Gladiolus permeabilis	
Garuleum bipinnatum	

Table 15. A list of species recorded in the study area and regarded as endemic to the Fish river scrub variation of the Valley Bushveld.

the vegetation of this region.

3.4.8 CONSERVATION STATUS

Of the 24 264 km² of Valley Bushveld which exists in southern Africa, 97.93 km² (0.4%) is conserved by Provincial and National Parks in the Cape Province and Natal (Edwards, 1974). A comparison of the checklists of the flowering plants recorded on AVKR, AENP and TBNR indicate that the conservation of these variations is justified. The statement by Huntley (1978) that this Veld Type is adequately conserved is accepted, as this examination of the variations within the Veld Type has shown that some of the differences in species composition are well represented. However, the adequacy of plant community conservation cannot be discussed without comparative Braun-Blanquet data from the other two areas.

Further conservation of this ecosystem should concentrate on consolidation of existing areas in accordance with the principles of insular ecology (Wilcox, 1980).

4. PHENOLOGY

4.1 INTRODUCTION

Phenology is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic factors, and the interrelation among phases of the same or different species (Lieth, 1974). Phenological observations have been used for thousands of years in agriculture. The term was first proposed by Morren in 1853, but modern plant phenology owes its origin to Carolus Linnaeus (Hopp, 1974). This early work with a calendar origin has progressed to ecosystem studies, with emphasis on the response of tropical perennial species to environmental factors (Frankie et al., 1974a and 1974b; Borchert, 1980). The plant activity patterns which become apparent during phenological studies give clues as to what animal groups may be operating at certain times of the year in particular communities (Frankie et al., 1974b).

Huxley & Van Eck (1974) reviewed the subject of endogenous or exogenous control of phenological events in plants, but did not attempt statistical correlation of data. One of the aims of this study was to ascertain whether or not a relationship existed between the phenological events of selected plant species and two physical environmental factors, namely rainfall and air temperature. By comparing the previous mean weekly rainfall with phenophase, the aim was also to determine if a "lag phase" existed before bud production and the onset of flowering.

Leaf-size is regarded as an indicator of adaptation to micro-climate (Raunkiaer, 1934). In order to describe the morphological adaptation of leaves to the climate of the study area, the leaf-sizes (mm^2) of all micro-phanerophytes collected during the study were determined.

Plant species possess different photo-synthetic capabilities (Black, 1971). This prompted the hypothesis that these characteristics may be associated with specific environmental conditions (Black, 1971; Doliner & Jolliffe, 1979). In this study a literature survey was undertaken to determine the occurrence of the C_3 and C_4 photosynthetic pathways in Poaceae (Graminae) collected in the study area (Ellis, 1977; Vogel et al., 1978; Waller & Lewis, 1979; Hnatiuk, 1980).

4.2 MATERIALS AND METHODS

Phenological data were collected for 51 species at consistent intervals from December 1979 to March 1981. The plant species selected for examination were chosen subjectively on the basis of their abundance within the succulent bushclump savanna physiognomic class. Species were selected in thirteen of the life forms described by Leistner (1967) and listed in Table 16. The phenological condition of these plant species, which occur throughout the study area, was visually assessed. Assessment was only finalised after a thorough inspection of plants along a line transect. The transect consisted of the road system beginning at the entrance gate in the west and ending at weather station TH3 in the east. The transect was travelled twice on each sampling occasion, and frequent stops were made to enable careful assessment of the phenological condition of each species. A species was regarded as being at a particular phenophase if at least 20% of the plants of that species were in that stage. This information was recorded on the field data sheet.

The following developmental stages, modified after Van Rooyen et al. (1979), were recorded:

1. Vegetative growth I : the plant was not apparently undergoing any change in growth i.e. mature leaves only were present. Leaf-fall of deciduous species was recorded in this stage by denoting an 's'.

<u>Life Form</u>	<u>Symbol</u>
MICROPHANEROPHYTES	
Evergreen	M:1
Summer green-short period	M:2:1
long period	M:2:2
NANOPHANEROPHYTES	
Evergreen	N:1
Summer green-short period	N:2:1
long period	N:2:2
CHAMAEPHYTES	Ch
HEMICRYPTOPHYTES	
Caespitose (Graminae)	
Non-rhizomatous	H:1
Non-caespitose	
erect	H:2:1
decumbent	H:2:2
GEOPHYTES	G
THEROPHYTES	
Summer	T:1
SUCCULENTS	S

Table 16. Life form classification and symbols used to describe selected species in the phenodiagrams (After Leistner, 1967).

2. Vegetative growth II : the production, unfolding or expanding of leaves and shoot extension.
3. Production of floral buds : unopened flower buds present on the plants
4. Flowering : flowers at anthesis on plants
5. Developing fruit : developing fruit present on plants; and
6. Mature fruit : mature fruits present on plants.

Vegetative growth I and II have been included in the stages presented by Van Rooyen et al. (1979) to allow for differentiation between the early stages of plant growth. These stages are of particular interest in those plant species which are browsed by ungulates during the growing period. If the aerial parts of a plant were not seen during the regular sampling, this was also recorded on the data sheet.

An assessment of the relationship between physical environmental data and the phenology of the selected species was achieved by correlating the mean weekly rainfall (between sampling occasions), and the maximum and minimum air temperatures (weekly means and extremes) with phenophase. Previous mean weekly rainfall was also compared with phenophase to determine if a 'lag phase' existed before bud production and the onset of flowering. These factors were always correlated with the highest phenophase recorded on each sampling occasion. The product-moment correlation co-efficient (r) was used as it provides a statistically testable estimate of association between two variables (Hinds & Rottenberry, 1979).

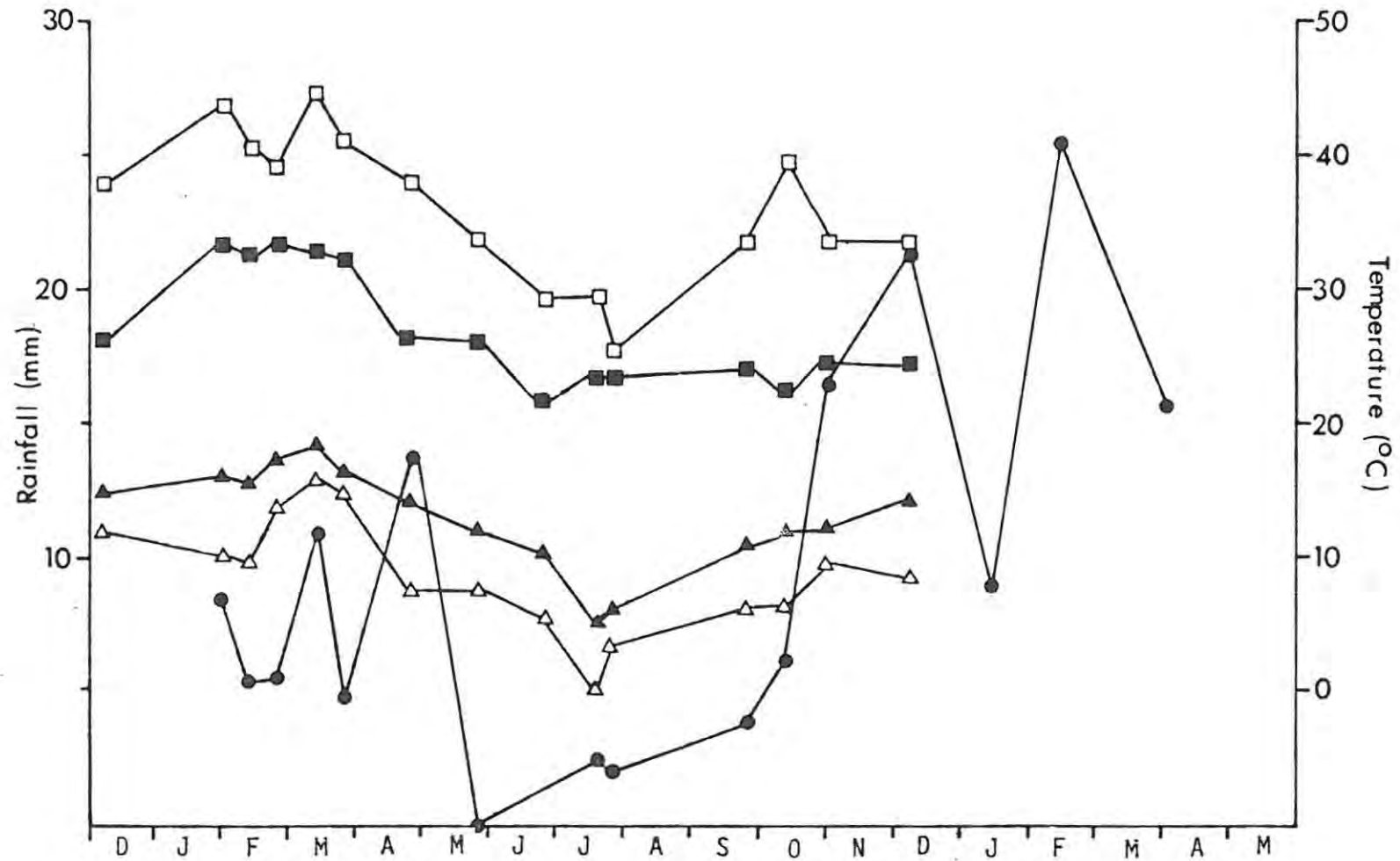


Fig. 14. The climatic details against which phenology was correlated. ● = mean weekly rainfall between sampling occasions; □ = extreme maximum temperature; ■ = mean maximum temperature; ▲ = mean minimum temperature; and △ = extreme minimum temperature. * between sampling occasions

<u>Leaf-size class</u>	<u>Leaf size</u>
Leptophyll	up to 25 mm ²
Nanophyll	25-225 mm ²
Microphyll	225-2025 mm ²
Mesophyll	2025-18225 mm ²

Table 17. Leaf-size classes and the corresponding leaf areas (Shimwell, 1971).

4.3 RESULTS

The results are presented in the form of 51 phenodiagrams (Figs. 15 - 22). The phenodiagrams have been arranged according to degree of correlation (Table 19) with one or other of the climatic factors tested. The life form classification (Raunkiaer, 1934; Leistner, 1967; and Shimwell, 1971) is indicated for each species. This classification (Table 16) has been subdivided into smaller groups to show more clearly the inter-relationships between plant form and behaviour.

The leaf-size and gross leaf morphology of the phanerophytes recorded in the study area are presented in Table 18. The phanerophytes are dominated by micro- and nano-phyllous leaves with differentiated dorso-ventral surfaces.

Table 20 summarises the physiological characteristics of the important grass species in the study area, as determined from the literature (Ellis, 1977; Vogel *et al.*, 1978; Waller & Lewis, 1979; Hnatiuk, 1980).

The results of the statistical analysis of the relationship between climatic data and phenological behaviour are presented in Table 19. Species have been arranged into groups which show similar significant correlations.

- Group 1 (13 species) shows no significant correlation;
- Group 2 (9 species) shows a correlation with mean weekly rainfall (Rainfall_a);

<u>Life-form</u>	<u>Species</u>	<u>Leaf-size</u>	<u>Leaf morphology</u>	
M:1	<i>Pappea capensis</i>	nano	diff.	
	<i>Putterlickia pyracantha</i>	nano	diff.	
	<i>Rhus refracta</i>	nano	diff.	
	<i>Maytenus polycantha</i>	nano	diff.	
	<i>Schotia afra</i>	nano	undiff.	
	<i>Ptaeroxylon obliquum</i>	nano	undiff.	
	<i>Euclea undulata</i>	micro	diff.	
	<i>Ozoroa mucronata</i>	micro	diff.	
	<i>Buddleia saligna</i>	micro	diff.	
	<i>Harpephyllum caffrum</i>	micro	diff.	
	<i>Rhus lancea</i>	micro	diff.	
	<i>R. baürii</i>	micro	diff.	
	<i>Pterocelastrus</i> <i>tricuspidatus</i>	micro	diff.	
	<i>Cassine crocea</i>	micro	diff.	
	<i>Allophylus decipiens</i>	micro	diff.	
	<i>Hippobromus pauciflorus</i>	micro	diff.	
	<i>Scutia myrtina</i>	micro	diff.	
	<i>Ziziphus mucronata</i>	micro	diff.	
	<i>Scolopia zeyheri</i>	micro	diff.	
	<i>Scolopia mundii</i>	micro	diff.	
	<i>Combretum caffrum</i>	micro	diff.	
	<i>Heteromorpha arborescens</i>	micro	diff.	
	<i>Sideroxylon inerme</i>	micro	diff.	
	<i>Euclea undulata</i>	micro	diff..	
	<i>Diospyros dichrophylla</i>	micro	diff.	
	<i>Olea africana</i>	micro	diff.	
	<i>Grewia occidentalis</i>	micro	diff.	
	<i>G. robusta</i>	micro	diff.	
	<i>Maytenus capitata</i>	micro	undiff.	
	<i>M. heterophylla</i>	micro	undiff.	
	M:2:1	<i>Acacia karoo</i>	nano	undiff.
		<i>Ehretia rigida</i>	micro	diff.
M:2:2	<i>Rhus incisa</i>	nano	diff.	
	<i>Rhus sp.</i>	nano	diff.	

Table 18. The life-form, leaf-size and leaf morphology of the selected phanerophytes of the study area (diff.= differentiated dorso-ventral surface; undiff.= undifferentiated dorso-ventral surface).

SPECIES	RAINFALL ^a	RAINFALL ^b	MEAN MAX. TEMP	MEAN MIN. TEMP	EXT. MAX. TEMP	EXT. MIN. TEMP
Crassula lycopodioides	-0.07; 13; ns	-0.04; 13; ns	0.38; 10; ns	0.03; 10; ns	0.29; 10; ns	0.11; 10; ns
Asparagus striatus	0.13; 13; ns	0.39; 13; ns	-0.11; 10; ns	-0.21; 10; ns	-0.48; 10; ns	0.23; 10; ns
Brachylaena ilicifolia	0.38; 14; ns	0.07; 14; ns	0.54; 11; ns	0.42; 11; ns	0.33; 11; ns	0.51; 11; ns
Capparis sepiaria	0.003; 13; ns	-0.04; 13; ns	0.07; 11; ns	-0.24; 11; ns	-0.43; 11; ns	-0.12; 11; ns
Delosperma calycinum	0.02; 15; ns	0.1; 15; ns	0.41; 12; ns	0.18; 12; ns	0.03; 12; ns	0.52; 12; ns
Euclea undulata	-0.18; 14; ns	-0.27; 14; ns	-0.02; 11; ns	-0.36; 11; ns	-0.22; 11; ns	-0.39; 11; ns
Panicum deustum	0.49; 14; ns	0.36; 14; ns	-0.22; 11; ns	-0.02; 11; ns	-0.14; 11; ns	0.08; 11; ns
Pappea capensis	0.26; 14; ns	0.33; 14; ns	-0.21; 11; ns	0.21; 11; ns	0.05; 11; ns	0.35; 11; ns
Phyllanthus verucosus	0.32; 17; ns	0.43; 17; ns	0.17; 14; ns	0.31; 14; ns	0.03; 14; ns	0.4; 14; ns
Portulacaria afra	0.13; 17; ns	-0.1; 16; ns	-0.12; 15; ns	0.13; 15; ns	0.21; 15; ns	0.06; 15; ns
Maytenus capitata	-0.04; 16; ns	0.43; 16; ns	0.39; 13; ns	0.12; 13; ns	0.08; 13; ns	0.14; 13; ns
Rhigozum obovatum	0.36; 16; ns	0.32; 16; ns	-0.38; 13; ns	0.02; 13; ns	0.03; 13; ns	0.03; 13; ns
Schotia afra	0.1; 17; ns	-0.07; 16; ns	-0.06; 14; ns	0.2; 14; ns	-0.08; 14; ns	0.35; 14; ns
Grewia robusta	0.72; 16; ***	0.39; 15; ns	0.4; 13; ns	0.65; 13; *	0.59; 13; *	0.62; 13; *
Buddleia saligna	0.54; 13; *	0.33; 13; ns	0.03; 11; ns	0.43; 11; ns	0.23; 11; ns	0.47; 11; ns
Grewia occidentalis	0.53; 13; *	0.26; 13; ns	0.07; 10; ns	0.04; 10; ns	0.18; 10; ns	0.11; 10; ns
Gazania linearis	0.60; 14; *	0.19; 13; ns	-0.21; 12; ns	0.3; 12; ns	0.23; 12; ns	0.34; 12; ns
Jasminum multipartitum	0.78; 9; **	0.53; 9; ns	-0.09; 7; ns	0.43; 7; ns	0.09; 7; ns	0.47; 7; ns
Pentzia incana	0.61; 17; **	0.25; 17; ns	0.07; 14; ns	0.25; 14; ns	0.22; 14; ns	0.15; 14; ns
Ptaeroxylon obliquum	0.5; 16; *	0.3; 16; ns	0.15; 13; ns	0.43; 13; ns	0.34; 13; ns	0.49; 13; ns
Salvia triangularis	0.59; 17; **	0.19; 16; ns	-0.49; 14; ns	-0.25; 14; ns	-0.11; 14; ns	-0.2; 14; ns
Setaria sphacellata	0.48; 17; *	0.37; 16; ns	0.47; 14; ns	0.43; 14; ns	0.35; 14; ns	0.4; 14; ns
Panicum maximum	0.71; 14; **	0.59; 14; *	-0.32; 11; ns	0.15; 11; ns	-0.17; 11; ns	0.12; 11; ns
Rhus incisa	0.74; 17; ***	0.66; 16; **	0.02; 15; ns	0.28; 15; ns	0.1; 15; ns	0.31; 15; ns
Felicia muricata	0.58; 13; *	0.63; 13; *	0.43; 10; ns	0.52; 10; ns	0.08; 10; ns	0.62; 10; *
Themeda triandra	0.52; 17; *	0.83; 16; ***	0.47; 14; ns	0.58; 14; *	0.44; 14; ns	0.47; 14; ns
Asparagus africanus	0.05; 13; ns	0.68; 13; **	-0.39; 10; ns	-0.27; 10; ns	-0.24; 10; ns	-0.04; 10; ns
Ehretia rigida	0.28; 15; ns	0.51; 15; *	-0.02; 12; ns	0.31; 12; ns	0.12; 12; ns	0.05; 12; ns
Hibiscus pusillus	0.54; 12; ns	0.72; 12; **	0.22; 9; ns	0.39; 9; ns	0.23; 9; ns	0.44; 9; ns
Acacia karroo	0.31; 14; ns	0.67; 14; **	0.56; 13; *	0.65; 13; *	0.52; 13; ns	0.49; 13; ns
Cymbopogon plurinodis	0.33; 14; ns	0.7; 15; **	0.72; 12; **	0.66; 12; *	0.45; 12; ns	0.73; 12; **
Digitaria eriantha	0.18; 15; ns	0.68; 16; **	0.73; 13; **	0.62; 13; *	0.44; 13; ns	0.69; 13; **
Crassula expansa	-0.45; 13; ns	-0.47; 13; ns	0.78; 10; **	0.38; 10; ns	0.54; 10; ns	0.37; 10; ns
Crassula perforata	-0.18; 13; ns	0.001; 13; ns	0.64; 10; **	-0.29; 10; ns	-0.2; 10; ns	0.0; 10; ns
Ozoroa mucronata	0.03; 15; ns	0.48; 15; ns	0.65; 12; *	0.52; 12; ns	0.44; 12; ns	0.05; 12; ns
Euphorbia bothae	0.21; 16; ns	0.25; 16; ns	0.19; 13; ns	0.41; 13; ns	0.29; 13; ns	0.58; 13; *
Eragrostis lehmanniana	0.47; 13; ns	0.5; 13; ns	0.18; 10; ns	0.51; 10; ns	0.27; 10; ns	0.68; 10; *
Hermannia althaeoides	0.48; 13; ns	0.13; 13; ns	0.39; 10; ns	0.51; 10; ns	0.40; 10; ns	0.61; 10; *
Lantana salvifolia	0.5; 10; ns	0.18; 9; ns	0.24; 9; ns	0.45; 9; ns	0.47; 9; ns	0.63; 9; *
Helichrysum rosom	0.37; 14; ns	0.27; 14; ns	0.48; 11; ns	0.59; 11; *	0.44; 11; ns	0.71; 11; **
Gnidia cuneata	-0.05; 11; ns	0.02; 11; ns	0.58; 10; ns	0.68; 10; *	0.58; 10; ns	0.83; 10; **
Eragrostis obtusa	0.47; 14; ns	0.12; 14; ns	0.51; 11; ns	0.73; 11; **	0.6; 11; *	0.75; 11; **
Rhus sp.	0.45; 16; ns	0.45; 16; ns	0.34; 13; ns	0.58; 13; *	0.57; 13; *	0.58; 13; *
Becium burchellianum	0.42; 16; ns	0.43; 14; ns	0.75; 12; **	0.78; 12; ***	0.74; 12; **	0.82; 12; ***
Jatropha capensis	0.07; 12; ns	0.1; 12; ns	0.73; 10; **	0.74; 10; **	0.67; 10; *	0.76; 10; **
Kalanchoe rotundifolium	0.15; 14; ns	0.12; 14; ns	0.73; 11; **	0.66; 11; *	0.59; 11; *	0.67; 11; *
Plumbago auriculata	0.32; 17; ns	0.42; 17; ns	0.51; 15; *	0.52; 15; *	0.54; 15; *	0.56; 15; *
Chrysocoma tenuifolia	0.21; 15; ns	0.58; 15; *	0.58; 16; *	0.86; 13; ***	0.77; 13; ***	0.73; 13; **
Aristida congesta	0.60; 14; *	0.4; 14; ns	0.68; 11; *	0.8; 11; **	0.63; 11; *	0.84; 11; **
Walafrika geniculata	0.63; 16; **	0.11; 15; ns	0.59; 13; *	0.74; 13; **	0.72; 13; **	0.62; 13; **
Sutera pinnatifida	0.53; 15; *	0.66; 14; **	0.57; 14; *	0.77; 14; ***	0.72; 14; **	0.66; 14; **

Table 19. Product moment correlation co-efficients for the relationship between phenology and climatic factor of 51 selected plant species. ns=not significant; * $p < .05$; ** $p < .01$; *** $p < .001$

<u>Species</u>	<u>Photosynthetic pathway</u>	<u>Source</u>
Enneapogon scoparius	C4	Ellis, 1977
Tragus berteronianus	C4	"
Chloris virgata	C4	"
Cynodon dactylon	C4	"
Eustachys mutica	C4	Ellis (pers. comm.)
Oropetium capense	C4	Ellis, 1977
Eragrostis lehmanniana	C4	"
E. curvula	C4	"
E. obtusa	C4	"
Sporobolus fimbriatus	C4	"
S. nitens	C4	"
Brachiaria serrata	C4	"
Digitaria eriantha	C4	"
Panicum deustum	C4	"
P. maximum	C4	"
Pennisetum clandestinum	C4	"
Rhynchelytrum setifolium	C4	"
Setaria sphacellata	C4	"
Cymbopogon plurinodis	C4	"
Hypparhenia hirta	C4	"
Themeda triandra	C4	"
Aristida congesta	C4	"
Merxmullera disticha	C3	Ellis (pers. comm.)
Schismus inermis	C3	"
Stipa dregeana	C3	"

Table 20 . Photosynthetic categories of some of the members of the family Graminae collected in the study area.

Group 3 (4 species) shows a significant correlation with Rainfall^a and Rainfall^b (previous mean weekly rainfall) ;

Group 4 (3 species) shows a positive correlation with Rainfall^b;

Group 5 (3 species) shows a positive correlation with Rainfall^b, mean maximum and mean minimum air temperatures;

Group 6 (3 species) correlates positively with mean maximum temperatures;

Group 7 (4 species) correlates positively with extreme minimum temperature; and the remaining groups show varying degrees of correlation with all the climatic factors.

4.4 DISCUSSION

Huxley and Van Eck (1974) have attributed the onset of a particular phenophase to various climatic factors. Dormancy or senescence has been attributed to seasonal drought, low atmospheric humidity and low night temperatures. The start of new growth has been attributed to the onset of rain, an increase in air temperature, an increase in the level of incoming solar radiation, the decrease in temperature followed by a rise, or a combination of these factors. The evidence however is far from clear, as too many environmental variables were involved in most of these studies. In loco investigation of phenological behaviour is fraught with problems, and the results can only be discussed within the context of these limitations.

The phenology of 13 species showed no significant correlation with any of the climatic factors tested. These species can be sub-divided into two groups:

I) Crassula lycopodioides, Pappea capensis, Phyllanthus verucossus, Portulacaria afra, Rhigozum obovatum and Schotia afra (Fig. 15). It would appear that the phenology of this group is triggered by some endogenous factor which is independent of environmental variable. Phenology however corresponds with that period when environmental conditions favour the growth and reproduction of the species.

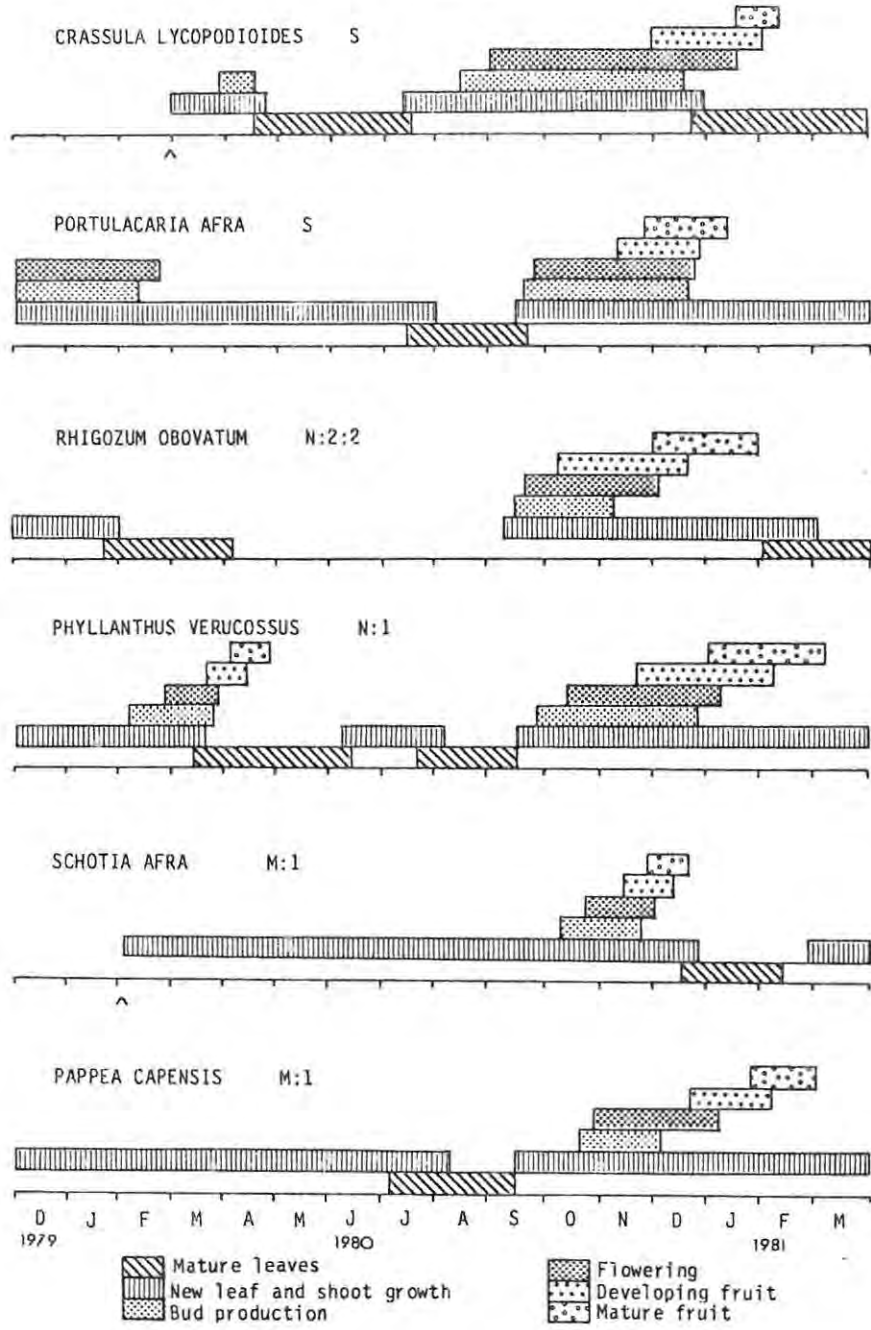


Fig. 15. Phenodiagrams of those species whose phenology appears to be controlled by endogenous factors. ^ = point of initiation of sampling.

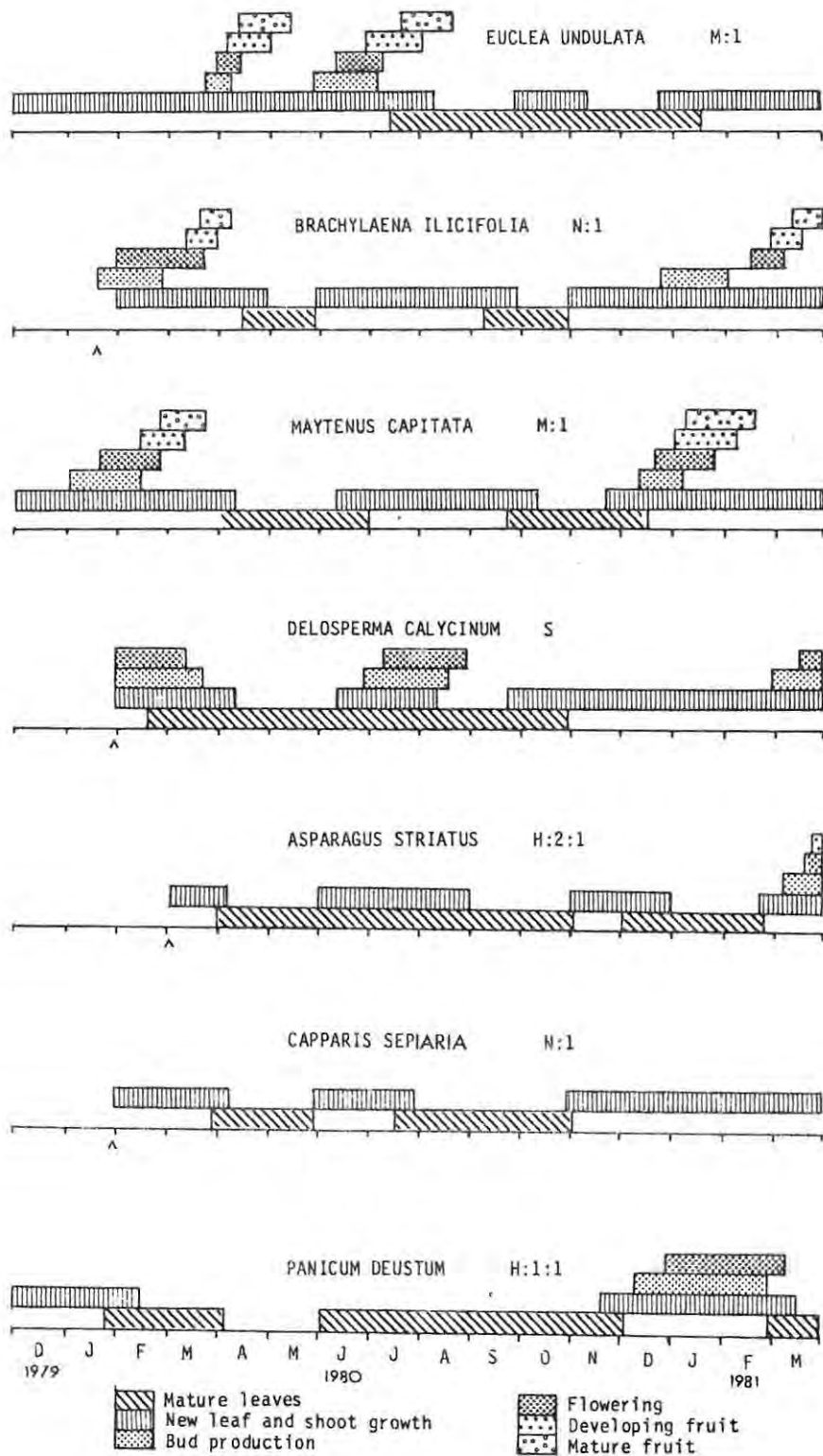


Fig. 16. Phenodiagrams of species whose phenology could not be explained by correlation with climatic factors. \wedge = point of initiation of sampling.

II) Maytenus capitata, Asparagus striatus, Brachylaena ilicifolia, Capparis sepiaria, Delosperma calycinum, Euclea undulata and Panicum deustum (Fig. 16). This group consists of those species whose phenology could not be explained, either due to lack of sufficient evidence, or perhaps unconventional phenophases.

The phenology of thirteen of the species examined displayed a significant correlation between phenological behaviour and the mean weekly rainfall between sampling dates (Fig. 17 & 18). These species include the climax grass Setaria sphacellata, and the woody species Grewia occidentalis and G. robusta. This could be regarded as an endogenous response, as mean monthly rainfall showed a positive correlation to the expected monthly rainfall for the study area (Fig. 5). The rainfall during the study period corresponded remarkably well with that predicted by Buys et al., 1979 at the 60% confidence limit. Two woody species, Buddleia saligna and Ptaeroxylon obliquum, also showed a significant correlation with mean weekly rainfall.

Panicum maximum and Themeda triandra responded positively to both Rainfall^a and Rainfall^b. The test against Rainfall^b (previous mean weekly rainfall) was conducted to ascertain if a 'lag phase' existed before the onset of new growth, bud production and flowering. A positive response is possibly an adaptive feature of the plants responding to the historically unreliable spring rain. The response in these climax grasses suggests that the practise of burning shortly after the advent

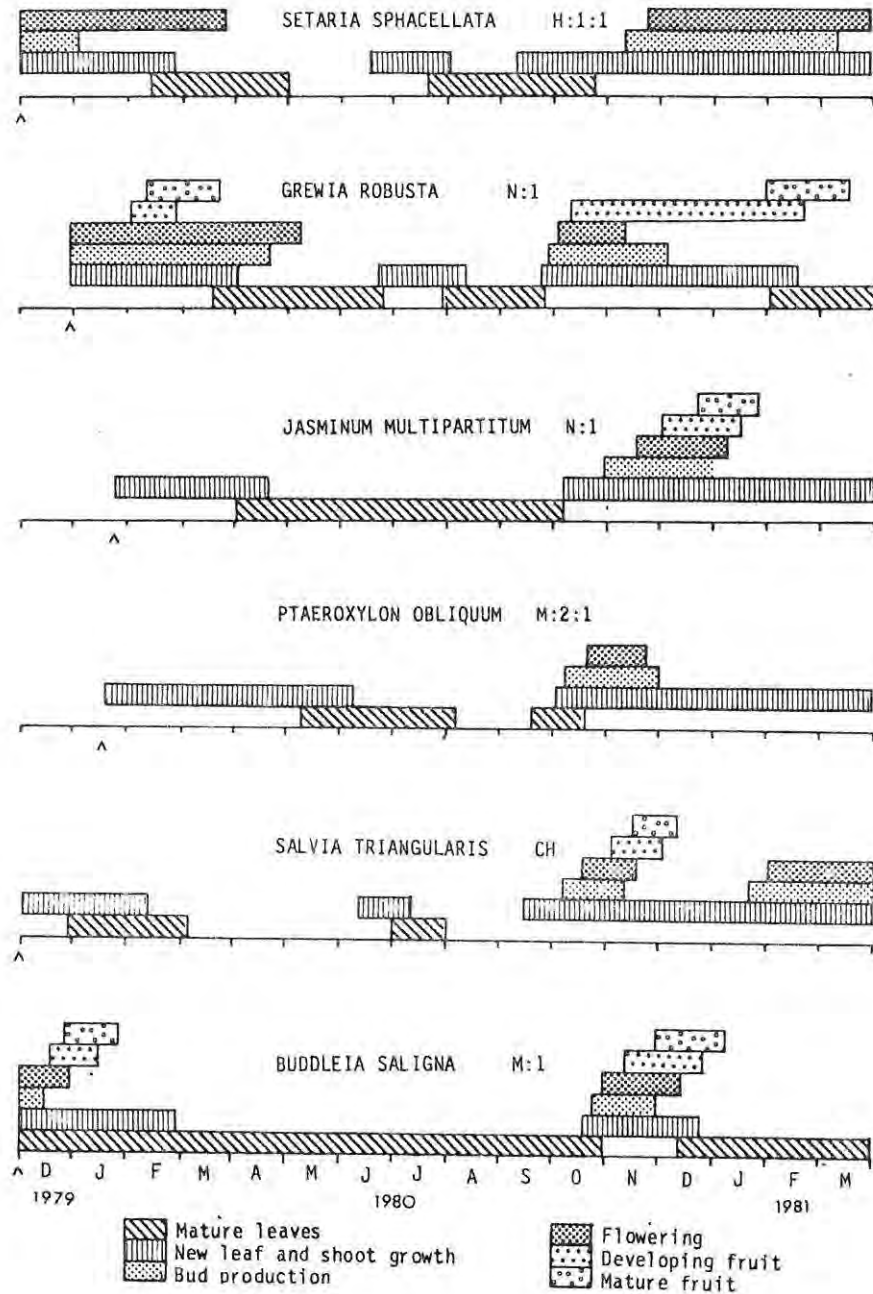


Fig. 17. Phenodiagrams of species whose phenology demonstrated a positive correlation with mean weekly rainfall between sampling occasions. ^ = point of initiation of sampling.

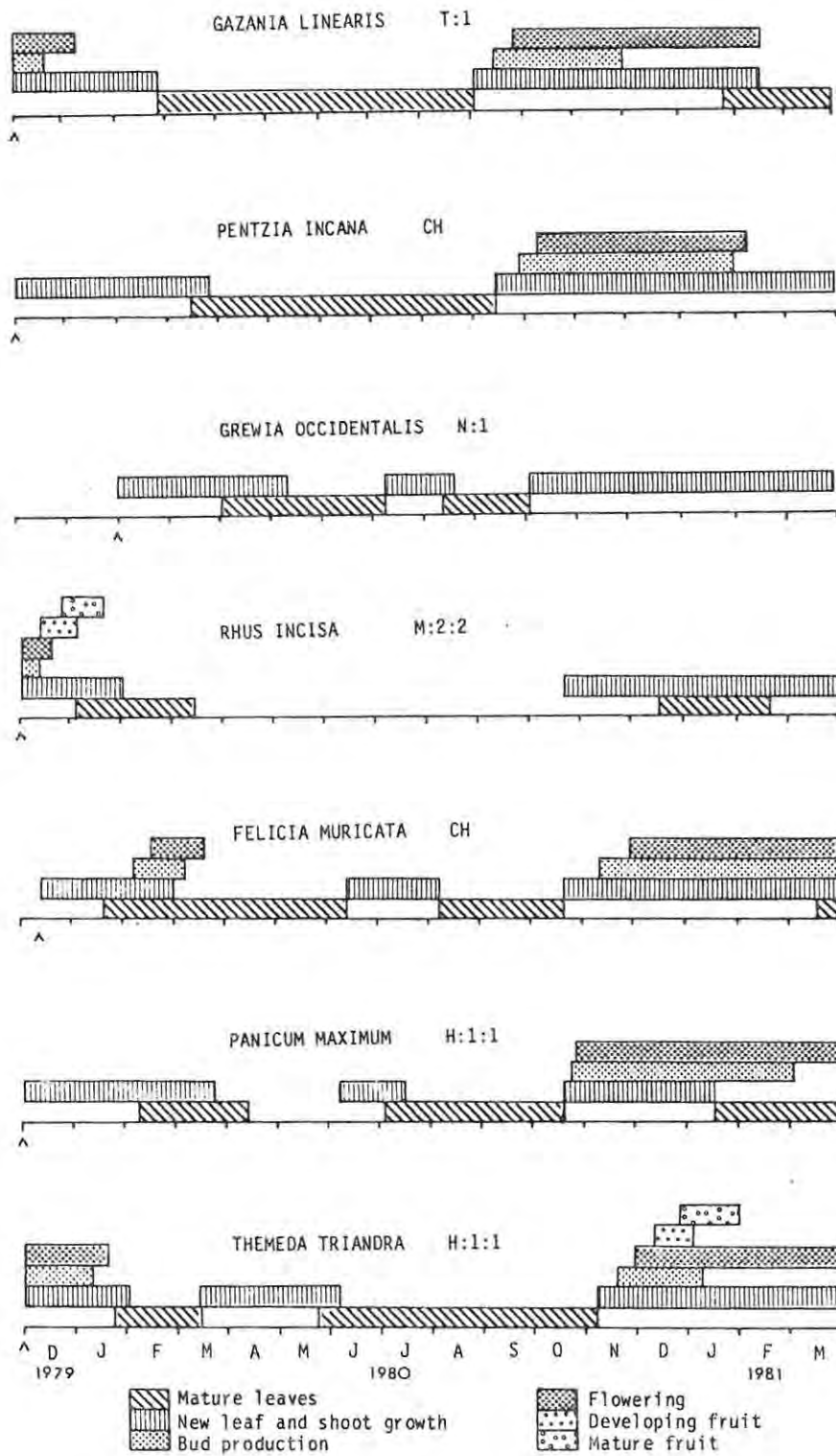


Fig. 18. Phenodiagrams of species whose phenology showed a significant positive correlation with mean weekly rainfall and previous mean weekly rainfall.
 ^ = point of initiation of sampling.

of spring rains (Trollope, 1978) would not adversely affect these species, as the production of new growth is delayed. The phenology of Asparagus africanus, Ehretia rigida and Hibiscus pusillus (Fig. 19) also showed a significant correlation with Rainfall^b.

The phenology of the climax grasses Cymbopogon plurinodis and Digitaria eriantha, as well as the ubiquitous Acacia karroo (Fig. 19) correlated positively with Rainfall^b, and mean maximum and minimum air temperatures. Once again a lag phase is evident before the onset of new growth.

Two differentiating species of the Ozoroa mucronata-Phyllanthus verucossus-Barleria obtusa sub-variation (Ozoroa mucronata and Crassula perforata) (Fig. 20) show a significant correlation with mean maximum temperature. This could account for the adaptability of these species to the warm, north facing slopes of the study area.

Four species (Fig. 20) displayed a positive correlation to extreme minimum temperature. These include the karroid chamaephytes (Lantana salvifolia and Hermannia althaeoides), a non-rhizomatous hemicryptophytes (Eragrostis lehmanniana) and a succulent (Euphorbia bothae). These species are either low growing, and therefore subject to frost damage; or adapted to the flat, windswept plain. Flowering and fruiting occurs in two peaks, in late summer and again in spring. This is possibly an example of maximising on optimum growth conditions in a semi-

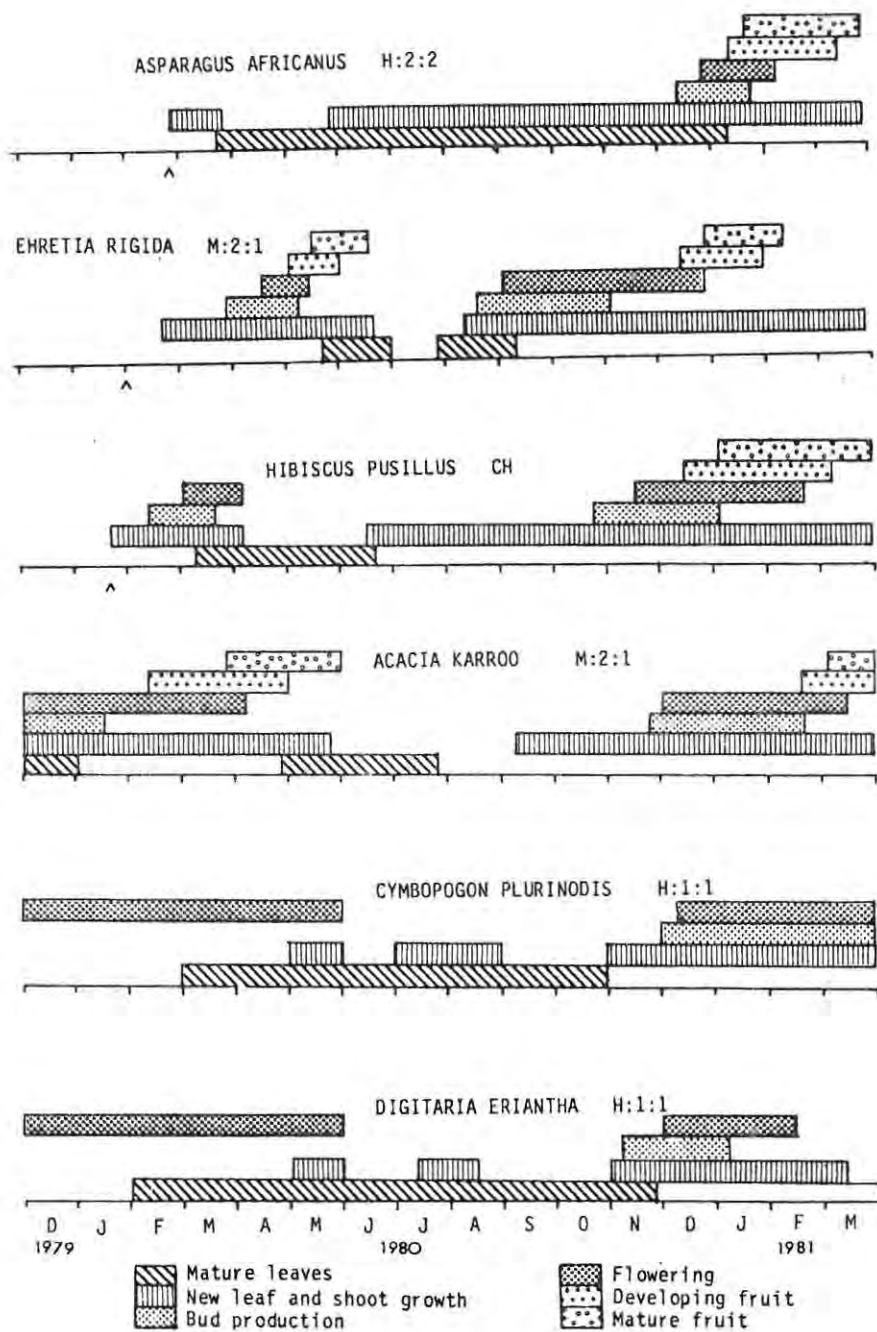


Fig. 19. Phenodiagrams of those species whose phenology correlated significantly with previous mean weekly rainfall and mean maximum and minimum air temperature. \wedge = point of initiation of sampling.

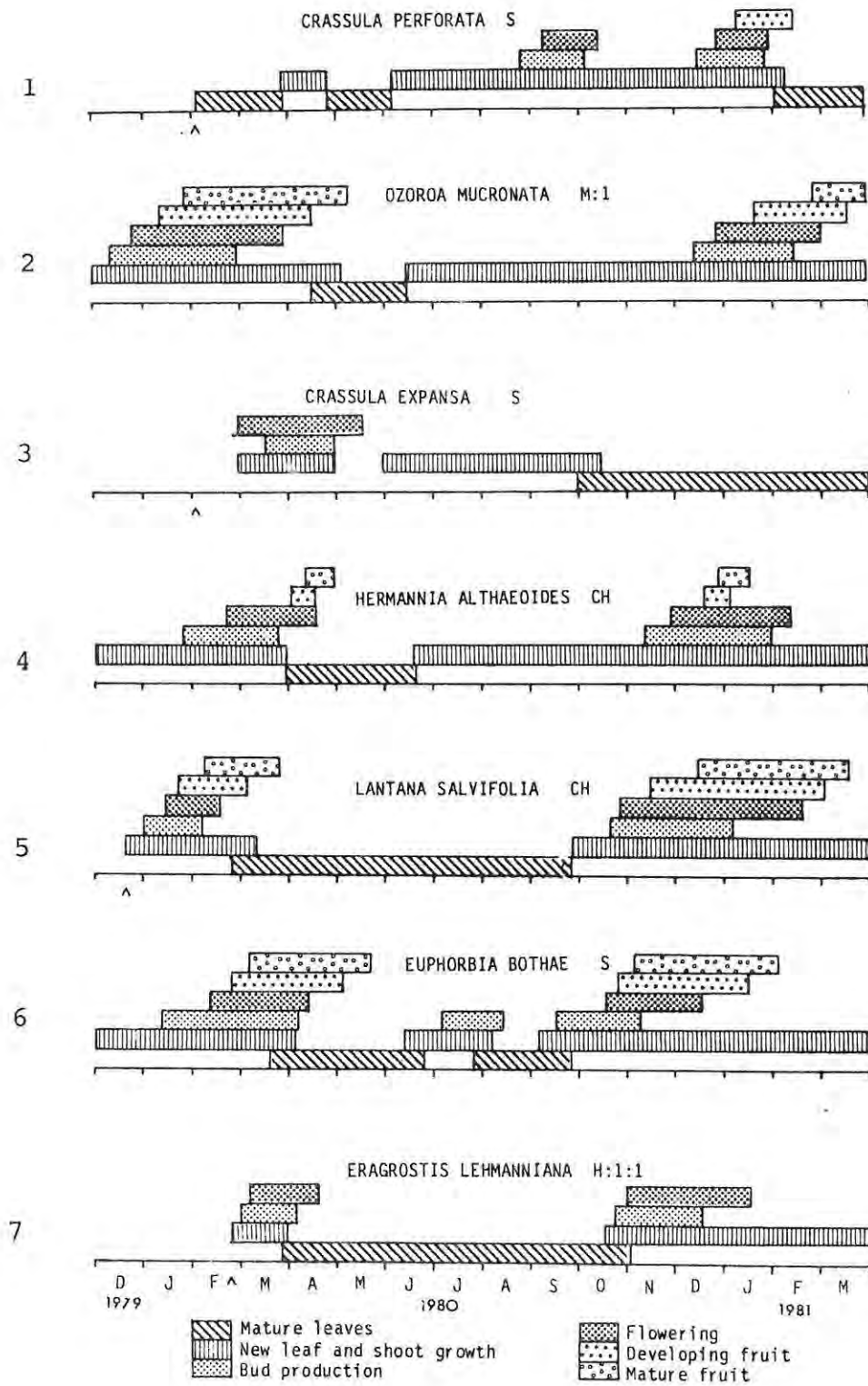


Fig. 20. Phenodiagrams of species whose phenology correlated significantly with mean maximum air temperature (1,2,3), and extreme minimum air temperature (4,5,6 & 7).

arid environment. The double peak in the reproductive phase of E. bothae has been recorded previously in the genus (Van Rooyen et al. 1979).

The geophytes, Jatropha capensis and Kalanchoe rotundifolium (Fig. 21), responded positively to extremely low air temperatures. The phenology of the annual and weak perennial pioneer grasses Aristida congesta and Eragrostis obtusa (Fig. 21) also demonstrated a positive response to extreme minimum temperature. Larger woody species are generally excluded from this group, as above ground air temperatures are higher than surface or sub-soil temperatures during the heat of the day.

Two species, Walafrida geniculata and Aristida congesta (Fig. 22), showed a positive correlation between five of the factors tested. Correlation was strongest with mean weekly rainfall and extreme minimum temperature. These species, which are at different ends of the growth form spectrum, demonstrate the diversity of species which have adapted successfully to extreme environments. Both species are representative of the Karoo-Namib biogeographical region.

Only one species, Sutera pinnatifida (Fig. 22), displayed a positive correlation between phenology and all the climatic factors tested. The phenology of this species is apparently regulated by the advent of favourable climatic conditions.

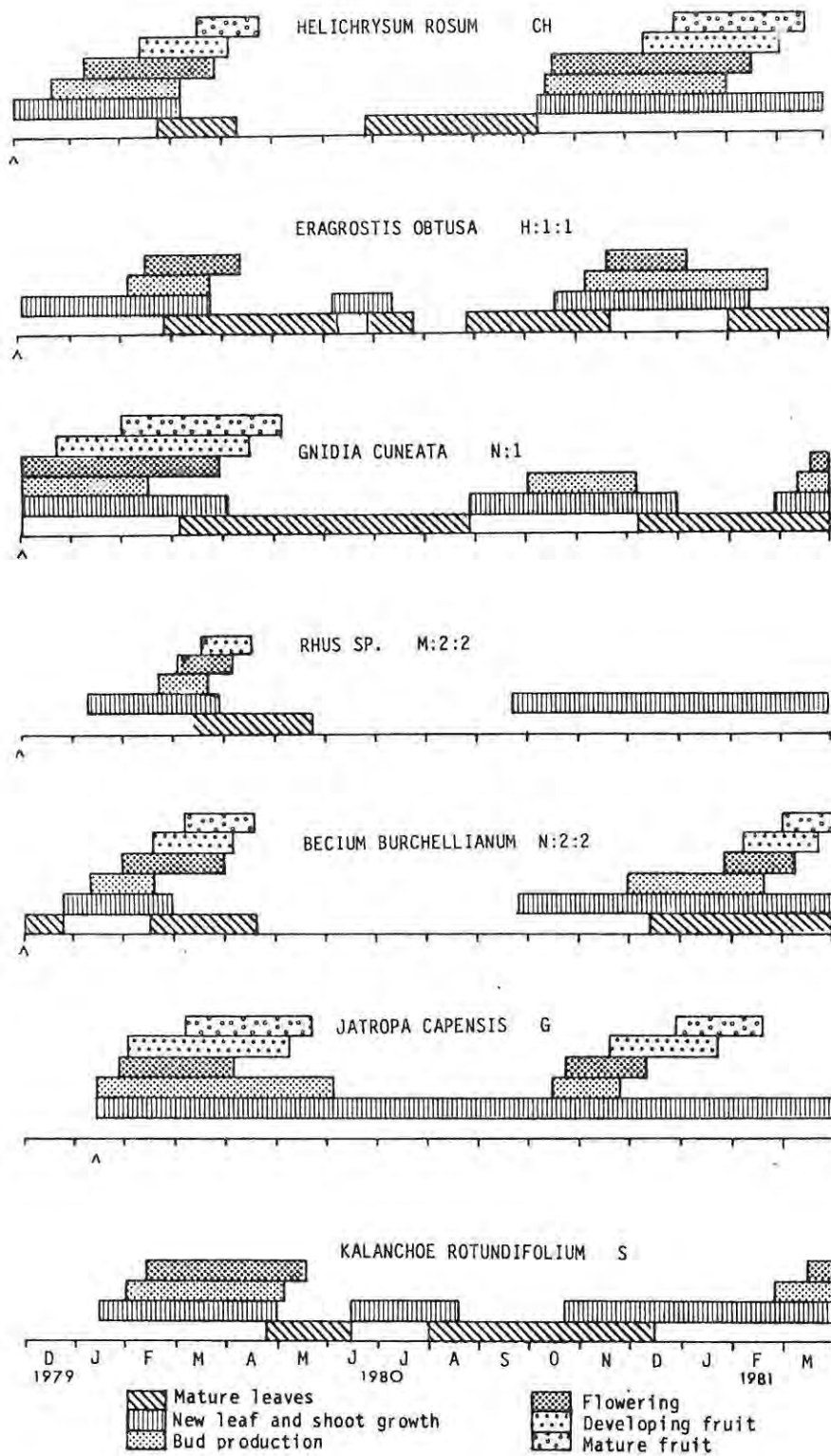


Fig. 21. Phenodiagrams of species whose phenology correlated with three or more of the climatic factors tested.

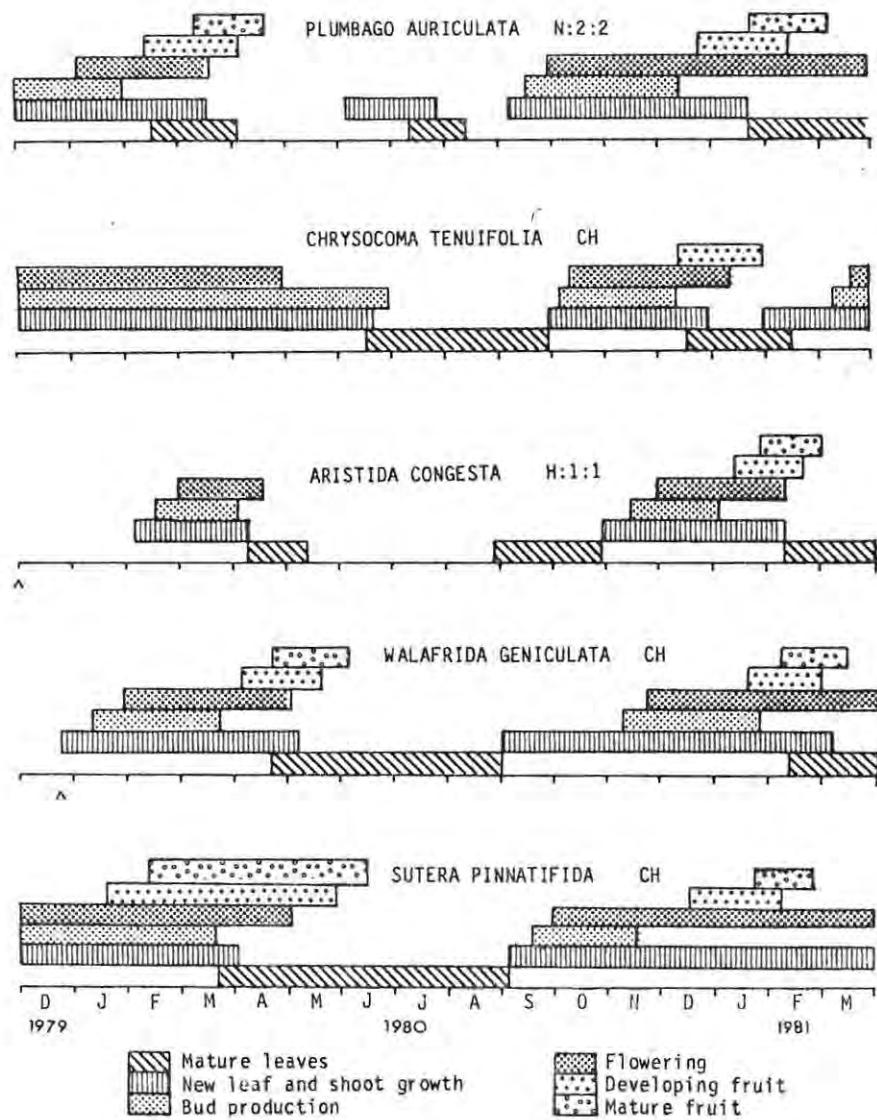


Fig. 22. Phenodiagrams of species whose phenology displayed a positive correlation with three or more of the climatic factors tested.

All the Crassula species tested displayed a negative correlation with rainfall. This is an interesting feature and may account for the adaptability of these species to a xeric environment.

The growing season for most plants is after the occurrence of the first spring rains. Those plants which did not respond to the onset of rains, or a decrease in temperature, included some of the most abundant species within the succulent bushveld (Portulacaria afra, Phyllanthus verucossus and Euclea undulata), suggesting a successful adaptation to the environment. Flowering in woody species generally occurs after a vegetative growth flush which has provided new and photosynthetically efficient leaves.

Plants adapt to edaphic and climatic heterogeneity by the production of different species or genetic races in the areas subject to different seasonal stress (Foster, 1980). As no assessment of intra-specific variation was made during this study, corroboration of this statement at the specific level cannot be made. However, variations in the extent and duration of phenophases were noticed between different localities within the study area. When these variations occurred within the same species (e.g. Acacia karroo), these differences were usually associated with different moisture regimes.

Borchert (1980) found that flowering in the genus Erythrina is not directly determined by environmental change, and suggests that growth periodicity of tropical perennial trees is

primarily the manifestation of endogenous periodic processes. No published studies could be found on sub-tropical and temperate African species, and it appears from this study that some do show significant endogenous response.

4.4.1 ADAPTATIONS TO THE ENVIRONMENT

Frankie et al. (1974a) have observed that if there is a slight drought during the dry season, then fruiting takes place towards the end of the wet season. If a severe drought is experienced during the dry season, then flowering takes place at the beginning of the wet season. Severe droughts are not a feature of this ecosystem, and the phanerophytes examined during this study demonstrated the former trend (Table 21) in agreement with the observation of Frankie et al. (1974a).

The microphanerophytes (Table 18) appear to cope with the environmental extremes (air temperature, water stress) in one of two ways:

- i) by possessing leathery, microphyllous leaves, with differentiated dorso-ventral surfaces e.g. Buddleia saligna, Euclea undulata and Ozoroa mucronata.
- ii) by possessing nanophyllous leaves, with undifferentiated surfaces. These are usually highly palatable species which produce new growth throughout most of the year e.g. Schotia afra and Ptaeroxylon obliquum.

The majority of grasses make use of the C₄ photosynthetic pathway, with the exception of Merxmüllera disticha, Schismus

SPECIES	TIME OF FRUITING
Acacia karroo	end
Brachylaena ilicifolia	end
Ehretia rigida	end
Euclea undulata	end
Ozoroa mucronata	end
Pappea capensis	end
Maytenus capitata	end
Buddleia saligna	middle
Ptaeroxylon obliquum	middle
Schotia afra	middle

Table 21. Phanerophytes whose phenology was investigated during the study, indicating tendency to fruit towards the middle and end of the wet season.

inermis and Stipa dregeana, which are all C₃. Doliner & Jolliffe (1979) found that C₄ plants occurred in greater numbers in areas experiencing relatively high air temperatures and low moisture availability. A similar situation prevails in the distribution of grasses within study area. The C₄ species are associated with the warmer, drier plant communities, and C₃ species are found in more mesic, cooler environments.

5. CONCLUSIONS

An understanding of disturbance-recovery cycles (White, 1979) is particularly important in management practices following the establishment of nature reserves. The major edaphic disturbance cycle acting on the AVKR i.e. agricultural mismanagement, has been eliminated. The major remaining cycle is the advent of severe short-term climatic disturbance i.e. drought and flood. The creation of large reserves provides the best insurance against the deleterious effects of disturbance (Foster, 1980). It is recommended that efforts be made to enlarge the AVKR by the inclusion of adjacent land and the initiation of a joint operation with the Ciskeian authorities who have planned a nature reserve on the east bank of the Great Fish River.

Vegetation recovery time may be far in excess of 100 years in arid regions where vegetation and soil have been severely disturbed (Webb & Wilshire, 1980). Pedogenesis must take place before a the historical climax grassland can be attained. Webb & Wilshire (1980) note that compaction of soil exaggerates the length of time taken to revegetate disturbed areas. High ungulate densities on AVKR (Allen-Rowlandson, 1980) are currently retarding pedogenesis between bushclumps. In addition, Acocks (1979) notes that erosion is not so obvious until one notices that some of the perennial bushes are standing on 30 cm pedestal. A reduction in total population numbers is essential to ensure revegetation of the inter bushclump areas. Future ungulate introductions should be

restricted to large bulk and roughage eaters (Mentis, 1976), rather than concentrate selectors. These species encourage the dispersal of perennial grasses by tiller formation. Calculation of carrying capacity (Appendix 5) should be based on Coe et al. (1976).

The re-establishment of historic grasslands will involve the use of fire to remove karroid species (Chrysocoma tenuifolia, Pentzia incana, Pteronia incana and Walafrida geniculata) according to the regimes recommended by Trollope (pers. comm.), and to promote the development of the fire climax grassland.

This study has elucidated the nature of the inter-relationships between plant community, phenology, soil climate and biotic influence. It would be presumptuous to interpret these relationships further without a study of the energy flow through the ecosystem. However, the ecosystem is subjected to short term climatic disturbances (dry, cold winters), and the effect of these disturbances on the vegetation has been elucidated in the phenology study. Ecosystem managers should take cognisance of these troughs in the cycle, and reduce ungulate populations accordingly. Excessive browsing pressure is being placed upon those species which appear to respond endogenously (Portulacaria afra, Pappea capensis,

Phyllanthus verucossus,^{and} Schotia afra),

and are therefore relatively independent of prevailing climatic disturbances. Ungulate numbers should be maintained at a level which favours these species.

If the establishment of other large conservation areas on land previously used for pastoral agriculture, is to be justified in southern Africa, then certain basic ecological factors have to be recognised. These are:

- a) most of the surface area of the land has undergone degradation due to over-utilization by domestic livestock. This has led to the development of a sub-climax vegetation type, and erosion of the A-horizon of the soil profile;
- b) natural pedogenesis may take centuries under arid and semi-arid climatic conditions following compaction and erosion;
- c) large wild ungulate populations can have an enormous impact on the vegetation of an extensive free range ecosystem, and managers should outline an objective statement which considers the relationships between ungulate population size and the degree of vegetation utilization (Appendix 6).

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APPENDIX 1

An annotated checklist of the Pteridophyta, Gymnospermae and Angiospermae of the Andries Vosloo Kudu Reserve. (This list does not claim any degree of completeness. It only records those species collected within the study area and stored at the AVKR Herbarium, the Albany Museum Herbarium and the Rhodes University Herbarium.)

PTERIDOPHYTA

POLYPODIACEAE

Pellaea Link.

- P. viridus* (Forsk.) Prantl "myrtle fern".
edge of bush clumps; Palmer 382.

MARSILIACEAE

Cheilanthes Swartz

- C. hirta* Swartz "Parsley fern".
moist shaded areas; Palmer 241.

GYMNOSPERMAE

ZAMIACEAE

5 Encephalartos Lehm.

- E. trispinosus* (Hook.) R.A.Dyer "cycad".
dry, north-facing slopes; Palmer 740.

ANGIOSPERMAE - MONOCOTYLEDONEAE

APONOGETONACEAE

65 Aponogeton L. f.

- A. junceus* Lehm. ex Schlechtd. "wateruintjie".
perennial dams, fl. 4; Palmer 718.

POACEAE (GRAMINAE)

K72 Cymbopogon Spreng.

- C. plurinodis* (Stapf.) Stapf. ex Burt Davy.
Palmer 640. "turpentine grass".

C. marginatus (Steud.) Stapf.
Burdett 1.

K73 Hyparrhenia Anders.

- H. hirta* (L.) Stapf. "thatch grass".
tufted perennial; valuable grazing during growing
period; Lubke 2458.

- K80 Heteropogon Pers.
H. contortus (L.) Beauv. "thatch grass".
 tufted perennial; Palmer 995.
- K83 Themeda Forsk.
T. triandra Forsk. "rooigras".
 tufted perennial; good indicator of well managed
 veld; associated with rocky soils of sandstone and
 doleritic origin; fl. 9 - 12; Burdett 103.
- K89 Digitaria Heist. ex Hall.
D. eriantha Steud. "vingergras".
 tufted perennial; highly palatable; shallow sandy
 soils; fl. 1-5; Burdett 106.
- K104 Brachiaria Griseb.
B. serrata (Spreng.) Stapf. "velvet signal grass".
 loosely tufted perennial; dry grassy heath; fl. 10-
 11; Burdett 3.
- K107 Paspalum L.
P. paspaloides (Michx.) Scribn. "buffelsgras".
 perennial; favours moist habitat;
 Burdett 2.
- K116 Panicum L.
P. deustum Thunb. "breeblaarbuffelsgras".
 tufted perennial; palatable and nutritious; fl. 1-
 12; Burdett 105.
- P. maximum* Jacq. "buffelsgras".
 large tufted perennial; palatable and nutritious;
 found in shade adjacent to bush clumps; soils moist
 and clayey; fl. 11-1; Burdett 104.
- K128 Setaria Beauv.
S. sphacelata (Schumach.) Moss var. *sphacelata* "setaria"
 abundant; mudstone koppies; Burdett 5, Lubke 2407,
 Palmer 252, 383.
S. verticillata (L.) Beauv. "burbristle grass".
 tufted annual pioneer; alien; shade, heavy soils;
 Burdett 6.
- K132a Rhynchelytrum Nees
R. setifolium (Stapf.) Chiov. "red. top".
 relatively unpalatable; densely tufted perennial;
 uncommon; restricted to shallow soils; fl. 11-4;
 Burdett 4.

- K204c Merxmuellera Conert.
M. disticha (Nees) Conert. "suurpol".
 densely tufted perennial; mountain sourveld; fl. 11-12; Palmer 745.
- K214 Phragmites Trin.
P. communis Trin. "fluitjiesriet".
 riparian reed; banks of the Great Fish River; Palmer 948.
- K262 Aristida L.
A. congesta Roem. & Schult. subsp. *barbicollis* "steekgras".
 variable perennial; indicates mismanagement; Burdett 7 & 8.
A. congesta Roem. & Schult. subsp. *congesta* "aapstert steekgras".
 densely tufted perennial; Burdett 9.
- K263 Stipa L.
S. dregeana Steud. "garinggras".
 tufted perennial; undergrowth of bush clumps; fl. 4; Burdett 10.
- K274 Tragus Haller
T. berteronianus Schult. "kruipgras".
 short rosette shaped annual; pioneer, typical of disturbed veld; fl. 2; Lubke 2408, Palmer 19.
- K283 Sporobolus R. Br.
S. fimbriatus Nees "blousaadgras".
 densely tufted perennial; palatable in growing period; fl. 2-3; Burdett 11.
S. nitens Stent.
 favours 'brak' soils; fl. 12; Burdett 12, Palmer 188.
S. ioclades (Trin.) Nees "soetkweek".
 Burdett 13.

- K286 Eragrostis Beauv.
E. curvula (Schrad.) Nees "weeping lovegrass".
 palatable in early spring; fl. 9-4; Burdett 20.
E. lehmanniana Nees "knietjiesgras".
 fl. 10; Burdett 22, Palmer 216.
E. heteromera Stapf.
 Burdett 21.
E. obtusa Munro ex Fical. & Hiern. "hartjiesgras".
 tufted perennial; pioneer of low to medium
 palatability; fl. 2-4; Burdett 23, Palmer 170.
E. cilianensis (Alln.) Lutati
 Burdett 19.
- K296 Cynodon Rich. ex Pers.
C. dactylon (L.) Pers. "kweekgras".
 variable creeping perennial; disturbed areas; fl.
 10-4; C4 (Doliner & Jolliffe, 1979); Burdett 14.
C. incompletus Nees "kwaggakweek".
 Burdett 15.
- K301 Chloris Swartz
C. virgata Swartz "sweetgrass".
 annual or weak perennial; pioneer of disturbed
 soils; fl. 11-4; Burdett 17.
- K302 Eustachys Desv.
E. mutica L. "hoenderspoorgras".
 tufted stoloniferous perennial; fl. 4; Burdett 16.
- K320 Oropetium Trin.
O. capense Stapf. "haasgras".
 shallow soils; Burdett 24.
- K357 Enneapogon Desv. ex Beauv.
E. scoparius Stapf. "dassiegras".
 wiry, tufted perennial; stony slopes in dry areas;
 Burdett 18.
- K386 Melica L.
M. racemosa Thunb. "rough cutting grass".
 fl. 10-11; Palmer 309.
- K405 Schismus Beauv.
S. inermis (Stapf.) Hubb. "haasgras".
 Lubke 2406.

CYPERACEAE

- 49 Typha L.
T. capensis Rohbr. "bulrush".
 riparian; banks of the Great Fish River.
 Palmer 998.
- 459 Cyperus L.
C. teneriffae Poir.
 Curtis 237, Lubke 2419.
C. sp.
 Burdett 58.
- 459a Pycnus Beauv.
P. lanceus (Thunb.) Turnl.
 Kentucky dam; Palmer 355, 997.
- 459c Mariscus Gaertn.
M. capensis (Steud.) Schrad. "bobbejaanuintjie".
 Burdett 25, Palmer 311.

COMMELINACEAE

- 896 Commelina L.
C. africana L. var. *africana* L. "African commelina".
 fl. yellow, 1-4; Palmer 368.
C. benghalensis L. "blouσαadblommetjie".
 fl. blue; Lubke (vis. rec.)
- 904 Cyanotis D. Don.
C. speciosa (L. f.) Hassk. "bloupoeierkwassie".
 dry grassland of bushclump savanna; fl.-blue, 1-2;
 Lubke 2418, Palmer 366.

LILIACEAE

- 985 Bulbine Willd.
B. caulescens L. "rankkopieva".
 fl.-yellow, 10; Palmer 235.
- 990 Chlorophytum Ker-Gawler
C. comosum (Th.) Bak.
 fl.-white; stream banks, shade, rocky slopes;
 Lubke 2417.
- 1012 Eriospermum Jacq. ex Willd.
E. sp. cf. *E. dyeri* Archibald "bobbejaanoor".
 fl.-white; Palmer 56.

- 1026 Aloe L.
A. ciliaris Haw. "climbing aloe".
 fl.-scarlet tipped, 1; Palmer 246.
A. ferox Mill. "bitteralwyn".
 fl. 6; Palmer 746.
- 1027 Gasteria Duval
G. sp. cf *G. beckeri* Schonl. "bontaalwyn".
 karroid grassland; Palmer 747.
- 1080 Urginea Steinh.
U. altissima (L.f.) Bak. "maerman".
 Lubke 2416.
- 1086 Scilla L.
S. rigidifolium Kunth.
 Palmer
- 1110 Sansevieria Thunb.
S. hyacinthoides (L.) Druce "mother-in-laws tongue".
 Palmer 748.
- 1113 Asparagus L.
A. africanus Lam. "wag-'n-bietjie".
 Lubke 2414, Palmer 390, Burdett 27.
A. asparagoides (L.) Wight.
 Palmer 429
A. crassycladus Jess.
 Lubke 2413.
A. densiflorus (Kunth.) Jess.
 Palmer 121.
A. macowanii Bak.
 Palmer 287, Burdett 29.
A. plumosus Bak. "feathery asparagus".
 Lubke 2412, Palmer 118.
A. racemosus Willd. "wag-'n-bietjie".
 Lubke 2411, Palmer 242.
A. setaceus (Kunth.) Jess.
 Palmer 400.
A. striatus (L.f.) Thunb. "bergappeltjie".
 Palmer 721.
A. suaveolens Burch. "wild asparagus".
 Lubke 2409.
A. subulatus Thunb. "katdoring".
 fr. 2-3; Lubke 2410, Palmer 417.

AMARYLLIDACEAE

- 1168 Boophane Herb.
B. disticha (L.f.) Herb. "gifbol".
 Palmer 749.
- 1191 Cyrtanthus L.f.
C. sp. cf C. sanguineus (Lindl.) Hook. "fire lily".
 fl. red, 1; Palmer (vis. rec.)

IRIDACEAE

- 1265 Moraea Miller
M. polystachya Ker. "bloutulp".
 Burdett 30.
- 1265a Dietes Salisb.
D. vegeta (Mill.) N.E.Br. "bloutulp".
 Lubke 2421.
- 1306 Tritonia Ker
T. securigera (Ait.) Ker.
 Burdett 31.
- 1311 Gladiolus L.
G. permeabilis Delaroché spp. *edulis* (Buch. ex Ker) Oberm.
 Palmer 143.
- 1319 Strelitzia Ait.
S. reginae Dryand.
 Palmer 992.

ANGIOSPERMAE - DICOTYLEDONEAE

SALICACEAE

- 1873 Salix L.
S. mucronata Th. "Cape willow".
 riparian; banks of the Great Fish River;
 Palmer 991.

MORACEAE

- 1961 Ficus L.
F. capensis Thunb. "wildfig".
 tree in riverine gorge; Palmer 444.
F. burtt-davyi Hutch.
 Palmer 453.

LORANTHACEAE

- 2074 Moquinella Balle.
M. rubra (Spreng.f.) Balle. "loranthus".
 parasite on woody species; Burdett 32.

- 2093 Viscum L.
V. rotundifolium L.f. "mistletoe".
 parasite on woody species; Palmer 5, 386.

SANTALACEAE

- 2118 Thesium L.
T. flexuosum A.DC.
 parasitic on roots of host plant; fl. greenish-white,
 10; Palmer 392.

AMARANTHACEAE

- 2328b Achyroopsis Hook.f.
A. leptostachya Hoof. F.
 Lubke 2420, Palmer 379

AIZOACEAE

- 2376 Limeum L.
L. aethiopicum Burn.
 fl. greenish-white; Lubke 2454, Palmer 281.
- 2389 Pharnaceum L.
P. detonsum Fenzl.
 Palmer 288.
- 2401 Aizoon L.
A. glinoides L.f.
 Burdett 33, Lubke 2440, Palmer 268.

MESEMBRYANTHEMACEAE

- 2405 Delosperma N.E.Br.
D. calycinum L. Bd.
 Palmer 163, 271.
D. echinatum (Ait.) Schw.
 Palmer 196.
- 2405 Mestoklema N.E.Br.
M. albanicum N.E.Br.
 Palmer 169.
- 2405 Ruschia Schwant.
R. sp. cf *R. uncinata* (L.) L. Bol.
 fl. purple; Curtis 232; Palmer 59.
R. sp. cf *R. dyeri* L. Bol.
 Curtis 208, Palmer 17.

PORTULACACEAE

- 2419 Portulacaria Jacq.
P. afra Jacq. "spekboom".
 fl. pink, 10-1; Palmer 365.

RANUNCULACEAE

- 2542 Clematis L.
C. brachiata Th.
 Burdett 34.

CRUCIFERAE

- 2875 Heliophila L.
H. suavissima Burch. ex DC.
 fl. blue; Palmer 119, 206.
- 2883 Lepidium L.
L. divaricatum Ait. subsp. *divaricatum*
 fl. white, 5-6; Palmer 243.

CAPPARACEAE

- 3101 Capparis L.
C. sepiaria L. var. *citrifolia* (Lam.) Toelken
 frt. 3; Lubke 2422. Palmer 87. "wild capers".
- 3106 Boscia Lam.
B. oleoides (Burch. ex DC.) Toelken "witgatboom".
 fl. white, 10-11; Burdett 35.
- 3109 Cadaba Forsk.
C. aphylla (Thunb.) Willd.
 Palmer 782.

CRASSULACEAE

- 3164 Cotyledon L.
C. velutina Hoof. f.
 Palmer 20.
C. campanulata Marloth
 Palmer 781.
- 3166 Kalanchoe Adans.
K. rotundifolia Harv.
 Burdett 36, Palmer 48.

3168 Crassula L.

- C. cultrata* L.
 Burdett 39
C. ericoides Haw.
 Palmer 724, Burdett 43.
C. expansa Dry
 Palmer 248.
C. lycopodioides Lam. "slangbossie".
 Palmer 723.
C. obvallata L.
 Palmer 168, 334
C. ovata Lam.
 fl. 7; Burdett 38.
C. parvula Endl.
 Burdett 42.
C. perforata L. "sosatie".
 Burdett 40.
C. sp. cf C. rogissae Schonl.
 Palmer 290a.
C. spathulata Thunb.
 Palmer 66, 270.
C. tetragona L.
 Burdett 41.
C. trachysantha (E. & Z.) Haw.
 Burdett 37, Palmer 186.
C. perfoliata L.
 Palmer 989

LEGUMINOSAE

3446 Acacia Mill.

- A. caffra* (Th.) Willd.
 riparian thicket near Double Drift;
 Palmer 996.
A. karroo Hayne "sweetthorn".
 Burdett 47.
 3506 Schotia Jacq.
S. afra (L.) Bodin. "karooboerboon".
 fl. 7, red; Burdett 107, Palmer 725.
S. latifolia Jacq. "bosboerboon".
 dry forests of the southern slopes; Palmer 329.

3657 Lotononis Eckl. & Zeyh.

- L. pungens* E. & Z.
 fl. 8-10, yellow; frt. 9-10;
 Burdett 45, Lubke 2445, Palmer 128, 212.

- 3673 Argyrolobium Eckl. & Zeyh.
 A. pauciflorum E. & Z.
 Lubke 2446.
- 3702 Indigofera L.
 I. disticha E. & Z.
 highland grasslands; fl. 2, mauve; Lubke 2423,
 Palmer 197.
 I. heterophylla Thunb.
 fl. mauve, 8-9; Palmer 126.
 I. sessilifolia DC.
 Lubke 2441, Palmer 43, 370.
- 3718 Tephrosia Pers.
 T. capensis (Jacq.) Pers.
 fl. 5, 9, purple; Palmer 140.
 T. sp.
 Palmer 42.
- 3756 Lessertia DC.
 L. physodes E. & Z.
 fl. 9, white; frt. inflated; Palmer 144.
 L. annularis Burch.
 moist drainage line communities; frt. 8, 9;
 Burdett 46, Palmer 166.
- 3897 Rhynchosia Lour.
 R. calvescens
 Lubke 2448, Palmer 116, 790.
 R. totta (Thunb.) DC.
 Palmer 197, 202.
 R. ciliata (Thunb.) Druce.
 margin of bush clumps; fl. 10, yellow;
 Palmer 210, 305.
- 3909a Dipogon Liebm.
 D. hastaeformis E. Mey
 Lubke 2461.
 D. sp. cf. D. lignosus (L.) Verdc.
 Palmer 340.
- 3910 Dolichos Lam. emend. DC.
 D. hastaeformis E. Mey.
 Palmer 57, 219.

GERANIACEAE

- 3926 Sarcocaulon Sweet
S. vanderietiae L. Bol. "Bushmans candle".
 Palmer 750.
- 3928 Pelargonium L'Herit.
P. peltatum (L.) L'Herit. "ivy-leaved geranium",
 creeper with succulent leaves; fl. 10; Palmer 227.
P. reniforme Curtis
 fl. 8, crimson; Palmer 47.
P. zonale (L.) Ait.
 fl. 10-11, pink; Palmer 267.

OXALIDACEAE

- 3936 Oxalis L.
O. bowiei Lindl.
 Burdett 48

RUTACEAE

- 3991 Zanthoxylon L.
Z. capensis L. "small knobwood".
 Palmer 786.
- 4076 Vepris Comm. ex A. Juss.
V. undulata (Thunb.) Verd. & C.A.Sm "white ironwood".
 fl. yellow, 11-12; dry forest; Palmer 328.

BURSERACEAE

- 4151 Commiphora Jacq.
C. harveyi (Engl.) Engl. "copper paperbark".
 Palmer 751.

PTAEROXYLACEAE

- 4157 Ptaeroxylon Eckl. ° Zeyh.
P. obliquum (Thunb.) Radlk. "sneezewood".
 Burdett 108, Palmer 64.

POLYGALACEAE Reichb.

- 4273 Polygala L.
P. leptophylla Burch. ex DC.
 Burdett 49, Palmer 189, 313.
P. microlopha DC.
 fl. 8-9, white and mauve; Palmer 127.
P. hamata Burtt-Davy
 fl. 10, purple; Palmer 221.
P. myrtifolia L.
 fl. 9-10, white with mauve veination; Palmer 726.

EUPHORBIACEAE

- 4299 Phyllanthus L.
P. verrucosus Thunb.
 Palmer 61, 82.
- 4407 Acalypha L.
A. glabrata Th.
 herb of forest understory; Palmer
- 4433 Jatropha L.
J. capensis (L.f.) Sond.
 Palmer 752.
- 4448 Clutia L.
C. sp. cf *C. laxa* Eckl.
 fl. 10, greenish yellow; Burdett 50, Palmer 2.
- 4498 Euphorbia L.
E. bothae Lotsy & Godd. "noors".
 fl. 9-2, yellow; frt 11; Palmer 727.
E. fimbriata Scop.
 clay soils of dry thorny scrub; fl. 10, yellow;
 Palmer 229.
E. tetragona Haw. "honey euphorbia".
 Palmer 342.
E. sp. cf *E. inermis* Mill. "finger euphorbia".
 Palmer 119.
E. triangularis Desf. "river euphorbia".
 Palmer 753.
E. mauritanica L. "melkos".
 Palmer 231.

ANACARDIACEAE

- 4562 Harpephyllum Bernh. ex Krauss
H. caffrum Bernh. "wildplum".
 Palmer 439.
- 4589a Ozoroa Deliliet
O. mucronata (Bern. & Drauss.) R. & A.
 "Oos-Kaapse harpuisboom".
 frt. 7-8; Palmer 393.

- 4594 Rhus L.
R. incisa L.f. var. *obovata* Schoml. "baardbessie".
 Burdett 53,54; Palmer 38.
R. lancea L. "karee".
 Palmer 787.
R. baurii Schoml. "suurtaaibos".
 Palmer 414.
R. refracta E. & Z.
 Burdett 55, Palmer 49.
R. sp. cf. R. longispina E. et Z.
 fl. 7-8; Burdett 51,52; Lubke 2438, Palmer 357, 378.

CELASTRACEAE

- 4626 Maytenus Molina
M. capitata (E.Mey. ex Sond.) Marais
 Curtis 207, Palmer 351,352.
M. heterophylla (E. & Z.) N.K.Br. "common spikethorn".
 fl. 11; Burdett 57, Palmer 130, 323.
M. undata (Thunb.) Blakelock "kokoboom".
 Palmer 260.
M. peduncularis (Sond.) Loes.
 Palmer 446.
M. polyantha (Sond.) Marais "kraalpendoring".
 frt. 8,9; Burdett 56, Palmer 669.
- 4628 Putterlickia Szyszyl.
P. pyracantha (L.) Szyszyl. "basterpendoring".
 frt. 6; Palmer 269.
- 4630 Pterocelastrus Meisn.
P. tricuspидatus (Lam.) Sond. "cherrywood".
 component of bush clumps; rare; Palmer 406.
- 4641 Cassine L.
C. crocea (Thunb.) Kuntze "red saffronwood".
 frt. 9, yellow; Palmer 344.
- 4646 Pleurostyliia W. & A.
P. capensis Oliv.
 Palmer 438.

SAPINDACEAE

- 4734 Allophylus L.
A. decipiens (Sond.) Radlk. "bastertaaibos".
 small tree, 3-4m; Palmer 306.

- 4784 Pappea E. & Z.
P. capensis E. & Z. "bergpruim".
 Palmer 376.
- 4836 Hippobromus E. & Z.
H. pauciflorus (Thunb.) Radlk. "basterperdepis".
 dry forest of southern slopes; Palmer 433.
- 4861 Ziziphus Mill.
Z. mucronata Willd.
 Curtis 225, Palmer 789.

RHAMNACEAE

- 4874 Scutia Comm. ex Brongn.
S. myrtina (Burm.f.) Kurz. "katdoring"
 frt. 4, 8-9; Palmer 109, 209.
- 4905 Helinus E. Mey.
H. integrifolius (Lam.) O. Ktze
 Palmer

VITACEAE

- 4917 Rhoicissus Planch.
R. tridentata (L.f.) Wild & Drummond
 frt. 8; Palmer 23, 89.
R. digitata (L.f.) Gilg. & Brandt
 Palmer

TILIACEAE

- 4966 Grewia L.
G. occidentalis L. "kruisbessie"
 Lubke 2424, Palmer 303.
G. robusta Burch. "kruisbessie"
 Curtis 209, Palmer 176.

MALVACEAE

- 4983 Abutilon Mill.
A. sonneratianum (Cav.) Sweet
 fl. yellow, 10; frt. 10-11; Lubke 2452, Palmer 335.
- 4998 Sida L.
S. ternata L.f.
 weed of disturbed areas; Lubke 2455.
- 5013 Hibiscus L.
H. pusillus Thunb.
 fl. white, 10; Palmer 185, 211.

STERCULIACEAE

- 5056 Hermannia L.
H. althaeoides Link.
 fl. yellow, 11; Palmer 33, 62.
H. coccocarpa (E. & Z.) O. Hoffmg.
 fl. red, 8-9; Palmer 72, 226.
- 5083 Sterculia L.
S. alexandri Harv.
 fl. 12; Palmer 325.

FLACOURTIACEAE

- 5304 Scolopia Schreb.
S. zeyheri (Nees) Harv. "thorn pear".
 bush clumps; Lubke 2425, Palmer 341.
S. mundii (E. & Z.) Warb. "red pear".
 forest; Palmer 295.
- 5328 Dovyalis E. Mey. ex Arn.
D. caffra (J.D.Hook & Harv.) "kei apple".
 introduced; Palmer 410.

THYMELAEACEAE

- 5435 Gnidia L.
G. cuneata Meisn.
 fl. yellow-orange, 8-9; Palmer 191, Burdett 62.
G. coriacea Meisn.
 Palmer 74.

COMBRETACEAE

- 5538 Combretum Loefl.
C. caffrum (E. & Z.) O. Kuntze "bushwillow".
 frt. 2; Curtis 226, Palmer 449.

ARALIACEAE

- 5872 Cussonia Thunb.
C. spicata Thunb. "cabbage tree".
 Palmer 346.

UMBELLIFERAE

- 5992 Heteromorpha Cham. et Schlechtd.
H. arborescens (Spreng.) Ch. et Schl.
 fl. yellow, 7; Palmer 728.

PLUMBAGINACEAE

- 6343 Plumbago L.
P. auriculata Lam. "plumbago".
 fl. pale blue; Burdett 63, Palmer 67.

SAPOTACEAE

- 6368 Sideroxylon L.
S. inerme L. "milkwood".
 Palmer 447.

EBENACEAE

- 6404 Euclea Murray
E. undulata Thunb. var. *undulata* "gwarrie".
 Burdett 64, 65; Palmer 24.
- 6406 Diospyros L.
D. dichrophylla (Gand.) de Winter "monkey apple".
 Palmer 112, 276.
D. lycioides Desf. subsp. *lycioides* "bluebush".
 frt. 2; Palmer 411.
D. scabrida (Harv. ex Hiern.) de Winter var. *cordata*
 (E.Mey. ex A.D.C.) de Winter
 fl. 9; Burdett 66, Palmer 224.
D. sp.
 Palmer 309.

OLEACEAE

- 6434 Olea L.
O. africana Mill. "wild olive".
 frt. 8-9; Burdett 67, Palmer 111.
- 6440 Jasminum L.
J. angulare Vahl. "jasmine".
 fl. white, 12; Lubke 2426, Palmer 330.
J. multipartitum Hochst. "jasmine".
 fl. 10; Lubke 2462, Palmer 207.

SALVADORACEAE

- 6444 Azima Lam.
A. tetraacantha Lam. "needlebush".
 Burdett 68, Lubke 2439, Palmer 266.

LOGANIACEAE

- 6473 Buddleia L.
B. dysophylla (Benth.) Radlk.
 Burdett 69.
B. saligna Willd. "witolienhout".
 fl. 9; Burdett 70, 71.

APOCYNACEAE

- 6558 Acokanthera G. Don.
A. oppositifolia (Lam.) Codd. "poison bush".
 Palmer 757.

- 6559 Carissa L.
C. haematocarpa (Eckl.) A.DC. "num-num".
 Palmer 729.

- 6681 Pachypodium Lindl.
P. bispinosum (L.f.) A.DC.
 fl. pale pink, 11-12; Palmer 717.
P. succulentum (L.f.) A.DC.
 Burdett 72.

ASCLEPIADACEAE

- 6849 Sarcostemma R.Br.
S. viminale (L.) R.Br. "melktou".
 Burdett 73, Palmer 388.

- 6860 Secamone R.Br.
S. frutescens (E.Mey.) Decne
 climber; bush clumps; fl. green;
 Lubke 2459, Palmer 274.

- 6874 Ceropegia L.
C. ampliata E. Mey.
 fl. 1, pale green; Palmer 783.

CONVOLVULACEAE

- 6972 Falkia L.f.
F. repens L.f.
 Palmer 52, 103.

- 7003 Ipomoea L.
I. ficifolia Lindl.
 Lubke 2450.

BORAGINACEAE

- 7043 Ehretia L.
E. rigida (Th.) Druce
 fl. purple, 8-9; Curtis 203, Palmer 83, 143.

VERBENACEAE

- 7144 Lantana L.
L. salvifolia Jacq.
 fl. 9; Palmer 91, 171.
- 7148 Chaschanum E. Mey.
C. dehiscens L.f. Moldenke
 Palmer 190.

- 7153 Priva Adans.
P. leptostachya Juss.
 fl. 9; Lubke 2451, Palmer 172.

LABIATAE (LAMIACEAE)

- 7217 Teucrium L.
T. africanum Thunb.
 Palmer 45.
- 7264 Leonotis R. Br.
L. leonitis (L.) R. Br.
 Burdett 74.
- 7268a Lasiocorys Benth.
L. capensis Benth.
 fl. cream, 9; Burdett, 75, Palmer 55.
- 7281 Stachys L.
S. cooperi Skan.
 fl. white, 3; Lubke 2442.
S. aethiopica L.
 fl. white, 3; Lubke 2427.
- 7290 Salvia L.
S. triangularis Thunb.
 Lubke 2453; Palmer 27, 34, 160, 84.
- 7350 Plectranthus L. 'Herit
P. madagascariensis (Pers.) Benth.
 Palmer 398.
- 7366a Becium Lindl.
B. burchellianum Benth. N.E.Br.
 fl. violet, 7; Burdett 76, Palmer 297.

SOLANACEAE

- 7379 Lycium L.
L. campanulatum E. Mey.
 fl. white, 8-9; frt. 9;
 Curtis 224, Lubke 2449, Palmer 95.
L. austrinum Miers
 Palmer 471.
- 7407 Solanum L.
S. rigescens Jacq.
 fl. deep blue, 11; frt. 11; Burdett 78.
S. coccineum Jacq.
 Burdett 79.

SCROPHULARIACEAE

- 7467 Aptosimum Burch.
A. depressum Burch. "karoo violet".
 fl. blue, 9-10; Palmer 192.
- 7476 Nemesia Vent.
N. floribunda Lehm. "leeubekkie".
 fl. 9; Palmer 152, 254.
- 7519 Sutera Roth
S. campanulata (Benth.) O. Kuntze.
 fl. orange, 8; Palmer 36, 304.
S. pinnatifida (Benth.) O. Kuntze
 fl. purple, 7; Palmer 310.

SELAGINACEAE

- 7568 Selago L.
S. corymbosa L.
 Palmer 225.
- 7568a Walafrida E. Mey.
W. geniculata Rolfe
 Burdett 81,82, Palmer 41, 101.

BIGONIACEAE

- 7713 Tecomaria Spach.
T. capensis (Th.) Spach.
 fl. orange, 8-9; Curtis 253, Palmer 86.
- 7722 Rhigozum Burch.
R. obovatum Burch. "wildegranaat".
 fl. yellow, 10; Burdett 83, Curtis 227.

ACANTHACEAE

- 7914 Thunbergia Retz
T. dregeana Nees
 Lubke 2460.
- 7973 Barleria L.
B. obtusa Nees
 fl. pale violet; fl. 3,6,7,10;
 Lubke 2432,2433, Palmer 71,159,220,247.
B. pungens L.
 Lubke 2431, Palmer 53.

- 8007 Asystasia Blume
A. stenosiphon C.B.Cl.
 Lubke 2458.
- 8026 Peristrophe Nees
P. cernua Nees
 fl. 3; Lubke 2430.
- 8032 Hypoestes Soland. ex R.Br.
H. verticillaris (L.f.) R.Br. ex C.B.Cl.
 fl. white, 10;
 Curtis 251, Lubke 2429, Palmer 219, 272.
- H. aristata* R.Br.
 fl. mauve, 1-2; Burdett 84, Palmer 353.
- 8094 Justicia L.
J. protracta (Nees) T. And.
 fl. 3; Lubke 2428, Palmer 28, 150.

RUBIACEAE

- 8283h Xeromphis Rafin.
X. rudis (E.Mey. ex Harv.) Codd.
 frt. 12; Burdett 85, Palmer 374.
- 8435 Galium L.
G. tomentosum Thunb.
 epiphyte; Palmer 719.
- 8438 Anthospermum L.
A. aethiopicum L.
 Palmer 885, 124.

CUCURBITACEAE

- 8568 Kedrostis Medik.
K. africana (L.) Cogn.
 Lubke 2437, Palmer 250.

CAMPANULACEAE

- 8670 Lightfootia L'Herit.
L. albens Spreng.
 Lubke 2457.

LOBELIACEAE

- 8681 Cyphia Berg.
C. sylvatica Eckl.
 Burdett 86.

COMPOSITAE (ASTERACEAE)

- 8751 Vernonia Schreb.
V. capensis (Houtt.) Druce
 fl. lilac, 11; Palmer 720.
- 8862 Pteronia L.
P. incana (Burm.) DC. "bluebush".
 fl. yellow, 9; Palmer 196.
- 8919 Felicia Cass.
F. elongata O. Hoffm.
 Burdett 89.
F. muricata (Thunb.) Nees
 fl. 3,9; Burdett 88, Lubke 2436, Palmer 114,182.
F. filifolia (Vent.) Burtt. Davy.
 fl. 7; Burdett 87.
- 8930 Chrysocoma L.
C. tenuifolia Berg. "bitterkaroo".
 fl. yellow; Burdett 90.
- 8936 Brachylaena R.Br.
B. ilicifolia (Lam.) Phill. & Schw. "vaalbos".
 Burdett 91, Lubke 2435, Palmer 22,39.
- 8992 Gnaphalium L.
G. declinatum L.f. "cudweed".
 Burdett 92, Palmer 68.
- 9006 Helichrysum Mill.
H. rosum (Berg.) Less.
 fl. yellow-white; Lubke 2434, Palmer 15,111,249.
H. nudifolium (L.) Less.
 Palmer 125.
H. cymosum (L.) D.Don
 Palmer 123,184,730.
- 9041 Elytropappus Cass.
E. rhinocerotis (L.f) Less. "renosterbos".
 Palmer 407.
- 9311 Tagetes L.
T. minuta L. "kakibos".

- 9320 Eriocephalus L.
 E. africanus L. "kapokbos".
 fl. 8-9; Palmer 105.
 E. punctulatus DC.
 Palmer 208.
- 9336 Phymaspermum Less.
 P. parvifolium (DC) Benth, et Hook. "vaalkaroobos".
 Palmer 288.
- 9366 Pentzia Thunb.
 P. incana (Thunb.) O. Kuntze. "common karoobush".
 Burdett 94, Curtis 256, Palmer 19.
- 9406 Cineraria L.
 C. lobata L'Herit.
 fl. yellow; Lubke 2443.
- 9411 Senecio L.
 S. radicans (Thunb) DC.
 fl. 8; Palmer 60.
 S. burchellii DC.
 yellow, 7; Burdett 95, Palmer 14, 175.
 S. deltoideus DC.
 Burdett 96, Palmer 70, 167.
 S. longifolius L.
 Burdett 97.
 S. inaequidens DC.
 Burdett 98.
- 9417 Euryops Cass.
 E. tenuissimus (L.) DC. "harpuisbos".
 fl. yellow, 7; Burdett 99, Palmer 413.
 E. anthemoides B. Nord. spp. anthemoides
 fl. yellow; Palmer 106, 156.
- 9420 Othonna L.
 O. carnosia Less.
 fl. yellow and white, 8-9; Palmer 731.
- 9426 Garuleum Cass.
 G. bipinnatum (L'Her.) DC "slangwortel".
 Palmer 405.
- 9432 Arctotis L.
 A. acaulis L.
 fl. yellow, 8-9; Palmer 131.

9432a Venidium Less.

V. decurrens Less.

fl. 7; Burdett 100, Palmer 294.

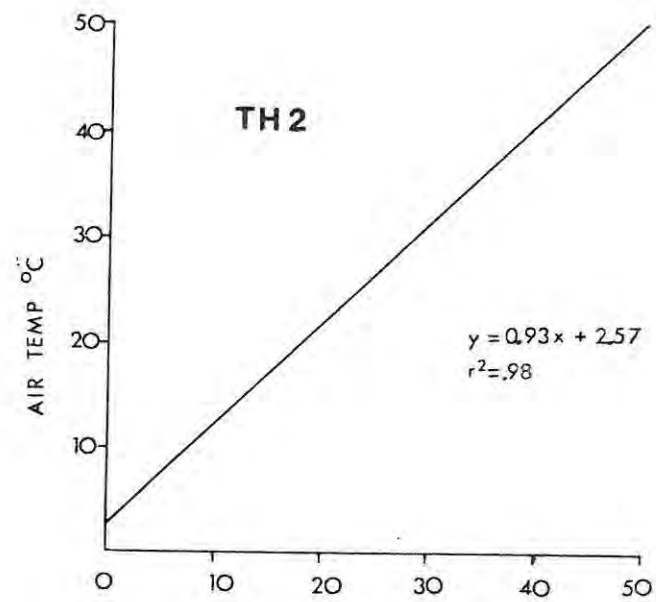
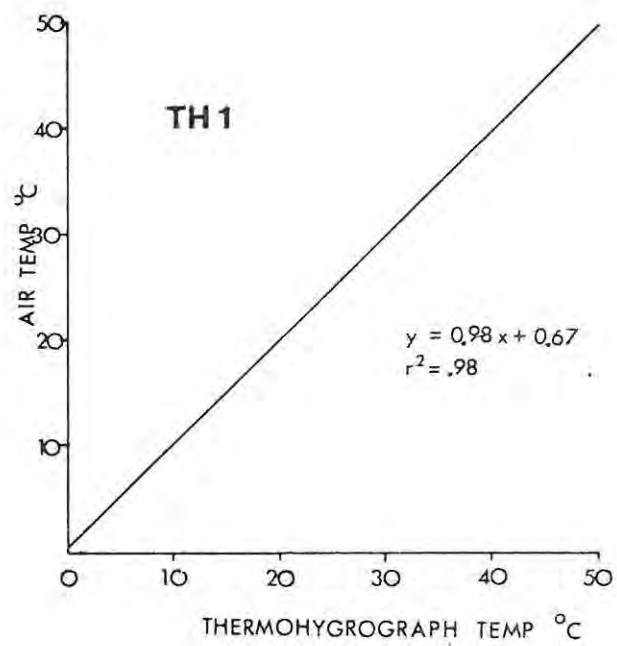
9434 Gazania Gaertn.

G. linearis (Thun.) Druce.

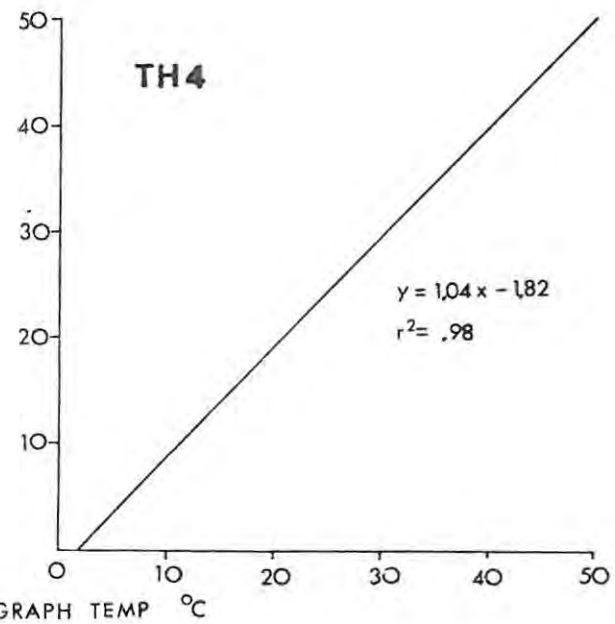
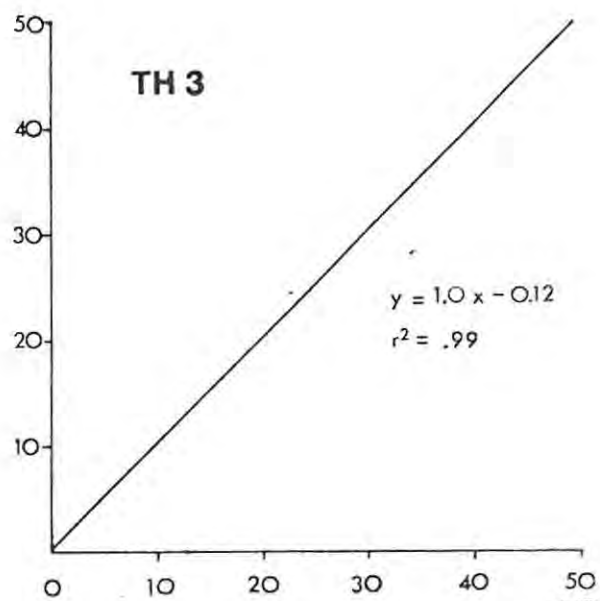
Burdett 102, Palmer 151.

EXOTICS

<i>Agave americana</i> L.	"American aloe".
<i>Cirsium vulgare</i> (Savi) Ten.	"scotch thistle"
<i>Atriplex semibaccata</i> R.Br.	
<i>Erigeron bonariensis</i> L.	"horseweed"
<i>Opuntia ficus-indica</i> (L.) Mill.	"prickly pear"
<i>O. aurantiaca</i> (Haw.) DC.	"katjie"
<i>Pennisetum clandestinum</i> Hochst. ex Chiov.	"kikuyu"



APPENDIX 2. Thermohydrograph calibration curves.



APPENDIX 2. Thermohygrograph calibration curves.

APPENDIX 3

THE SORTING OF SPECIES-RELEVÉ GROUPS IN PHYTOSOCIOLOGY BY MEANS
OF AN INFORMATION PROCESSOR

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ABSTRACT

A rapid and efficient process for arranging a Braun-Blanquet phytosociological table is described. Making use of an Information Processing System, a table containing up to 220 relevés and 980 species can be manipulated and produced for publication.

UITTREKSEL

'n Vinnig en doeltreffende proses vir die rangskiking van 'n Braun-Blanquet plantesosiologiese tabel word beskryf. Deur middel van 'n "Information Processing System" kan 'n tabel bestaande uit 220 relevés en 980 spesies bewerk en vir publikasie geproduseer word.

The process of arranging a Braun-Blanquet phytosociological table has been the dilemma of many phytosociologists in recent years. Numerous solutions have been presented, including manual rearrangement (Muller et al., 1972) and computer tabulation (Ceska & Roemer, 1971; Spatz & Siegmund, 1973). After making extensive use of computer tabulation (Ceska & Roemer, 1971), an alternative more rapid and efficient process was developed using the ICL 7700 Information Processing System (IPS) and the WORDSKIL software package, although any other system (e.g. Wang or Philips) with similar facilities would be suitable.

ICL's 7700 IPS comprises a software package called WORDSKIL which runs on a Word Processing Unit (WPU). The WPU consists of two video display units, one 8 inch disc unit and a Qume printer. The ICL 7700 IPS costs approximately R 27000 (excluding annual fee for up-dated software) and is available in South Africa from International Computers Limited. The system is described as a flexible, easy-to-use word processor, and is superior to common micro-computers.

After the "systems disc" (WORDSKIL) is activated, a separate "user's disc" is opened for entering the data. A matrix 240 characters wide and 999 lines long can be accommodated. This means that, allowing for headings and species names, a table of about 220 relevés and 980 species can be manipulated which is usually well within the requirements of most phytosociological studies. In a detailed study of the vegetation of the Andries Vosloo Kudu Reserve (Palmer, 1981), data were entered after

preliminary arrangement of the "raw table" (Werger, 1974). This is not a prerequisite and field data may be entered directly into the system, as was done with the short table of data presented here as an example (Table 1). Entering these 16 lines of data took approximately 15 minutes. A hard copy of the "raw table" was produced immediately on the printer. Once the data table has been entered it may be thoroughly checked and then rearranged without the problem of transcribing errors which normally occur in such studies (Muller et al., 1972).

WORDSKIL provides an EDIT/M (move) facility which enables up to 20 rows of data (species) to be moved to any point in the table. This ensures a rapid examination of the possible species associations. Positively associated species are grouped, and the general and infrequent species which do not show clear associations ("tail species") are listed at the end of the table (Werger, 1974). Although an intermediate table would normally be printed and examined at this stage, the table is not presented here. In our example the table with final species associations took 10 minutes to produce.

The second stage in the rearrangement of the matrix is to group relevés with similar species associations together (Werger, 1974). WORDSKIL provides an EDIT/W (walk) facility which enables the operator to move one or more columns of text (relevés) across the table. A maximum of 20 rows can be operated on at one time. The column or columns of relevés being moved displaces the existing matrix to the left or to the right, depending upon

the direction of movement. The cursor is returned to the original co-ordinates (column, row), and the text is scrolled 20 rows (species). The operation of moving columns (relevés) is then repeated for the next 20 lines of text. The process of rearranging 27 relevés to produce the final table containing 15 species took a further 90 minutes (Table 2). Manipulating one relevé of a phytosociological table containing 56 relevés and 180 species in the Andries Vosloo Kudu Reserve study (Palmer, 1981) took approximately three minutes, as naturally the process takes longer with a larger matrix. The only additional operation required to complete the table for publication is the drawing of lines between relevé and species groups.

The sorting and rearrangement of species and relevés in the Braun-Blanquet table by means of an IPS has proved to be very rapid and has many advantages over manual and mainframe computer manipulations. Once the raw table has been compiled from the field data sheets and checked, no further errors should occur, which is a common fault of rewriting and rearranging tables manually. The immediate changes and production of printouts makes this system more versatile than mainframe computer manipulating procedures. Moreover, the end product is a table which is in a form suitable for publication.

Table 1. "Raw" phytosociological table of the Serpentine River aquatic vegetation.

Relevé number.....	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
<i>Phragmites australis</i>	3	3	2	5		4	3	2	3		+	1	+														+		+		
<i>Stenotaphrum secundatum</i>		1	5	1	4						4	5	5	5		3		+	5		5	2			+		+		1	+	
<i>Juncus kraussii</i>		1	2	1	3	2		1	2		3					3		3	2	3	1	5	5							2	
<i>Scirpus littoralis</i>						1		5		5					3		2								2		2	3	2	3	3
<i>Chara globularis</i> var. <i>kraussii</i>																	5														
<i>Hydrocotyle verticillata</i>													r																		
<i>Falkia repens</i>													r																		
<i>Rumex crispus</i>												+		+																	
<i>Conyza scabrida</i>																	+														
<i>Typha latifolia</i> subsp. <i>capensis</i>																		4		3		5	5			3		+			
<i>Cliffortia strobilifera</i>																				+											
<i>Potamogeton pectinatus</i>																								5	3	3		+		1	
<i>Enteromorpha</i> sp.....																								3		2		1			
<i>Cotula coronopifolia</i>																									+			+		+	+
<i>Scirpus ludwigii</i>																												+		+	

170.

Table 2. Phytosociological table of the Serpentine River aquatic vegetation.

Relevé number.....	24 26	28 30 25 31	10 15 17	06 08	27 29	23 18 20 22	11 02 03 04 13 12 14 19 21 05 16 09 01 07
Potamogeton pectinatus.....	5 3	+ 1 3					
Enteromorpha sp.....	3 2	1					
Cotula coronopifolia.....		+ + + +					
Scirpus ludwigii.....		+ +					
Scirpus littoralis.....		3 3 2 3	5 3 2	1 5	2 2		
Typha latifolia subsp. capensis....					3 +	5 4 3 5	
<u>Differential species of the Stenotaphrum secundatum-Juncus kraussii community</u>							
Stenotaphrum secundatum.....		+ 1 + +				+ 2	4 1 5 1 5 5 5 5 5 4 3
Phragmites australis.....				4 2	+ +		+ 3 2 5 + 1 3 3 2
Juncus kraussii.....		2		2 1		5 3 3 5	3 1 2 1 2 1 3 3 2
<u>Infrequent species</u>							
Rumex crispus.....							+ +
Chara globularis var. kraussii....			5				
Conyza scabrida.....			+				
Falkia repens.....							r
Hydrocotyle verticillata.....							r
Cliffortia strobilifera.....							+ +

ACKNOWLEDGEMENTS

The authors would like to extend their thanks to the Director, Computer Services, Rhodes University, for providing the facilities; the Director, Cape Department of Nature and Environmental Conservation, by whom one of us (ARP) is employed; and to the under-graduate students who helped in providing the field data used in the example.

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APPENDIX 4

```

1 C THIS PROGRAM PLOTS THE CO-ORDINATES OF THE PRINCIPAL COMPONENT
2 C ANALYSIS CALCULATED USING COMP. POINTS WILL BE NUMBERED FROM 1 TO NP
3     LIST
4     LIBRARY(SUBGROUUPLOT)
5     PROGRAM(PHCM)
6     INPUT5=CR0
7     OUTPUT6=LP0
8     COMPRESSINTEGERANDLOGICAL
9     COMPACTDATA
10    TRACE2
11    END
12    MASTER
13    DIMENSION X(61),Y(61)
14 C NP= NUMBER OF POINTS PLOTTED
15    NP=61
16    XS=48.
17    YS=32.
18    GAP=2.0
19    DO10I=1,NP
20    READ(5,500)X(I)
21 10  CONTINUE
22    DO20I=1,NP
23    READ(5,500)Y(I)
24 20  CONTINUE
25    CALL CREATEPLOTTER('BOAP')
26    YSH=YS+2.
27    CALL HGPlot(-1.,YSH,3,4)
28    N=NP
29    K=1
30    CALL HGPSCALE(X,N,XS,XMIN,DX,K)
31    N=NP
32    K=1
33    CALL HGPSCALE(Y,N,YS,YMIN,DY,K)
34    DX=DX*GAP
35    DY=DY*GAP
36    CALL HGPAXISV(0.,0.,'COMPONENT 1',-11,XS,0.,XMIN,DX,GAP,4)
37    CALL HGPAXISV(0.,0.,'COMPONENT 2',11,YS,90.,YMIN,DY,GAP,4)
38    DO30I=1,NP
39    CALL PLOT(X(I),Y(I),1)
40 30  CONTINUE
41    CALL ENDGRAPH
42    STOP
43 500 FORMAT(18X,F9.6)
44    END
45    SUBROUTINE PLOT(X,Y,I)
46    DIMENSION BCD(1)
47    DATA H1,H2,BCD/0.2,0.2,'X'/
48    X=X-(2./7.)*H1
49    Y=Y-0.5*H1
50    CALL HGPSYMBL(X,Y,H1,BCD,0.,1)
51    X=X+(3./7.)*H1
52    AI=FLOAT(I)
53    CALL HGPNUMBER(X,Y,H2,AI,0.,0,2,0)
54    RETURN
55    END
56    FINISH

```

APPENDIX 5

CARRYING CAPACITY BASED ON MEAN ANNUAL RAINFALL

Precipitation must be taken into account when determining the carrying capacity of the study area for wild ungulates. Carrying capacity may be altered by both long and short term variations in climate, and particularly in precipitation (Phillipson, 1975). Coe et al. (1976) suggest that carrying capacity of large herbivore communities in central and southern Africa can be calculated from annual precipitation using the equation:

$$y = 1.685 (\pm 0.238)x - 1.095 (\pm 0.661) \text{ where}$$

$$y = \log_{10} \text{ large herbivore biomass (kg km}^{-2}\text{)}$$

$$x = \log_{10} \text{ rainfall (mm annum}^{-1}\text{)}.$$

With a mean annual rainfall of 434 mm, and an area of 6493 ha, the following calculation is possible:

$$y = 2237,1 \text{ kg km}^{-2}$$

$$\text{Calculated biomass} = 145251,8 \text{ kg}$$

$$= 318,53 \text{ Animal Units (1 A.U.} = 456 \text{ kg.)}$$

$$= 796 \text{ kudu (2.5 kudu/A.U.-Mentis \& Duke, 1976)}$$

Although these figures are empirical, they enable a calculation of carrying capacity as they are based on net above ground primary production. Allen-Rowlandson (1980) has estimated the kudu population to be between 1000 & 1200.

APPENDIX 6

RECOMMENDED OBJECTIVE STATEMENTS

The following brief objective statements are considered applicable to the study area:

1. The conservation and preservation of the genetic variability of the floras of the five phytochoria (Capensis, Karoo-Namib, Sudano-Zambezian, Afro-montane and Indian Ocean Coastal Belt) which are represented in Acocks's Fish river scrub variation of the Valley Bushveld.
2. The stimulation of upland and pediment slope pedogenesis by reduction of wild ungulate population numbers.
3. The re-establishment and maintenance of fire climax grasslands in the succulent bushclump savanna physiognomic class.
4. The introduction and management of all vertebrate species whose historical presence is substantiated by well documented records.

APPENDIX 7

A COMPUTER-BASED NATURAL RESOURCE MAPPING SYSTEM FOR USE
ON SMALL NATURE RESERVES.

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ABSTRACT

Natural resource data (aspect, slope, altitude, geology, soils, vegetation) for a small nature reserve are presented as digital maps. The information may be stored in a computerised data bank using the coding format presented.

Poster paper accepted for presentation at the 1982 AETFAT Congress, CSIR, Pretoria.

INTRODUCTION

The efficient management of a terrestrial ecosystem is facilitated if reliable natural resource data is available in a readily accessible form. A computerized data bank is an efficient means of achieving this objective. Natural resource data on geology, physiography, vegetation, climate and soils can be stored in an easily retrievable form, and any facet correlated, updated or presented in numerous ways.

The major aim of the system would be to give ecosystem managers ready access to integrated natural resource data, which would assist in explaining plant community distribution patterns and wild ungulate populations movements.

MATERIALS AND METHODS

The example chosen in this study is the Andries Vosloo Kudu Reserve (Valley Bushveld Veld Type; 6496 ha.). The important natural resources within the study area display a remarkable uniformity (small geological variation and low plant community diversity), and variations in ungulate populations densities could not be explained. A data bank was established which would assist in determining small natural resource variations.

In extensive ecosystems, it is necessary to select a grid size which will satisfy the requirements of the many natural resource characteristics which are being recorded. A 200 metre grid was selected, as each kilometre square could be divided into twenty-five 200 metre (4 hectare) recording squares. This grid size was chosen independently in this study and has subsequently been recorded in recent literature (Webb & Haskins, 1980). The grid was chosen as the best compromise between an area that could be readily identified and surveyed in the field, and yet was sensitive enough to detect changes in vegetation structure and composition.

The SA Topo Series (1:50 000) proved unsuitable for the purposes of the survey as the scale was not sufficiently sensitive to indicate minor changes in natural resource and ungulate distribution patterns. A new map (scale 1:18 000) was drawn for the purposes of this study. This topographical map was copied directly from the 1:18 000 series, which has been discontinued as the official topographical map. Contour intervals and spot heights were

converted to metres, and new features such as roads, buildings, dams, water points and fences were included. This map was overlain by a system of 4 hectare quadrats, which were numbered alpha-numerically (Fig. 1).

Quadrats were numbered from south to north, and from west to east.

Five altitude classes were recognised subjectively and their boundaries indicated on the map using Winsors & Newtons Town and Country Planning Colours. The altitude classes are given in the coding format.

Four slope classes were recognised i.e. flat, low medium and steep. Slope was determined by measuring the distance between contour lines and dividing by the contour interval. The four slope classes were shaded on the grid map.

The overall aspect of each quadrat was subjectively assessed and recorded as one of the four points of the compass. No concession was made for marginal quadrats, and these were also given one or other aspect.

Plant communities were mapped from an enlarged LANDSAT image following a comprehensive Braun-Blanquet survey. The communities are listed in the coding format.

Numerous others aspects have been included in the coding format, and are currently in the process of being mapped. These include exotic plant requiring eradication, human development (roads, buildings, water points), drainage lines and climatic characteristics.

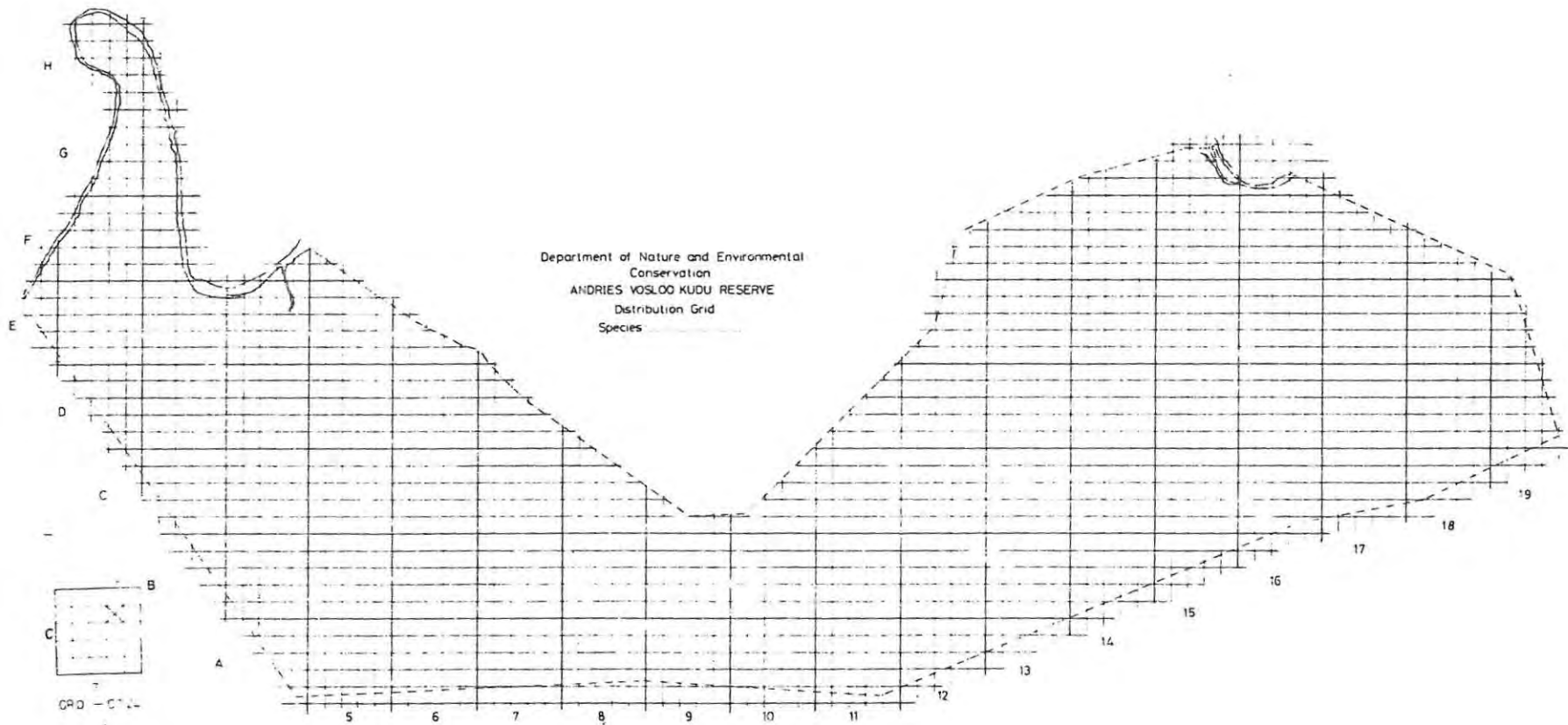


Fig. 1. The alphanumeric grid system prepared for the digital mapping of natural resources on the Andries Vosloo Kudu Reserve.

CODING FORMAT

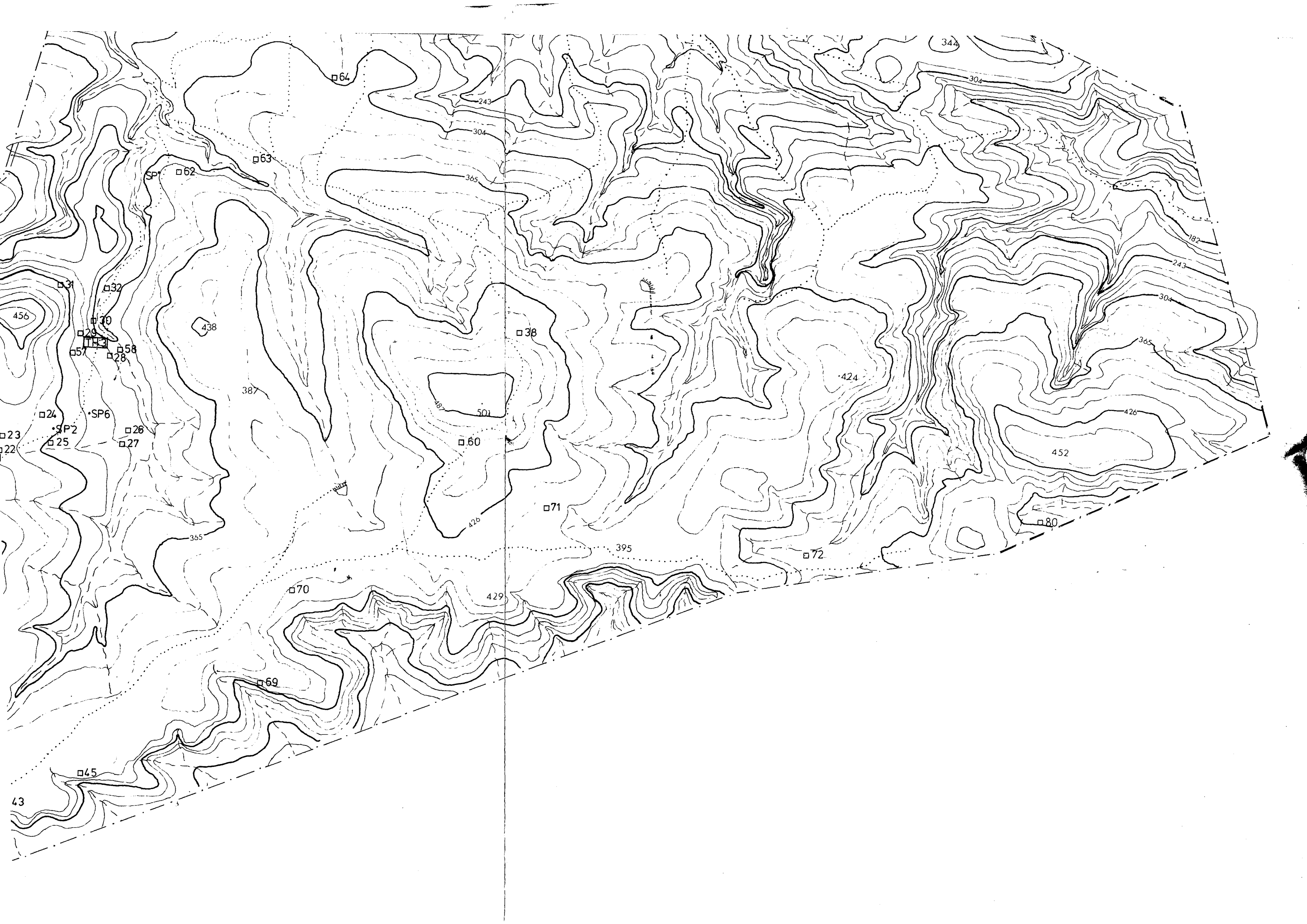
The columns of the coding form contain the following data:

	<u>Column</u>	<u>Code</u>	
Grid Reference	1-5		
Altitude Class	6-7	01	182-242 m
		02	243-303 m
		03	304-364 m
		04	365-425 m
		05	426-501 m
Slope Classes	8-9	01	flat 1:10
		02	low slope 1:10-1:5
		03	medium slope 1:5-1:3.3
		04	steep slope 1:3.3
Aspect	10-11	01	north
		02	east
		03	south
		04	west
Plant community	12-13	01	Felicia muricata-Walafrida geniculata
		02	Rhus refracta-Walafrida geniculata
		03	Portulacria afra-Barleria obtusa
		04	Senecio radicans-Barleria obtusa
		05	Hippobromus pauciflorus-Schotia latifolia

Exotic plant	14-15	01	Jointed cactus
		02	Prickly pear
		03	Both species
Human development	16-17	01	Buildings
		02	Roads
		03	Artificial water points
		04	Historically overutilized areas
		05	Erosion
		06	Dam
Drainage line	18-19	01	Open
		02	Covered
Climate	20-21	01	Dry and hot
		02	Dry and cool
		03	Wet and hot
		04	Wet and cool

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ANDRIES VOSLOO KUDU RESERVE

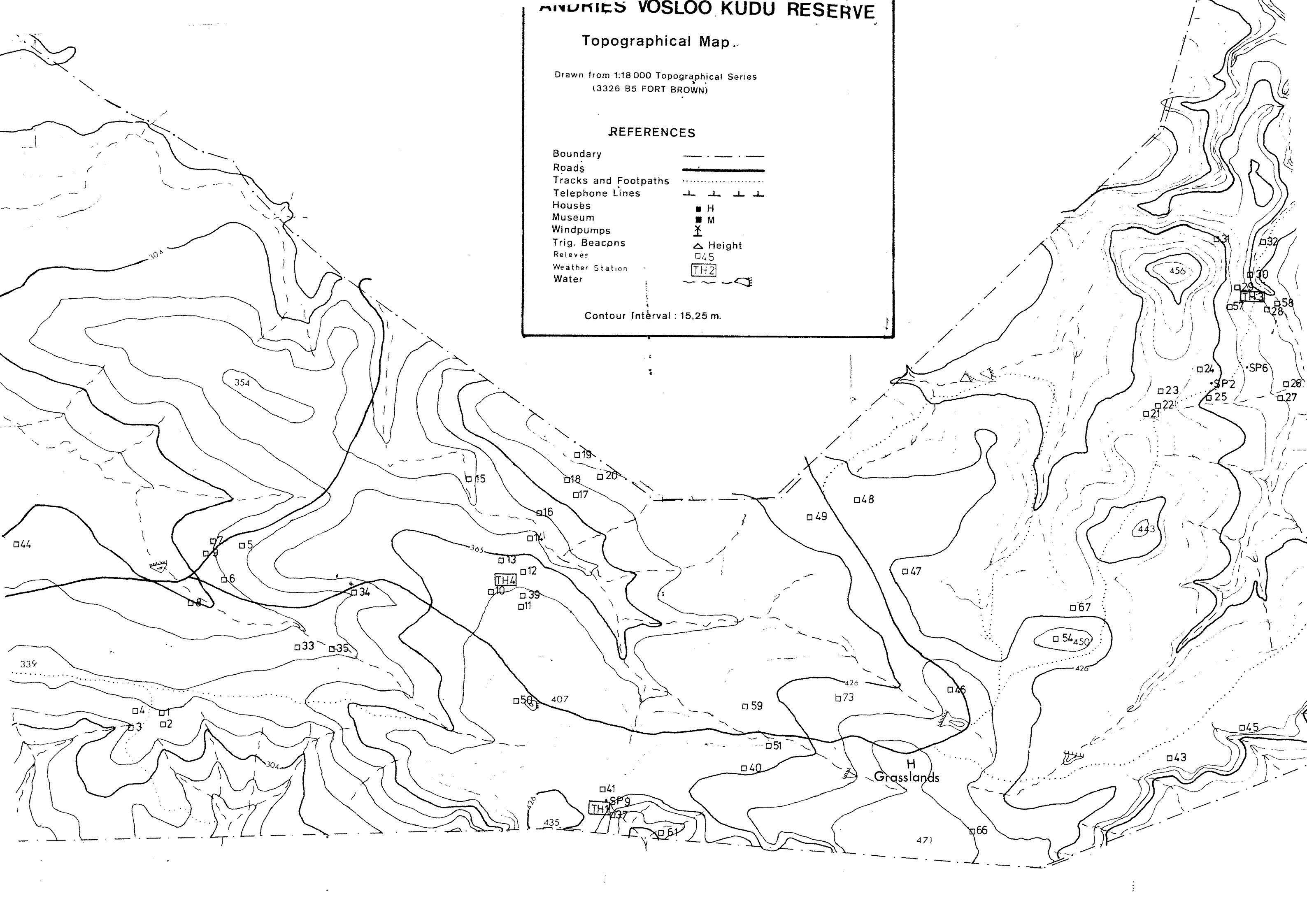
Topographical Map

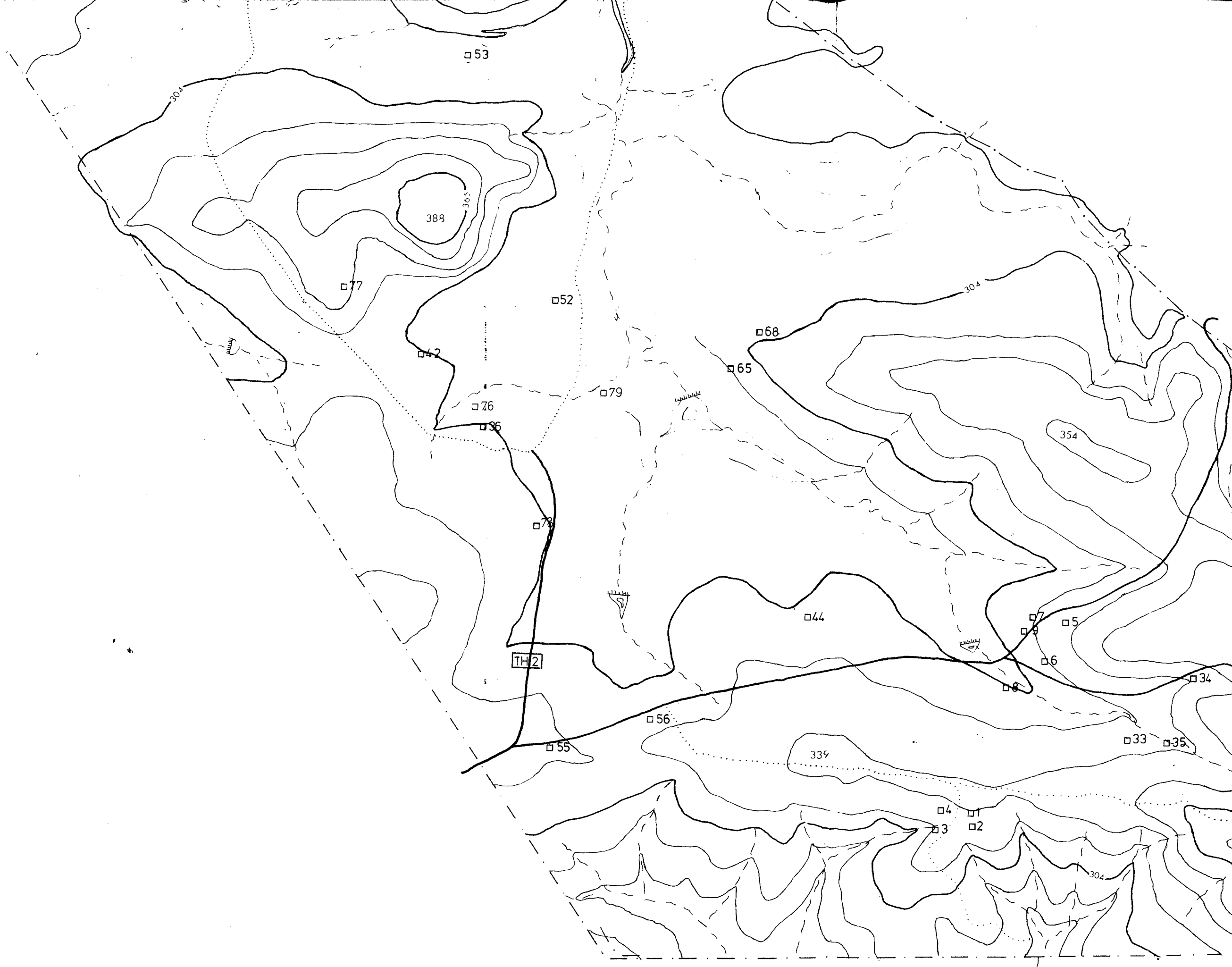
Drawn from 1:18 000 Topographical Series
(3326 B5 FORT BROWN)

REFERENCES

Boundary	---
Roads	==
Tracks and Footpaths
Telephone Lines	- - - - -
Houses	■ H
Museum	■ M
Windpumps	⊥
Trig. Beacons	△ Height
Reliever	□ 45
Weather Station	TH2
Water	~~~~~

Contour Interval : 15.25 m.





	1.1						1.2													
	1.1.a		1.1.b		1.1.2		1.2.1	1.2.2	1.2.3											
Relieve number.....	2	3	7	0	1	0	4	2	3	5	4	5	7	6	5	4	4	4	5	5
Altitude (m).....	354	300	300	270	33	320	320	305	308	350	360	410	365	328	410	426	302	432	411	412
Aspect (°).....	33	270	115	270	10	180	E	S	S	S	N	0	S	E	0	0	200	200	200	200
Slope (°).....	-	12	0	258	304	20	20	5	5	3	3	0	2	1	2	3	3	3	3	3
No. of species.....	37	26	14	16	18	29	25	20	33	28	19	30	18	38	33	45	36	33	35	35
Total % cover.....	70	-	95	90	18	60	60	75	90	90	90	43	43	90	80	60	95	70	85	85
Soil texture (s=sand, c=clay, l=loam)	SC	SC	-	CL	SC	CL	SC	CL	SC	CL	C	C	SC	SC	SC	C	SC	SC	SC	SC
pH.....	5.6	6.7	7.2	5.8	6.3	5.7	5.9	6.2	5.4	6.1	6.3	5.4	5.4	6.6	6.6	6.6	6.1	6.1	6.3	6.3
Moisture content (% dry weight)...	4	13	3	4	4	7	11	4	11	7	6	5	5	3	4	4	6	6	6	6
Organic content (% dry weight)....	4	4	4	4	4	7	7	4	7	7	4	4	4	5	5	5	6	6	6	6
Magnesium (ppm).....		30									3			3			5			
Calcium (ppm).....		118									17			9			18			
Sodium (ppm).....	8										7			6			7			
Potassium (ppm).....	62										74			28			55			
Differential species of the Mariscus capensis-Rhus refracta-Walafrida geniculata sub-variation (1.1.1)																				
Mariscus capensis.....						+	+	+	+								1	1		
Crassula expansa.....						+	1	+												
Hyparrhenia hirta.....								+	1					+						
Urginea altissima.....										+										
Schismus inermis.....										1	2									
Differential species of the Olea africana-Rhus refracta-Walafrida geniculata sub-variation (1.1.2)																				
Olea africana.....									1		+	+					r		1	1
Laziocorys capensis.....											2		+	1	+	+	r	+	+	
Lepidium divaricatum.....													+				+			1
Differential species of the Rhus refracta-Walafrida geniculata variation (1.1)																				
Rhus refracta.....	2	2	2	2		+		2	1		+			+	+	+				
Acacia karroo.....		+	2	2				2	1	1	1	+	+	3	1		+	2		
Indigofera sessilifolia.....				1			+	2	+	+					2	+			+	
Azima tetraacantha.....	2	1								1										
Buddleia saligna.....		1													1					
Limeum aethiopicum.....							+	+								r				
Oxalis boweie.....								1		1			+	+						
Differential species of the Becium burchellianum-Eragrostis lehmanniana-Walafrida geniculata sub-variation (1.2.1)																				
Polygala leptophylla.....																		+	+	
Becium burchellianum.....																	r		2	
Crassula rogissae.....																	+	+		
Cyanotis speciosa.....														+			+	1		
Differential species of the Rhus incisa-Eragrostis lehmanniana-Walafrida geniculata sub-variation (1.2.2)																				
Asparagus densiflorus.....																		+		
Rhus incisa.....																	2			
Hermannia flammae.....																				
Scutia myrtina.....																+			1	1
Cassine crocea.....																			1	2
Differential species of the Anthospermum aethiopicum-Eragrostis lehmanniana-Walafrida geniculata sub-variation (1.2.3)																				
Dolichos haestaeformis....																			1	+
Helichrysum cymosum.....																			1	+
Anthospermum aethiopicum..																			+	+
Lotononis pungens.....																			+	+
Gazania linearis.....																				1
Differential species of the Eragrostis lehmanniana-Walafrida geniculata variation (1.2)																				
Eragrostis lehmanniana....														1			r	+	1	+
Crassula ericoides.....															+			+	+	2
Asparagus macowanii.....														1	2	+				+
Xeromphis rudis.....														1				+	+	+
Differential species of the Walafrida geniculata-Felicia muricata community (1)																				
Helichrysum rososum.....	2		1			+	+	+	+		1	1	1		1	1	2	1	3	2
Felicia muricata.....			r	1		+	+	3	+	+							+	+	+	+
Clusia laxa.....							+	2	+	1	+	+								1
Walafrida geniculata.....											2	+	+	2	2	+	1	+		
Sporobolus fimbriatus.....			2	2	2	+	+				2	+	2							
Nemesia floribunda.....															r		r	+		+
General and infrequent species																				
Grewia robusta.....	2		+	+	2	+	2				+	1	1	2	+	+	1	r	1	1
Panicum maximum.....	2	2	3	+	1	+	+	1	2	1	1	2					2	2		1

Walafrida geniculata.....	+	+	+	+	2	+	+	2	2	+	1	+	+	
Sporobolus fimbriatus.....	2	2	2	+	+	2	+	2	+	2	+	+	+	+
Nemesia floribunda.....														
General and infrequent species														
Grewia robusta.....	2	+	+	2	+	2	+	1	1	2	+	+	1	2
Panicum maximum.....	2	2	3	+	1	+	+	1	2	1	1	2	2	1
Digitaria eriantha.....	2	2	+	2	3	2	2	3	1	1	1	+	3	1
Setaria sphacellata.....	1	+		+	2	2		3	1				+	2
Sutera pinnatifida.....														
Eragrostis obtusa.....	2	1	+	+	2	+	+	+	1	2	1	1	1	+
Aristida congesta.....	2				3	3	+						+	+
Chrysocoma tenuifolia.....	+							1					+	1
Delosperma calycinum.....	+				+	+	+			2	1	+	r	+
Brachylaena ilicifolia.....	2				+					2	2	2	2	1
Kalanchoe rotundifolium...	+				+					1	+	+	+	+
Asparagus africanus.....	+				+					+	+	+	+	+
Salvia triangularis.....	+				+	+				2				
Asparagus striatus.....					+	+				+	+	+	+	+
Hermannia althaeoides.....	+	+								2	1	+	+	+
Pteroxylon obliquum.....										+	+	+	1	+
Maytenus capitata.....	2									1	1	1	2	2
Themeda triandra.....	2				2					+	+	+	2	1
Cymbopogon plurinodis.....					3						3	2		+
Hibiscus pusillus.....									1	1	+	1	r	+
Ehretia rigida.....									+	2			+	2
Usnea sp.....											1	+		1
Euclea undulata.....	+													+
Viscum rotundifolium.....											r			+
Pentzia incana.....		3	4	+	2			4					r	+
Asparagus suaveolens.....	1	+			+	1								2
Pelargonium reniforme.....					+								r	2
Opuntia ficus-indica.....														+
Rhigozum obovatum.....					+	+					1			+
Crassula lycopodioides....					+									+
Maytenus heterophylla.....	2	+												+
Commelina africana.....					+	+							+	+
Portulacaria afra.....	+												1	1
Grewia occidentalis.....	1	+												+
Panicum deustum.....	2													+
Barleria obtusa.....								1						+
Phyllanthus verucossus....													1	+
Hermannia coccocarpa.....	+	+			1	+								+
Lantana salvifolia.....	+				+								r	+
Carissa haematocarpa.....	1												1	+
Lycium campanulatum.....	+	1						+	2	+	2			+
Sporobolus nitens.....	+	r			2	+								+
Falkia repens.....														1
Gnidia cuneata.....	+				1									+
Barleria sp.....								1						+
Asparagus racemosus.....	+													+
Rhus sp. longispina.....													3	+
Hypoestes verticillaris...					1			2						1
Mestoklema albanicum.....					+						1			+
Crassula obvallata.....											+			+
Diospyros lycioides.....														+
Cyperus teneriffae.....	+				+	+								+
Justicia protracta.....	+													+
Achyroopsis leptostachya...	+													+
Arctotis acaulis.....														1
Rhynchosia capensis.....														+
Chaschanum dehiscens.....													r	+
Capparis sepiaria.....					2									+
Priva leptostachya.....														+
Cheilanthes hirta.....														+
Peristrophe cernua.....	+							2						+
Blepharis capensis.....					+									+
Cineraria lobata.....														+
Erigeron linifolium.....	+							1						+
Senecio deltoideus.....										2				+

Abutilon sonneratianum (15,+), Acalypha glabrata (32,+), Aizoon glinoides (33,1; 58,r), Allophylus decipiens (59,r), Androcymbium sp. (40,+), Argemone pauciflora (16,+), Asparagus crassifolius (16,+), Asparagus plumosus (73,+), Barleria pungens (23,+; 40,+), Boopha disticha (51,+), Cussonia spicata (59,+; 49,+), Crassula cultrata (58,1), Crassula falcata (23,+), Cynodon dactylon (40,2; 79,2), Diospyros scabrida (54,1; 32,+), Dipogon haestaeformis (8,+), Dolichos haestaeformis (54,+), Eragrostis curvula (23,+; 73,2), Eriospermum dyeri (40,+), Euphorbia bothae (50,+; 79,2), Euphorbia mauritanica (5,+; 8,+), Euryopa tenuissimus (47,+), Eustachys mutica (16,+), Gamelopsis sp. (7,+), Indigofera disticha (23,1), Ipomoea ficifolia (14,1), Lessertia annularis (51,+), Lightfootia albens (16,+), Maytenus polycantha (14,+), Merxmullera disticha (49,2), Oropetium capense (8,1), Oxalis sp. (16,+; 49,+), Pachypodium succulentum (23,+), Pappia capensis (54,1), Pellea viridis (14,+), Phymaspermum parvifolium (8,+; 9,+), Plumbago auriculata (32,+), Polygala hamata (54,+), Pycnos lanceus (15,1), Rhoicissus tridentata (58,+; 73,+), Rhynchosia ciliata (54,1), Ruschia sp. cf. dyeri (16,+), Sansevieria hyacinthoides (58,r), Sarcostemma viminalis (5,+), Scolopia mundii (25,+; 59,+), Secamone frutescens (25,+), Senecio burchellii (51,+; 54,+), Senecio radicans (5,+), Sida ternata (14,+; 59,+), Solanum sodanum (16,+), Stachys aethiopica (58,1), Tephrosia capensis (49,+; 54,+), Tephrosia sp. (40,r), Teucrium africanum (32,+; 51,+), Thesium flexuosum (54,+), Thunbergia dregeana (32,2), Venidium decurrens (15,+; 59,+).

Table 7. A phytosociological table of Walafrida geniculata-Felicia muricata riparian thicket community of the Andries Vosloo Kudu Reserve.

Table 8a. A Roman or Summary Table of the differential and abundant species recorded in the plant communities of the Andries Vosloo Kudu Reserve. Each community, based on several relevés, is reduced to a single column. The roman numerals are ratings of constancy of each species in each community based on a five point scale: I=1 to 20% constancy; II=21 to 40% constancy; III=41 to 60% constancy; IV=61 to 80% constancy; and V=81 to 100% constancy.

Community number.....	1	1	1	1	1	2	2	2	2	2	2	3	
.....	1	1	2	1	2	1	1	2	2	2	2	2	
	a	b				a	b	a	b	c			
Number of quadrats.....	5	5	6	3	3	2	8	5	11	9	3	8	4
Mariscus capensis	I	IV		IV					I	I		I	
Crassula expansa		III											
Hyparrhenia hirta		II											
Urginea altissima		II	I						I	III			
Schismus inermis		II										I	
Olea africana		I	III		IV				I	I			
Lasiocorys capensis	II		V	V		III	I		I			III	
Lepidium divaricatum	I		II	II					II	I	I		
Rhus refracta	IV	III	IV						I	I		I	I
Acacia karroo	IV	III	V	IV					I	I		I	
Indigofera sessilifolia	I	IV		II									
Azima tetraantha	II	I							I				III
Buddleia saligna	II	I	I						I			I	
Limeum aethiopicum	I	II	I						I	I			
Oxalis boweie	I	II	II							I	I		
Polygala leptophylla				IV			I	I					
Becium burchellianum				IV			II						
Crassula rogissae			I	IV									
Cyanotis speciosa				IV			I	I	I	I			
Asparagus densiflorus				II	IV								
Rhus incisa				II									
Hermannia flammae				V						I			
Scutia myrtina			I	IV	I								
Cassine crocea				IV						I			
Dolichos haestaeformis				IV	III								
Helicrysum cymosum				IV			I	I					
Anthospermum aethiopicum				IV	III								
Lotononis pungens		II		II	V								
Gazania linearis	I	I		V			I	I	I	I			
Eragrostis lehmanniana		I	IV	V	V		I	I	II		I	I	
Crassula ericoides		I	II	V	V		I	I					
Asparagus macowanii		III	II	II	III		I						
Xeromphis rudis		I	II	V	III				II				
Helicrysum rosum	II	IV	IV	V	V	IV	III	III	IV	III	I		
Feliccia muricata	II	IV	II	V	IV	III	I	II	I	I			
Clutia laxa	I	IV	IV	IV	IV	II		II	I	I			
Walafrida geniculata	III	I	V	V	V		I		II	II			
Sporobolus fimbriatus	III	II	III	I					II	II			
Nemesia floribunda		II	II	II	II				I				
Tragus berteronianus							IV						
Senecio radicans		I					III						
Ruschia sp. cf dyeri		I					IV						
Gasteria sp. cf beckerii							II						
Pachypodium succulentum	I						II			I			
Crassula trachysantha							I	I					
Cymbopogon plurinodis		I	II	V	III	II	IV	I					I
Themeda triandra	I	I	IV	II	V	III	III	II	I				
Gnidia cuneata	II	I		I		IV	III	III	III	I	I		
Asparagus striatus		II	II	IV	IV	III	IV	V	IV	II	II	I	
Hibiscus pustulatus			IV	V	IV	V	IV	IV	II	I			
Kalanchoe rotundifolia	I	I	II	IV		III	IV	III	V	II			
Rhigozum obovatum		II	II	I		I	V	I	II	II	II	I	
Euphorbia bothae	I						V	I					
Delosperma calycinum	I	IV	III	IV			III	III	IV	II			
Crassula perforata							I	I	IV	II	IV	II	
Ozoroa mucronata							I	I	III	III	V	I	
Crassula spathulata							I		III	II	V		
Grewia occidentalis	I		I	I			I		II	IV	V	II	
Abutilon sonneratianum	I								III	II	II	II	
Rhynchosia calvescens								I	I	IV			
Justicia protracta	I	I					I	I	I	IV			
Asystasia stenosisiphon									I	III			
Plumbago auriculata	I								I	II		III	IV
Asparagus densiflorus									I		I	I	III
Maytenus heterophylla	II	I			I					IV	II	III	
Cynodon dactylon	I		I						I	I	I	III	
Scolopia mundii									I	I	IV	I	III
Cussonia spicata									I			I	IV
Phyllanthus verucosus			II	I	V	I	I	V	V	V	V	III	
Pteroxylon obliquum			II	IV	I	I	I	I	III	III	V	IV	III
Barleria obtusa		I	I	I	I	V	IV	VI	II	V	II	III	III
Portulacaria afra	I				V		III	V	IV	IV	III	III	III
Rhoicissus tridentata			I	I			IV	III	V	II	II	III	
Schotia afra							II	III	I	III	II	III	III
Euclea undulata	I			I	II	V	III	V	III	III	III	II	III
Crassula lycopodioides		I	I	I		I	IV	III	III	III	II	II	I
Jatropha capensis							I	II	V	III	IV	III	III
Commelina africana		III		IV			I	II	IV	IV	IV	II	I
Panicum deustum	I		I	I			I	II	IV	III	II	III	I
Hippobromus pauciflorus													IV
Schotia latifolia													IV
Rhoicissus sp.											I		III
Achyroopsis leptostachya													II
Panicum maximum	V	V	II	IV	V	II	IV	I	V	IV	V	IV	IV
Grewia robusta	III	III	V	V	IV	V	V	IV	V	IV	IV	IV	I
Brachylaena ilicifolia	I	I	III	III	V	V	III	V	V	V	II	II	II
Digitaria eriantha	IV	III	IV	V	V	V	III	IV	V	III		II	III
Setaria sphacellata	II	III	II	V	V	III	IV	IV	III	IV	II	III	IV
Eragrostis obtusa	V	III	III	IV	III	V	III	I	III	IV	II	II	II
Ehretia rigida			III	V	II	II	II	III	II	II	V	IV	IV
Aristida congesta	II	III	II	IV	IV	V	IV	III	II	III	II	II	II
Chrysocoma tenuifolia	I	I	II	III	V	V	IV	II	II	III	IV	II	
Sutera pinnatifida	II	II	IV	II	V	III	II	I	III	II		II	

Species	AVKR cover ab.	Capensis	Karoo- Namib	Sudano- Zambezian	Pondaland- Tongaland	Afro- montane
Polygala myrtifolia.....	r	1,3				
Anthospermum aethiopicum..	+	1,3				
Eriocephalus africanus....	+	1,3				
Helichrysum cymosum.....	1	1,3				
Melica racemosa.....	r	1				
Dietes vegeta.....	1	1				
Commelina benghalensis....	+	1				
Pharnaceum detonsum.....	r	1				
Crassula expansa.....	1	1				
Crassula cultrata.....	1	1				
Elytropappus rhinocerotis..	-	1				
Falkia repens.....	1	3				
Crassula lycopodioides....	2	1,3	8			
Senecio burchellii.....	+	3	2			
Hibiscus pusillus.....	2		2,8			
Aptosimum depressum.....	r		2,8			
Lightfootia albens.....	+		2,8			
Eragrostis lehmanniana....	2		2,8			
Asparagus striatus.....	2		2,8			
Clematis brachiata.....	r		2,8			
Hermannia coccocarpa.....	1		2,8			
Chrysocoma tenuifolia....	2		2,8			
Eragrostis obtusa.....	2		2,8			
Tragus berteronianus.....	1		2,8			
Eustachys mutica.....	+		2,8			
Felicia filifolia.....	1		2,8			
Chloris virgata.....	+		2,8			
Rhus lancea.....	r		2,8			
Tragus koeleroides.....	+		8			
Sporobolus fimbriatus.....	2		8			
Oropetium capense.....	1		8			
Maytenus polycantha.....	+		8			
Solanum coccineum.....	-		8			
Viscum rotundifolium.....	+		8			
Rhigozum obovatum.....	2		8			
Sarcostemma viminale.....	+		8			
Setaria sphacellata.....	3		8			
Arctotis acaulis.....	1		2			
Setaria verticillata.....	-		2			
Schismus inermis.....	-		2			
Moraea polystachya.....	-		2			
Carissa haematocarpa.....	1		12			
Euphorbia mauritanica.....	+		2			
Nemesia floribunda.....	+		2			
Pachypodium succulentum...+	+		2			
Walafrida geniculata.....	2		2			
Lepidium divaricatum.....	+		2			
Pentzia incana.....	4		2			
Atriplex semibaccata.....	-		8			
Cineraria lobata.....	-		8			
Limeum aethiopicum.....	+		8			
Cymbopogon plurinodis....	3		8,2			
Mariscus capensis.....	+		8	6		
Commelina africana.....	+		2,8	6,9		
Heteromorpha arborescens..	-		2	6,9		
Asparagus suaveolens.....	2		8,2	6,9		
Asparagus setaceus.....	-		8	6		
Felicia muricata.....	3		8,2	6		
Aristida congesta.....	3		2,8	6,9		
Brachiaria serrata.....	-		8	6,9		
Rhynchelytrum setifolium..	-		2	6,9		
Kalanchoe rotundifolium....	1		2	9		
Buddleia saligna.....	2		2	6,9		
Enneapogon scoparius.....	-		2	9		
Digitaria eriantha.....	3		8,2	6		
Hyparrhenia hirta.....	-		8,2	6,9		
Cheilanthes hirta.....	-		8,2	6		
Maytenus undata.....	-			6,9		
Ochna atropurpurea.....	-			6,9		
Hypoestes verticillaris....	2			6		
Boophae disticha.....	-			6		
Cyanotis speciosa.....	1			6,9		
Asparagus africanus.....	2			9		
Rhoicissus tridentata.....	2			6	10	
Vepris undulata.....	r			6	10	
Xanthoxylon capensis.....	+			6,9	10	
Acalypha glabrata.....	+			6	10,11	
Acocanthera oppositifolia..	r			6,9	10	
Pappea capensis.....	2			6,9	10	
Panicum maximum.....	4			6	10	
Pellea viridis.....	+			6	10	
Helichrysum nudifolium....	r			6	10	
Asparagus asparagoides....	r				10	
Asparagus setaceus.....	r				10	
Barleria obtusa.....	2				10	
Capparis sepiaria.....	1				10	
Commiphora harveyii.....	-				10	
Euclea undulata.....	3				10	
Jasminum multipartitum....	2				10	
Justicia protracta.....	+				10	
Maytenus undata.....	r				10	

Mariscus capensis.....	+	8		6		
Commelina africana.....	+	2,8		6,9		
Heteromorpha arborescens..	-	2		6,9		
Asparagus suaveolens.....	2	8,2		6,9		
Asparagus setaceus.....	-	8		6		
Felicia muricata.....	3	8,2		6		
Aristida congesta.....	3	2,8		6,9		
Brachiaria serrata.....	-	8		6,9		
Rhynchelytrum setifolium..	-	2		6,9		
Kalanchoe rotundifolium....	1	2		9		
Buddleia saligna.....	2	2		6,9		
Enneapogon scoparius.....	-	2		9		
Digitaria eriantha.....	3	8,2		6		
Hyparrhenia hirta.....	-	8,2		6,9		
Cheilanthes hirta.....	-	8,2		6		
Maytenus undata.....	-			6,9		
Ochna atropurpurea.....	-			6,9		
Hypoestes verticillaris....	2			6		
Boophane disticha.....	-			6		
Cyanotis speciosa.....	1			6,9		
Asparagus africanus.....	2			9		
Rhoicissus tridentata.....	2			6	10	
Vepris undulata.....	r			6	10	
Xanthoxylon capensis.....	+			6,9	10	
Acalypha glabrata.....	+			6	10,11	
Acocanthera oppositifolia..	r			6,9	10	
Pappea capensis.....	2			6,9	10	
Panicum maximum.....	4			6	10	
Pellea viridis.....	+			6	10	
Helichrysum nudifolium....	r			6	10	
Asparagus asparagoides....	r				10	
Asparagus setaceus.....	r				10	
Barleria obtusa.....	2				10	
Capparis sepiaria.....	1				10	
Commiphora harveyii.....	-				10	
Euclea undulata.....	3				10	
Jasminum multipartitum....	2				10	
Justicia protracta.....	+				10	
Maytenus undata.....	r				10	
Panicum deustum.....	2				10	
Phyllanthus verucossus....	2				10	
Sanservieria hyacinthoides	1				10	
Sarcostemma viminale.....	+				10	
Scutia myrtina.....	1				10	
Secamone frutescens.....	+				10	
Senecio deltoideus.....	2				10	
Stachys aethiopica.....	1				10	
Thunbergia dregeana.....	2				10	
Xeromphis rudis.....	1				10	
Portulacaria afr.....	3				11	
Tecomaria capensis.....	2				11	
Scolopia mundii.....	+				10	4
Scolopia zeyheri.....	-				10	4
Ptaeroxylon obliquum.....	2				10	4
Ficus burtt-davyi.....	-				10	5
Cassine crocea.....	1					4
Azima tetracantha.....	2					4
Hippobromus pauciflorus....	2					5
Schotia latifolia.....	2					5
Harpephyllum caffrum.....	-					5,7
Allophylus decipiens.....	+					5
Ficus capensis.....	-					5
Maytenus peduncularis.....	-					7
Cussonia spicata.....	2		6	10		4
Ziziphus mucronata.....	-	2	6,9	10		7
Diospyros lycioides.....	1	2,8	9	10		
Eragrostis curvula.....	2	2,8	6,9	10		
Acacia karroo.....	3	8,2	6,9	10		
Grewia occidentalis.....	2	8	6,9	10		
Ehretia rigida.....	2	2	9	11		
Themeda triandra.....	2	1,3	2,8	6,9	10	
Olea africana.....	1	3	2,8	6		4
Stipa dregeana.....	-	1		9		
Cynodon dactylon.....	4	3	2	9		
Maytenus heterophylla.....	2	3	8	6,9	10	
Cymbopogon marginatus.....	-	3	2	9		
Pterocelastrus tricuspidatus		3				4
Sideroxylon inerme.....	-	1,3			10	4

Table 14. 132 plant species on the AVKR, indicating affinity to the five biogeographical regions which meet in the study area. Authors consulted: 1 = Van der Merwe, 1976; 2 = Jooste, 1980; 3 = Taylor, 1969; 4 = White, 1978; 5 = Acocks, 1975; 6 = Coetzee, 1975; 7 = Rogers & Moll, 1975; 8 = Werger, 1973; 9 = Coetzee, 1974; 10 = Weisser & Drews, 1980; 11 = Pooley, 1980; 12 = Codd, 1963.