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A SYNECOLOGICAL STUDY OF THE VEGETATION OF THE NORTH-EASTERN ORANGE FREE STATE

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A synecological study of the vegetation

of the north-eastern Orange Free State

by

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for the degree

MAGISTER SCIENTIAE (WILDLIFE MANAGEMENT)

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Co-supervisor: Prof. dr. G.J. BREDENKAMP

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Commit to the Lord

whatever you do,

and your plans will succeed.

Proverbs 16:3.

Dedicated to my parents

ABSTRACT

A synecological study of the vegetation of the north-eastern Orange Free State

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Supervisor: Dr. N. VAN ROOYEN

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MAGISTER SCIENTIAE (WILDLIFE MANAGEMENT)

The deteriorating state of the Grassland Biome is a major concern which prompted the launch of the Grassland Biome Project. The objective of this project is to develop a better knowledge and understanding of the grassland structure and functioning to permit efficient land use planning and conservation. The identification of areas with conservation status forms part of this study. A total of 374 sample plots were randomly distributed over an area of 5 600 km^2, comprising the north-eastern corner of the Orange Free State. Stratification was based on land types and terrain units. The vegetation was classified by means of TWINSPAN and Braun-Blanquet procedures. The 41 plant communities identified, were further described and ecologically interpreted. The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity was also tested. The Ecological Index Method was used and showed promising results. Further application of this technique in the grasslands of South Africa should be considered.

UITTREKSEL

'n Sinekologiese studie van die plantegroei van die noordoostelike Oranje-Vrystaat

deur

HOLGER CHRISTIAN ECKHARDT

Studieleier: Dr. N. VAN ROOYEN

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SENTRUM VIR NATUURLEWENAVORSING

UNIVERSITEIT VAN PRETORIA

MAGISTER SCIENTIAE (NATUURLEWEBESTUUR)

Die verswakkende toestand van die Grasveld Bioom is 'n groot bron van bekommernis wat tot die ontstaan van die Grasveld Bioom Projek gelei het. Die doel van hierdie projek is om die kennis en verstandhouding van die grasveld struktuur en funksionering daarvan uit te brei sodat effektiewe veldbenutting en bewaring beplan kan word. Die identifisering van gebiede met bewaringsstatus vorm deel van hierdie studie. 'n Totaal van 374 monsterpersele is ewekansig oor 'n gebied van 5 600 km^2 in die verre noordoostelike Oranje-Vrystaat, uitgeplaas. Stratifisering is gebaseer op landtipes en terreineenhede. Die plantegroei is deur middel van TWINSPAN en Braun-Blanquet-prosedures geklassifiseer. Die 41 geïdentifiseerde plantgemeenskappe is verder beskryf en ekologies geïnterpreteer. Die aanwending van Braun-Blanquet-data vir die bepaling van veldtoestand en die berekening van weikapasiteite is

ook getoets. Die Ekologiese Indeks Metode is gebruik en het belowende resultate opgelewer. Die verdere aanwending van hierdie tegniek in die grasvelde van Suid-Afrika moet oorweeg word.

ACKNOWLEDGEMENTS

All praise to God who gave me the perseverance and will-power to succeed.

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CHAPTER 1

INTRODUCTION

The Grassland Biome covers approximately 27% of South Africa. The country's major production of beef, dairy, wool, timber and various important crops such as maize, sunflowers, wheat and sorghum is derived from this biome (Mentis & Huntley 1982). The greatest concentration of urban areas such as the Pretoria-Witwatersrand-Vereeniging (PWV), Pietermaritzburg and Bloemfontein area are situated in the grasslands (Rutherford & Westfall 1986). Mining activities concentrating on the main economic mineral reserves such as gold, coal, diamonds, uranium and aluminium are greatly restricted to the Grassland Biome.

Obviously the different kinds of exploitation and utilization have had adverse effects on the grasslands of South Africa. In 1920, the Drought Investigation Commission was appointed to investigate the occurrences of periodic droughts. The results of the investigation suggested that although various factors contribute to the increase in drought incidence, mankind plays an important role in the aggravation of the latter (Tainton 1984). The influence of such droughts and mismanagement of the land have had detrimental consequences for the vegetation cover and species composition. The deterioration of the grassland has taken the form of reduction in number and vigour of palatable food plants, an increase in the proportion of less palatable and less nutritious plants, and a marked decrease in the absolute vegetation cover with a subsequent increase in sheet and donga erosion (Phillips 1938).

Concern about the degradation process in the Grassland Biome has prompted the launch of the Grassland Biome Project (Mentis & Huntley 1982). The ultimate objective of this project is to develop a better understanding and knowledge of the grassland structure and functioning to permit efficient land use planning, utilization, conservation and management. The existing large scale classification of vegetation by Acocks (1953, 1975, 1988) is not sufficient in providing a basis for management planning. The acknowledged veld types had therefore to be refined. This reclassification includes a more detailed identification, description and mapping of the present grassland types (Scheepers 1986). Numerous papers were devoted to the phytosociology of the vegetation of different parts of the Grassland Biome (Van Wyk & Bredenkamp 1986; Bezuidenhout 1988; Bloem 1988; Bredenkamp et al. 1989; Turner 1989; Kooij 1990; Du Preez 1991; Matthews 1991; Fuls et al. 1992; Smit 1992; Coetzee 1993).

The north-eastern Orange Free State was identified as an area where little or no phytosociological data exist. Therefore this area was selected for a synecological study to develop a better understanding and knowledge of the grassland. This area contains elements of moist sour grassland restricted to higher altitudes, and dry sweet grassland occurring on lower lying areas.

A synecological study of this area was undertaken with the goals of the Grassland Biome Project in mind. The collected data was therefore also used for the identification of potential conservation areas. The identification of such areas is considered most important by the Department of Environment Affairs in ensuring the preservation of genetic resources and the diversity of species (Department of Environment Affairs n.d.). The data of certain areas within the study area was also applied for the determination of veld condition and grazing capacity.

This thesis consists of several manuscripts which have either been accepted for publication or are submitted for publication in various scientific journals. Although details of the study area, methods, results, discussion and references are presented in the individual contributions, the methods, conservation status, a floristic analysis, a general discussion, a checklist of species and a complete list of references are treated under separate chapters or as an appendix.

Stylistic discrepancies and repetitiveness between the different manuscripts are due to differences in layout and style required by the various scientific journals. Tables and figures are numbered consecutively within each chapter and a summary of all figures and tables is given in the front of the thesis. The phytosociological tables of the various chapters and a synoptic table are included in the folder in the back of the thesis. These tables are not numbered consecutively, therefore the numbers are preceded by the relevant chapter numbers.

CHAPTER 2

METHODS

The study area was demarcated on the Land Type Series map 2728 Frankfort, scaled 1:250 000. Six different land types were distinguished, embracing the total study area in the far north-eastern corner of the Orange Free State (Land Type Survey Staff 1984). The Ad, Bb, Bd, Ca, Ea and Fa land types were clearly marked and used as stratification units. A land type is an area which is uniform with respect to terrain form, soil pattern and climate (Land Type Survey Staff 1984). A terrain unit is any part of the land surface with homogeneous form and slope (Land Type Survey Staff 1986).

To obtain background information on the vegetation of the study area, the publications of Acocks (1953, 1975, 1988) on veld types, and Edwards (1983) for a structural classification of the vegetation, were the only ones which could be consulted. The geology was described by making use in the first place of the geological map (adapted from Department of Mineral and Energy Affairs 1984). Descriptions of the various geological formations were done following Du Toit (1954) and SACS (1980) (South African Committee For Stratigraphy). Soils were classified and described according to MacVicar et al. (1977), Land Type Survey Staff (1984) and Department of Agricultural Development (1991). The terrain morphological map of Kruger (1983) was used to give a topographical description of the area. Information on the climate was obtained from the Department of Agriculture and Water Supply (1986) and the Weather Bureau (1986, 1991).

A reconnaissance survey of the entire study area preceded the plant surveys. During the first survey, a general idea was formed of the topography, farming practices and vegetation. Unknown plant species were collected for identification at the National Botanical Institute in Pretoria.

Number, size and distribution of sample plots

The number of sample plots to be distributed in a given area depends on the scale of the survey, heterogeneity of the area and the accuracy required for the classification (Bredenkamp 1982). The number of sample plots per stratification unit was based on area size. Sample plots were randomly distributed within stratification units. Stratification was primarily based on land types (Land Type Survey Staff 1984; Bezuidenhout 1988; Bredenkamp et al. 1989) and secondarily on terrain units. Within these relatively homogeneous stratification units the sample plots were subjectively positioned (Werger 1973; Whittaker 1980; Bredenkamp 1982). This was done by choosing the position in such a way that the sample plots adequately represent the vegetation concerned. Here the approach of the Zürich-Montpellier School (Braun-Blanquet 1932) was followed. This approach has been successfully applied in South Africa and more specifically in the Grassland Biome (Bezuidenhout 1988; Bredenkamp et al. 1989; Kooij 1990; Matthews 1991; Smit 1992).

Sample plot sizes of 100 m^2 for grassland (Bredenkamp 1975) and 200 m^2 for woodland (Bredenkamp 1982) were chosen. The shape of these sample plots were generally square and were only adapted to circumstances where it was necessary, e.g. in ravines or along watercourses. Sampling was carried out from January to April of the years 1991 and 1992. A total of 374 sample plots were surveyed.

Sampling method

A standardised and widely used sampling technique for South Africa is the Braun-Blanquet method (Bredenkamp 1982). In order to make results of different areas comparable to each other, it is advisable to apply the same technique throughout the country. Subsequently, the same technique has been applied to produce a comprehensive floristic and habitat description.

Floristic analysis

During the survey all plant species in the sample plots were recorded. The species were allocated a value of the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974) depending on the cover and/or abundance of each species.

- r one or few individuals (rare) with less than 1% cover of total sample plot area;
- \+ occasional and less than 1% of total sample plot area;
- 1 abundant and with very low cover, or less abundant but with higher cover, 1-5% cover of total sample plot area;
- 2 abundant with >5 - 25% cover of total sample plot area;
  A: >5 - 12%
  B: >12 - 25%
- 3 >25 - 50% cover of total sample plot area, irrespective of the number of individuals;
- 4 >50 - 75% cover of total sample plot area, irrespective of the number of individuals;
- 5 >75% cover of total sample plot area, irrespective of the number of individuals.

Names of taxa are in accordance with those of Gibbs Russell et al. (1985, 1987) and De Wet et al. (1989, 1990 & 1991).

Habitat analysis

The distribution of plant communities is closely related to environmental conditions (Daubenmire 1968; Gauch 1982). These conditions are the products of the combined influences of various environmental variables. To understand the distribution of plant communities, it is inevitable to consider these variables which are referred to below.

1. Geology

The geology of the study area is described by making use of the 1:250 000 geological survey maps (Department of Mineral and Energy Affairs 1984).

2. Land type

For each sample plot the land type was annotated by referring to the 1:250 000 Land Type Series Maps (Land Type Survey Staff 1984).

3. Topography

The following topographical positions were distinguished (Land Type Survey Staff 1984):

1 - crests

2 - scarps

3 - midslopes

4 - footslopes

5 - valley bottoms, floodplains or drainage lines

Altitude, slope and aspect of the slope was determined for each sample plot. The following classes for slopes were distinguished:

Low - $0-3^{o}$

Moderate - $>3-30^{o}$

Steep - $>30^{o}$

4. Rockiness

The rockiness of the soil was expressed in terms of percentage cover of the total sample plot:

0 - none

1 - 0-2%

2 - >2-5%

3 - >5-10%

4 - >10-20%

5 - >20%

The general rock size was also noted:

small rocks = 0-100 mm

medium rocks = >100-250 mm

medium/large rocks = >250-500 mm

large rocks/boulders = >500 mm

5. Soil type and soil depth
These were determined by using an auger. Soil nomenclature conforms to those of Department of Agricultural Development (1991). The following depth classes were used:

1 - <150 mm
2 - 150-300 mm
3 - >300-500 mm
4 - >500 mm

6. Percentage clay
Clay content of the soil was determined by the "sausage method" (Du Toit 1982) and was expressed as a percentage. The following classes were distinguished which are partially based on MacVicar et al. (1977):

1 - 0-15%
2 - >15-25%
3 - >25-35%
4 - >35%

7. General observations
These include extent of erosion, utilization and trampling. Disturbances of the vegetation and management practices where possible were noted.

Data processing

A list of observations of a sample plot with all its floristic and associated environmental data is called a relevé. The floristic data sets of 1991 and 1992 were separately processed. These were subjected to the two-way indicator species analysis technique (TWINSPAN) (Hill 1979b) and subsequently refined by Braun-Blanquet procedures. TWINSPAN was applied to derive a first approximation of the vegetation units. These classifications were further refined by the application of Braun-Blanquet procedures to determine the plant communities for the Ea land type and the major plant communities for the second data set. Both the techniques are contained within the mainframe computer programme BBNEW which is available at the Botany department of the University of Pretoria.

All the data obtained during 1991 was derived from a single land type (Ea) embracing one third of the total study area. The data set of 1992 contains the floristic data of five different land types. A synoptic table was compiled for this data set which confirmed the distinction of six major plant communities. The latter communities were subsequently divided into four phytosociological tables. Of these tables, one represents the thickets and woodlands, two represent the grassland communities, and one the wetlands. The phytosociological tables were each subjected to TWINSPAN and afterwards refined by Braun-Blanquet procedures to determine the plant communities within the major plant communities. In Chapter 5 an overview of the major plant communities relating to the second data set, is given.

Some of the smaller data sets were subjected to an ordination algorithm, Detrended Correspondence Analysis (DECORANA) (Hill 1979a). This technique was used to determine vegetation gradients relating to certain environmental variables.

Veld condition assessment

The data of the grassland communities of the Ea land type, excluding those of the hills and floodplains, were also used to assess veld condition and grazing capacity. The Ecological Index Method (EIM) (Vorster 1982) was best employed for this purpose. Veld condition scores (VCS) were obtained by substituting Braun-Blanquet cover-abundance values for point cover-values. Veld benchmarks had to be assigned to enable the calculation of veld condition scores. Grazing capacity was calculated by using a published formula (Danckwerts & Teague 1989).

This is the first detailed classification and description of the vegetation of the north-eastern Orange Free State and most of the chapters are therefore presented in publication form.

<u>CHAPTER 3</u>

The vegetation of the north-eastern Orange Free State, South Africa: the physical environment of the total study area and plant communities of the Ea land type.

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Accepted by <u>Bothalia</u>

Keywords: Braun-Blanquet method, classification, geology, Grassland Biome, land types, soils.

ABSTRACT

The research was carried out in the Ea land type of the north-eastern Orange Free State, with the objective of reclassifying and refining Acock's veld types and identifying possible conservation areas. TWINSPAN classification results were further refined by Braun-Blanquet procedures. The 100 relevés distributed over the Ea land type resulted in the recognition of four major vegetation types which were divided into nine plant communities. The communities were hierarchically classified, described and ecologically interpreted. DECORANA ordination was used to determine vegetation/environmental gradients and relationships.

UITTREKSEL

'n Studie van die plantegroei-tipes van die Ea-landtipe in die noordoostelike Oranje-Vrystaat is uitgevoer met die doel om Acocks se veldtipes te herklassifiseer en te verfyn en om moontlike bewaringsgebiede te identifiseer. Die resultate van die TWINSPAN-klassifikasie is met behulp van Braun-Blanquetprosedures verder verwerk. Die 100 relevés wat oor die hele Ea-landtipe

versprei is, het vier hoofplantegroeitipes opgelewer wat in nege plantgemeenskappe onderverdeel is. Die gemeenskappe is hiërargies geklassifiseer, beskryf en ekologies geïnterpreteer. Plantegroei- en omgewingsgradiënte is met behulp van DECORANA-ordening bepaal.

INTRODUCTION

The Grassland Biome of South Africa covers approximately 27% of the country (Rutherford & Westfall 1986). As a result of intensive agricultural practices and urbanization, together with industrialization, the deterioration of the grassland led to concern amongst decision-makers, resulting in the launch of the Grassland Biome Project (Mentis & Huntley 1982). This project aims at developing a better knowledge and understanding of the grasslands of South Africa to permit efficient land-use planning, utilization, conservation and management. To reach these goals, it is necessary to reclassify Acocks's (1988) Veld Types. This reclassification means a more detailed identification, description and mapping of the present grassland types (Scheepers 1986). The north-eastern Orange Free State was identified as an area for which little or no phytosociological data exist.

The aim of this study was therefore to reclassify and describe the vegetation and to identify possible conservation areas. This study will also contribute to the syntaxonomic synthesis presently being undertaken by the Botany department of the University of Pretoria (Bezuidenhout 1988; Bredenkamp et al. 1989; Kooij 1990; Fuls et al. 1992b;).

STUDY AREA

The total study area is situated in the north-eastern corner of the Orange Free State, i.e. between 29° 00' and 29° 47' E longitude and 27° 00' and 28° 00' S latitude, bordering Transvaal and Natal (Figure 1). It covers approximately 5 600 km^2 and comprises six land types, namely land types Ad, Bb, Bd, Ca, Ea and

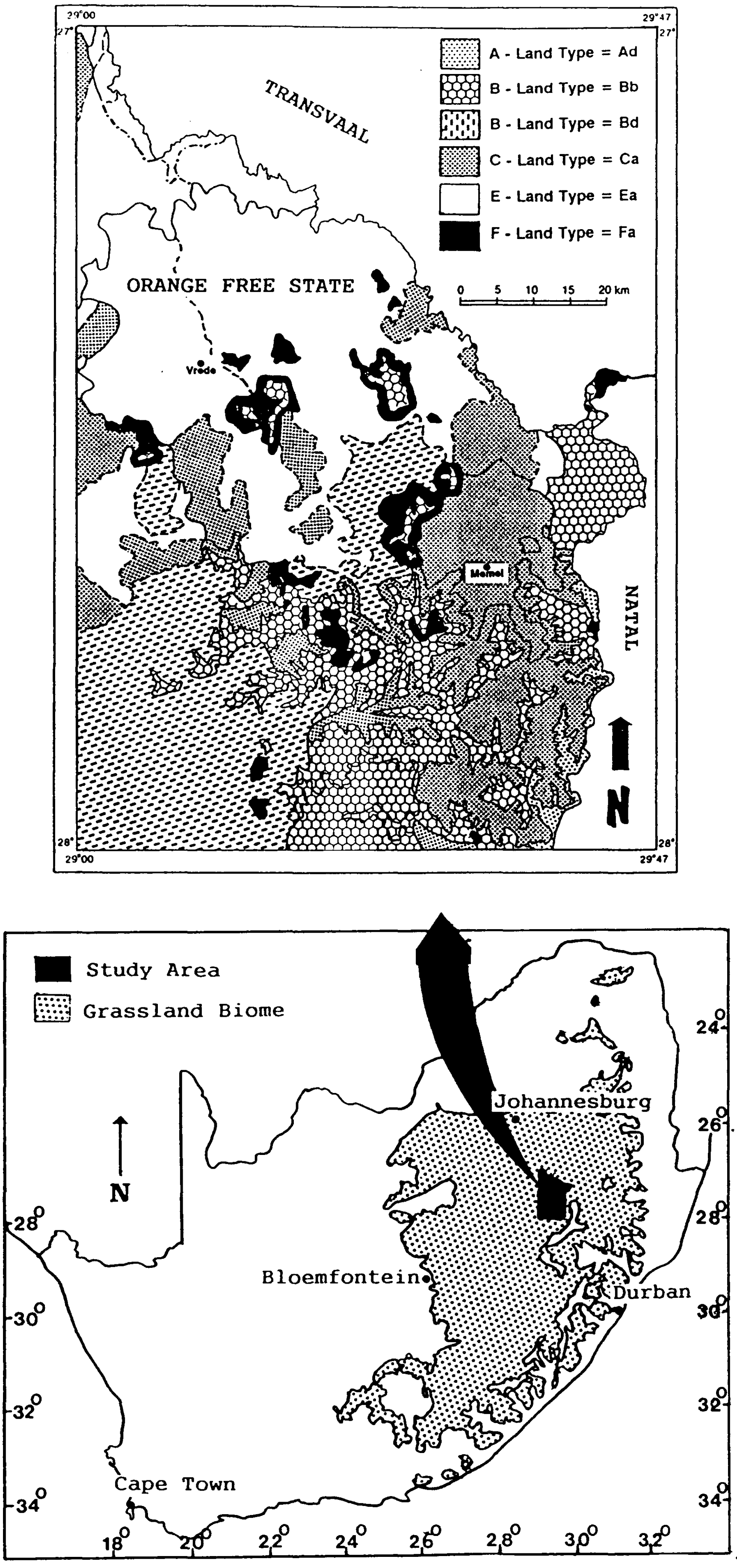


Figure 1. Map indicating the total study area within the Grassland Biome, and the distribution of the land types (Land Type Survey Staff 1984; Siegfried 1989).

Fa (Land Type Survey Staff 1984), which can be further subdivided (Figure 1). One third of the area (184 000 ha) is covered by the Ea land type which is dealt with in this report. The other land types are to be discussed in detail in later papers. A land type is an area which is uniform with respect to terrain form, soil pattern and climate. Towns situated in the area are Vrede and Memel (Land Type Survey Staff 1984). According to Acocks (1953, 1988), the study area represents six veld types (Figure 2): The Patchy Highveld to Cymbopogon-Themeda Veld Transition, covering approximately 50% of the total study area, is restricted to the northern and central parts. The Highland Sourveld stretches along the Natal border in the east. Smaller patches of Cymbopogon-Themeda Veld and Highland Sourveld to Cymbopogon-Themeda Veld Transition occur in the south-western and southern parts. The Turf Highveld to Highland Sourveld Transition stretches over the central eastern part, while one isolated patch of Southern Tall Grassveld occurs to the south of Memel (Figure 2).

GEOLOGY

Karoo Sequence

The Karoo Sequence occupies almost the total study area (Figure 3). Two important groups which can be distinguished here, are the Ecca and Beaufort Groups. The Clarens, Elliot and Molteno Formations are also part of this sequence, but they are limited in extent.

Ecca Group

This group is restricted to the north and north-eastern parts of the study area, bordering Transvaal (Figure 3). The Ecca Group can be subdivided into a Lower Ecca sandstone and shale, a Middle Ecca shale, and an Upper Ecca sandstone and shale (SACS 1980). Ecca shales are in general dark grey and carbonaceous. Ecca sandstone was deposited in an aquatic environment.

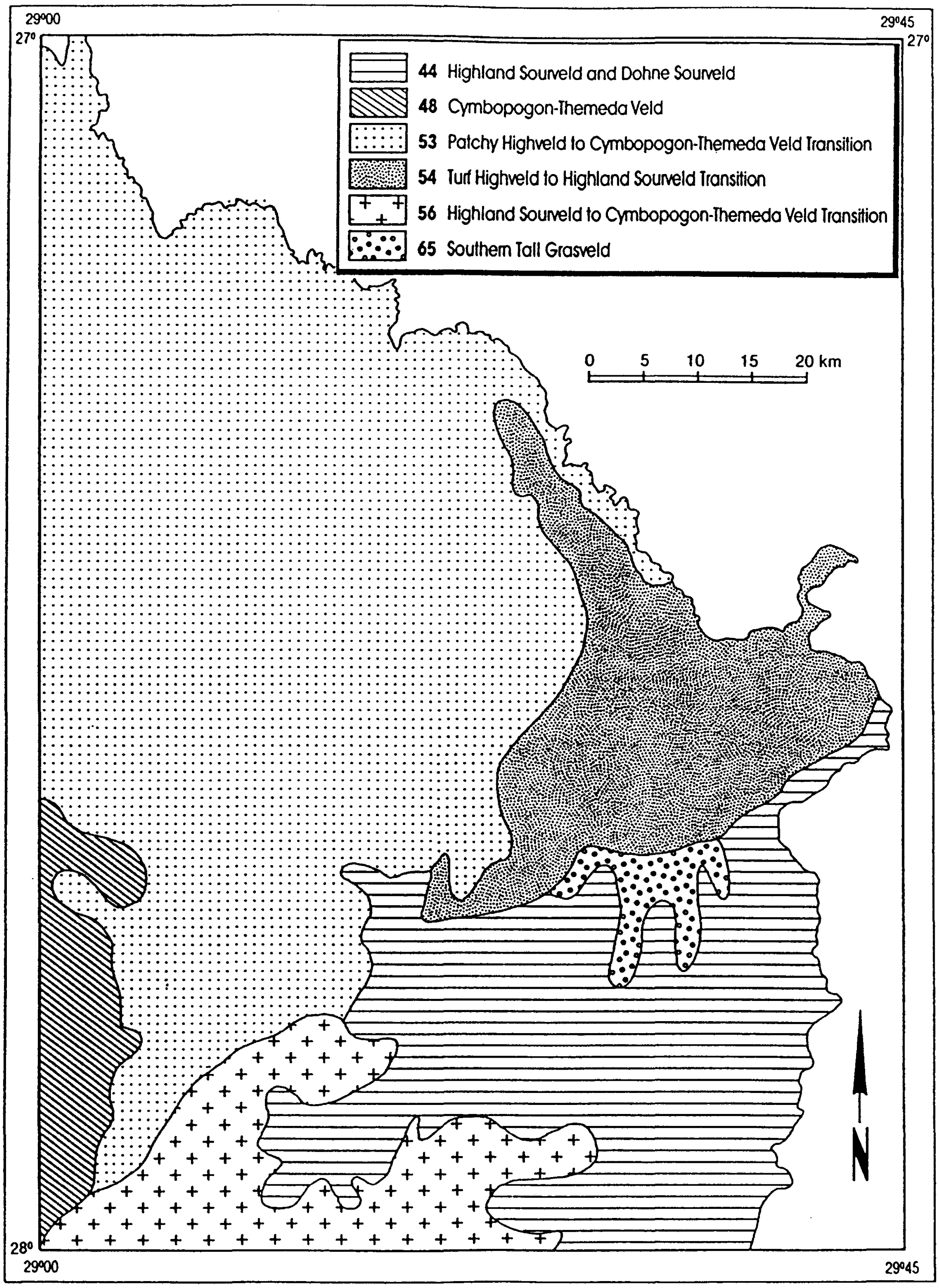


Figure 2. The distribution of the different veld types within the total study area according to Acocks (1953, 1988).

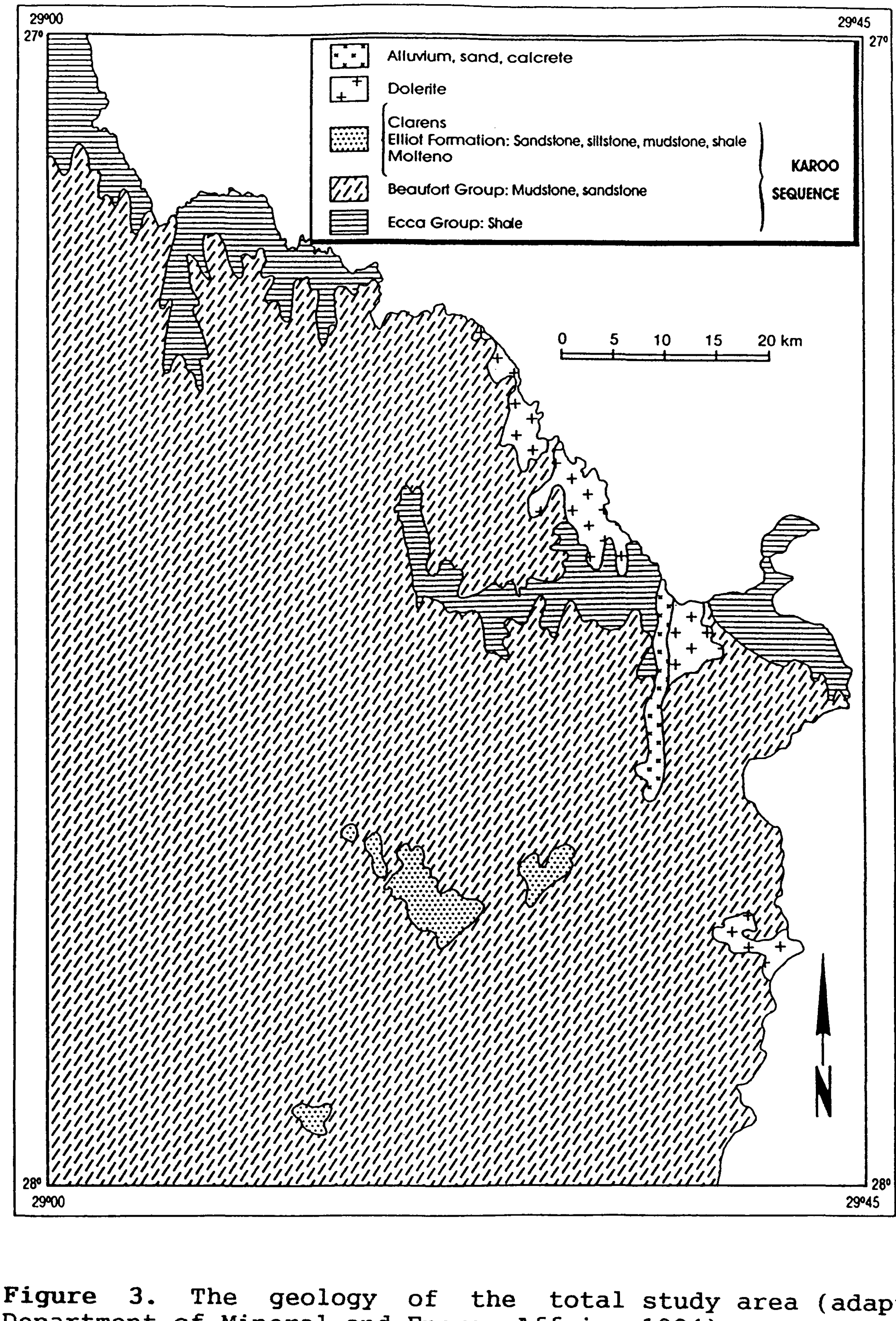


Figure 3. The geology of the total study area (adapted from Department of Mineral and Energy Affairs 1984).

Beaufort Group

The Beaufort Group covers more than 80% of the study area. It can be divided into three subdivisions, namely the Lower, Middle, and Upper Beaufort Beds. The argillaceous rocks are massive or blocky weathered. The mudstones are greenish-grey, blue-grey or red. Cross-bedded sandstones are common.

Molteno Formation

This formation is distinguished by the typical grey and blue colouration of the shales, and the coarse grain and "sparkling" appearance of the dominating sandstones. Between Harrismith and Memel the Molteno Formation occurs only as a single thin grit, covered by the Elliot Formation and underlain by the Beaufort Group (Du Toit 1954).

Elliot Formation

Purple and red mudstones and shales, together with red sandstones and thick beds of yellow and white feldspathic sandstones are characteristic of this formation (Du Toit 1954). The formation is well distinguished by its prevailing colouration as can be seen on the slopes of the few koppies in the study area.

Clarens Formation

The Clarens Formation, previously known as Cave Sandstone, is a massive, fine-grained rock type, which reaches a thickness of up to hundreds of metres. Under weathering conditions, this formation features fantastic shapes in the forms of pillars and caves. Exposed surfaces are white or cream-coloured, while at its base it is pink or deep red. A few isolated hills in the central and southern part of the study area have the characteristic shapes of this formation as described above. The main components are subangular to rounded grains of quartz and subordinate feldspar. The accumulation of sandstone is probably of aeolian origin, being rearranged later by flowing water (Du Toit 1954).

Alluvium, sand, calcrete

Alluvium and sand are more recent by-products of erosion, most probably originating from the Beaufort Group (pers. observ.). A narrow strip of these deposits, together with calcrete, occurs in the Seekoeivlei-area, which is drained by the Klip River (Department of Mineral and Energy Affairs 1984).

Dolerite

The dolerites intruded the sediments of the Karoo Sequence during the last stages of the Drakensberg volcanicity. These intrusions are either horizontal, evenly inclined or undulating sheets (SACS 1980). The dolerite dykes are restricted to the eastern part of the study area.

PHYSIOGRAPHY

Topography

The study area is part of the inland plateau region or highveld (Figure 1) and consists of plains with moderate relief to closed hills and mountains with moderate and high relief (Mentis & Huntley 1982; Kruger 1983). The altitude is between 1 500 m and 2 000 m with some peaks reaching heights of up to 2 200 m. There is a clear gradient in the physiography of the area from south to north. Three broad divisions can be distinguished.

The southern and eastern parts are characterized by isolated hills and mountains with moderate and high relief. The middle part is depicted by lowlands, hills and mountains with a moderate to high relief, and can further be described as strongly undulating irregular land, gradually changing over into plains with moderate relief. These plains are slightly irregular, undulating, with occasional hills scattered over the area. This region is most suitable for cultivation purposes, whereas the rest of the area is more suited to cattle farming.

Drainage

The Drakensberg forms a clear watershed, separating the tributaries of the Vaal River, west of the escarpment, from the tributaries of the Tugela River, east of the escarpment. The study area is situated in the catchment area of the Vaal River. The Klip River is the main drainage line into which several smaller rivers and spruits flow (Figure 4). The northern part of the study area is mainly drained by the Spruitsonderdrift and Kommandospruit, which are both perennial streams. There is a gradual flattening towards the north, resulting in less deeply incised low to moderate undulating plains in the north. These are in strong contrast to the deeply incised mountainous southern part.

SOILS

According to Land Type Survey Staff (1984), the soils are undifferentiated and can have one or more of either vertic, melanic and red structured diagnostic horizons. The names and descriptions of the different soil forms are used according to the Department of Agricultural Development (1991). The Glenrosa and Mispah Forms are restricted to terrain units 1 and 2 and very often occur together to form a complex. These soils are shallow (< 200 mm) and have a relatively low clay content (>15-25%) and are mostly not arable. Terrain units 3 and 4 are characterized predominantly by pedocutanic, lithocutanic and yellow-brown apedal B horizons. Soils are more than 300 mm deep and have a higher clay content (> 35%). Although the Ea land type is generally more suitable for crop production than the rest of the study area, large areas are non-arable because of the high clay content of the soils. Terrain unit 5 is characterized by either rock and alluvium or the vertic Rensburg and Arcadia soil forms. The last two forms have a clay content of more than 35% and are deep (> 500 mm).

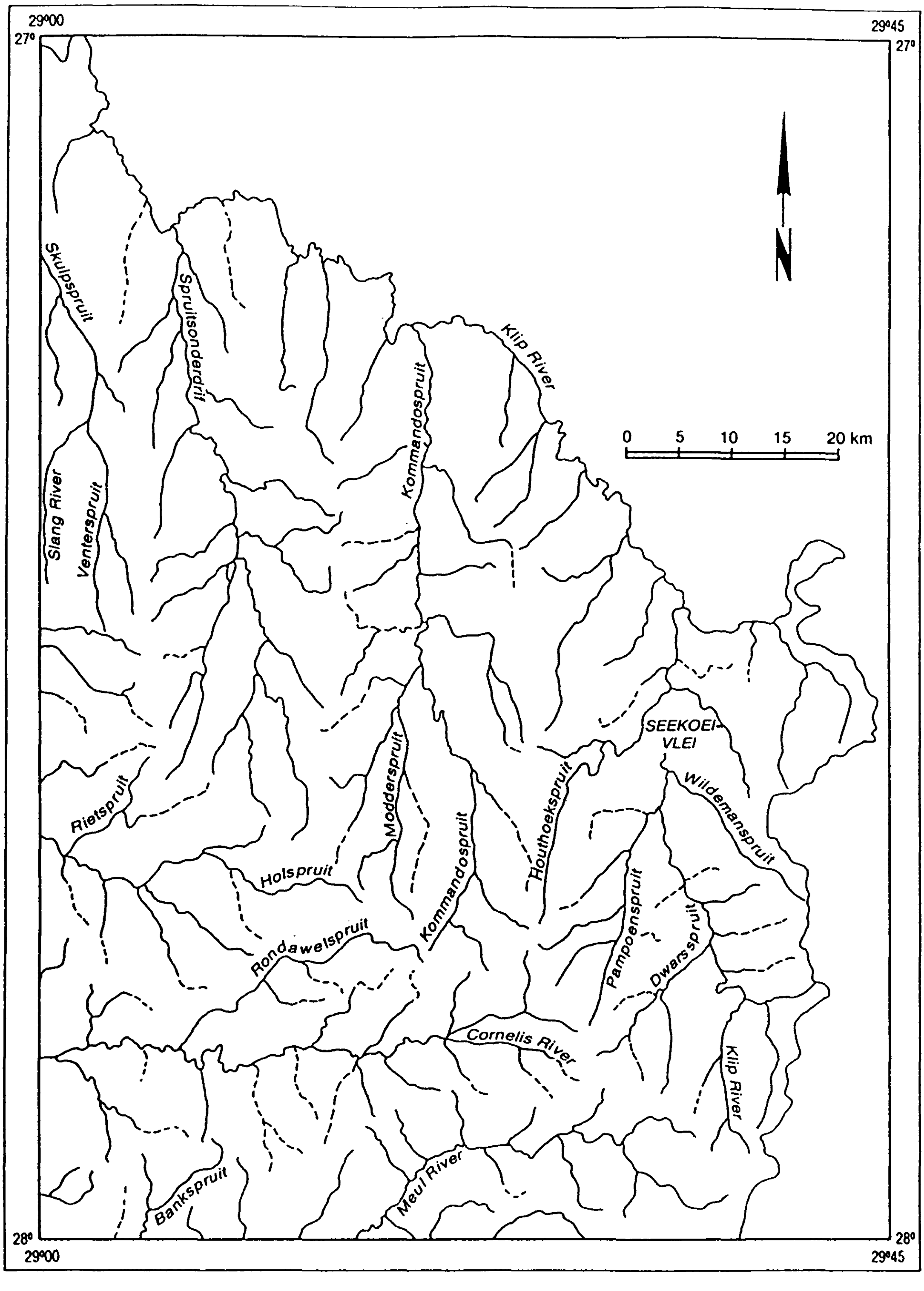


Figure 4. The drainage of the total study area with the Klip River as main drainage line (Land Type Survey Staff 1984).

CLIMATE

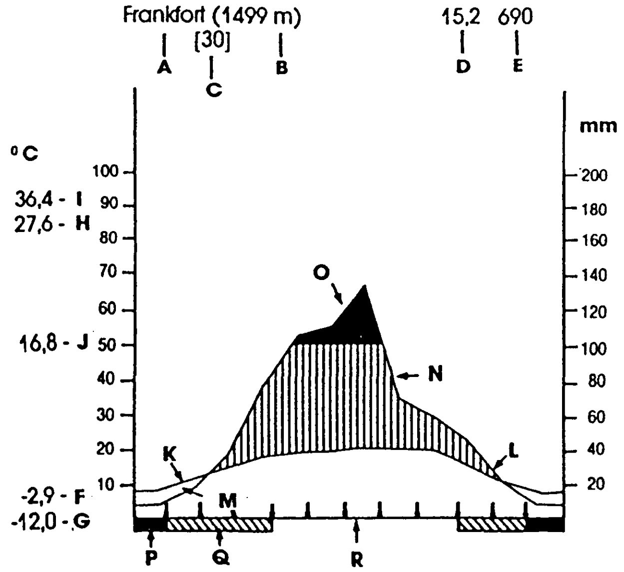
Rainfall

The study area is situated in the summer rainfall zone with an average annual rainfall of 750 mm (Department of Agriculture and Water Supply 1986). Precipitation takes place mostly in the form of thunderstorms, between November and March. Midsummer droughts occur towards the end of December until middle of January (Department of Agriculture and Water Supply 1986).

Rainfall data for weather stations at Frankfort and Standerton are given in Figure 5 (Weather Bureau 1986).

Temperature

Mean monthly maximum and minimum temperatures recorded at Frankfort and Standerton for the period 1985 to 1990 are given in Table 1. Absolute maximum and minimum temperatures for the two weather stations are given in Table 2. The date indicates the day, month and year at which these temperatures were recorded. The frost period stretches from April to October (215 days), which means a frost-free period of approximately 150 days a year (Weather Bureau 1986).



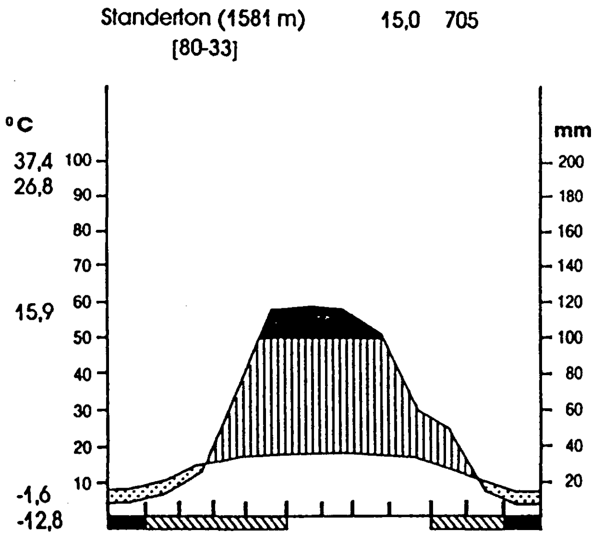


Figure 5. Climatic diagrams for two weather stations. A - station; B - height above sea level; C - duration of observations in years (indicates temperature and precipitation respectively); D - mean annual temperature in °C; E - mean annual precipitation in mm; F - mean daily minimum temperature (coldest month); G - lowest temperature recorded; H - mean daily maximum temperature (hottest month); I - highest temperature recorded; J - mean daily temperature fluctuation; K - mean monthly temperature; L - mean monthly precipitation; M - dry season; N - wet season; O - very wet season (mean monthly precipitation > 100 mm); P - cold season (mean daily minimum below 0°C); Q - month with absolute minimum below 0°C; R - frost-free period (after Walter and Lieth as quoted by Larcher 1980).

Table 1. The mean monthly maximum and minimum temperatures (°C) for two weather stations (Weather Bureau 1991).

Date 1985--1990	Frankfort Max.	Frankfort Min.	Standerton Max.	Standerton Min.
Jan.	28,3	14,8	27,3	14,4
Feb.	27,0	13,9	26,5	14,0
Mar.	26,5	11,3	26,0	12,4
Apr.	23,5	7,5	24,2	8,8
May	21,6	1,0	21,3	2,7
Jun.	18,1	-2,9	17,6	-1,1
Jul.	18,6	-3,7	18,5	-2,1
Aug.	21,8	0,4	21,7	1,7
Sep.	23,3	5,2	23,6	5,9
Oct.	24,8	9,3	24,6	9,5
Nov.	26,1	12,1	25,6	11,5
Dec.	27,3	13,5	26,5	13,5
Av.	23,9	6,9	23,6	7,6

Table 2. Absolute maximum and minimum temperatures (°C) for each month for two weather stations (Weather Bureau 1986).

	Frankfort				Standerton			
Month	Max.	Date	Min.	Date	Max.	Date	Min.	Date
Jan.	36,4	18-01-73	4,0	30-01-61	37,2	05-01-29	2,5	05-01-60
Feb.	36,1	27-02-83	4,4	28-02-65	35,0	15-02-84	3,3	20-02-24
Mar.	35,0	03-03-84	0,6	19-03-74	34,0	03-03-84	0,6	15-03-30
Apr.	31,5	05-04-83	-4,0	27-04-55	31,7	01-04-33	-5,3	30-04-17
May	29,0	02-05-79	-7,5	19-05-84	30,0	03-05-33	-10,6	31-05-18
Jun.	24,6	09-06-83	-11,0	20-06-57	25,0	01-06-32	-12,8	11-06-07
Jul.	23,8	29-07-60	-12,0	23-07-54	26,1	31-07-40	-12,8	18-07-13
Aug.	27,9	19-08-77	-10,0	14-08-55	29,9	30-08-22	-11,7	16-08-13
Sep.	33,7	29-09-83	-8,3	09-09-74	34,4	30-09-23	-7,8	16-09-30
Oct.	34,2	30-10-65	-1,9	21-10-65	35,2	21-10-61	-3,8	01-10-13
Nov.	35,6	07-11-68	1,4	15-11-76	34,4	06-11-68	-1,1	25-11-12
Dec.	36,0	31-12-84	1,1	06-12-84	37,4	31-12-82	2,2	08-12-70

METHODS

Relevés were compiled in 100 stratified random sample plots within the Ea land type of the study area. Stratification was based on terrain units (Land Type Survey Staff 1984; De Beer 1988). Sampling of the different terrain units was done on a subjective basis. Five different topographical positions were distinguished, namely 1=crests, 2=scarps, 3=midslopes, 4=footslopes and 5=valley bottoms, floodplains or drainage lines (Land Type Survey Staff 1984). Minimum plot sizes of 16 m^2 are considered to be adequate for grassland surveys (Scheepers 1975). Nevertheless, it was decided to fix the plots at 100 m^2 because of the large scale on which this survey was conducted, and to ensure that scarce, possible diagnostic species were included. The plots for woodlands were fixed at 200 m^2 (Bredenkamp 1982). This is essential for efficient Braun-Blanquet type data processing and also in accordance with the aim of identifying areas for possible conservation. The floristic composition in each sample plot was determined by using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). In accordance with Werger (1973), scale-unit 2 was divided as follows:

A: covering 5-12% of the sample plot area

B: covering >12-25% of the sample plot area.

Taxon names conform to those of Gibbs Russell et al. (1985 & 1987) and De Wet et al. (1989, 1990, 1991). Structural classification was according to Edwards (1983). The following habitat data were recorded in each sample plot: geology, topography, terrain unit, slope and aspect, rockiness, soil types and erosion.
To derive a first approximation of the vegetation types, two way indicator species analysis (TWINSPAN) (Hill 1979b) was applied. This was further refined by Braun-Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp et al. 1989). The results obtained are presented in a phytosociological table (Table 3). Detrended

correspondence analysis (DECORANA) (Hill 1979a) was applied to the floristic data set to determine vegetation gradients and illustrate vegetation/environmental relationships.

RESULTS AND DISCUSSION

Classification

The Ea land type is characterized mainly by the constant presence, mostly with high cover-abundance values, of *Themeda triandra*, *Eragrostis curvula* and *E. plana* (Species group L, Table 3). The number of species recorded per relevé varies from 15 to 25, with an average of 19 species.

The following plant communities were distinguished in the Ea land type:

1. *Artemisia afra*-*Rhus dentata* shrubveld of the slopes

    1.1. *Hyperthelia dissoluta*-*Eragrostis curvula* shrubveld of steep slopes

    1.2. *Hyparrhenia hirta*-*Diospyros lycioides* shrubveld of moderate slopes

2. *Themeda triandra*-*Elionurus muticus* grassland of relatively dry undulating midslopes/ plains

    2.1. *Elionurus muticus*-*Trachypogon spicatus* grassland of relatively dry, rocky, shallow soils

        2.1.1. *Vernonia oligocephala*-*Trachypogon spicatus* grassland of relatively dry, rocky, shallow soils

        2.1.2. *Harpochloa falx*-*Trachypogon spicatus* grassland of relatively moist, rocky, shallow soils

    2.2. *Microchloa caffra*-*Elionurus muticus* grassland of relatively moist soils

        2.2.1. *Tristachya leucothrix*-*Elionurus muticus* variation

        2.2.2. *Heteropogon contortus*-*Eragrostis plana* variation

3. Themeda triandra-Eragrostis plana transitional dry/wet grassland

4. Eragrostis plana-Eragrostis curvula wet/moist grassland

   4.1. Eragrostis curvula-Setaria sphacelata moist grassland

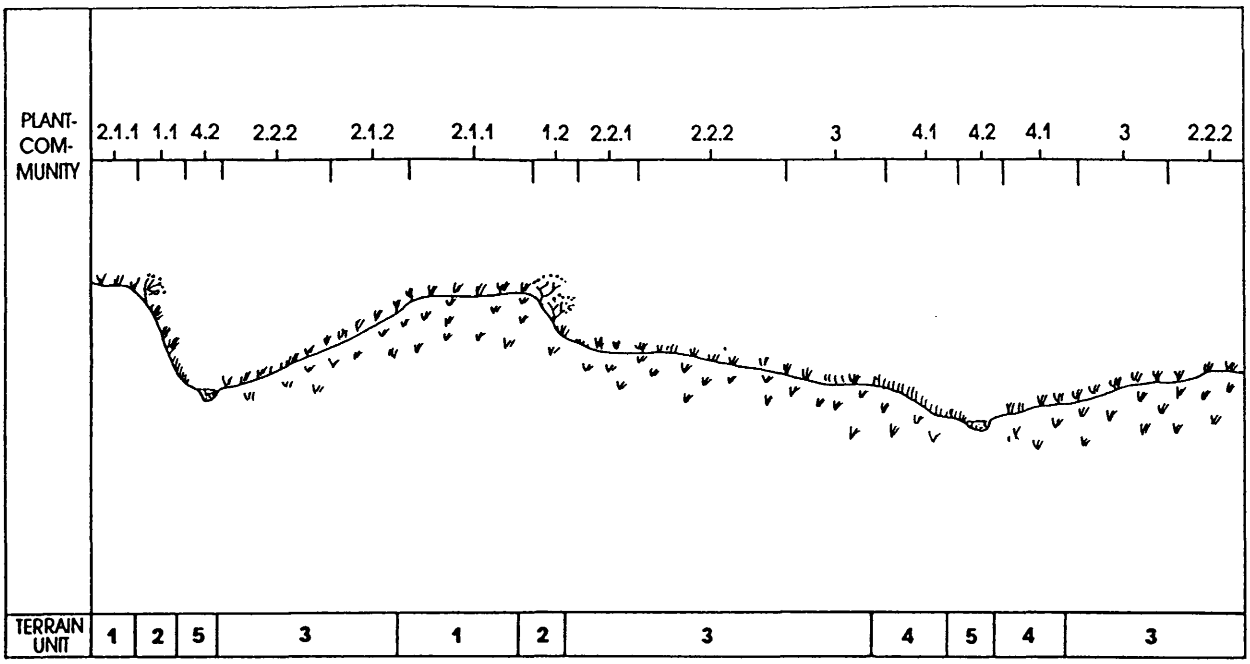
   4.2. Eragrostis plana-Paspalum distichum wet grassland

Description of the communities:

1. Artemisia afra-Rhus dentata shrubveld

This shrubveld is situated on moderate to steep scarps (20^{o}-45^{o}), sometimes reaching 90^{o} (terrain unit 2) facing rivers and streams. Shallow, rocky soils of the Glenrosa and Mispah Forms are typical of this terrain type (Figure 7). The average rock size is more than 500 mm in diameter, covering more than 20% of the surface. Clear signs of erosion can be observed, which are ascribed mainly to the steepness of the slopes. The utilization of the vegetation by dassies Procavia capensis (Skinner & Smithers 1990) is present in some areas.

The vegetation is characterized by species group C (Table 3) and the diagnostic species include the shrubs Artemisia afra, Rhus dentata and Diospyros austro-africana. Bidens pilosa and Hibiscus trionum are weeds and are often associated with disturbed areas. Dominant woody species are the diagnostic shrub species.



1.1	Hyperthelia dissoluta-Eragrostis curvula shrubveld
1.2	*Hyparrhenia hirta-Diospyros lycioides* shrubveld
2.1.1	*Vernonia oligocephala-Trachypogon spicatus* grassland
2.1.2	*Harpochloa falx-Trachypogon spicatus* grassland
2.2.1	*Tristachya leucothrix-Elionurus muticus* variation
2.2.2	*Heteropogon contortus-Eragrostis plana* variation
3	*Themeda triandra-Eragrostis plana* grassland
4.1	*Eragrostis curvula-Setaria sphacelata* grassland
4.2	*Eragrostis plana-Paspalum distichum* grassland

Figure 6. A schematic representation of the terrain units with the associated plant communities identified in the Ea land type.

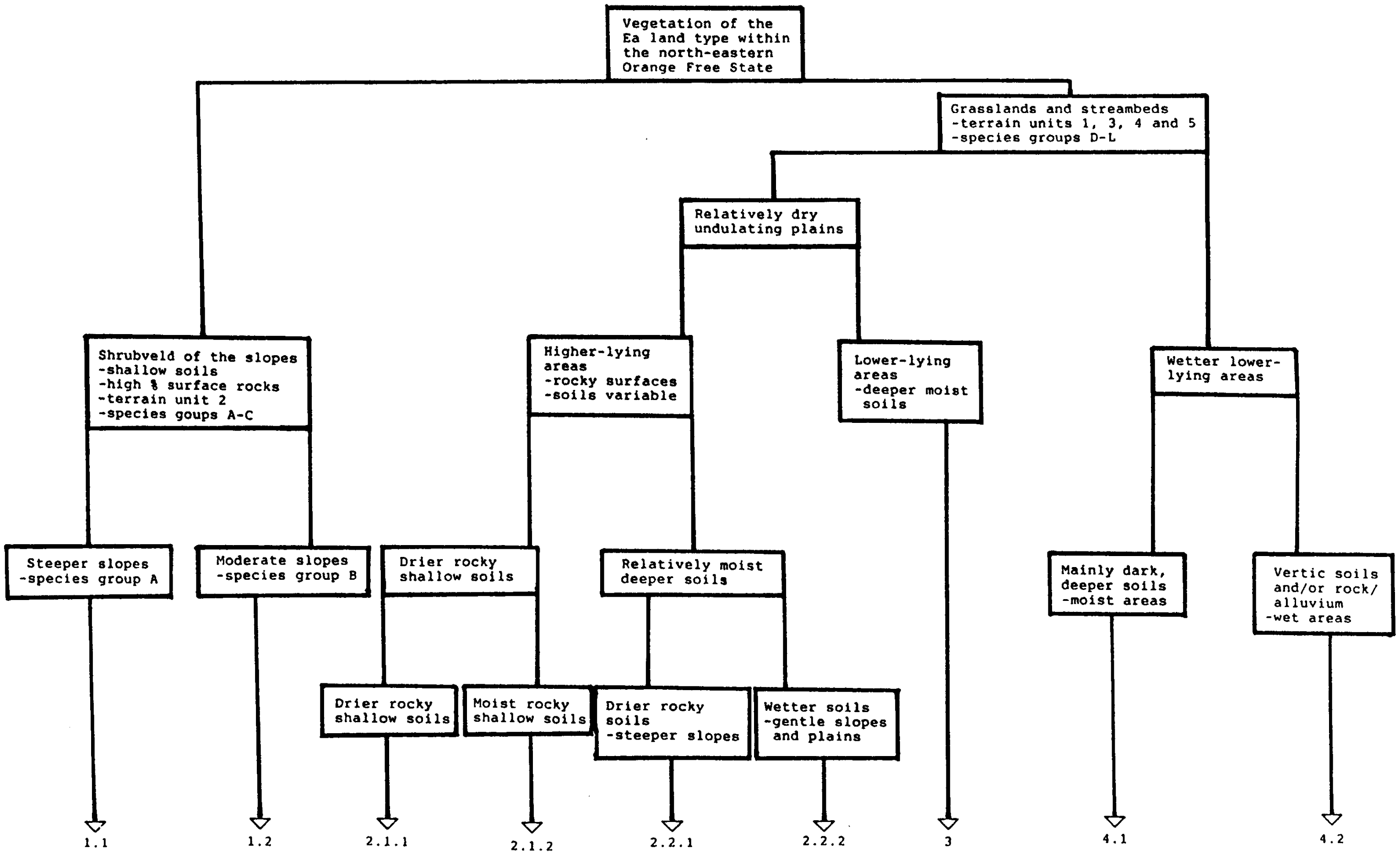


Figure 7. Hierarchical diagram to indicate the prominent habitat characteristics which are associated with the respective plant communities.

Conspicuous and dominant grasses include Themeda triandra, Eragrostis curvula and E. plana of species group L, and Aristida congesta and A. junciformis of species group I (Table 3). The herbaceous layer of terrain unit 2 is more conspicuous and better developed than those of other terrain units.

1.1 Hyperthelia dissoluta-Eragrostis curvula shrubveld

This shrubveld is situated on steep (40^o-90^o) slopes and displays patches of bare soil with a relatively high degree of erosion (Figures 6 & 7). Diagnostic species include the dominant grass species Hyperthelia dissoluta, the forbs Clutia natalensis, Garuleum woodii, Sutera polelensis, the xerophytic fern Pellaea calomelanos and the grass Melica racemosa (species group A, Table 3). Themeda triandra, Eragrostis curvula and E. plana are of the most constantly present companion grass species occurring in this community. An average of 15 species was recorded per sample plot.

1.2 Hyparrhenia hirta-Diospyros lycioides shrubveld

This shrubveld is characterized by species group B (Table 3) and can be further distinguished from the Hyperthelia dissoluta-Eragrostis curvula shrubveld by the presence of conspicuous and constantly present grass species of species group I (Table 3). Diagnostic species include the tall and dominant grass species Hyparrhenia hirta, the shrubs Diospyros lycioides, Grewia occidentalis and Heteromorpha trifoliata, and the weedy Zinnia peruviana and Monsonia angustifolia (species group B, Table 3). A further characteristic of this community is the presence of seral and pioneer species listed in species group I, for example the grasses Aristida junciformis, A. congesta and Aristida bipartita. An average of 23 species was recorded per sample plot.

2. Themeda triandra-Elionurus muticus grassland

This plant community is to a great extent similar to grasslands described by Bezuidenhout (1988) and Kooij (1990), except for the prominence of Eragrostis plana and other species typical of the moister eastern grasslands of the Orange Free State. This community compares well with the Elionurus muticus-Themeda triandra alliance described by Fuls et al. (1992a). This grassland type covers more than 60% of the Ea land type enclosed by the study area. A great diversity of soil forms occur, including Mispah, Glenrosa, Mayo, Inhoek, Westleigh, Swartland, Clovelly, Oakleaf, Glencoe, Bonheim and Arcadia. Soil depth varies from 100 to more than 700 mm. Deeper soils (> 500 mm) display higher clay contents (>35%). Most of these soils have been ploughed, and cultivated lands replace this grassland community to a great extent.

This grassland is characterized by species group G (Table 3) and the diagnostic grass species are the prominent and conspicuously present Elionurus muticus, Heteropogon contortus, Eragrostis capensis, E. racemosa, Brachiaria serrata, Helictotrichon turgidulum, Aristida diffusa and Trichoneura grandiglumis. Diagnostic forbs are Crabbea acaulis and Berkheya onopordifolia (Table 3). Other prominent species are Themeda triandra, Eragrostis plana and E. curvula, while the asteraceous forbs Helichrysum rugulosum and Berkheya pinnatifida are conspicuously present.

2.1 Elionurus muticus-Trachypogon spicatus grassland

This grassland is situated on terrain unit 1 and the higher-lying parts of terrain unit 3, with low to moderate slopes (2^{o}-30^{o}). Soils are shallow (< 300 mm) (Figure 7) and have a clay content of less than 15%.

Species group D (Table 3) characterizes this grassland and includes the diagnostic co-dominant grass species Trachypogon spicatus, as well as the forbs Acalypha punctata, Striga bilabiata and Polygala hottentotta (Table 3). Prominent species include Elionurus muticus, Themeda triandra and Eragrostis curvula.

Two variations can be distinguished, namely the Vernonia oligocephala-Trachypogon spicatus variation (2.1.1) and the Harpochloa falx-Trachypogon spicatus variation (2.1.2). These two variations are distinguished by the presence of species groups E and F respectively (Table 3). No clear differences in the habitat can be found to explain the occurrences of the two variations, but soil moisture regime seems to be decisive in the delimitation of the two variations.

2.2 Microchloa caffra-Elionurus muticus grassland

This grassland covers the largest part of the Ea land type within the study area with respect to the other plant communities. It occurs on a wide range of soil types, for example vertic Arcadia to orthic Glenrosa Forms. This grassland occurs on crests, slopes and plains (Figure 6). The terrain as a whole is gently undulating with slopes of 0^{o}-8^{o}. Overgrazing, especially by sheep, often results in patches of bare soil, which are prominent in this grassland. The reason for patch-overgrazing is the disproportionate utilization of the veld, resulting in patches being overutilized (Fuls 1992). These patches are gradually retrograding until bare patches of soil develop.

This grassland is the typical form of the Themeda triandra-Elionurus muticus grassland and is characterized by the presence of species group G and the absence of species group D (Table 3). Dominant grass species include Elionurus muticus, Heteropogon contortus, Eragrostis curvula, Themeda triandra and Eragrostis plana. The forb Helichrysum rugulosum is constantly present but less conspicuous. An average of 20 species was recorded per sample plot. Two variations can be distinguished, the Tristachya leucothrix-Elionurus muticus variation and Heteropogon contortus-Eragrostis plana variation. The former is characterized by the presence of species group F, and is further distinguished from the other variation by a higher percentage surface rock and lower soil moisture regime (Figure 7). The Heteropogon contortus-Eragrostis plana variation is clearly distinguished by higher cover-abundance values for Eragrostis curvula and E. plana (Table 3), indicating a higher soil moisture content with respect to the former variation.

3. Themeda triandra-Eragrostis plana dry/wet grassland

This grassland represents a transitional zone between relatively dry and wet grasslands, separating the relatively drier communities on the higher-lying terrain units from the relatively moister communities on the lower-lying terrain units (Figure 6). The soils are deep (> 500 mm) and moist (Figure 7). Overgrazing in this grassland can be observed to a lesser extent in the form of bare soil patches, but rather as dense patches of Eragrostis plana, invading the disturbed areas.

The transitional grassland is differentiated by the presence of species groups H and I, and the absence of species group G (Table 3). No diagnostic species could be identified for this grassland. The dominant species include Eragrostis plana, Themeda triandra, Eragrostis curvula and Aristida bipartita. The herbaceous layer is not well developed and open and includes species such as the forbs Helichrysum rugulosum and Berkheya pinnatifida, indicating a degree of degradation. An average of 15 species per sample plot was recorded, indicating a decrease in species diversity with an increase in soil moisture.

4. Eragrostis plana-Eragrostis curvula wet grassland

This grassland represents the vegetation falling within moist to wet areas, including footslopes and drainage lines. The areas adjacent to drainage lines, display low to moderate slopes (0^o-5^o) and subsequently show few signs of erosion. Rivers and streams in contrast, often used by cattle and sheep as drinking places, frequently show serious signs of erosion. Seasonal and perennial water pans occur widely scattered over the area, often attracting a variety of birds. These pans are also accessible to cattle and sheep. Since most of the rivers and streams flow throughout the year, they may be used by stock at any time.

This grassland is characterized by species group J (Table 3) and the diagnostic grass species are Paspalum dilatatum, Cynodon dactylon, Eragrostis micrantha, and the forbs Conyza sumatrensis, Pseudognaphalium oligandrum, Helichrysum dregeanum and Cephalaria scabiosa (Table 3). Two communities can be distinguished:

4.1 Eragrostis curvula-Setaria sphacelata moist grassland

This grassland represents the vegetation found in moist areas adjacent to drainage lines, and is transitional to grassland (Figure 6). This is indicated by the presence of species groups H and I, which are differential species for this community. Soils are deep (> 500 mm) and without any surface rocks. These areas are not suitable for cultivation due to the high clay content (> 35%) of the soils. Cover-abundance values for the diagnostic and dominant species are relatively high, indicating a dense vegetation cover.

Conspicuous and constant species are the grasses Eragrostis curvula, Aristida bipartita, Setaria sphacelata, Themeda triandra and Eragrostis plana, as well as the forbs Berkheya pinnatifida and Hermannia depressa (Table 3). An average of 17 species was recorded per sample plot.

4.2 Eragrostis plana-Paspalum distichum wet grassland

This grassland represents the vegetation found along rivers, streams and pans (Figure 6). River- and stream-beds are degraded to a large extent, often displaying bare rock surfaces and alluvium (Figure 7). Soils found here are of the Rensburg Form, being deeper than 500 mm. Few widely spaced pans do occur in the area, being restricted to depressions. Trampling effects by cattle and sheep are noticeable especially on the margins of these pans, where the animals normally drink. The vegetation in these marginal zones is clearly disturbed.

A decrease in species diversity can be observed, if the species-richness of this community is compared with that of other communities described. This grassland is characterized by species group K (Table 3) and the diagnostic species include the grasses Paspalum distichum, Cymbopogon excavatus and Diplachne fusca, the herbs Cyperus longus, Mariscus congestus, Bidens bipinnata, Chenopodium ambrosioides, Argyrolobium pauciflorum, Juncus exsertus, Sium repandum, Deverra burchellii, Gerbera ambigua, Cyperus marginatus and Schoenoplectus decipiens (Table 3). Other conspicuous species are the grasses Eragrostis plana, Cynodon dactylon, Paspalum dilatatum and Eragrostis micrantha, and the herbs Pseudognaphalium oligandrum and Conyza sumatrensis.

The herbaceous layer is prominent, but not dominant over the grass layer. The presence of species group K and the simultaneous absence of species groups H and I distinguishes this community from the Eragrostis curvula-Setaria sphacelata grassland. An average of only 13 species was recorded per sample plot.

Ordination

Figure 8 represents the distribution of all 100 relevés along the first and second axes of a DECORANA ordination. No discontinuities are observed and by inspection it is clear that the vegetation communities are distributed along a moisture/trophic gradient. This gradient is extracted by the first axis of the DCA ordination. McDonald (1987) found in his study on the vegetation of the Swartboschkloof that soil moisture played a secondary role next to the major role being played by soil geology. In his study on the vegetation of the mire Northern Kisselbergmosen, SE Norway Okland (1990) found that soil depth down to the water table has had a major influence on the distribution pattern of the vegetation. The communities found under extreme conditions, namely the dryland and wetland communities, occur on the periphery of the diagram. The dryland community is represented by the Artemisia afra-Rhus dentata shrubveld, occurring on dry, sandy, dystrophic soils to the top-left of the diagram.

The wetland community, Eragrostis plana-Eragrostis curvula grassland, occurs on wet, clayey, eutrophic soils to the right of the diagram. The Themeda triandra-Elionurus muticus and Themeda triandra-Eragrostis plana grasslands are situated in an intermediate position. No separation occurs in Figure 8, concerning the last two grassland types. A gradient along the second axis can also be observed. Communities at the top of the axis occur on scarps and slopes, whilst the bottom part represent communities occurring on undulating terrain.

Figure 9 represents an ordination of only the Themeda triandra-Elionurus muticus grassland (2). The relevés of variations 2.2.1 and 2.2.2 are more or less situated to the right of the relevés of community 2.1. The fact that no clear discontinuity can be observed emphasizes the indistinct, gradual change from dry- to wetland communities associated with the gradually undulating terrain. Relevés to the right of the diagram are situated on wetter lower-lying bottomland areas with deep, clayey vertic soils. The left part of the diagram represents drier higher-lying areas with shallow, sandy orthic soils. No gradient can be observed along the second axis.

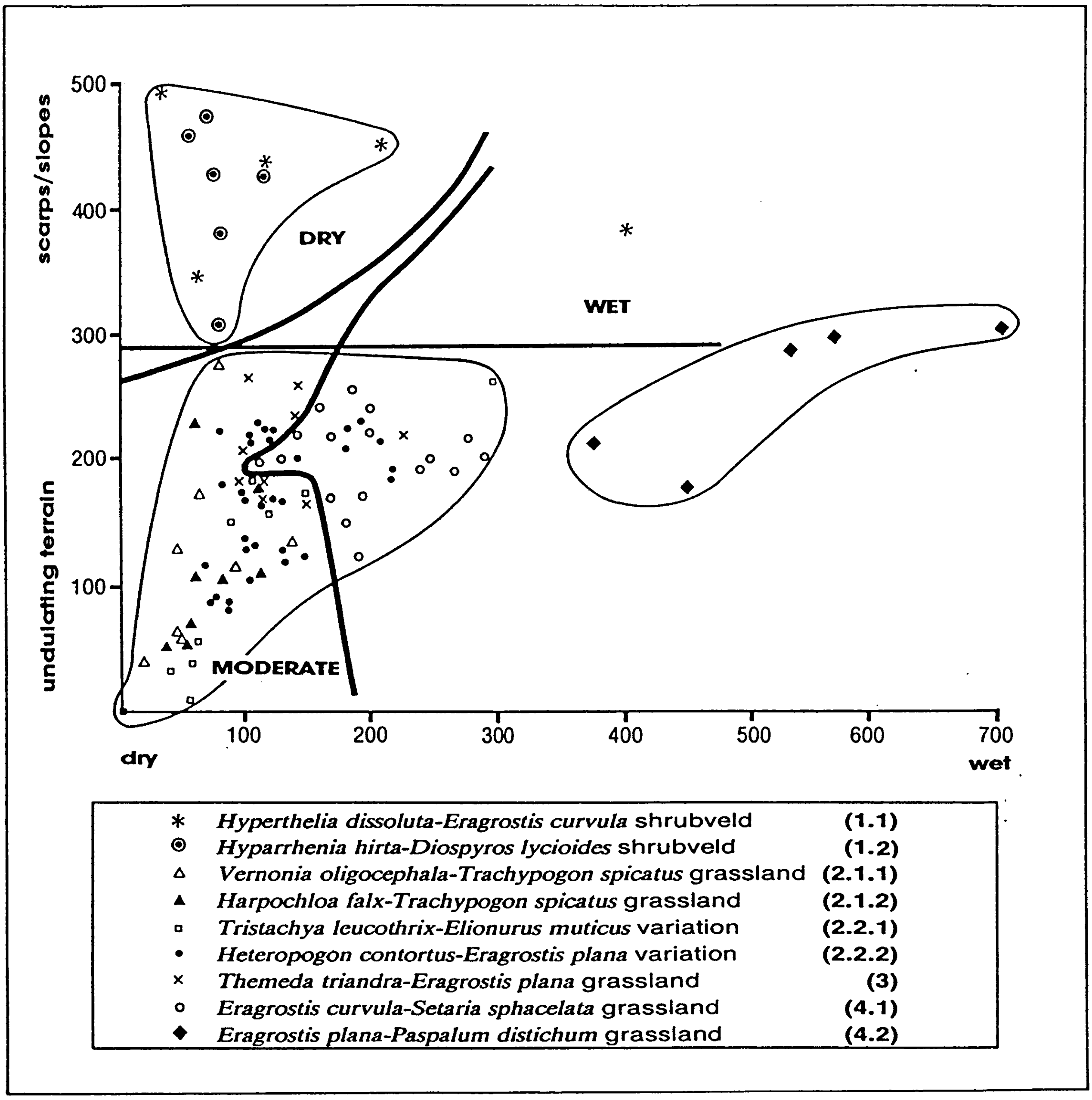


Figure 8. A scatter diagram of the ordination of the vegetation on the Ea land type.

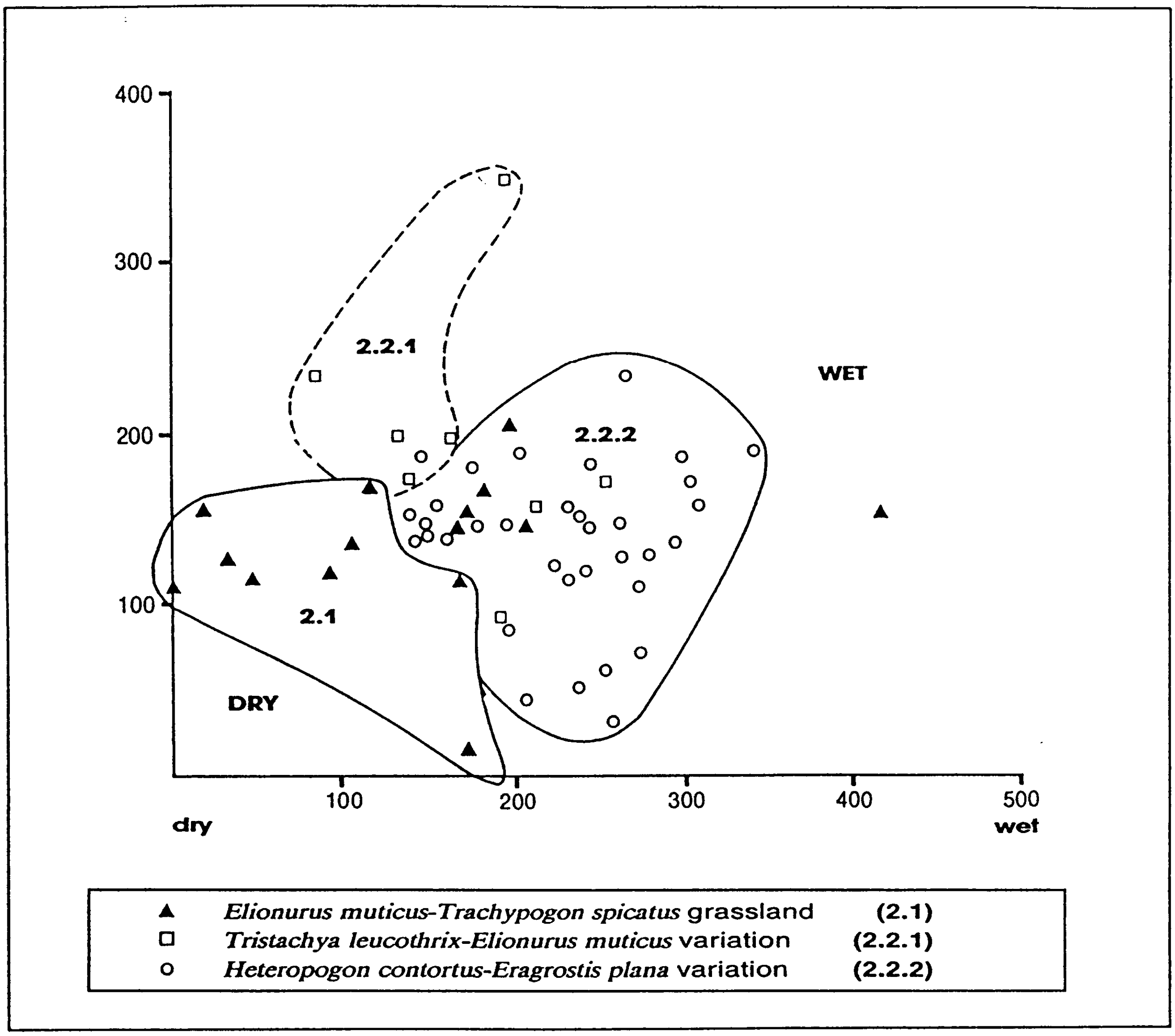


Figure 9. A scatter diagram of the ordination of plant community 2.

CONCLUDING REMARKS

The application of Braun-Blanquet procedures to refine the results of the TWINSPAN classification was successful. Four major vegetation types were identified, which are further subdivided into nine plant communities. These units are distinguishable at farm scale level and can be incorporated in veld management programmes.
It is of utmost importance that the farmer considers each unit on its own and that management programmes take into account the characteristics of each unit (see Eckhardt *et al.* 1993).

Communities, which are considered as having conservation value, are those occurring on steep slopes (40^{o}-90^{o}) adjoining wet grassland communities. The *Hyperthelia dissoluta*-*Eragrostis curvula* shrubveld and *Eragrostis plana*-*Paspalum distichum* grassland together form a complex in some areas, which is worthwhile conserving. Some of these areas are partly or totally inaccessible to cattle and sheep and therefore still remain in a relatively undisturbed condition.

The results obtained by ordination (DECORANA) indicate the response of vegetation types to different environmental conditions. Moisture and trophic regimes have strong influences on the distribution of vegetation types. A correlation between these two habitat factors and the vegetation can be observed. The application of the Braun-Blanquet method for the B, C and F land types should result in the identification of many more vegetation units, since these land types appear to be heterogenous with respect to their topography.

If farmers are to benefit practically from the results obtained in this study, it is advisable to bring to their attention the diagram presented in Figure 7. This diagram serves as an important key for the delimitation of vegetation types and habitat units, which are to be managed in accordance with the characteristics of each.

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CHAPTER 4

The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity in grassland.

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Abstract

Braun-Blanquet vegetation surveys are easier and quicker to do than point surveys and much data of this type has been published. This paper reports on the assessment of veld condition and the calculation of the grazing capacity (GC) of five plant communities of the Ea land type of the north-eastern Orange Free State, using existing Braun-Blanquet data. Veld condition scores (VCS) were obtained by substituting Braun-Blanquet cover-abundance values for point cover-values as required by the Ecological Index Method (EIM). Grazing capacity was calculated using published procedures. Results indicate that grazing capacities (0,2 - 0,3 LSU/ha, mean 0,2) fall into the range of current recommendations, and that veld condition of the five communities can be classified as fair. This method shows promise for application in the Grassland Biome for veld condition assessment and estimation of carrying capacity.

Uittreksel

Braun-Blanquet-plantopnames is makliker en vinniger uitvoerbaar as puntopnames en baie data wat daaruit spruit is al gepubliseer.

Hierdie artikel handel oor die aanwending van Braun-Blanquet-data vir die bepaling van veldtoestand en die berekening van die weikapasiteite van vyf plantgemeenskappe in die Ea-landtipe van die noordoostelike Oranje-Vrystaat. Deur Braun-Blanquet-bedekkings-getalsterktewaardes te vervang met punt-bedekkingswaardes, soos vereis deur die Ekologiese Indeks Metode (EIM), kon veldtoestandwaardes verkry word. Weikapasiteit is bereken deur gebruik te maak van gepubliseerde prosedures. Resultate dui daarop dat weikapasiteite (0,2 - 0,3 GVE/ha, gemiddelde 0,2) in die klas van aanbevole waardes val, en dat veldtoestand van die vyf plantgemeenskappe as redelik geklassifiseer kan word. Die aanwending van hierdie metode in die Grasveldbioom hou belofte in vir die bepaling van veldtoestand en weikapasiteit.

Introduction

Stocking rate is probably the single most important element in determining sustainability of animal production from natural veld. The need for veld condition assessment and simultaneous determination of grazing capacity of relatively homogeneous vegetation units cannot be overemphasized for the sustained use and management of the vulnerable vegetation cover of South Africa.

Many publications have in the past been devoted to the subject of veld condition assessment and grazing capacity (Foran, Tainton & Booysen 1978; Vorster 1982; Mentis 1983; Willis & Trollope 1987; Danckwerts & Teague 1989). Research has mainly been concentrated on the grasslands of the Eastern Cape and Natal. Tainton (1988) considered a variety of veld condition assessment techniques. Many techniques have inadequacies while some are more applicable to certain areas than to others. Subsequently, it has been decided to recommend only one specific method for each biome. The method recommended for the grassveld is similar in principle to that of Vorster (1982), which is recommended for the Karoo. The former method has the additional categories of Increaser Ia and

Ib. Heard et al. (1986) compared five methods for assessing veld condition and found that by basing veld condition estimates on only a limited number of key species, a considerable degree of precision could be achieved. These responsive key species only give an indication of the past grazing pressure, but do not necessarily indicate the grazing potential of an area, unless a direct linear relationship exists between veld condition and grazing capacity. Barnes et al. (1984) calculated grazing capacity by relating it to veld composition and palatability. They divided the different species, which were encountered in the botanical surveys, into four palatability classes. Weighting values were then allocated to each of these classes in order to give the highest correlation between weighted proportional species composition and estimated mean grazing capacity. A deficiency of the data base used by Barnes et al. (1984) is that the relative quantities of herbage, which determine among others the grazing capacity, were not measured. According to Hardy & Hurt (1989), methods indexing veld condition are insensitive to grazing intensity. The Key Species method, whereby species reacting most sensitively to grazing management are included, appears to have the greatest potential for indexing veld condition (Hurt & Bosch 1991).

No or very little information exists on the vegetation and veld condition of the north-eastern Orange Free State. Subsequently it was decided to use existing Braun-Blanquet data, initially gathered to identify and classify plant communities (Eckhardt et al. 1993), to assess the veld condition and grazing capacity of these grassland communities. Communities of the hills and floodplains are excluded from this study and only data from the plains are included. The reason for this is the vegetation of the plains being totally different from those of the hills and floodplains. The vegetation of the latter two terrain units includes also woody species, and no ecological grouping system could be found for this growth form. Furthermore, no benchmarks for these terrain units could be identified, since the vegetation as a whole was found to be in a relatively badly disturbed state.

Westfall et al. (1983) also made use of Braun-Blanquet data to assess veld condition in sour bushveld. However, they also determined canopy cover-abundance and basal cover to facilitate veld condition assessment.

The aim of this paper is to assess veld condition and to calculate grazing capacity of some plant communities in the Ea land type of the north-eastern Orange Free State by using existing Braun-Blanquet data. Vegetation surveys using the Braun-Blanquet method are more cost-effective than point surveys, published community information exists and, if veld condition and grazing capacity can adequately be inferred using this data, then a valuable management tool will become available to pasture scientists.

Methods

One of the prerequisites of the Ecological Index Method (Vorster 1982) is the identification of veld benchmarks (VBM), which represent areas of veld that are in optimum condition for sustained livestock production (Tainton 1981). Vorster (1982) uses a benchmark as an indicator of the best known veld condition index (VCI) which is equivalent to the potential veld condition score (VCS) for that community.

In this study no benchmarks were available, as they were not selected during the field survey. It was decided to test the Braun-Blanquet data for the assessment of veld condition after the completion of the field survey. The plant communities of the plains (Communities 2.1.1, 2.1.2, 2.2.1, 2.2.2 and 3, Table 3, Eckhardt et al. 1993), covering more than 60% (120 000 ha) of the Ea land type, were included in this study, and were renumbered

1-5 respectively. These communities are represented by 63 relevés. The number of relevés per community is given in Table 3. The relevés were randomly stratified on different terrain types (Land Type Survey Staff 1984, Eckhardt et al. 1993). In each relevé of 100 m^2, total floristic composition was noted and the cover-abundance of each species estimated by using the Braun-Blanquet cover-abundance scale as used by Werger (1973) (Table 2).

All the grass species constituting the relevant communities were divided into ecological groups (Trollope et al. 1990, Van Oudtshoorn 1991), viz.: Decreasers (species decreasing under mis-management), Increaser I (species increasing when veld is underutilized), Increaser IIa and IIb (species increasing when veld is lightly to moderately overutilized) and Increaser IIc (species increasing when veld is heavily overutilized). Data derived from the C land type (Bosch & Janse van Rensburg 1987; Janse van Rensburg & Bosch 1990) and an overall species list, indicating the ecological status of each species (Van Oudtshoorn 1991) were used to classify the species into the different categories (Table 1). Since the C land type is very similar to the Ea land type, concerning both topography and species composition, the application of the above-mentioned data is acceptable.

Relative index values were allotted to each ecological group, namely Decreasers = 10, Increaser I = 7, Increaser IIa and b = 4 and Increaser IIc = 1 (Vorster 1982). The average percentage cover (APC) of each ecological group for each relevé was obtained by conversion of the Braun-Blanquet cover-abundance values to their class mid-point values following the table in Vorster (1982). These average cover-values were then multiplied with the relevant index values. The multiplied values of each ecological group were summed to obtain a veld condition index for each relevé. To select a benchmark from all relevés of a certain community, it was necessary to consider those relevés with the highest veld condition index concomitant with the highest values represented by the Decreaser group. The veld condition score (VCS) for each community is the mean veld condition index of the relevés in that community expressed as a percentage of the VCI of the relevant benchmark (Table 3). If the benchmark VCI is assumed to represent the current potential maximum index for that community, the condition of a community can be described (relative to its benchmark) as very poor, poor, fair, good and excellent (Vorster 1982).

Table 1. Classification of grass species from the Ea land type of the north-eastern Orange Free State into ecological groups (after Vorster 1982 and Heard et al. 1986).

Species category	Species	Relative index
DECREASER	Cymbopogon plurinodis Digitaria eriantha Eragrostis capensis E. racemosus Helictotrichon turgidulum Setaria sphacelata Themeda triandra	10
INCREASER I	Brachiaria serrata Harpochloa falx Hyparrhenia hirta Hyperthelia dissoluta Melica racemosus Trachypogon spicatus Tristachya leucothrix	7
INCREASER IIa+b	Aristida junciformis Elionurus muticus	4
INCREASER IIc	Aristida bipartita A. congesta A. diffusa Eragrostis curvula E. plana Heteropogon contortus Microchloa caffra Trichoneura grandiglumis	1

The results obtained for the veld condition assessment were then used to determine the grazing capacity for each community. The following formula was used for this purpose (Danckwerts & Teague 1989):

$$GC = -0{,}03 + 0{,}00289\ X1 + 0{,}000633\ (X2 - 419{,}7)$$

GC = Grazing capacity expressed as LSU ha^{-1}

X1 = % veld condition score; and

X2 = mean annual rainfall (750 mm).

Since the benchmark of Community 1 has the highest VCI-value (1067,0, Table 3) all the VCI-values of the other benchmarks were expressed as a percentage of this value. The derived values were then applied in the above formula to calculate the grazing capacity of each benchmark. If the veld condition scores of the various benchmarks (100%, Table 3) would have been applied in the above formula, all benchmarks would have the same grazing capacity, which seems unrealistic. Thus, the above formula is used only to calculate the grazing capacity of each benchmark.

Table 2. Mean percentage cover and percentage cover ranges for the cover-abundance scale of Braun-Blanquet (1932), as modified by Werger (1973) and adapted by Vorster (1982).

Cover-abundance scale	% cover ranges	mean % cover
r) +	< 1	1
1) 2m	1,0 - 5,0	3
2a	5,1 - 12,0	9
2b	12,1 - 25,0	19
3	25,1 - 50,0	38
4	50,1 - 75,0	63
5	75,1 - 100,0	88

The grazing capacity for each relevé in a specific community was calculated as a proportion of that of the benchmark (Danckwerts & Teague 1989):

Grazing capacity of sample site =

$$\frac{\text{VCS (\%) at sample site} \times \text{grazing capacity of benchmark}}{100}$$

The grazing capacity of a community was calculated as the mean grazing capacity of all the relevés sampled within that community.

Results and discussion

1. Vernonia oligocephala-Trachypogon spicatus grassland (Community 2.1.1, Eckhardt et al. 1993)

This community occurs on low to moderate slopes. Soils are dry, rocky and shallow with a low clay content (Eckhardt et al. 1993).

Veld condition

The benchmark has a relatively high veld condition index value (1067,0), which can be ascribed to a high average percentage cover (72%) of the Decreaser group (Table 3). The contribution of Increaser IIc's to the VCI is low, which is characteristic for a benchmark representing veld under well-managed conditions. A high figure for Increaser I's stresses the fact that the community as a whole is slightly under-utilized, favouring grass species such as Hyparrhenia hirta, Trachypogon spicatus and Brachiaria serrata. A standard deviation of 25,7% relative to the tally of 23,8% for the Decreaser group indicates a big difference in Decreaser species composition between different relevés. This deviation is reflected in the standard deviation of the VCS and GC. Theoretically a community should have the same potential VCS and GC, as the specific environmental conditions are fairly homogeneous, and species composition should be similar. The great variation in VCS and GC within this community is due to different management strategies being applied within this community on different farms or camps. The community as a whole is however in a fair condition.

Grazing capacity

The GC of this community (0,264 LSU ha^{-1}) is the highest of all communities studied (Table 3). The relatively high standard deviation indicates differences in GC within the community. Local overgrazing has lowered the GC of the community, whilst judicious management in other areas has maintained a relatively high GC. The average grazing capacity for the eastern Highveld, including the areas Vrede, Memel and Warden, is estimated at 0,25 LSU ha^{-1} (4 ha LSU^{-1}) (Resource Section Highveld Region, pers. comm. 1991[1]), which is slightly lower than the 0,264 LSU ha^{-1} calculated for this community. Areas in good condition should serve as benchmarks so that less well-managed areas can be compared to the former. Management practices can then be adapted according to practices being applied to veld in good condition. When the GC of this community is compared with those of the benchmark, it is clear that this grassland type as a whole will have to be improved drastically.

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1. Address: Department of Agricultural Development, Highveld Region, Private Bag X804, Potchefstroom 2520.

Table 3. Mean contributions and standard deviations (SD) of species categories to the veld condition indices (VCI) of five communities and their respective benchmarks (VBM) from the Ea land type of the north-eastern Orange Free State. Community veld condition scores (VCS) and grazing capacities (GC) are calculated from these data.

Community	1	VBM	2	VBM	3	VBM	4	VBM	5	VBM
Relevés community^{-1}	8		6		9		31		9	
Decreaser %	23.8	72.0	27.8	48.0	26.7	46.0	29.8	91.0	22.2	44.0
SD	25.7		17.0		12.9		21.7		20.3	
Increaser I %	31.9	41.0	12.5	13.0	7.0	9.0	1.5	1.0	0.2	0.0
SD	22.4		15.4		12.3		3.8		0.4	
Incr. IIa + b %	29.6	12.0	2.8	0.0	23.1	41.0	1.1	3.0	16.8	38.0
SD	22.0		3.3		26.0		15.8		23.8	
Incr. IIc %	21.9	12.0	20.3	0.0	32.9	9.0	44.8	7.0	64.9	22.0
SD	17.4		15.3		23.7		26.4		42.5	
VCI	601.0	1067.0	397.5	571.0	441.0	696.0	408.5	936.0	355.8	614.0
SD	277.1		105.3		150.0		207.0		218.4	
VCS (%)	56.3	100.0	69.6	100.0	63.3	100.0	43.7	100.0	57.9	100.0
SD	26.0		18.4		21.5		22.1		35.6	
GC (LSU ha^{-1})	0.264	0.468	0.233	0.334	0.233	0.368	0.190	0.433	0.200	0.346
SD	0.122		0.062		0.079		0.099		0.123	
Condition	Fair		Good		Good		Fair		Fair	

2. Harpochloa falx-Trachypogon spicatus grassland
(Community 2.1.2, Eckhardt et al. 1993)

This community occurs on low to moderate slopes, but the soils are relatively moist, rocky and shallow with low clay contents (Eckhardt et al. 1993).

Veld condition

According to the VCI (397,5), this community is in a good condition (Table 3). The figures, especially for Increaser II's, are relatively high compared to those of the veld benchmark, resulting in a relatively high VCS-value for the community. This is, however misleading, since relatively high values of the Increaser group are normally indicative of veld in less good condition. The benchmark contains only Decreaser and Increaser I species. The rest of this community is constituted predominantly of Decreasers and Increaser I's, and to a lesser degree of Increaser IIa's and b's and IIc's. The relatively small standard deviation (105,3) of the VCI (397,5) (Table 3) indicates similar veld conditions throughout this community. The reason for this might be that the veld of this community has a higher resilience and does not change dramatically under different management strategies.

Grazing capacity

The GC is relatively high and constant throughout, but can still be improved (Table 3). Despite a higher soil moisture content relative to the Vernonia oligocephala-Trachypogon spicatus grassland (Community 1) (Eckhardt et al. 1993), the GC of the latter is higher than that of this community. This can be ascribed to a poorer vegetation cover, with a subsequent reduction in the amount of plant material available for utilization.

3. *Tristachya leucothrix*-*Elionurus muticus* grassland
(Community 2.2.1, Eckhardt *et al*. 1993)

This grassland community is distinguished from Community 4 by a higher percentage surface rock and lower soil moisture content (Eckhardt *et al*. 1993).

Veld condition
The condition of this grassland community is classified as good. Standard deviation in the number of the Decreasers is low, indicating a small degree of variation among the relevés regarding the contribution made by the Decreasers (Table 3). The benchmark displays a high number (41,0%) for the Increaser IIa and b category, stressing the influence of light to moderate overgrazing. From Table 3 it can be seen that the relevés of this community differ strongly with respect to their composition of Increaser IIa and b species. Thus, moderate overgrazing can be ascribed to overstocking and should therefore be prevented by applying the correct stocking rates.

Grazing capacity
Throughout the community a relatively high GC (0,233 LSU ha^{-1}) can be observed (Table 3). This is close to the figure of 0,250 LSU ha^{-1} recommended by the Resource Section (pers. comm. 1991[2]) of the Highveld Region. The *Tristachya leucothrix*-*Elionurus muticus* community together with Community 2 has the second highest GC of all communities to be found in the Ea land type. By exerting high grazing pressure on a vegetation unit for a short period of time, the grazing capacity of the latter can be increased (Tainton 1981) by eliminating selective grazing.

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2. Address: Department of Agricultural Development, Highveld Region, Private Bag X804, Potchefstroom 2520.

4. <u>Heteropogon</u> <u>contortus</u>-<u>Eragrostis</u> <u>plana</u> grassland (Community 2.2.2, Eckhardt <u>et</u> <u>al</u>. 1993)

This community occurs on gentle slopes and plains with wetter soils than the former community (Eckhardt *et al*. 1993).

Veld condition

Although this community has the highest figure for the Decreaser group, species of the Increaser IIc group are also strongly represented. The average condition as a whole is described as being fair (Table 3). Species of the Increaser III group are strongly represented. High standard deviations in the ecological groups indicate great differences in the composition and condition of this community from area to area. This variation is the result of different management strategies being applied. The high subtotal-value (91,0%) for the Decreaser group in the benchmark indicates to what extent the condition of this community can be improved (Table 3).

Grazing capacity

Of all the communities in the Ea land type, the *Heteropogon contortus*-*Eragrostis plana* community has the lowest GC (Table 3). Since GC-values are dependant on vegetation biomass, shortly grazed areas in many parts of this community have a negative influence on the grazing capacity. This community has the potential of carrying twice as many livestock per unit area as it does presently, if managed well. This is based on a comparison of the grazing capacity with that of the benchmark (Table 3). Lower-lying areas are more clayey and moist and are subsequently capable of maintaining relatively high GC's. The largest area of the Ea land type is covered by this grassland community (Eckhardt *et al*. 1993); thus by increasing its grazing capacity, the GC of the Ea land type as a whole will also be increased.

5. *Themeda triandra-Eragrostis plana* grassland
(Community 3, Eckhardt *et al.* 1993)

This grassland type occurs on lower-lying areas with deep moist soils (Eckhardt *et al.* 1993).

Veld condition
This grassland is in a fair condition and has the lowest VCI-value with respect to the other communities (Table 3). Increaser I species are poorly represented, while Increaser IIc species are dominant. A high standard deviation in all ecological categories, as well as in the VCI and VCS, clearly indicate the different management practices being applied in different areas. Some parts are overutilized, whilst others are lightly to moderately utilized, the latter displaying a stronger component of Decreaser species. The benchmark contains a high proportion of species of the Increaser IIa and b category, indicating the strong influence of moderate overgrazing. Normally, this relevé would not have been selected as a benchmark, but was chosen because of a high Decreaser-tally and VCI-value as well as low tallies for the Increaser I and IIc categories.

Grazing capacity
There is a great variation in the GC within the community (Table 3). This corroborates the fact, that management strategies differ within the community. Grazing capacities of the different sites vary from 0,044 to 0,346 LSU ha^{-1}. These figures are adequate proof of injudicious farm management which are encountered in the study area. With the application of proper management strategies, the grazing capacity of this community can be increased to a considerable degree.

Concluding Remarks

The biggest problem encountered with assessing veld condition, was the classification of the species in the correct ecological groups. Most of the research dealing with this aspect, has taken place in the Eastern Cape and Natal. As a result, lists of species indicating their ecological status are available for these areas. However, these lists can not be used for other grassveld types, since the ecological status of a specific species may vary from one vegetation type to another. This problem was overcome by making use of information applicable to the north-eastern Orange Free State (Janse van Rensburg 1987) and the latest list of grass species of South Africa (Van Oudtshoorn 1991).

The second problem encountered, was the allocation of relative index values to each ecological group. The values adopted here are those used by Vorster (1982). Since the relative index values determine the accuracy of the EIM, it will be necessary to quantify these values for each ecological group in different areas by characterizing them in terms of grazing values, animal production and soil conservation characteristics (Vorster 1982).

The selection of benchmarks also proofed difficult. Well managed sites were not specifically selected as benchmarks. However, veld in good condition was generally surveyed for vegetation mapping/classification purposes. Benchmarks had therefore to be selected by choosing relevés which represent the best veld available. This procedure is supported by the fact that these relevés have the highest grazing capacities of all relevés in the analyses. The selected benchmarks are optimal only under present conditions, but are not necessarily the ultimate optimum. As the general veld condition may improve under good management over the years, new benchmarks may have to be selected from time to time. This ensures that prevailing veld conditions will always be compared to sites in a better condition, as required for optimal long-term animal production.

The present overall veld condition of the communities can be classified as fair. The respective grazing capacities of the different communities compare well with the overall grazing capacity of 0,250 LSU ha^{-1} for the north-eastern Orange Free State as recommended by the Resource Section of the Highveld Region (pers. comm. 1991). The average grazing capacity of all the communities together is 0,224 LSU ha^{-1}, which is slightly lower than the recommended norm. Therefore, these grazing capacity values can be considered as satisfactory.

It must be stressed here that this method was only used to test the suitability of Braun-Blanquet data to determine veld condition and grazing capacity. No real grazing capacity values, determined on a scientific basis, are available for the region, and the values obtained in this study therefore can be applied in the short term.

It may be argued that the seven class cover-abundance scale is not adequate for veld condition assessment purposes, because the class ranges are too wide. We consider, however, that the results obtained confirm the adequacy of the scale.

The Ecological Index Method conforms to most of the requirements for successfull veld condition assessments, as set out by Humphrey (1962). These requirements include accuracy, speed of evaluation of extensive areas, minimum decisions required, objectivity and ecological basis. It is, however, necessary to know all grass species occurring in the study area. This method has the advantage that botanical composition and cover are used as one indicator instead of considering each separately. This means that fewer calculations need to be done which should make the method more attractive to farmers. The amount of Braun-Blanquet data available could, in the future, be more often applied for veld condition assessments and determinations of grazing capacities. This will result in the time required for plant surveys being more effectively used as the maximum information is generated from the data.

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CHAPTER 5

An overview of the vegetation of the Vrede - Memel - Warden area, north-eastern Orange Free State

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Abstract

An analysis of the major plant communities of the north-eastern Orange Free State is presented. Relevés were compiled in 274 stratified random sample plots. Refinement of a TWINSPAN classification by Braun-Blanquet procedures revealed six major plant communities, for which a hierarchical classification, description and ecological interpretation are given. These major communities are large-scale ecological units, each having its own specific species composition and agricultural potential, and each requiring different management strategies for optimal utilization and conservation.

Uittreksel

'n Analise van die hoofplantgemeenskappe van die noordoostelike Oranje-Vrystaat word aangebied. Relevés is in 274 ewekansige gestratifiëerde monsterpersele saamgestel. Verfyning van 'n TWINSPAN-klassifikasie met behulp van Braun-Blanquet-prosedures het ses hoofplantgemeenskappe opgelewer, waarvoor 'n hiërargiese klassifikasie, beskrywing en ekologiese interpretasie aangebied word. Elke hoofgemeenskap is 'n ekologiese eenheid met 'n eie spesifieke spesiesamestelling en eie landboukundige potensiaal. Hierdie eenhede vereis verskillende bestuurstrategieë vir optimale benutting en bewaring.

Introduction

In depth studies of the vegetation of different parts of southern Africa, including detailed maps and descriptions of vegetation units, are mainly limited to small areas. Meanwhile, various agricultural practices have led to destruction or deterioration in the quality of grassland ecosystems (Fuls 1992), with the possible extinction of many species. Thus, a widespread lack of basic data (Codd 1949; Edwards 1972) and the scarcity of nature reserves or protected areas leave us only with the unprotected present-day vegetation. Comparisons between earlier-day and present-day vegetations are rendered impossible (Codd 1949).

The Grassland Biome Project aims at initiating the development of a better knowledge and understanding of the grasslands of South Africa. The controversy surrounding the aspects of land-use planning, management and conservation strategies has already been acknowledged since the earlier days, when Pentz (1938) stated that "any farming system not in accord with the natural vegetation must be regarded as artificial and a danger to permanent occupation of the land". Future land-use planning, management and conservation strategies must be based on sound ecological principles, so that further deterioration in grassland ecosystems can be limited to a minimum and ultimate recovery as well as maintenance of the vegetation can be achieved (Eckhardt et al. 1993; Fuls et al. 1992). To reach these goals, it is necessary to identify, describe and map the present grassland types (Scheepers 1986) at a more intensive scale than Acocks's (1953, 1988) Veld Type classification. Therefore this study, which forms part of a comprehensive syntaxonomical synthesis of the grasslands of southern Africa (see also Bredenkamp et al. 1989; Kooij 1990; Fuls et al. 1992), and was conducted in the north-eastern parts of the Orange Free State, aims at refining the existing Veld Type classification of Acocks (1953, 1988). An earlier report by Eckhardt et al. (1993) is dealing with the description of the physical environment of the total study area and the vegetation of the Ea land type.

The present paper provides an adequate vegetation-cum-habitat inventory and deals with the major plant communities of the Ad, Bb, Bd, Ca and Fa land types, which extend over 66% of the total study area. These major plant communities are further divided into communities and are discussed in following chapters.

Study area

The study area covers approximately 5 600 km^2 and is situated between 29^0 00' and 29^0 47' E longitude and 27^0 00' and 28^0 00' S latitude (Figure 1). The area comprises the central-eastern part of the 2728 Frankfort map (1:250 000) (Land Type Survey Staff 1984) and falls within six veld types (Acocks 1953, 1988; Eckhardt et al. 1993).

The topography consists of slightly irregular undulating plains with occasional hills in the northern parts to strongly undulating irregular land with moderate and high relief mountains in the central and southern parts of the area. The south-eastern and certain central parts are mainly dominated by continuous hills and mountains with moderate to high relief (Eckhardt et al. 1993; Kruger 1983), allowing only stock farming and small-scale crop production. The altitude varies between 1 500 m and 2 000 m. The geology is dominated by mud- and sandstone of the Beaufort Group. Alluvium, sand and calcrete, as well as dolerite intrusions and shale outcrops are limited to the eastern parts of the study area. Clarens, Elliot and Molteno Formations occur on a limited scale in the southern parts (Department of Mineral and Energy Affairs 1984; Eckhardt et al. 1993).

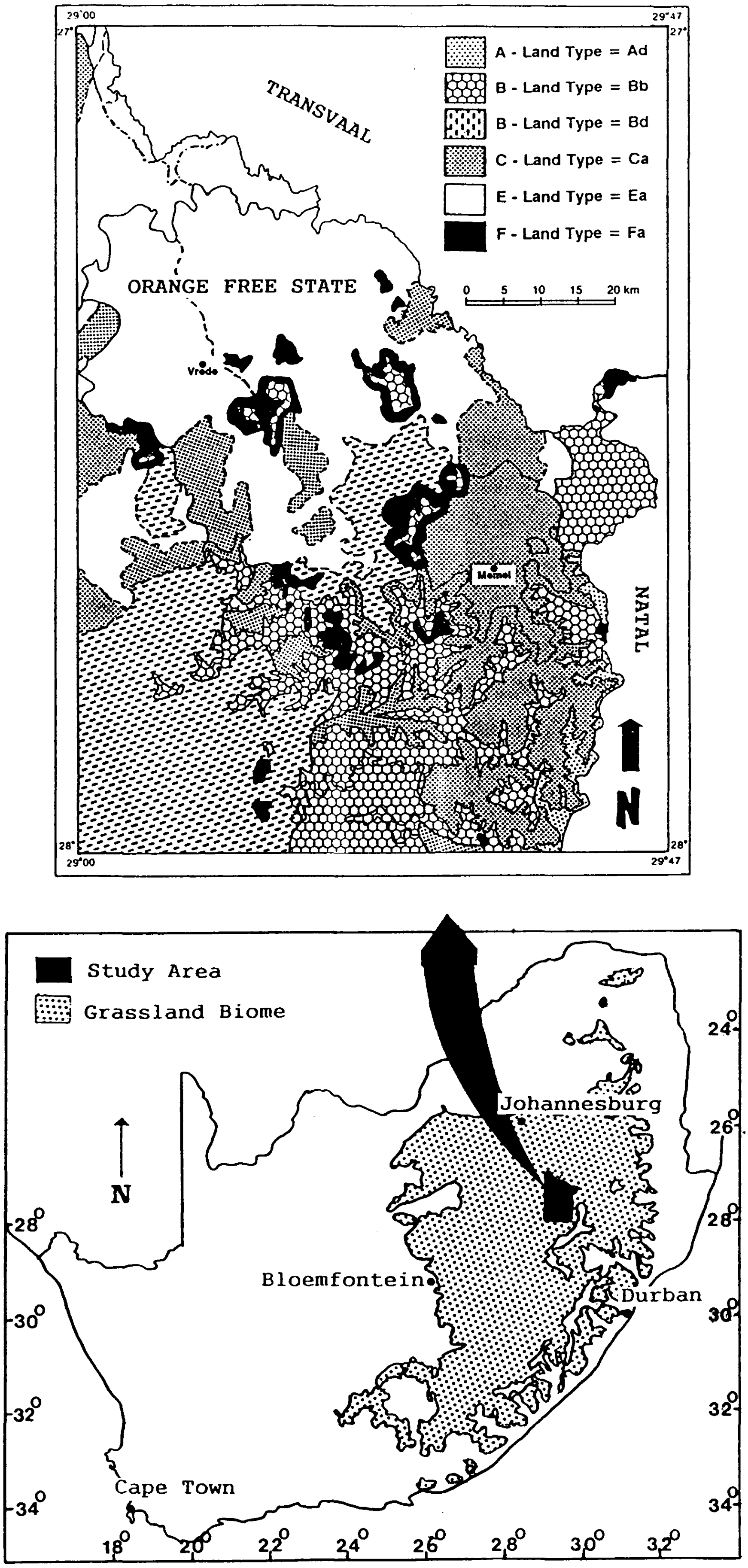

Figure 1. Map indicating the study area within the Grassland Biome, and the distribution of the land types (Land Type Survey Staff 1984; Siegfried 1989).

Methods

Relevés were compiled in 274 stratified random sample plots during the 1991-1992 summer season. Stratification was based on land types and terrain units (De Beer 1988; Land Type Survey Staff 1984). Care was taken to sample all possible terrain units in the five different land types. Plot sizes were fixed at 100 m^2 for grassland and 200 m^2 for woodland (Bredenkamp 1982). In each sample plot all species were recorded, using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974) to assign a quantitative value to each species. Taxon names conform to those of Gibbs Russell et al. (1985 & 1987) and De Wet et al. (1989, 1990, 1991). Habitat data collected at each plot included geology, topography, slope, aspect, terrain unit, rockiness of the soil surface, soil types and erosion. Names and descriptions of soils are according to the Department of Agricultural Development (1991).

Two-way indicator species analysis (TWINSPAN) (Hill 1979) was applied to the floristic data set in order to derive a first approximation of the major plant communities of the area. This was further refined by Braun-Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp et al. 1989; Fuls et al. 1992; Eckhardt et al. 1993). The results of the refinement are presented in a synoptic table (Table 1). In this table the matrix represents the constancy of the species in each vegetation unit (see also Bredenkamp 1987) as follows: 1 = 1-20% presence, 2 = 21-40% presence, 3 = 41-60% presence, 4 = 61-80% and 5 = 81-100% presence. Species with a constancy of less than 20% in all the respective units have been omitted from the table.

The structural classification of the vegetation was done in accordance with Edwards (1983).

Results and discussion

The general vegetation of this area can be considered as the Eragrostis curvula-Themeda triandra vegetation unit (species group P, Table 1). This vegetation can be divided into grassland and thicket/woodland of relatively drier areas on the one hand, and wetlands on the other. The grassland and thicket/woodland can be further divided into bush clumps or low thicket/low woodland, confined to moderate to steep slopes, and grassland of the plains and slopes. The bush clumps are characterized mainly by woody species such as Leucosidea sericea (species group D), Rhus pyroides, R. dentata and Diospyros lycioides (species group C), as well as prominent grass species such as Hyparrhenia hirta (species group B) and Themeda triandra (species group P) (Table 1). Dominant graminoids of the grasslands include Heteropogon contortus (species group K), Aristida junciformis (species group L), Eragrostis plana, E. curvula, Themeda triandra (species group P) and Elionurus muticus (species group L) (Table 1).

Wetlands include riverbanks, streambanks, vleis (= marshes), bottomlands and pans. These are generally characterized by the grass species Agrostis lachnantha (species group M), Eragrostis plana (species group P) and Paspalum dilatatum (species group N). Prominent forbs include Conyza bonariensis, Mariscus congestus and Verbena brasiliensis (species group N, Table 1). In general, the thickets/woodlands are more species rich than the grasslands. Leucosidea sericea is the most prominent woody species, occurring in some areas as dense stands, presenting a bush-encroachment problem.

A schematic representation of the hierarchical classification and associated environmental characteristics of the major plant communities is given in Figure 2.

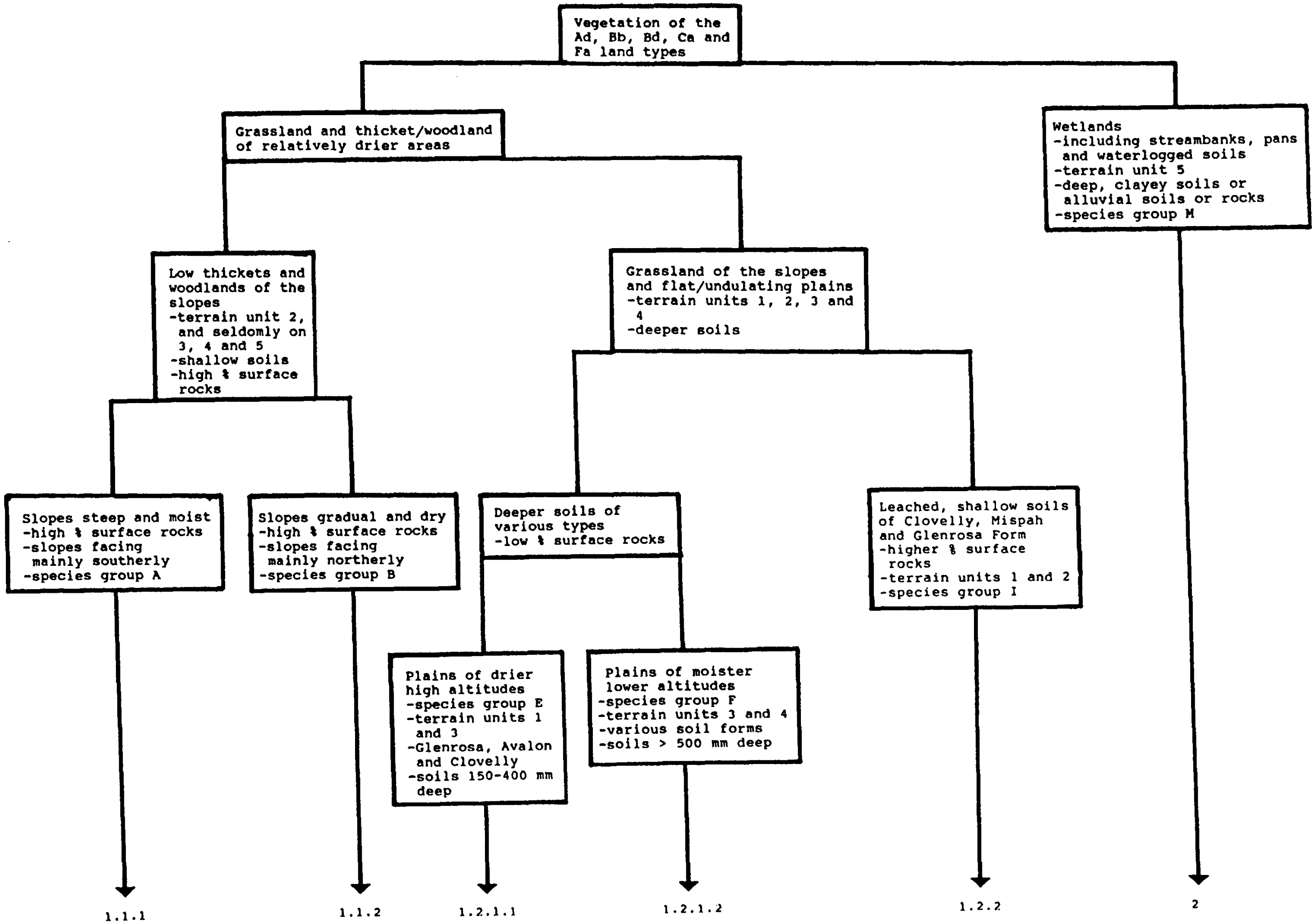

Figure 2. The hierarchical classification and associated environmental characteristics of the major plant communities.

Classification

The hierarchical classification of the major plant communities of the Eragrostis curvula-Themeda triandra vegetation unit is as follows:

1. Aristida junciformis-Themeda triandra Grassland and Thicket/Woodland of relatively drier areas

1.1 Rhus pyroides-Leucosidea sericea Low Thicket/Woodland of the slopes

1.1.1 Poa annua-Leucosidea sericea Low Open/Closed Woodland of the slopes

1.1.2 Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland of the slopes

1.2 Heteropogon contortus-Eragrostis curvula Grassland of the plains and slopes

1.2.1 Helichrysum rugulosum-Eragrostis curvula Grassland of drier higher-lying and moister lower-lying plains

1.2.1.1 Aristida junciformis-Themeda triandra Grassland of drier, high altitude plains

1.2.1.2 Eragrostis plana-Themeda triandra Grassland of moister, lower altitude plains

1.2.2 Monocymbium ceresiiforme-Tristachya leucothrix Grassland of very moist, high altitude plains, and slopes

2. Eragrostis plana-Agrostis lachnantha Wetlands

Description of the communities

1. Aristida junciformis-Themeda triandra Grassland and Thicket/Woodland

This vegetation includes the low thickets and woodlands of the slopes and the largest part of the grassland of the Ad, Bb, Bd, Ca and Fa land types, excluding all watercourses and wetlands. The area covered by this vegetation varies widely in topography, ranging from high altitude grassland plateaux to slopes and low-lying undulating grassplains. The geology is relatively uniform, dominated mainly by mud- and sandstone. Soil types vary according to terrain units, with shallow rocky soils occurring on terrain unit 2 and deeper soils on terrain units 1, 3 and 4 (Figure 3). Dominant species in almost all the major communities of this vegetation are Aristida junciformis (species group L), Eragrostis curvula and Themeda triandra (species group P) (Table 1).

1.1 Rhus pyroides-Leucosidea sericea Low Thicket/Woodland

This vegetation of the slopes (terrain unit 2) (Figure 3) of the Bb, Bd, Ca and Fa land types can be found on all possible aspects. In exceptional cases, this vegetation may also occur on terrain units 3, 4 and 5. Soils are shallow and a high percentage of the soil surface is covered with rocks and stones. Vertical rock-faces are common in ravines, receiving only limited sunlight. Dense thickets are often characterized by soils covered with organic material. Trees are bushlike with an average height of 3-5 m. In some places this vegetation type is spreading into the upper parts of terrain unit 3 with Leucosidea sericea the dominant species, and the vegetation changing gradually into the grasslands of undulating plains. Diagnostic and sometimes dominant woody species include Rhus pyroides, R. dentata, Diospyros lycioides and Euclea undulata. The lower-stratum vegetation found underneath the trees and shrubs is dominated by the diagnostic weedy forbs Bidens bipinnata, Cyathula cylindrica and Sutera polelensis (species group C, Table 1). The thickets/woodlands of the slopes are very species rich (average number of 29 species per sample plot) and unique relatively to the rest of the study area, and is therefore considered to have a high conservation priority.

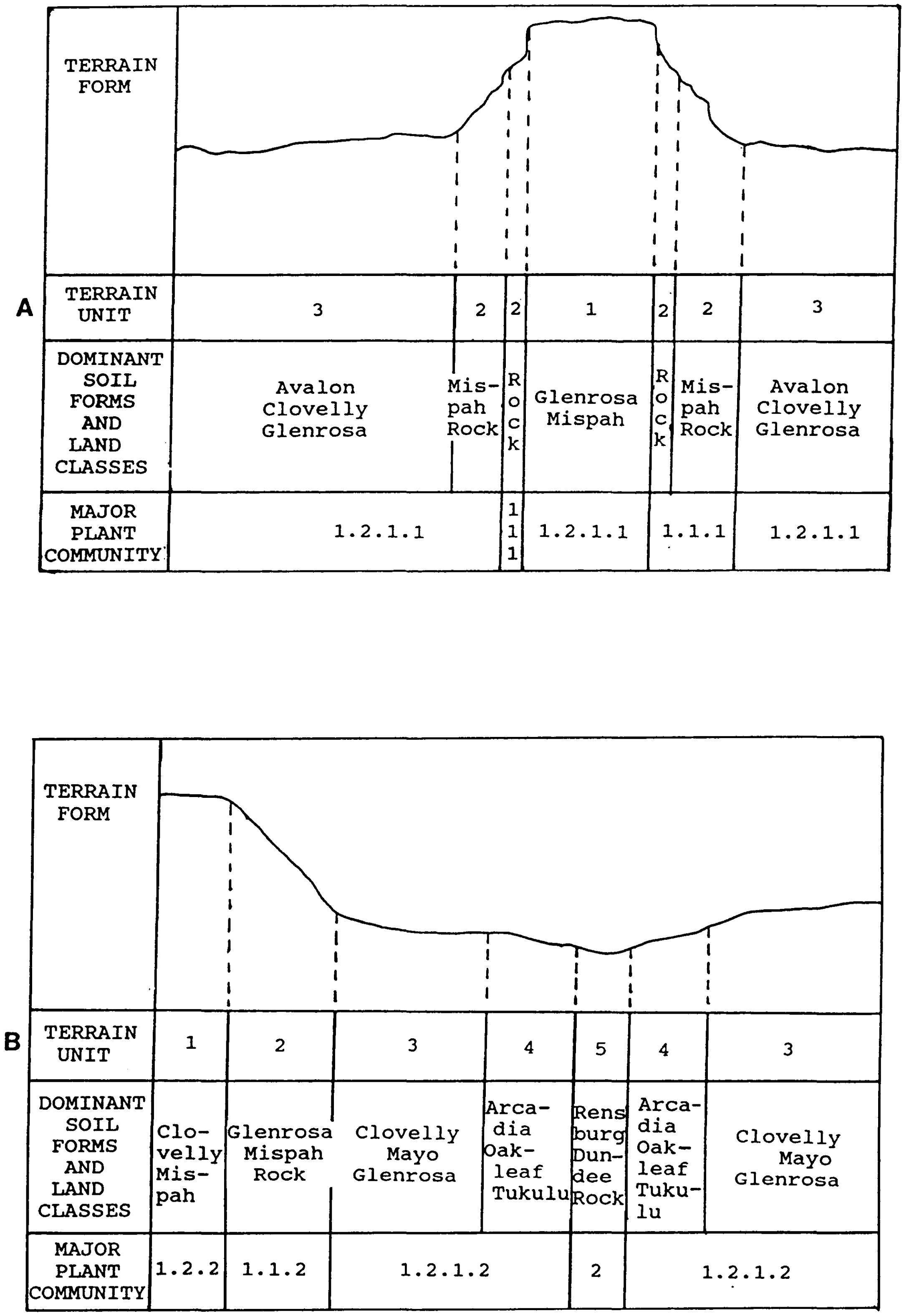

Figure 3. A schematic illustration of the distribution of the major plant communities along the terrain form and associated soil forms and land classes.

1.1.1 *Poa annua*-*Leucosidea sericea* Low Open/Closed Woodland

This woodland occurs on steep (> 30^{o}), moist slopes (Figures 2 & 3). These slopes face mainly in a southerly direction, explaining the higher moisture contents of the soil. The Mispah Soil Form is typical of this habitat with surface-rock percentages exceeding 20%. Various levels of erosion occur which can mainly be ascribed to the steepness of the slopes.

Dominant woody species which reach heights of up to 5 m, are *Leucosidea sericea*, *Rhus pyroides* and *Heteromorpha trifoliata*. Diagnostic species include the graminoid *Poa annua* and the forbs *Myrsiphyllum asparagoides*, *Leonotis dysophylla*, *Clutia pulchella* and the fern *Cheilanthes quadripinnata* (species group A, Table 1). Limited sunlight penetration to the lower stratums is the reason for a sparse undergrowth, which is dominated by a non-grassy herbaceous layer. An average number of 31 species was recorded per sample plot, indicating the species richness of these slopes.

1.1.2 *Hyparrhenia hirta*-*Rhus dentata* Low Thicket/Low Open Woodland

This thicket/woodland occurs on moderate (15^{o}-30^{o}), dry slopes facing mainly northerly (Figures 2 & 3). Soils are rocky (> 20%) and shallow. Signs of overgrazing are obvious in some cases with the pioneer species *Aristida congesta* and *A. diffusa* prominently present. The herbaceous layer is less conspicuous than in the former vegetation type. Diagnostic species include *Hyparrhenia hirta*, *Aristida diffusa*, *Solanum panduriforme* and *Senecio hieracioides* (species group B, Table 1). The woody component has an average height of 3 m and is more sparsely scattered, and includes species such as *Rhus dentata*, *Diospyros lycioides* and *Rhus discolor*. This thicket/woodland is floristically related to the

Hyparrhenia hirta-Diospyros lycioides Shrubveld of the Ea land type (Eckhardt et al. 1993). An average number of 28 species was recorded per sample plot.

1.2 Heteropogon contortus-Eragrostis curvula Grassland of the plains and slopes

This grassland covers slopes and the flat and undulating plains, which include amongst others high-lying plateaux and low-lying footslopes (terrain units 1, 2, 3 and 4) (Figure 2). The different soil types to be found vary from shallow (< 150 mm) to very deep (> 500 mm), and the percentage cover by surface rocks may also vary considerably (Figure 2). This grassland is characterized by the absence of species groups A, B, C and M (Table 1) and has no diagnostic species. The dominant species that occur throughout the area are the graminoids Heteropogon contortus, Eragrostis curvula, Themeda triandra, Eragrostis capensis, Aristida junciformis and Elionurus muticus. Generally, these species comprise the major part of the vegetation cover. The conspicuous woody species Leucosidea sericea and Rhus discolor are encountered only in the transitional zone between the woody communities and the grasslands. Prominent forbs include Helichrysum rugulosum, H. pilosellum and Vernonia oligocephala.

1.2.1 Helichrysum rugulosum-Eragrostis curvula Grassland of drier higher-lying and moister lower-lying plains

This grassland occurs mostly on deeper soils of various types (Figures 2 & 3). The percentage surface rock cover is very low, but may vary to a great extent. Diagnostic species include the small inconspicuous forbs Helichrysum rugulosum, Crabbea acaulis and Anthospermum rigidum (species group G, Table 1). Prominent species include the graminoids Heteropogon contortus, Eragrostis capensis (species group K), E. curvula, E. plana and Themeda triandra (species group P).

Two major plant communities can be distinguished within this grassland:

1.2.1.1 Aristida junciformis-Themeda triandra Grassland of drier, high altitude plains (terrain units 1 and 3) (Figures 2 & 3).

This major community is found on terrain units 1 and 3, but may very seldomly also occur on terrain unit 2 . Various soil forms are encountered here, with Glenrosa, Clovelly and Avalon as the most prominent. The soil depth varies between 150-400 mm with a variable percentage surface rock cover. Soil conditions are dystrophic to mesotrophic (Land Type Survey Staff 1984), lowering the grazing potential of this typical short grassveld during the winter months. This major community has only one diagnostic species, namely Helichrysum dasycephalum (species group E, Table 1). Other prominent species include Harpochloa falx, Heteropogon contortus, Eragrostis capensis, E. racemosa, Aristida junciformis, Elionurus muticus, Tristachya leucothrix, Themeda triandra, and the forb Helichrysum rugulosum. The average number of species recorded per sample plot is 24.

1.2.1.2 Eragrostis plana-Themeda triandra Grassland of moister, lower altitude plains.

This grassland occurs on terrain units 3 and 4 (Figures 2 & 3) of the Bd and Ca land types, but may exceptionally also occur on terrain unit 2. A wide range of soil forms occur, including Clovelly, Mayo, Glenrosa, Arcadia, Oakleaf and Tukulu, all having relatively high clay contents (> 35%) with depths generally exceeding 500 mm. Species group F (Table 1) contains the diagnostic species of this grassland. Prominent and sometimes dominant graminoids include Heteropogon contortus, Eragrostis capensis, E. curvula, E. plana and Themeda triandra. The relatively wetter parts (terrain unit 4) of this grassland are mainly characterized by the strong presence and high cover of Eragrostis plana, with Themeda triandra more indicative of relatively drier parts. An average number of 20 species was recorded per sample plot.

1.2.2 Monocymbium ceresiiforme-Tristachya leucothrix Grassland of very moist, high altitude plains (> 2 000 m), and slopes (Figures 2 & 3).

This grassland occurs on leached, shallow (< 150 mm) soils of the Mispah and Glenrosa Soil Form and deeper (150-300 mm) soils of the Clovelly Form (see also Smit et al. 1992). Seen from a topographical point of view, this major plant community seems to be related to the Aristida junciformis-Themeda triandra Grassland (1.2.1.1). However, major differences in species composition can be ascribed to higher rainfall and soil characteristics. Diagnostic species include Trachypogon spicatus, Monocymbium ceresiiforme, Diheteropogon filifolius, D. amplectens, Sporobolus centrifugus and the forb Helichrysum aureonitens (species group I, Table 1). This grassland is also distinguished from the former major communities by the absence of species groups A to H. Prominent and sometimes dominant species are the graminoids Heteropogon contortus, Eragrostis racemosa, Tristachya leucothrix, and the forbs Helichrysum pilosellum and Vernonia oligocephala. An average number of 22 species was recorded per sample plot.

2. Eragrostis plana-Agrostis lachnantha Wetlands

This major plant community includes riverbanks, streambanks, vleis, bottomlands and pans (terrain units 4 & 5) (Figures 2 & 3). The vegetation present is associated with seasonal waterlogged soils or flooded areas. Soils are clayey (> 35%) and deep (> 500 mm) (Figure 2). Rocks and gravel are mostly found in streambeds, with alluvium and silt deposited along the banks. In some areas even peatlands can be found. Peat consists of loosely compacted, half-decayed plant material, which is rich in fibre and can contain up to 97% water (Van Vuuren 1992). The positive effects peatlands have on the environment give it a high conservation status. This major community is characterized by species group M (Table 1) with diagnostic species such as the hygrophilous Agrostis lachnantha, Conyza bonariensis, Pseudognaphalium oligandrum, Mariscus congestus and Veronica anagallis-aquatica. Grasses that are very conspicuous and sometimes dominant are Eragrostis plana and Paspalum dilatatum. An average number of 18 species was recorded per sample plot.

Concluding remarks

The Eragrostis curvula-Themeda triandra Grassland and Thicket/Woodland has been successfully divided into various major communities together with their associated environmental conditions. These communities are broadly recognizable in the veld and should be used as ecological units in a management strategy. The various plant communities found within these major communities are identified and described for syntaxonomical treatment of the vegetation. The refined classification will facilitate management not only on regional and farm-scale level but also on conservational level as applicable to nature reserves. Ecologically homogeneous units form the basis of veld management and should therefore be fenced off and each managed separately. If these homogeneous units are not separated from each other, disproportionate utilization by herbivores/livestock of the various plant communities and/or terrain units included within such heterogeneous areas, will occur (Fuls 1992). Communities consisting of more palatable species will certainly be more heavily utilized by livestock, resulting in the degradation of the basal cover and plant species composition. A common sight especially under a communal grazing strategy, are denuded slopes covered only by rocks and very often incised by deep erosion gullies or "dongas". The slopes are generally more utilized because the grasses are palatable for longer periods reaching the flowering stage only later due to relatively drier prevailing conditions. Under conditions of severe overutilization, these grasses never reach the maturity stage and subsequently no seed production can take place. Ecologically sound management, taking into consideration the conservation status of each unit, will ensure long-term productivity and preservation of each specific area. A syntaxonomical synthesis of the high-lying eastern grasslands should reveal areas with conservational status. The management of such areas must be based on homogeneous units as mentioned above in order to maintain the original state thereof. However, the large-scale non-adoption of the controlled selective grazing system (CSG) by many farmers reflects some shortcomings in the system (Düvel et al. 1992). The main reason seems to be the financial inputs of farmers necessary to implement the CSG system not receiving the necessary attention. This means searching for alternative solutions which are more compatible with farmers' needs.

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CHAPTER 6

The phytosociology of the thicket and woodland vegetation of the north-eastern Orange Free State

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Keywords: Braun-Blanquet, classification, plant community, thickets, woodlands.

Abstract

A vegetation survey was conducted in the north-eastern Orange Free State to investigate the woody plant communities occurring on the mountain slopes. Relevés were compiled in 84 stratified random sample plots. Braun-Blanquet procedures were applied to refine a TWINSPAN classification of the vegetation. Nine plant communities were identified. A hierarchical classification, description and ecological interpretation are presented.

Uittreksel

'n Plantegroeiopname is in die noord-oostelike Oranje-Vrystaat uitgevoer om die houtagtige plantgemeenskappe van die berghange te ondersoek. Relevés is in 84 ewekansige gestratifiëerde monsterpersele saamgestel. Braun-Blanquetprosedures is toegepas om 'n TWINSPAN-klassifikasie van die plantegroei te verfyn. Nege plantgemeenskappe is geïdentifiseer waarvoor 'n hiërargiese klassifikasie, beskrywing en ekologiese interpretasie aangebied word.

Introduction

The agricultural sector in developed and rapidly developing countries is confronted with a set of problems, ranging from soil erosion and chemical pollution to decimation of genetic diversity of the major crops (Jackson & Piper 1989). All these factors contribute to the decapitalization and subsequent depopulation of rural areas. Ultimately, the consequences, which can be observed as veld deterioration and the loss of natural undisturbed areas, can be ascribed to the "cleverer-than-nature" approach, practised especially by biotechnologists. Sustainable agriculture must be based on the standards by which natural ecosystems function. Thus, sound ecological land-use planning, management and conservation can only be effective if the vegetation and habitat characteristics of the area concerned, are taken into consideration by the land-user. The only previous vegetation study of this area is that of Acocks (1953, 1988), a broad, insufficient description for ecological planning and management at farm level.

In the previous chapter, an overview of the vegetation of the north-eastern Orange Free State, excluding the Ea land type, was given (Eckhardt *et al.* 1993b). In the latter chapter, six major plant communities were described including the *Rhus pyroides*-*Leucosidea sericea* Thicket/Woodland found on the slopes. A phytosociological investigation of this vegetation revealed large variations in floristic composition and habitat characteristics. Further refinement of this vegetation by Braun-Blanquet procedures disclosed several different plant communities which will be dealt with here.

Study area

The study area comprises the central-eastern part of the 2728 Frankfort map (1:250 000) (Land Type Survey Staff 1984), and is situated between 29° 00' and 29° 47' E longitude and 27° 00' and 28° 00' S latitude (Figure 1). A detailed description of the physical environment is given in Eckhardt et al. (1993a).

The thickets and woodlands are mostly encountered on terrain unit 2 and only exceptionally on terrain units 3, 4 and 5 of the Bb, Bd, Ca and Fa land types (Figure 3). Gradients of the slopes vary greatly, with vertical sandstone cliffs often encountered on the brim of ravines. The slopes usually indicate the transition from one land type to another. The topography is generally dominated by mountains with moderate to high relief (Kruger 1983). The Mispah and Glenrosa Soil Forms (Department of Agricultural Development 1991) are predominant on the slopes.

Methods

Relevés were compiled in 84 stratified random sample plots. Care was taken to place sample plots on different terrain units and different aspects of the land types present in the study area (Land Type Survey Staff 1984). Plot sizes were fixed at 200 m^2 (Bredenkamp 1982) and cover-abundances of all species recorded were according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). The following parameters were also recorded at each sample plot: geology, topography, terrain unit, slope, aspect, rockiness of soil surface, depths of soils, soil types and erosion. Soil types are described according to the Department of Agricultural Development (1991). Taxon names conform to those of Gibbs Russell et al. (1985 & 1987) and De Wet et al. (1989, 1990, 1991).

Two-way indicator species analysis (TWINSPAN) (Hill 1979) was applied to the floristic data set in order to derive a first approximation of the vegetation units of the area. The resulting classification was further refined by Braun-Blanquet procedures (Table 1) (Behr & Bredenkamp 1988; Bredenkamp et al. 1989).

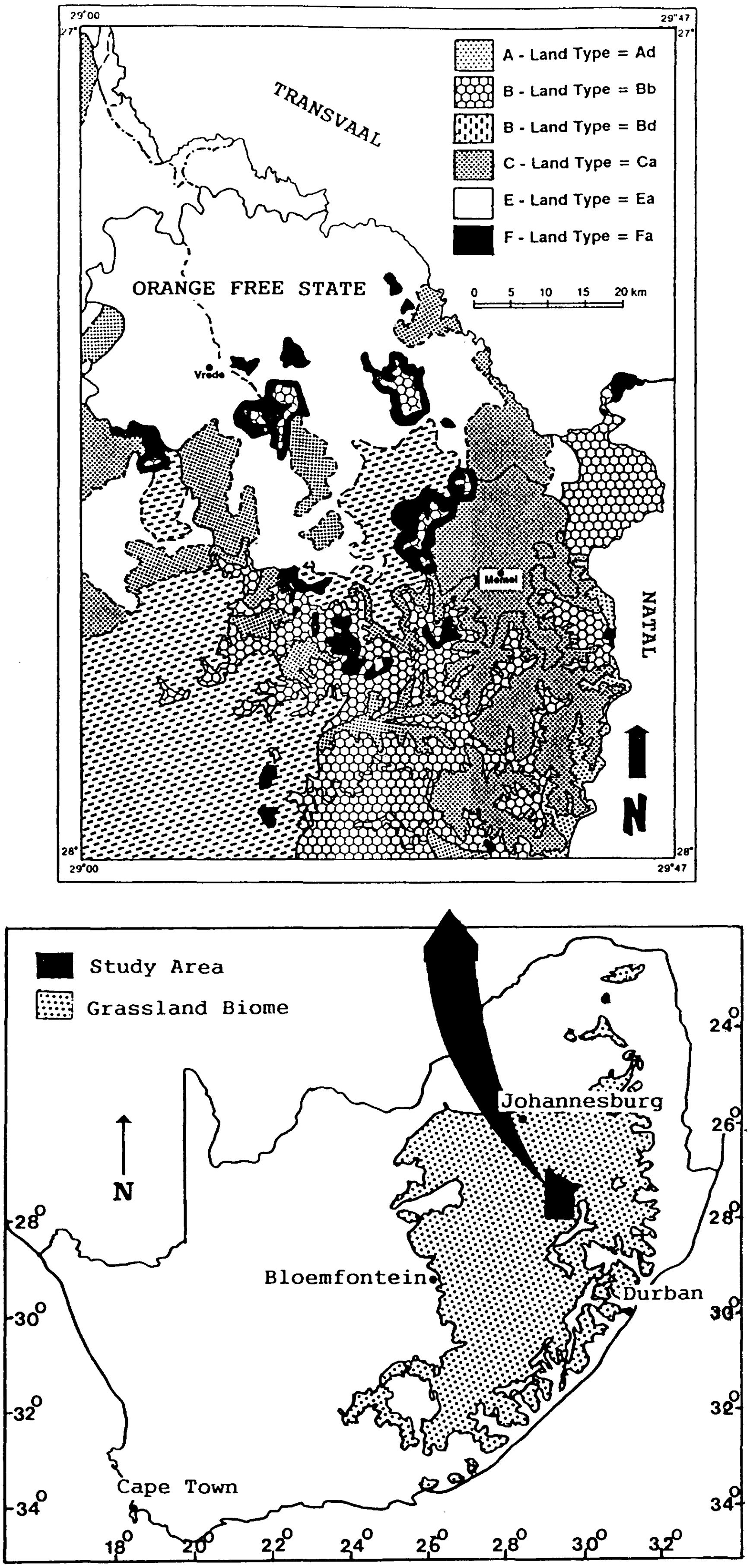

Figure 1. Map indicating the study area within the Grassland Biome, and the distribution of the land types (Land Type Survey Staff 1984; Siegfried 1989).

The structural classification of the vegetation and the denomination of communities were done in accordance with Edwards (1983).

Results and discussion

The vegetation of the thickets and woodlands represents the Rhus pyroides-Leucosidea sericea Low Thicket/Woodland, identified by Eckhardt et al. (1993b). This broadly defined vegetation is further divided into woodlands and thickets of moist and dry slopes and is virtually through-out characterized by the prominent and often dominant small tree Leucosidea sericea. Other conspicuous woody species include Rhus pyroides, R. dentata, Diospyros lycioides and Kiggelaria africana (Table 1). Conspicuous grasses occurring generally in the area include Hyparrhenia hirta, Themeda triandra, Eragrostis curvula and Aristida junciformis. The Artemisia afra-Rhus dentata Shrubveld of the Ea land type, which has been described in Eckhardt et al. (1993a), shows certain similarities with the vegetation of the gradual, dry slopes of the Bb, Bd, Ca and Fa land types, described here. The relatively large number of species groups (20 groups, Table 1) identified indicates the floristic heterogeneity of the slopes. Some species are not abundantly present, but are, however, indicative of different habitat conditions.

Slopes facing in southerly directions are characterized by cooler conditions with increased soil moisture and a well-developed generally closed tree stratum with an associated sparse grass layer. Northerly-facing slopes, on the other hand, display warmer, drier conditions, featuring an open tree stratum and denser grass layer.

A schematic representation of the hierarchical classification and associated environmental attributes of the plant communities is given in Figure 2. In Figure 3, only the distribution of the major plant communities 1 and 2 of the Rhus pyroides-Leucosidea sericea Low Thicket/Woodland, i.e. the Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland (1) and the Poa annua-Leucosidea sericea Low Open/Closed Woodland (2), is illustrated. This is because it was difficult to illustrate minor topographical and structural differences within the various plant communities.

Classification

The hierarchical classification of the vegetation of the Rhus pyroides-Leucosidea sericea Thicket/Woodland is as follows:

1. Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland of dry slopes

1.1 Pollichia campestris-Hyparrhenia hirta Low Thicket

1.2 Cymbopogon plurinodis-Themeda triandra Low Thicket/Low Open Woodland

1.2.1 Aristida diffusa-Hyparrhenia hirta Low Thicket

1.2.2 Helichrysum cephaloideum-Leucosidea sericea Low Open Woodland

1.3 Hypoxis obtusa-Eragrostis curvula Low Open Woodland

1.4 Andropogon appendiculatus-Eragrostis curvula Low Open Woodland

2. Poa annua-Leucosidea sericea Low Open/Closed Woodland of moist slopes

2.1 Poa annua-Hyparrhenia hirta Low Open Woodland

2.2 Senecio subrubriflorus-Poa annua Low Closed Woodland

2.3 Helichrysum umbraculigerum-Poa annua Low Closed Woodland

2.4 Plectranthus hereroensis-Poa annua Low Closed Woodland

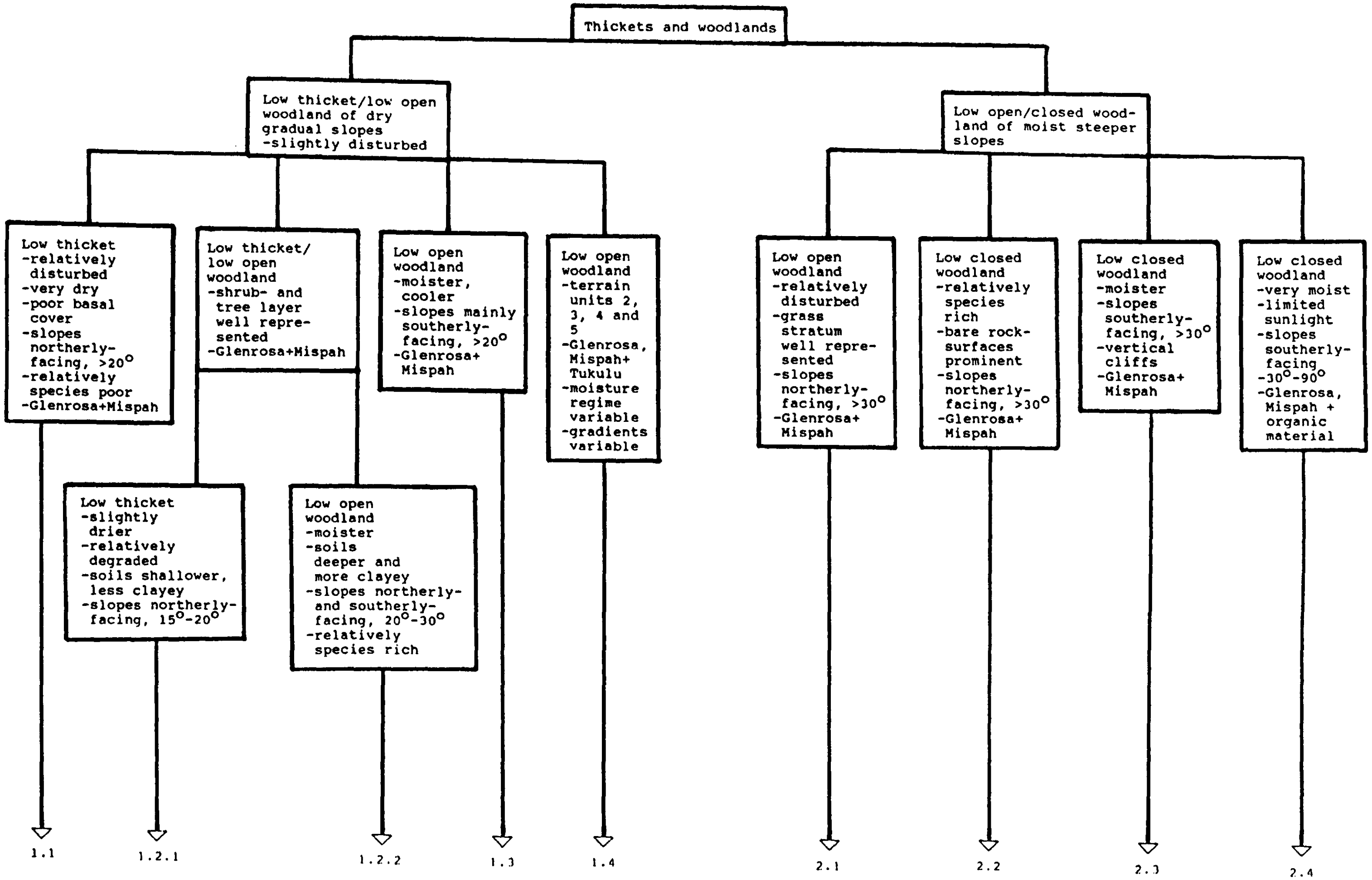

Figure 2. The hierarchical classification and associated environmental characteristics of the nine plant communities.

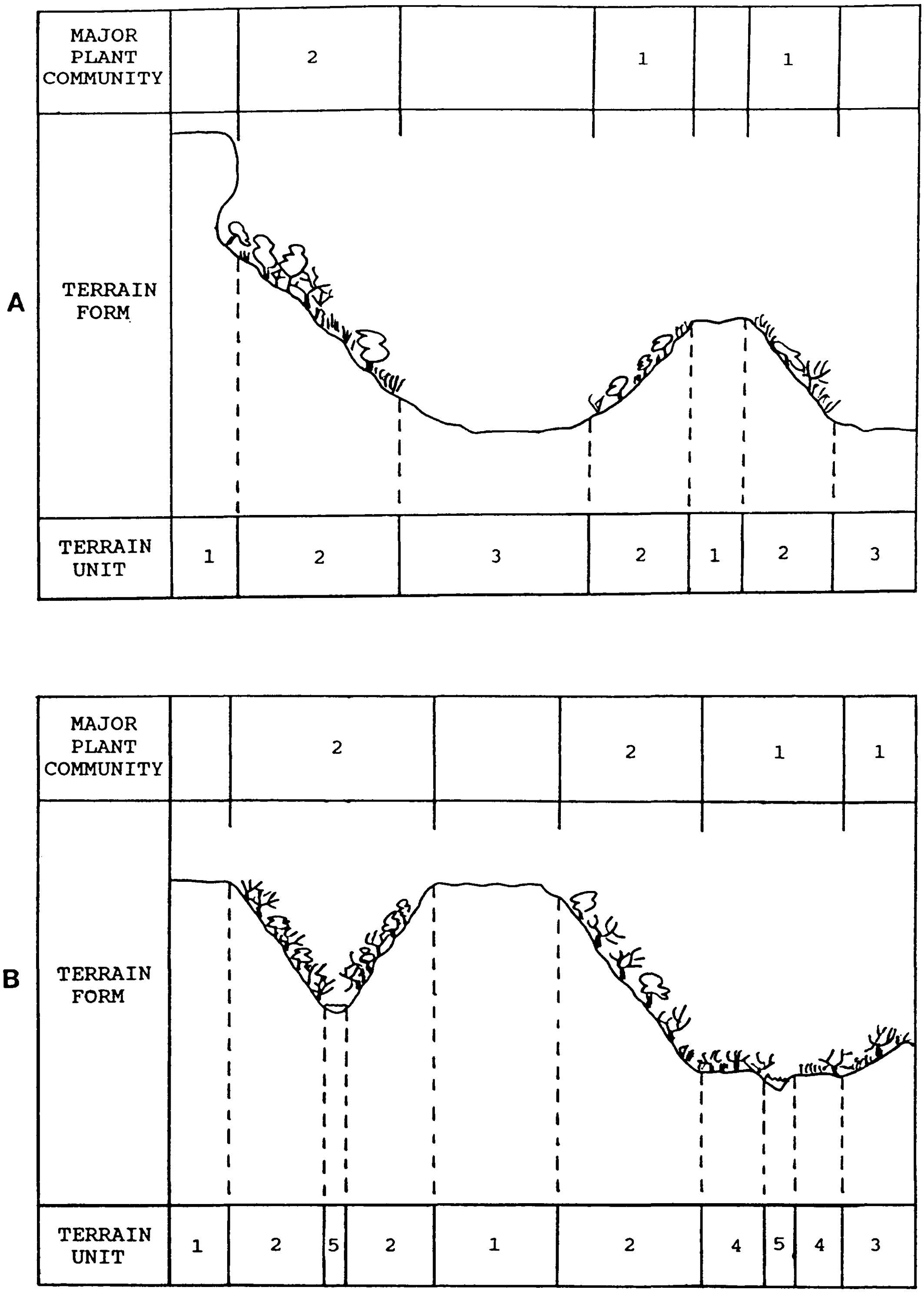

Figure 3. A schematic illustration of the distribution of the major plant communities Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland and Poa annua-Leucosidea sericea Low Open/Closed Woodland along the terrain form.

Description of the communities

1. Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland of dry slopes

Eckhardt et al. (1993b) identified this major plant community in an overview of the vegetation of the area. It occurs on gradual warm dry northerly-facing slopes with rocky, shallow soils. The pioneer grass species Aristida congesta subsp. congesta and A. diffusa are prominent, indicating the extent to which these slopes are disturbed by possible overutilization (see also Van Oudtshoorn 1991). The characteristic species groups A to J (Table 1) clearly distinguish this major plant community from the Poa annua-Leucosidea sericea Low Open/Closed Woodland. Hyparrhenia hirta, Heteropogon contortus, Eragrostis curvula and Themeda triandra are characteristic of these drier slopes, being replaced by different species on the wetter slopes. This major community is subdivided into two communities.

1.1 Pollichia campestris-Hyparrhenia hirta Low Thicket

This low thicket occurs on dry warm slopes facing mainly northerly, with gradients exceeding 20^{o} (Figures 2 & 3). Soils are rocky (> 20%) and shallow (< 150 mm), represented by the Glenrosa and Mispah Soil Forms. The diagnostic species feature low cover-abundance and constancy values, and include pioneer species such as Pollichia campestris, Trichoneura grandiglumis, Aristida congesta subsp. congesta and Bidens pilosa (species group A, Table 1), clearly indicating the disturbed state of these dry slopes. Other conspicuous species include the graminoids Hyparrhenia hirta and Eragrostis curvula, as well as the woody species Diospyros lycioides, Rhus dentata and R. pyroides. An average number of 25 species was recorded per sample plot.

1.2 Cymbopogon plurinodis-Themeda triandra Low Thicket/Low Open Woodland

This mosaic of low thicket and low open woodland is encountered on rocky, shallow Glenrosa and Mispah Soil Forms (Figures 2 & 3). Within this vegetation, considerable variation exists in the dominance of species and in the structure of the vegetation. The low thicket is mainly represented by the shrubby species Rhus dentata and the graminoid Hyparrhenia hirta, whilst the small tree Leucosidea sericea and the graminoids Tristachya leucothrix and Harpochloa falx are conspicuous in the low open woodland. This thicket/woodland is characterized by species group D, with diagnostic species Cymbopogon plurinodis and Indigofera woodii (Table 1). These diagnostic species are, however, not conspicuous in contrast to the strongly represented graminoids Themeda triandra, Eragrostis curvula and Elionurus muticus. Due to structural and floristic variations, this vegetation is subdivided as follows:

1.2.1 Aristida diffusa-Hyparrhenia hirta Low Thicket

This low thicket is found on dry slopes facing into northerly directions, with gradients of 15^{o} to 20^{o} (Figures 2 & 3). Soils are very shallow (< 150 mm), rocky (> 20%) and have low clay contents (15%). The poor vegetation cover can be ascribed to shallow soils, prevailing drought conditions and overutilization by rock dassies, Procavia capensis (Skinner & Smithers 1990). Therefore, clear signs of erosion are visible in the form of sheet erosion. Large parts of the slopes are covered by sandstone boulders, also contributing to the poor vegetation cover. Diagnostic species include the pioneers Aristida diffusa, Solanum panduriforme, Hermannia geniculata and Hermannia depressa (species group B, Table 1). The forb layer is poorly represented, whereas the grass species Hyparrhenia hirta, Themeda triandra, Eragrostis curvula and Elionurus muticus are featuring relatively high cover-abundance values. Shrub species include Diospyros lycioides, Euclea undulata and Rhus dentata. The herbaceous layer is poorly represented. The average number of species recorded per sample plot is 27.

1.2.2 Helichrysum cephaloideum-Leucosidea sericea Low Open Woodland

This woodland has a relatively dense vegetation cover and is distinguished from the former community by the presence of species groups F and H (Table 1).
This community occurs on rather dry slopes, but which are slightly moister than those of the Aristida diffusa-Hyparrhenia hirta Low Thicket (1.2.1). Soils are also somewhat deeper (150-300 mm) and have a higher clay content (15%-25%) than community 1.2.1 (Figures 2 & 3). The slopes covered by this community are generally facing northerly, with only a few slopes facing southerly. The gradients of the slopes vary from 20^{o} to 30^{o}.

The abundance of forb species is diagnostic of this community, including amongst others, species such as Helichrysum cephaloideum, H. pilosellum, Scabiosa columbaria and Rhynchosia totta (species group C, Table 1). Constant and sometimes dominant species are the graminoids Elionurus muticus, Eragrostis capensis, Heteropogon contortus, Tristachya leucothrix, Themeda triandra and Eragrostis curvula. The high constancy of Harpochloa falx indicates an increased moisture regime (Van Oudtshoorn 1991) for this open woodland. The trees Leucosidea sericea and Euclea undulata, varying in heights between 2-5m, together with the grass layer, contribute to the denser vegetation cover. An average number of 35 species was recorded per sample plot, indicating the species richness of this community in comparison to the former communities.

1.3 Hypoxis obtusa-Eragrostis curvula Low Open Woodland

This woodland is encountered on rocky, shallow (< 150 mm) soils of the Glenrosa and Mispah Soil Forms, containing low (15%) clay percentages (Figure 2). The slopes are steeper than 20^{o} (Figure 3) and receive less solar radiation due to the slopes facing southerly. Consequently, an increased soil moisture content and cooler conditions are prevalent, indicated by species such as the geophyte Eucomis autumnalis and the fern Mohria caffrorum. The diagnostic geophytic species Hypoxis obtusa, Eucomis autumnalis and Hypoxis argentea (species group E, Table 1) are clearly subordinate to dominant species such as Eragrostis curvula, Aristida junciformis, Harpochloa falx and Tristachya leucothrix. The prominence of Tristachya leucothrix and simultaneous low cover/abundance of species such as Themeda triandra, Heteropogon contortus and Hyparrhenia hirta, are indications of a higher soil moisture content. Prominent but not very constant woody species include Leucosidea sericea, Rhus pyroides, R. dentata and Diospyros lycioides. The average number of species recorded per sample plot is 28.

1.4 Andropogon appendiculatus-Eragrostis curvula Low Open Woodland

The occurrence of this scattered irregular low open woodland dominated by short to tall individuals of the woody Leucosidea sericea on terrain units 2, 3, 4 and 5 (Figures 2 & 3) cannot be clearly explained in terms of habitat variables. The prevailing habitat conditions within these terrain units vary, with rocky (> 20%), shallow (< 150 mm) Glenrosa and Mispah Soil Forms encountered on the slopes and the deep (> 500 mm) Tukulu Form on the footslopes. The moisture regime within this woodland varies greatly, with the shallow soils being drier than the deeper soils. The possible bush-encroachment on deeper soils may partly be ascribed to injudicious farming practices, using different terrain units as an entire management unit. Overutilization of mid- and footslopes inevitably leads to bush-encroachment (mainly by the increase of Leucosidea sericea), and the subsequent deterioration of the grass stratum. Species with high cover-abundance values include the graminoids Eragrostis curvula, Themeda triandra, Aristida junciformis, Hyparrhenia hirta and Eragrostis plana. Noteworthy is the high constancy and abundance of Eragrostis plana, indicating slightly moister conditions as well as the deterioration of the grass stratum. Diagnostic but subordinate species are the grass Andropogon appendiculatus, and the forbs Walafrida densiflora and Senecio isatideus (species group G, Table 1). Other woody species to be found include Rhus pyroides, R. dentata and Diospyros lycioides. An average number of 26 species was recorded per sample plot.

2. Poa annua-Leucosidea sericea Low Open/Closed Woodland

This major plant community, which has been identified by Eckhardt et al. (1993b) in an overview of the vegetation of the area, occurs on steeper (> 30^{o}), though moister and cooler slopes than major plant community 1 (Figures 2 & 3). The soil forms are mainly Glenrosa and Mispah, being 150 mm to 200 mm deep and clay percentages ranging from 15% to 25%. The total or partial absence of species (species groups H, I, J and K, Table 1) characteristic of the Hyparrhenia hirta-Rhus dentata Thicket/Woodland, and simultaneous presence of species such as Poa annua, Clematis oweniae and Myrsiphyllum asparagoides (species group Q, Table 1), distinguish these two major communities.

2.1 Poa annua-Hyparrhenia hirta Low Open Woodland

This woodland occurs on steep (> 30^{o}), northerly-facing slopes with shallow soils (< 150 mm) (Figures 2 & 3). Large rock boulders (more than 3 m in diameter) are scattered on the slopes. In some cases vertical sandstone rock cliffs separate the slopes from terrain unit 1. These cliffs serve as habitat for rock dassies, which severely utilize the herbaceous stratum in this area. Large areas below and adjacent to the rock cliffs are totally deprived of all vegetation. This community features characteristics of the Hyparrhenia hirta-Rhus dentata Low Thicket/Low Open Woodland of dry slopes as well as characteristics of the Poa annua-Leucosidea sericea Low Open/Closed Woodland of wet slopes. Although this community has no diagnostic species, the graminoid Hyparrhenia hirta, indicating relatively drier conditions, distinguishes this open woodland from the closed woodland communities (Table 1). Prominent species include the grasses Eragrostis curvula and Poa annua, the shrub Clutia pulchella, and the trees Rhus pyroides and Kiggelaria africana. An average number of 30 species was recorded per sample plot.

2.2 Senecio subrubriflorus-Poa annua Low Closed Woodland

This woodland is encountered on steep (> 30°), northerly-facing slopes with shallow (150-200 mm) soils (Figures 2 & 3). In some places only bare rock surfaces occur, sometimes covered with organic material. This community is principally characterized by trees exceeding 3 m. These include Leucosidea sericea, Heteromorpha trifoliata, Euclea undulata and Rhus pyroides. Due to the dominating effect of the tree layer, basal cover of the herbaceous species is low, constituted mainly by graminoids such as Poa annua, Pentaschistis setifolia and Helictotrichon turgidulum. Various smaller forbs, including climbers such as Rubia horrida and Clematis oweniae are found beneath the trees. Diagnostic but subordinate species include the forbs Senecio subrubriflorus and Helichrysum hypoleucum, the fern Polystichum sp., the graminoid Pentaschistis setifolia and the woody species Buddleja salviifolia (species group L, Table 1). These species are all clear indicators of a higher soil moisture content. The only conspicuous shrub species is Myrsine africana. An average number of 37 species was recorded per sample plot, which is slightly higher than the average number recorded for community 1.2.2.

2.3 *Helichrysum umbraculigerum*-*Poa annua* Low Closed Woodland

This community can be found on south-facing slopes, exceeding gradients of 30° and sometimes reaching 90°, receiving only limited solar radiation (Figure 3). Soils are 200 mm deep with clay percentages varying from 20% to 25%. The soils are further characterized by generally high (> 20%) surface-rock percentages and are featuring increased moisture contents (Figure 2).

The vegetation is very dense (> 75%) but varies greatly from one area to another. Although classified as closed woodland, in some parts the shrub layer seems to be more predominant while the tree cover hardly reaches 10%. Woody species include *Melianthus dregeanus*, *Heteromorpha trifoliata*, *Rhus pyroides* and the dominant *Leucosidea sericea*. This community is characterized by diagnostic species such as the forbs *Helichrysum umbraculigerum*, *Kniphofia linearifolia*, *Schoenoxiphium rufum*, *Cynoglossum lanceolatum*, the shrub *Printzia pyrifolia* and the climber *Dioscorea sylvatica* (species group M, Table 1). Basal cover is relatively high, constituted by graminoids such as *Poa annua*, *Bromus catharticus*, *Helictotrichon turgidulum*, *Themeda triandra* and the dominant *Eragrostis curvula*. The graminoid *Themeda triandra* is more strongly represented in areas displaying a relatively lower tree cover. An average number of 32 species was recorded per sample plot.

2.4 *Plectranthus hereroensis*-*Poa annua* Low Closed Woodland

In general, this woodland is associated with steep (> 30°) moist narrow ravines or areas directly below upright cliffs, facing into southerly directions (Figure 3). Due to the location of this community and the dense (> 75%) tree cover, little solar radiation reaches the lower strata of the vegetation. Subsequently, fewer species are found in the lower strata, with an average number of only 26 species per sample plot. Prevailing conditions within this community are more temperate. Soils are shallow

(< 150 mm) and very moist, generally covered with organic material (Figure 2). Large boulders are scattered around, often overgrown by diagnostic climbers such as Myrsiphyllum ramosissimum, Dioscorea retusa and Pergularia daemia (species group N, Table 1). Often, water can be seen trickling down rock surfaces. Rock-crevices are often used as shelter by rock dassies. Grasses are virtually absent in the shade, with individuals of Poa annua and Bromus catharticus only found scattered about. Other diagnostic species include the shade-loving forbs Plectranthus hereroensis, Eriospermum sp., Silene undulata, Plectranthus grallatus, Sutera pristisepala, and the scrabling shrubs Protasparagus virgatus and Rhamnus prinoides (species group N, Table 1). Prominent and sometimes dominant species include the forbs Cineraria aspera, Myrsiphyllum asparagoides, Cyathula cylindrica, the climber Clematis oweniae, and the woody species Melianthus dregeanus, Heteromorpha trifoliata, Kiggelaria africana, Leucosidea sericea and Rhus pyroides.

Concluding remarks

The vegetation of the slopes, i.e. the Rhus pyroides-Leucosidea sericea Thicket/Woodland, could be successfully divided into various plant communities. These are clearly related to certain environmental conditions prevalent within the respective communities. Aspect and topography and associated moisture regime can be considered as the most important factors controlling the distribution of the plant communities. Other factors such as soil form, soil depth and rockiness of the soil surface appear to be less influential.

Finally, since the woody species Leucosidea sericea is indigenous to South Africa and has always occurred in this area, it can be assumed that dense stands of this species are a natural occurrence. However, the many smaller shrubs appearing in otherwise pure grassveld stands, as revealed by the surveys, are a point of concern, since these reflect poor veld management. This includes the division of camps, being not based upon ecological principles. The slopes dominated by woody species, must obviously be managed separately from the lower-lying grassland plains. Managing different terrain units as one whole unit could result in disproportionate utilization of the different homogeneous units. The advancement of *Leucosidea sericea* into the grassland plains is a result of mismanagement, thereby reducing the grazing capacity of the veld and rendering it useless to cattle-farming.

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CHAPTER 7

The grassland communities of the slopes and plains of the north-eastern Orange Free State

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Abstract

A phytosociological survey of the grasslands of the north-eastern Orange Free State was conducted. Two separate phytosociological tables were compiled and the recognised plant communities are described and discussed in this report. Relevés were compiled in 148 stratified random sample plots. Refinement of a TWINSPAN classification of the vegetation was done according to Braun-Blanquet procedures. Fourteen plant communities and one variant were identified. A hierarchical classification and ecological interpretation of the vegetation are also presented.

Keywords: Braun-Blanquet, classification, Grassland, land type, phytosociology, terrain unit

Introduction

The highly variable and erratic rainfall over southern Africa has short- and long-term consequences for especially the agricultural sector. Drought conditions as experienced during the 1991/1992 period in most parts of the country, threaten the existence of the farming communities. The economic effects of such a development can be counteracted by introducing additional options such as ecotourism. The scenic north-eastern Orange Free State is particularly suitable for the expansion of ecotourism into this part of southern Africa. Certain farmers have already incorporated this facet into their management options. However, this kind of tourism is still in a developing phase and needs much more attention.

Phytosociological surveys and the identification of conservation areas can assist farmers in land-use planning and management. The relationship between plant ecological studies on the one hand and land-use planning, management and conservation on the other is well documented (Pentz 1938; Bayer 1970; Van Rooyen et al. 1981).

The aim of this study is to describe the grasslands of relatively low-lying areas, the slopes and the flat and undulating plains of the north-eastern Orange Free State, excluding the vegetation of the Ea land type (characterized by undifferentiated soils) which was discussed by Eckhardt et al. (1993a). This area is phytosociologically unknown and therefore no attempt was made to fix syntaxon names. This investigation should however contribute greatly to the knowledge of the vegetation of the area.

Study area

The study area comprises the central-eastern part of the 2728 Frankfort map (1:250 000) (Land Type Survey Staff 1984), and is situated between 29° 00' and 29° 47' E longitude and 27° 00' and 28° 00' S latitude (Figure 1). The physical environment of the entire study area has been described by Eckhardt et al. (1993a). The grasslands occur in the Ad (yellow, dystrophic and/or mesotrophic soils), Bb (dystrophic and/or mesotrophic soils), Bd (eutrophic soils), Ca (undifferentiated soils) and Fa (lime rare or absent) land types as described by the Land Type Survey Staff (1984) and comprise 66% of the study area.

Methods

Relevés were compiled in 148 stratified random sample plots. Plot sizes were fixed at 100 m^2 (Bredenkamp 1982) and the cover-abundance of all species recorded were according to the Braun-Blanquet scale (Mueller-Dombois & Ellenberg 1974). Through the application of TWINSPAN (Hill 1979), the total grassland data set has initially been divided into two distinct types, each with its own plant communities, which are consequently presented in two phytosociological tables. These two tables consist of three major plant communities, namely the Aristida junciformis-Themeda triandra and the Eragrostis plana-Themeda triandra Grassland contained within Table 1a, and the Monocymbium ceresiiforme-Tristachya leucothrix Grassland constituting a separate table (Table 1b). All three major communities are listed under the Heteropogon contortus-Eragrostis curvula Grassland recognized by Eckhardt et al. (1993b). The results of the TWINSPAN classification were further refined by Braun-Blanquet procedures (Table 1) (Behr & Bredenkamp 1988; Bredenkamp et al. 1989; Eckhardt et al. 1993a, b & c).

Taxon names conform to those of Gibbs Russell et al. (1985 & 1987) and De Wet et al. (1989, 1990, 1991) and the soil classification was done according to the system described by the Department of Agricultural Development (1991).

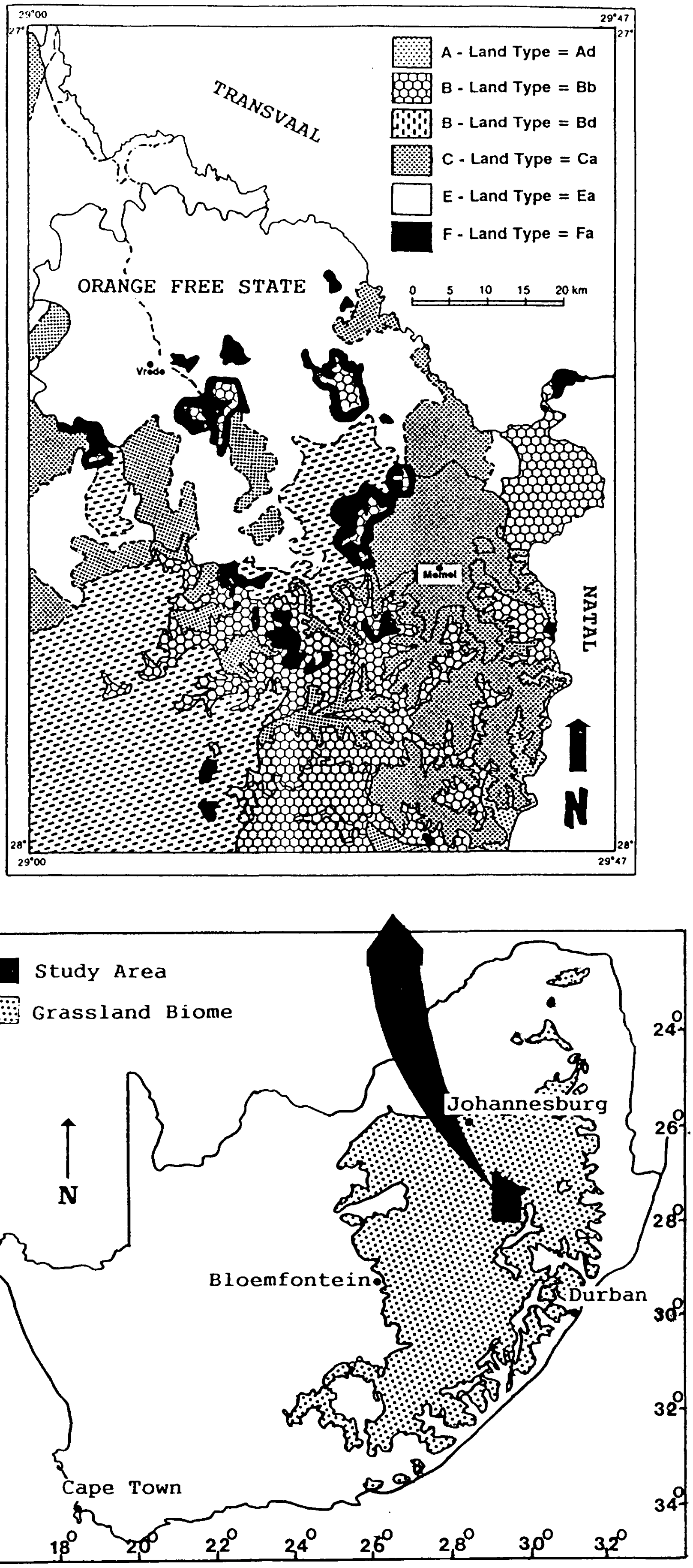

Figure 1. Map indicating the study area within the Grassland Biome, and the distribution of the land types (Land Type Survey Staff 1984; Siegfried 1989).

Results and discussion

The plant communities recognized in the two phytosociological tables, are presented separately. The grasslands of low-lying areas, and the flat and undulating plains with deeper soils, represented by the Aristida junciformis-Themeda triandra Grassland and the Eragrostis plana-Themeda triandra Grassland are given in Table 1a. These two major plant communities are sharing a number of the more conspicuous and dominant species, which include Themeda triandra, Eragrostis curvula, E. plana and Aristida junciformis, and are therefore related to each other. The former major community occurs at relatively higher altitudes than the latter one. In general, the grasslands are relatively species poor (an average number of only 19 species per sample plot was recorded), with forb species generally subordinate to the grass layer. This vegetation is divided into seven communities and one variant (Table 1a).

In Table 1b the Monocymbium ceresiiforme-Tristachya leucothrix Grassland is presented (see also Eckhardt et al. 1993b) which includes the grassland communities of the slopes and flat plains. This major plant community is also found at high altitudes, and under very moist conditions relatively to the Aristida junciformis-Themeda triandra and the Eragrostis plana-Themeda triandra Grasslands (Table 1b). The soils are virtually throughout shallow, consisting of Glenrosa (orthic A horizon on lithocutanic B horizon), Mispah (orthic A horizon on rock) and Clovelly (orthic A horizon on yellow-brown apedal B horizon) Forms (see also Smit et al. 1992). Dominant and conspicuous species include the graminoids Tristachya leucothrix, Heteropogon contortus, Eragrostis racemosa, Themeda triandra (species group J,) and Monocymbium ceresiiforme (species group I) (Table 1b). Species not restricted to a certain species group, but however, displaying high cover-abundance values for certain communities, are listed in species group K (Table 1b). This major community is divided into seven communities.

Schematic representations of the hierarchical classifications and associated environmental factors of the plant communities encountered within the Aristida junciformis-Themeda triandra and Eragrostis plana-Themeda triandra Grasslands are presented in Figure 2, while those for the Monocymbium ceresiiforme-Tristachya leucothrix Grassland are presented in Figure 4.

Classification

The hierarchical classification of the plant communities identified within the Aristida junciformis-Themeda triandra Grassland, the Eragrostis plana-Themeda triandra Grassland and the Monocymbium ceresiiforme-Tristachya leucothrix Grassland is as follows:

A. Aristida junciformis-Themeda triandra Grassland

1. Pennisetum sphacelatum-Eragrostis plana Wet Grassland

1.1 Oenothera rosea-Eragrostis plana Grassland

1.2 Helichrysum rugulosum-Eragrostis plana Grassland

2. Vernonia oligocephala-Tristachya leucothrix Grassland

2.1 Andropogon appendiculatus-Aristida junciformis Grassland

2.2 Hermannia depressa-Tristachya leucothrix Grassland

B. Eragrostis plana-Themeda triandra Grassland

3. Solanum panduriforme-Themeda triandra Dry Grassland

3.1 Indigofera woodii-Aristida junciformis Variant

4. Eragrostis curvula-Themeda triandra Dry grassland

4.1 Microchloa caffra-Walafrida densiflora Grassland

4.2 Eragrostis racemosa-Themeda triandra Grassland

C. Monocymbium ceresiiforme-Tristachya leucothrix Grassland

5. Helichrysum spiralepis-Trachypogon spicatus Grassland

6. Harpochloa falx-Tristachya leucothrix Grassland

7. Andropogon schirensis-Monocymbium ceresiiforme Grassland

7.1 Stiburus alopecuroides-Tristachya leucothrix Grassland

7.2 Rendlia altera-Monocymbium ceresiiforme Grassland

8. Helichrysum coriaceum-Themeda triandra Grassland

9. Berkheya setifera-Monocymbium ceresiiforme Grassland

10. Elionurus muticus-Themeda triandra Grassland

Description of the communities

A. Aristida junciformis-Themeda triandra Grassland

1. Pennisetum sphacelatum-Eragrostis plana Wet Grassland of low-lying areas

This grassland is found on flat floodplains (terrain unit 4) under, wet conditions adjacent to rivers and streams on deep (> 500 mm), clayey (> 25%) soils (Figures 2 & 3).

Species indicative of the wet conditions are the diagnostic grasses Pennisetum sphacelatum and Paspalum dilatatum, and the hygrophilous forbs Conyza bonariensis, Oenothera rosea and Centella asiatica (species group A, Table 1a). This grassland is often found to be overgrazed by livestock and in a disturbed state. In many parts, the vegetation of this grassland has been replaced mainly by Eragrostis curvula pastures. This is especially the case where terrain unit 4 encompasses large areas, rendering the latter suitable for the planting of pastures.

Two communities can be distinguished within this grassland:

1.1 Oenothera rosea-Eragrostis plana Grassland of relatively wet low-lying areas

This community occurs on wet low-lying areas and is often shortly grazed (Figure 2). The vertic Arcadia Soil Form is mostly associ-

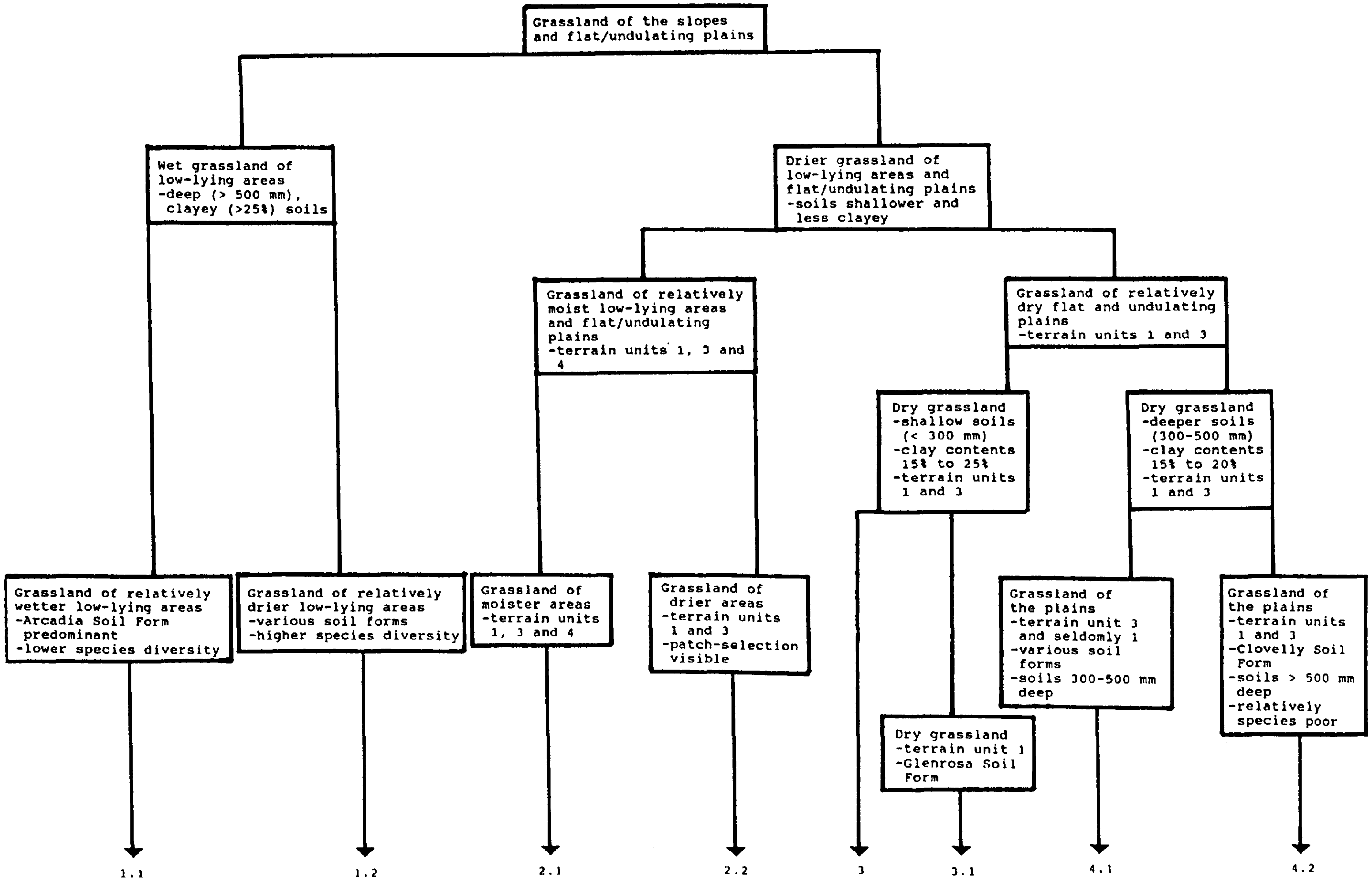

Figure 2. The hierarchical classification and associated environmental characteristics of the seven plant communities and one variant identified within the *Aristida junciformis*-*Themeda triandra* and *Eragrostis plana*-*Themeda triandra* Grasslands.

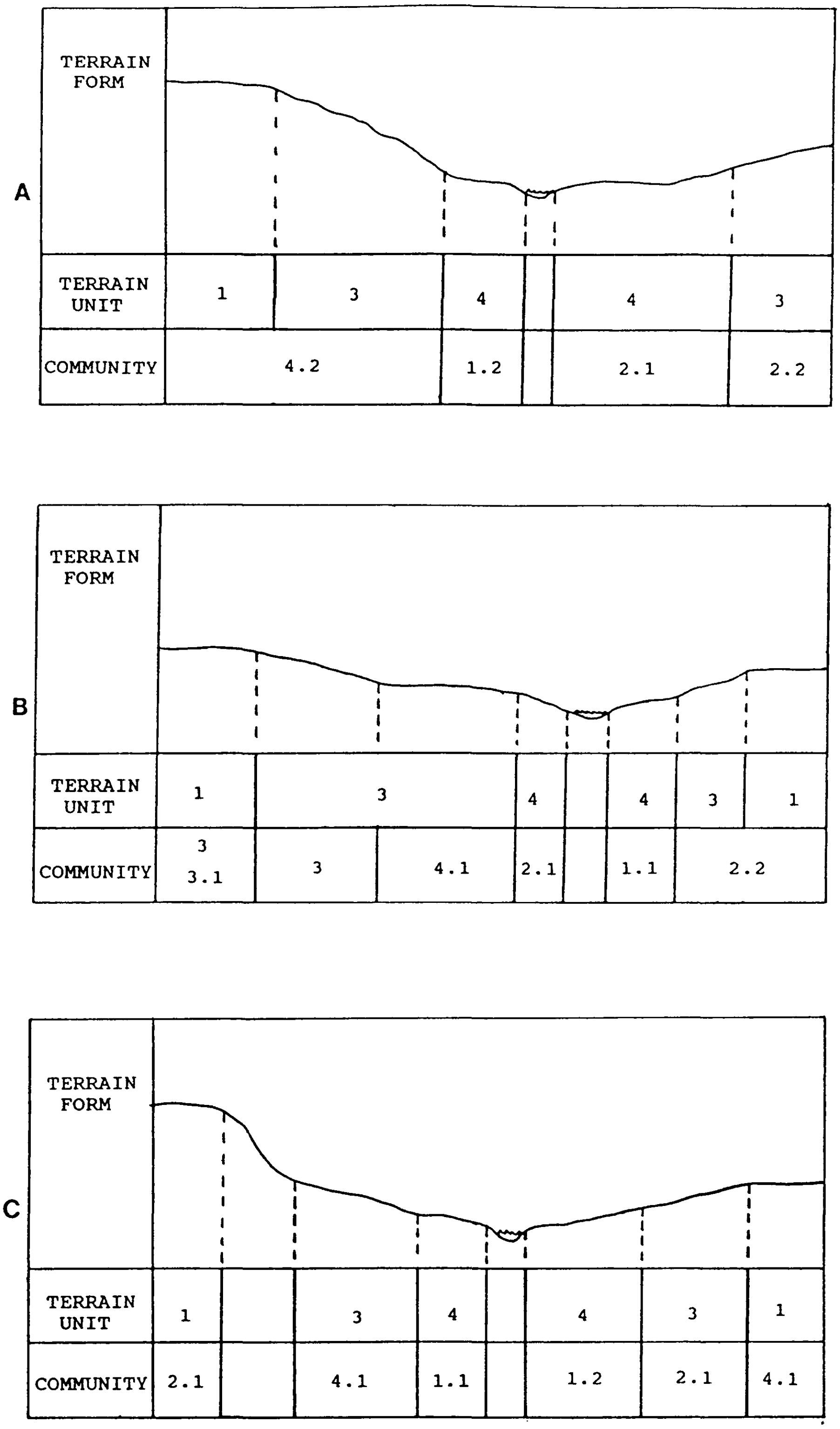

Figure 3. Schematic illustrations of the distribution of the plant communities identified within the *Aristida junciformis*-*Themeda triandra* and *Eragrostis plana*-*Themeda triandra* Grasslands along the terrain form.

ated with this terrain unit.

Noticeable is the low species diversity with forb species very poorly represented. This grassland is represented by species groups A, B and J (Table 1a) with the latter group containing the most prominent and conspicuous graminoids such as Eragrostis curvula, E. plana and Themeda triandra. No diagnostic species are associated with this community.

Overgrazing seems to benefit Eragrostis plana which increases under overgrazing and replaces grass species reacting more sensitively to overutilization. An average number of 12 species was recorded per sample plot.

1.2 Helichrysum rugulosum-Eragrostis plana Grassland of relatively dry low-lying areas

This community is found under drier conditions than the former community (Figure 2). The vegetation is relatively sparse in some places with bare patches often encountered. This grassland community is distinguished from the former community by the presence of species group I (Table 1a), consisting mainly of grasses and forbs typical for somewhat drier conditions. An average number of 23 species was recorded per sample plot. The relatively high species diversity can be ascribed to the occurrences of various forb species, which are fairly inconspicuous and subordinate to the grass layer.

2. Vernonia oligocephala-Tristachya leucothrix Wet grassland of low-lying areas and the flat and undulating plains

This grassland is mainly encountered on terrain units 1 and 3, and seldomly on terrain unit 4 (Figures 2 & 3), at an altitude of 1 700 to 2 000 m. This grassland falls within the following veld types of Acocks (1953, 1988), namely the Highland- and Dohne Sourveld, Patchy Highveld to Cymbopogon-Themeda Veld Transition and Highland Sourveld to Cymbopogon-Themeda Veld Transition. The clay contents of the wide range of soil forms encountered varies from 15% to 25%, with soil depths exceeding 200 mm.

Based on species composition, the higher-lying grasslands (terrain unit 1) cannot be separated from the lower-lying grasslands (terrain units 3 & 4). This grassland is characterized by species group C (Table 1a), containing only diagnostic forbs such as Vernonia oligocephala, Helichrysum coriaceum, H. pilosellum and Hypoxis rigidula.

Two communities can be distinguished:

2.1 Andropogon appendiculatus-Aristida junciformis Grassland of relatively wet areas

Due to a higher soil moisture content (Figure 2), the basal cover within this community is relatively dense. This grassland is more generally found on flatter areas of terrain units 1, 3 and 4.
The community has no diagnostic species group, but is represented by species groups B, C and G to K, consisting of common species such as Eragrostis curvula, Themeda triandra and Aristida junciformis (Table 1a). The strongly represented perennial Aristida junciformis acts as an indicator of veld mismanagement, gradually replacing other grass species under high grazing pressures. The presence of the tufted, perennial grass Andropogon appendiculatus (species group B, Table 1a) indicates wet prevailing conditions. An average number of 21 species was recorded per sample plot.

2.2 Hermannia depressa-Tristachya leucothrix Grassland of relatively dry areas

This community is encountered on terrain units 1 and 3 (Figures 2 & 3) and the habitat appears to be drier than the former community.

The basal cover within this grassland varies considerably. Large parts are subjected to heavy grazing with patch-selection clearly visible (Fuls 1992). Often, patches of tall *Themeda triandra* (species group J, Table 1a) stands are encountered which are a direct result of patch-selection, and can be ascribed to the grazing behaviour of sheep by which they avoid tall grass stands.

This community is distinguished from community 2.1 by the presence of species group F and simultaneous absence of species group B (Table 1a). Dominant species include the graminoids *Themeda triandra*, *Eragrostis curvula* and *Aristida junciformis* (species group J), with other conspicuous species such as *Elionurus muticus* and *Heteropogon contortus* (species group I) (Table 1a). An average number of 24 species was recorded per sample plot.

B. *Eragrostis plana*-*Themeda triandra* Grassland

3. *Solanum panduriforme*-*Themeda triandra* Dry Grassland of the flat and undulating plains

This grassland community is in principle restricted to shallow soils (< 300 mm) (terrain unit 1 and 3) (Figures 2 & 3) occurring under relatively drier conditions compared to the *Vernonia oligocephala*-*Tristachya leucothrix* Grassland. The clay content of the soils varies from 15% to 25%.

Some areas are characterized by a sparse vegetation cover and appear to be overutilized. This is especially the case with the grassland found on terrain unit 1, where more palatable grass species such as *Themeda triandra* and *Eragrostis curvula* (species group J, Table 1a) are overgrazed. Species with a high constancy are the diagnostic perennial forbs *Solanum panduriforme*, *Vernonia natalensis* and *Berkheya onopordifolia* (species group D, Table 1a). The relatively low constancy values of the perennial grasses

Tristachya leucothrix and Harpochloa falx (species group H) are indicative of drier prevailing conditions. An average number of 22 species was recorded per sample plot.

One variant could be distinguished within this community:

3.1 Indigofera woodii-Aristida junciformis Variant of the flat plains

This variant is virtually restricted to terrain unit 1, characterized by dry conditions, with the shallow (< 200 mm), less clayey (15%-25%) Glenrosa Soil Form predominantly present (Figures 2 & 3).

This grassland can be clearly recognized within the Solanum panduriforme-Themeda triandra community by the presence of species group E (Table 1a). The diagnostic species occurring within the latter species group include amongst others the forbs Indigofera woodii and Anthericum fasciculatum as well as the slender perennial graminoid Aristida diffusa, which is an indicator of overutilization (Van Oudtshoorn 1991). Another indication of overutilization is the relative strong presence of Aristida junciformis (species group J, Table 1a). An average number of 23 species was recorded per sample plot.

4. Eragrostis curvula-Themeda triandra Dry Grassland of the flat and undulating plains

This grassland is mainly encountered on the relatively drier undulating plains (terrain unit 3) and to some degree on the flat plains (terrain unit 1) (Figures 2 & 3). The soils are from 300 to 500 mm deep, with the clay percentages varying from 15% to 20%, sometimes exceeding 35%.

In general, this grassland is shortly grazed and has a relatively low basal cover. Areas which are subjected to high grazing pressures over longer periods are normally characterized by relatively high cover-abundance values for the unpalatable graminoid Aristida junciformis (species group J, Table 1a). Well-managed areas on the other hand, are principally characterized by dense stands of Themeda triandra (species group J), which together with Eragrostis curvula (species group J) are the most dominant and conspicuous grass species encountered in this grassland (Table 1a).

This grassland is represented by species groups F to J (Table 1a), consisting of species more general and common for all the grassland communities previously described. No diagnostic species could be identified.

Within this grassland two communities are distinguished:

4.1 Microchloa caffra-Walafrida densiflora Grassland of the flat and undulating plains

This community is more generally found on terrain unit 3, and only seldomly found on terrain unit 1 (Figures 2 & 3), with various types of soil forms present. The average soil depth varies from 300 to 500 mm, but sometimes as shallow as 200 mm, thus differing strongly on a local scale.

The basal cover of this grassland is relatively low with large parts completely overgrazed. The community has no diagnostic species but is distinguished by species groups F to J (Table 1a), including the predominant grass species Themeda triandra, Eragrostis curvula, Elionurus muticus and Heteropogon contortus. Only a few forb species are encountered, displaying low cover-abundance values and being primarily dominated by the grass stratum. An average number of 19 species was recorded per sample plot.

4.2 Eragrostis racemosa-Themeda triandra Grassland of the flat and undulating plains

This grassland is found on deep (500 mm) soils mainly of the Clovelly Form (Figure 2). The basal cover is higher than that of community 4.1. This can possibly be ascribed to the deeper soils, having a higher potential to support the vegetation encountered in this community. However, lower basal cover do occur, especially where soils are shallower and the moisture content subsequently being lower.

No diagnostic species are encountered. This community is represented only by the more common species groups H, I and J and is distinguished from the previously described community by the absence of species groups F and G (Table 1a). Noticeable are the low constancy values of the few forb species present. An average number of only 14 species was recorded per sample plot.

C. Monocymbium ceresiiforme-Tristachya leucothrix Grassland

5. Helichrysum spiralepis-Trachypogon spicatus Grassland of the slopes

This community occurs on steep slopes (30°-40°) with subsequent shallow (< 150 mm), rocky (> 20%) soils of the Glenrosa and Mispah Soil Forms (Figures 4 & 5). The clay contents of the soils are very low (< 15%). Although it is a typical sour grassland, receiving more than 1 000 mm of rain annually, the soil moisture content of the slopes is in general relatively low. Southerly facing slopes are characterized by a higher basal cover. No woody species can be found due to the harsh prevailing climatic conditions especially with very low temperatures during the winter months.

Diagnostic species include the forbs Helichrysum spiralepis, Selago galpinii, Berkheya cirsiifolia and Anthospermum herbaceum (species group A, Table 1b). Other dominant and conspicuous species are the graminoids Tristachya leucothrix, Trachypogon spicatus and Aristida junciformis (species group J), with the graminoid Andropogon appendiculatus (species group K) also sometimes found in this community (Table 1b). The average number of species recorded per sample plot is 25.

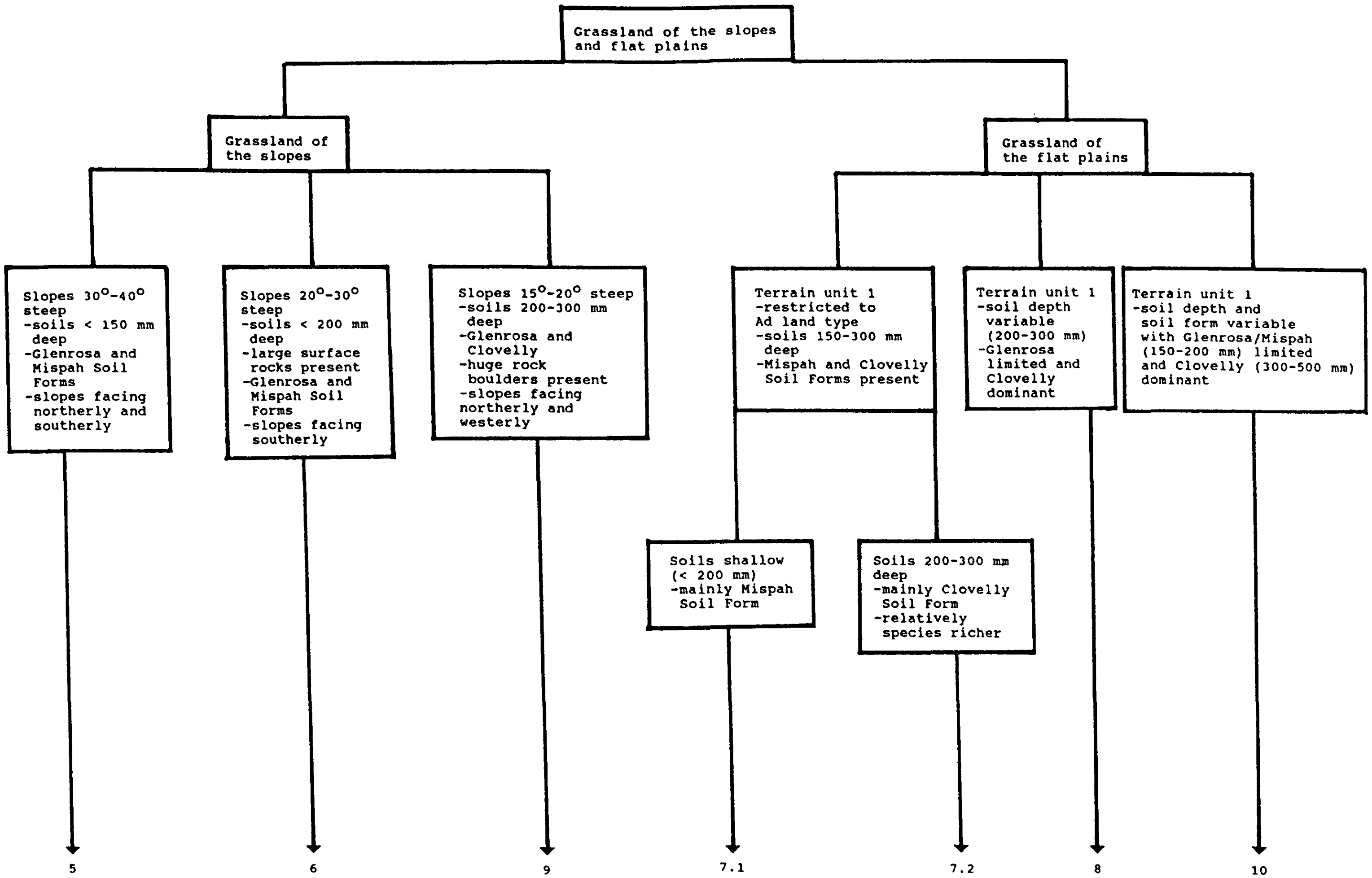

Figure 4. The hierarchical classification and associated environmental characteristics of the seven plant communities identified within the Monocymbium ceresiiforme-Tristachya leucothrix Grassland.

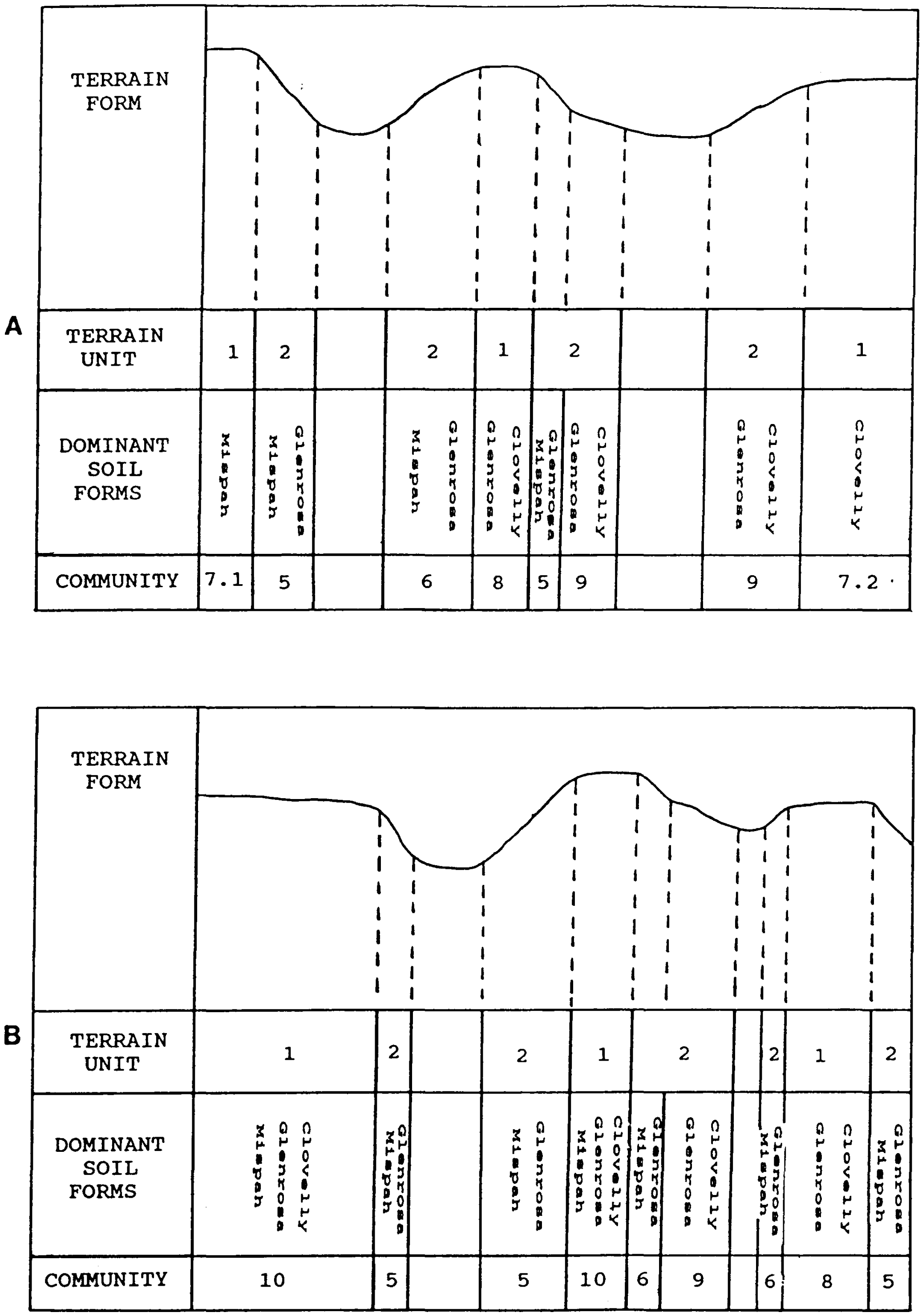

Figure 5. Schematic illustrations of the distribution of the plant communities identified within the *Monocymbium ceresiiforme*-*Tristachya leucothrix* Grassland along the terrain form and associated soil forms.

6. Harpochloa falx-Tristachya leucothrix Grassland of the slopes

This community is generally encountered on moderate (20-30°) southerly facing slopes (Figures 4 & 5). These slopes are characterized by the absence of large woody species and the subsequent presence of a relatively high basal cover of the grass layer. Soil moisture content appears to be relatively high. Typical soils are the shallow (< 200 mm) Glenrosa and Mispah Forms, featuring low clay percentages (15%-20%), with large surface rocks occurring scattered on the slopes.

Diagnostic species of this grassland are those of species group B (Table 1b), with the only woody species being the shrubby Rhus dentata and R. discolor. Other conspicuous and often dominant grass species include the perennials Tristachya leucothrix and Aristida junciformis (species group J, Table 1b). The relatively strong presence of Andropogon appendiculatus (species group K) is noteworthy, indicating moister conditions. An average number of 28 species was recorded per sample plot. This large number can be ascribed to the presence of various forbs, often occurring at very low constancies only and thus being omitted from the table.

7. Andropogon schirensis-Monocymbium ceresiiforme Grassland of the flat plains

In general, this grassland is associated with the Ad land type, which is restricted to the crests of the Drakensberg escarpment. This vegetation falls within Acocks's (1953, 1988) Highland Sourveld and Dohne Sourveld, displaying typical short grassveld. The soils are dystrophic or mesotrophic with clay percentages of 15% to 25%, and varying in depth from 150 to 300 mm (Figure 4). Although the Mispah Soil Form is often encountered with rock plates occasionally visible, the Clovelly Form is virtually through-out present in this land type (Figure 5).

This grassland is characterized by the diagnostic species group

E, including the graminoids Andropogon schirensis, Sporobolus centrifugus and Diheteropogon filifolius (Table 1b). The forb species encountered are less prominent and are dominated by the grass layer. Dominant grasses are the perennials Monocymbium ceresiiforme (species group I), Tristachya leucothrix, Heteropogon contortus and Aristida junciformis (species group J) (Table 1b).

Two communities can be distinguished within this grassland:

7.1 Stiburus alopecuroides-Tristachya leucothrix Grassland of the flat plains

This community is found on shallow soils (< 200 mm) of the Mispah Form which is underlain by rock plates (Figures 4 & 5). The basal cover is predominantly dense, although patches with a sparse vegetation cover may occur. Forbs are relatively poorly represented and are mainly restricted to smaller rocky outcrops.

The diagnostic species include the perennial tufted grasses Stiburus alopecuroides and Eragrostis caesia which are typical of mountainous sourveld with a high average rainfall, and the inconspicuous forbs Lotononis eriantha and Cyanotis speciosa (species group C, Table 1b). Dominant grasses are those contained within species groups I and J (Table 1b). The average number of species recorded per sample plot is 18.

7.2 Rendlia altera-Monocymbium ceresiiforme Grassland of the flat plains

The flat plains covered by this grassland are predominantly characterized by the Clovelly Soil Form, although the Mispah Form often occurs locally (Figures 4 & 5). Soil depth varies from 200 to 300 mm.

The relatively sparse vegetation cover may be ascribed to heavy grazing by livestock which also results in an increase in cover by Aristida junciformis (species group J, Table 1b). This community is distinguished from the previously described community by the presence of species group F (Table 1b), which contains only forbs. Diagnostic species amongst others include the graminoid Rendlia altera, found in shallow well-drained soils at high altitudes, and the perennial forbs Eriosema simulans and Gnidia nodiflora (species group D, Table 1b). An average number of 22 species was recorded per sample plot.

8. Helichrysum coriaceum-Themeda triandra Grassland of the flat plains

This community is encountered on flat plains (terrain unit 1) (Figures 4 & 5). The soils are mainly of the Clovelly Form with Glenrosa only occurring locally. Soil depth may vary greatly, with depths of more than 500 mm reached at some places, while the average lies between 200 and 300 mm. Clay percentages vary from 15% to 20%. The vegetation on deeper soils is more closed relatively to those on shallow soils.

Constantly occurring species such as those of species groups I and J are considerably less prominent with Themeda triandra (species group J) appearing relatively stronger (Table 1b). This community has no diagnostic species group, but is represented by species group F, consisting of the perennial forbs Helichrysum coriaceum, Hypoxis rigidula and Helichrysum oreophilum. This community is further represented by species groups H, I and J (Table 1b). An average number of 22 species was recorded per sample plot.

9. Berkheya setifera-Monocymbium ceresiiforme Grassland of the slopes

This grassland is encountered on moderate (15-20^{o}) slopes facing into northerly and westerly directions (Figures 4 & 5). Soils are of the Clovelly and Glenrosa Form, varying in depth from 200 to 300 mm, whilst clay percentages vary from 15% to 20%. Certain parts of these slopes, especially those with Clovelly Soils, are relatively undisturbed, generally characterized by a dense grass layer. Huge rock boulders of 5 to 10 m in diameter are scattered on these slopes. Isolated bush clumps may occur but are principally restricted to lower altitudes and drainage lines. Slopes where the Glenrosa Soil Form is more predominant are characterized by a sparse vegetation cover and superficial rocks.

This community is characterized by the diagnostic species group G and is further represented by species groups F, H, I and J (Table 1b). Diagnostic species include the perennial forbs *Berkheya setifera* and *Gladiolus sericeo-villosus*, and the small shrub *Indigofera hilaris*. An average number of 23 species was recorded per sample plot.

10. *Elionurus muticus*-*Themeda triandra* Grassland of the flat plains

This community is generally found on terrain unit 1 but may as an exception occur on terrain unit 2 in certain areas (Figures 4 & 5). Habitat conditions vary greatly within this grassland with shallow (150-200 mm), partially rocky soils of the Glenrosa and Mispah Form occurring at some places, while deeper (300-500 mm) soils of the Clovelly Form are encountered in large parts of this grassland. The clay contents of the various soil types vary from 15 to 20%.

One sample plot (180) was placed on top of a large hill, which was found to be in a totally undisturbed state and is characterized by a high percentage (> 20%) surface rocks and rock plates. The species composition of this hill is very diverse, including even small bushy shrubs confined only to localized bare rock surfaces. General species of species groups I and J (Table 1b) are nevertheless dominating the vegetation, featuring high cover-abundance values. Those parts of this community with deeper soils are characterized by a dense grass layer with Themeda triandra (species group J) often dominant over other grass species.

This grassland community has no diagnostic species, but is represented by species groups H, I and J. Conspicuous and sometimes dominant species include the graminoids Tristachya leucothrix, Heteropogon contortus, Themeda triandra (species group J), Monocymbium ceresiiforme (species group I), and Elionurus muticus (species group H). Forb species are less prominent and are subordinate to the grass species. An average number of 22 species was recorded per sample plot.

Concluding remarks

The three major plant communities, namely the Aristida junciformis-Themeda triandra, Eragrostis plana-Themeda triandra and Monocymbium ceresiiforme-Tristachya leucothrix Grasslands are divided into 14 communities and one variant. According to the synoptic table (Eckhardt et al. 1993b), the first two major communities were considered as separate entities although closely related. The newly described communities are not necessarily exclusively associated with certain terrain units since the same community may be encountered on different terrain units. The combined influence of soil form and soil depth, moisture regime, altitude, aspect and topography is determining the occurrence of a certain community rather than a single factor on its own.

The different communities identified and described should serve as ecological units which must be incorporated into management plans to achieve certain conservational goals, including the maintenance of species diversity. The relatively sparse vegetation cover encountered in large parts of most of the communities can partly be ascribed to the prevailing drought. Patch-selection, however, can only be ascribed to the type of management being applied and not to drought conditions. Delineation of camps must be based on either homogeneous vegetation units or on terrain units.

The grasslands are generally considered as the most important vegetation units for livestock farming, therefore it is necessary to manage them according to ecological principles to maintain the optimum floristic composition and subsequently achieve a high production per unit area.

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CHAPTER 8

Wetland plant communities of the Vrede-Memel-Warden area, north-eastern Orange Free State

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Submitted to Navorsinge van die nasionale Museum, Bloemfontein

ABSTRACT

A phytosociological survey of the wetlands of the Vrede-Memel-Warden area, north-eastern Orange Free State, was conducted. Relevés were compiled in 44 stratified random sample plots. Refinement of a TWINSPAN classification of the vegetation was done according to Braun-Blanquet procedures. Nine plant communities were identified and a hierarchical classification, description and ecological interpretation of these communities are presented. A general description of the vegetation of Seekoeivlei is also presented. (Braun-Blanquet, classification, ordination, species diversity, wetlands).

INTRODUCTION

Like many countries of the world, South Africa is rapidly approaching the position of maximum exploitation of it's conventional water resources (Alexander 1985; Walmsley 1988). South Africa is an arid country of which 65% of the total area receives a mean annual precipitation of less than 500 mm (Cowan 1991). Therefore, wetlands are a scarce commodity and should be considered as particularly important ecosystems. Various reasons exist why catchment areas and wetlands are so important and should enjoy high conservation priority. These include amongst others the role wetlands play in the flow of water, sediment and nutrients over the landscape. This means that wetlands serve as water storages, stream flow regulators, flood attenuators, water purifiers and controllers of soil erosion (Walmsley 1988). These wetland habitats are also attracting a vast variety of birds, amphibians and other animals.

Although South Africa is involved in the Ramsar Convention for some time now (Cowan 1991), many wetlands have been destroyed beyond rehabilitation, making them one of South Africa's most endangered ecosystem types (Walmsley 1988). The draining of the wetlands, for the provision of grazing and sometimes for crop production and urban development purposes, enhances the degradation and eventual destruction of such wetlands e.g. Seekoeivlei north of Memel (Van der Walt 1992). As yet no research has been done on the vegetation composition and condition of the wetland habitats of the north-eastern Orange Free State, to determine the state of health of these habitats. The conservation and management of wetlands need to be addressed with the aim to maintain species diversity and to ensure the natural functioning of these sensitive areas. Results obtained by Scheepers (1975) and Kooij, Scheepers, Bredenkamp & Theron (1991) in the Bethlehem and Kroonstad areas respectively, revealed quite distinct wetland plant communities for the respective areas compared to that of the north-eastern Orange Free State.

The wetlands described in this report include, amongst others, riverbanks, streambanks, bottomlands (including vleis) and also a few pans. The Seekoeivlei is an important and extensive wetland within the study area, already earmarked for possible conservation (Van der Walt 1992). Due to burning, excessive overgrazing and the prevailing drought of the 1991/1992 and 1992/1993 summer seasons, it was almost impossible to identify the plant species of the Seekoeivlei. It was therefore decided to exclude this area from the formal floristic and habitat survey of the wetlands and suffice with a general description of the vegetation of this vlei. A description of the wetland habitat, excluding those of the Ea land type, is included in an overview of the vegetation of the north-eastern Orange Free State (Eckhardt, Van Rooyen, Bredenkamp & Theron 1993b). Several plant communities are identified within the wetland habitat and these are dealt with in this report.

STUDY AREA

The study area is situated in the north-eastern corner of the Orange Free State between 29° 00′ and 29° 47′ E longitude and 27° 00′ and 28° 00′ S latitude (Figure 1), comprising the central-eastern part of the 2728 Frankfort map (1:250 000) (Land Type Survey Staff 1984). A detailed description of the physical environment and the climate is given by Eckhardt, Van Rooyen & Bredenkamp (1993a). The wetlands occur on terrain units 4 and 5 (Figures 2 & 3). The topography of these terrain units is generally flat to slightly undulating, becoming more rugged in mountainous regions. The soils encountered vary from deep (> 500 mm) vertic Rensburg and Arcadia Forms (Department of Agricultural Development 1991) to exposed rocks and gravel (Figure 3).

METHODS

Relevés were compiled in 44 stratified random sample plots. Stratification was based on topography, soil depth, incision of streambeds and land types. The plot size was fixed at 100 m^2 (Bredenkamp 1982). In each sample plot all plant species were recorded and each species was allocated a value, using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). The data were classified by means of a two-way indicator species analysis (TWINSPAN) (Hill 1979b) and the results were further refined by Braun-Blanquet procedures (Table 1) (Behr & Bredenkamp 1988; Bredenkamp, Joubert & Bezuidenhout 1989; Eckhardt, et al. 1993a, b,c,d). The floristic data set was further subjected to an ordination algorithm, Detrended Correspondence Analysis (DECORANA) (Hill 1979a), to determine vegetation gradients and the relationship with environmental variables.

Names of taxa are in accordance with Gibbs Russell, Reid, Van Rooy & Smook (1985); Gibbs Russell, Welman, Retief, Immelman, Germishuizen, Pienaar, Van Wyk, Nicholas, De Wet, Mogford & Mulvena (1987); De Wet, Gibbs Russell, Germishuizen, Schrire, Jordaan, Pienaar, Welman, Reid, Van Wyk, Fish, Immelman, Van Rooy, Glen & Barker (1989); De Wet, Germishuizen, Schrire, Jordaan, Pienaar, Welman, Reid, Van Wyk, Fish, Immelman, Van Rooy, Perold, Taussig, Barker & Glen (1990); De Wet, Archer, Fish, Germishuizen, Herman, Jordaan, Perold, Reid, Van Rooy, Welman & Glen (1991).

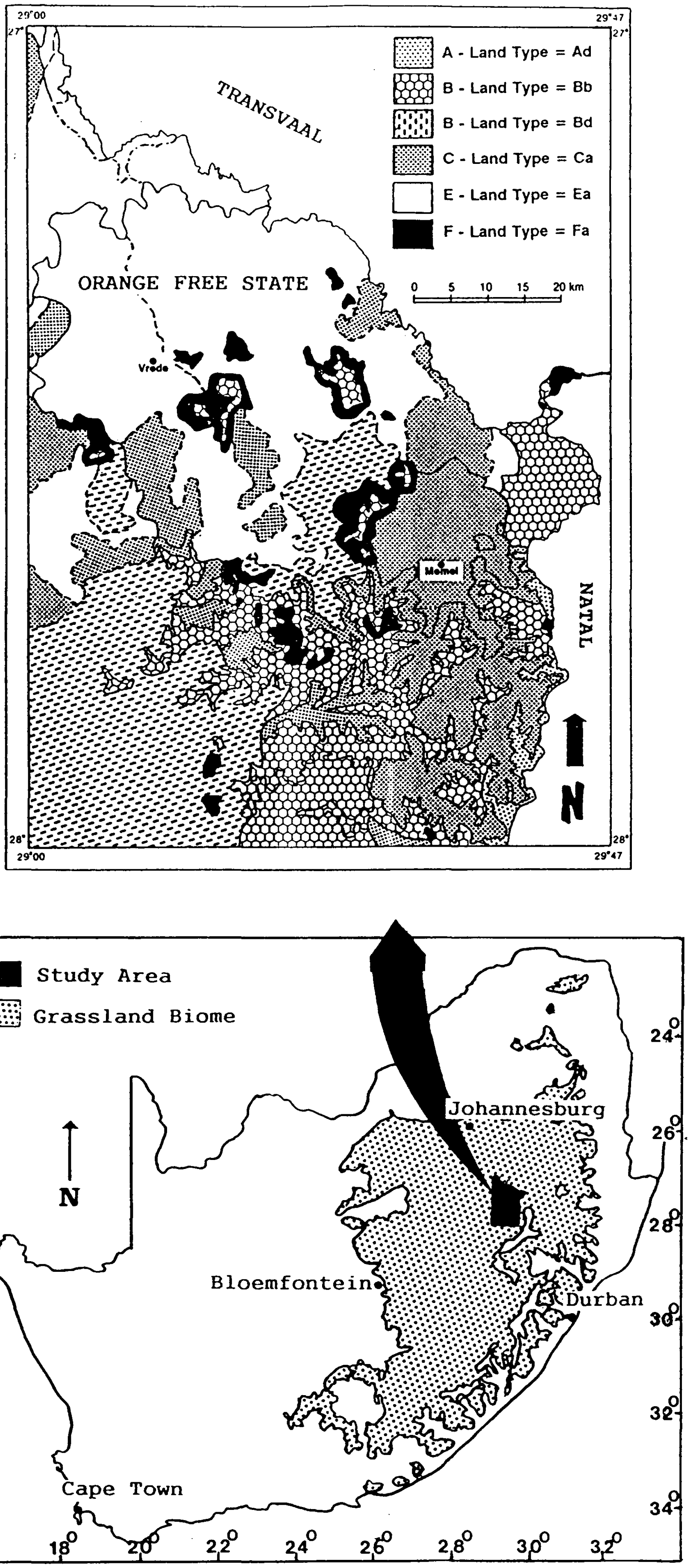

Figure 1. Map indicating the study area within the Grassland Biome, and the distribution of the land types (Land Type Survey Staff 1984; Siegfried 1989).

RESULTS AND DISCUSSION

The wetland habitat of the study area can be broadly classified as the Eragrostis plana-Agrostis lachnantha Wetlands (Table 1, see also Eckhardt et al. 1993b). This major plant community is not particularly rich in species, the average number of species recorded per sample plot being only 19 and the total number of species for all the wetlands in the study area, being 183. Forb species contribute the most to the species richness of the wetlands. The species composition varies greatly between the different wetland habitats, especially if the vegetation of mountain streamlets is compared to that of streams and rivers of the flat to undulating areas. The most conspicuous and often dominant species include the graminoids Eragrostis plana and E. curvula (species group I), and Agrostis lachnantha (species group G) (Table 1). Nine communities were identified within these wetlands, and a diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the plant communities is presented in Figure 2.

Classification

The following plant communities were identified within the Eragrostis plana-Agrostis lachnantha Wetlands:

1. Themeda triandra-Eragrostis curvula Wetland of drier bottomlands
2. Leucosidea sericea-Schizostylis coccinea Wetland of rocky mountainous areas
3. Fuirena pubescens-Mariscus congestus Streambeds
4. Berkheya pinnatifida-Eragrostis plana Streambeds
5. Hyparrhenia dregeana-Agrostis lachnantha Streambeds
6. Eragrostis curvula-Cyperus fastigiatus Riverbanks and streambanks
7. Senecio inaequidens-Cynodon transvaalensis Pan Community

8. Diplachne fusca-Cynodon transvaalensis Pan Community

9. Schoenoplectus sp.-Cynodon transvaalensis Pan Community

Description of the communities

1. Themeda triandra-Eragrostis curvula Wetland of drier bottomlands

This community is encountered on flat bottomlands or floodplains (terrain unit 4) along certain rivers and streams (Figures 2 & 3). The typical margalithic soils found here are deep (> 500 mm), clayey (> 35%) Rensburg, Sepane and Arcadia Forms. The herbaceous layer forms a relatively dense cover, but is often overutilized and partly characterized by patch-selection of certain plant species (see also Fuls 1992). This terrain is particularly vulnerable to the overgrazing and trampling effect of livestock, with donga-erosion ultimately as the end result. Diagnostic species include amongst others the perennial, rhizomatous graminoids Themeda triandra and Setaria sphacelata, and the annual, weedy forbs Bidens formosa and Oenothera tetraptera (species group A, Table 1). Other prominent species are the densely tufted perennials Eragrostis plana and E. curvula (species group I). The average number of species recorded per sample plot is 17, indicating a relatively low species richness for this community.

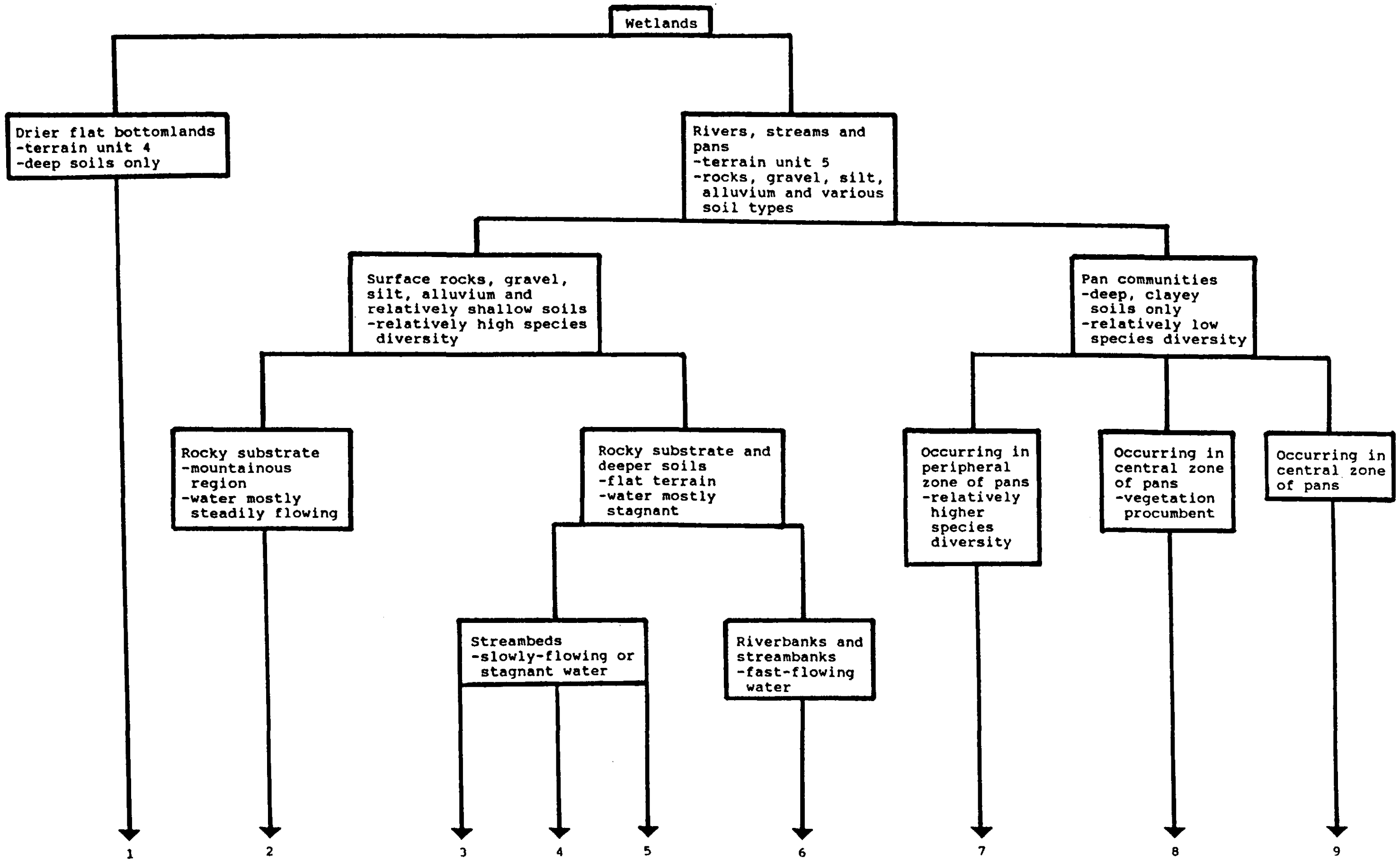

Figure 2. The hierarchical classification and associated environmental characteristics of the nine plant communities identified within the *Eragrostis plana*-*Agrostis lachnantha* wetlands.

2. Leucosidea sericea-Schizostylis coccinea Wetland of rocky mountainous areas

This wetland community is associated with streamlets in mountainous regions (terrain unit 5) (Figure 3). At various places in the beds of streamlets, soil is present, but the prominent substrate, however, being rocks (larger than 500 mm in diameter) and gravel (Figure 2). The streamlets encountered were all flowing steadily, although in some cases water was only trickling over the rocks. These streamlets are generally surrounded by relatively steep slopes. The vegetation found here is principally dominated by trees, varying in height from 2m to 5 m, and shrubs. Few grass species are found underneath the trees, the most prominent being Eragrostis plana and E. curvula (species group I), Paspalum dilatatum, Andropogon appendiculatus and Bromus catharticus (species group G). The diagnostic species include amongst several others the dominant woody trees Leucosidea sericea and Rhus pyroides, as well as the rare perennial forb Schizostylis coccinea (species group B, Table 1). This community is characterized by an exceptionally high species diversity compared to the other wetland communities, with an average number of 29 species recorded per sample plot. The species richness can be ascribed to the presence of a large number of forb species, particularly those occurring in species groups B and G.

3. Fuirena pubescens-Mariscus congestus Streambeds

Certain species of this community are either growing in water or occur directly adjacent to open or flowing water (terrain unit 5) (Figures 2 & 3). These seasonal watercourses are normally flowing during the rainy season. The trampling effect of livestock often results in exposed areas along the watercourses and deep footprints in the mud. The soils of the area include the vertic Arcadia or alluvial Dundee Forms, whilst rocks and alluvium occur on a limited scale. The clay percentage of the soils varies from 20% to more than 35%.

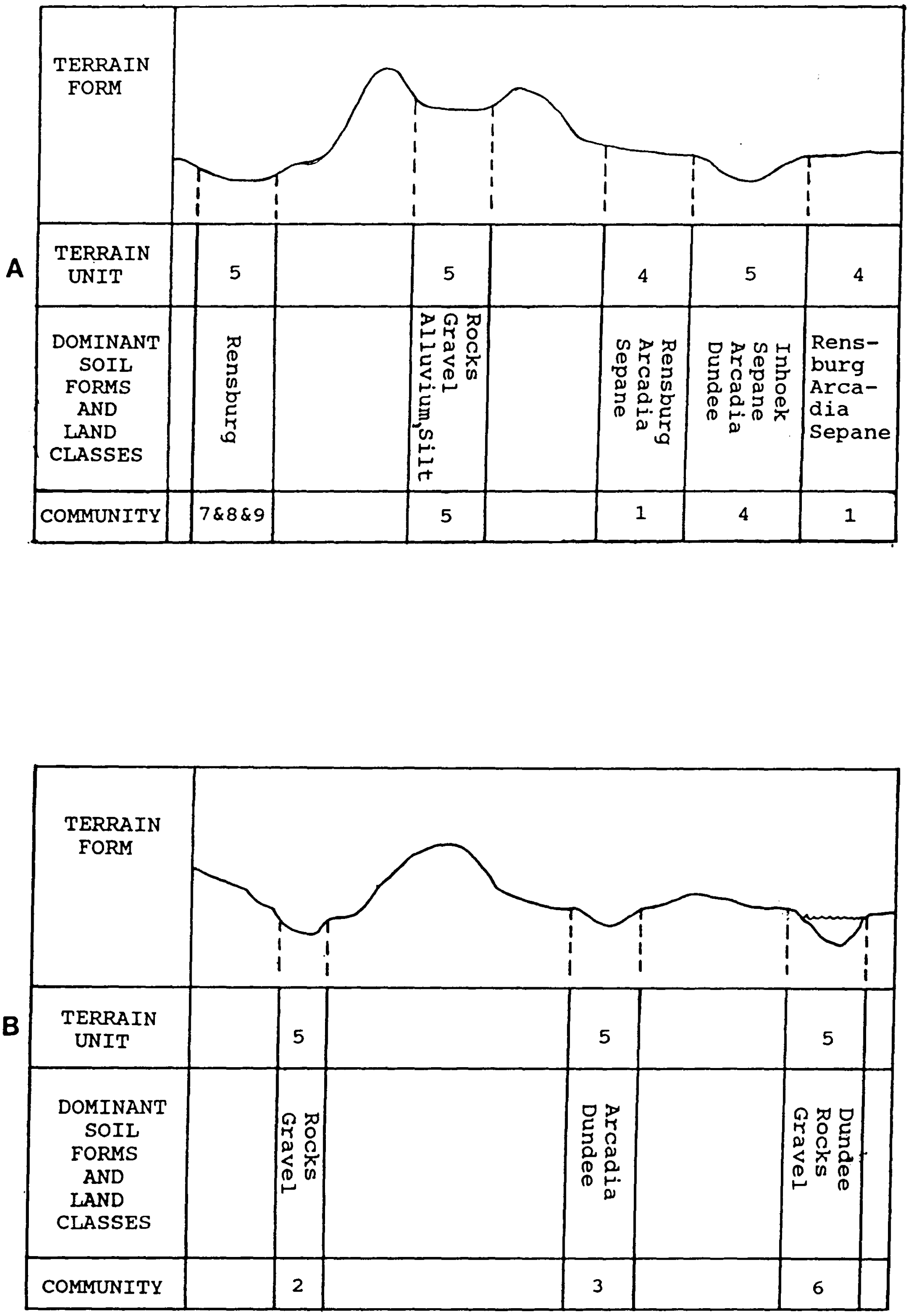

Figure 3. Schematic illustration of the distribution of the plant communities identified within the *Eragrostis plana*-*Agrostis lachnantha* wetlands.

This community is characterized by species group C, while species from species groups F, G, H and I are often present (Table 1). The diagnostic species include amongst others the hygrophytic Fuirena pubescens, Juncus punctorius, and Gunnera perpensa (species group C). Other prominent species include the sedge Mariscus congestus (species group G), the grass Eragrostis plana and the common reed Phragmites australis (species group I), which occurs in patchy clumps, scattered along the watercourses (Table 1). An average number of 17 species was recorded per sample plot.

4. Berkheya pinnatifida-Eragrostis plana Streambeds

This wetland is environmentally very similar to the Fuirena pubescens-Mariscus congestus Streambeds (community 3). The soils are principally similar although the Inhoek and Sepane Forms are also encountered here (Figure 3). Soil depth varies from 300 to 500 mm, and clay contents generally exceed 35%. Alluvium, silt, gravel and rocks can be observed at many localities, sometimes replacing the deep, clayey soils mentioned above.

The diagnostic species include amongst others the perennial forbs Berkheya pinnatifida, Oenothera rosea and the hygrophyte Juncus effusus (species group D). This community is related to the Fuirena pubescens-Mariscus congestus Streambeds by the presence of species group F, but is, besides the diagnostic species, also distinguished from the same by the presence of species group J (Table 1). The loosely tufted annual Agrostis lachnantha and the tufted perennials Paspalum dilatatum (species group G), Eragrostis plana and E. curvula (species group I), and the annual weedy forb Conyza bonariensis (species group J) are other prominent and often dominant species (Table 1). Species group J is characterized mainly by the presence of species indicative of wetter conditions. An average number of 22 species was recorded per sample plot.

5. Hyparrhenia dregeana-Agrostis lachnantha Streambeds

The habitat of the streambeds occupied by this community are not clearly distinguishable from those of communities 3 and 4. The vertic Arcadia and Rensburg Soil Forms are less prominent, being replaced by rocks, gravel, alluvium and silt (Figure 3). However, where these two soil forms are encountered, clay contents and soil depth are similar to those described for communities 3 and 4. The streams concerned are characterized in most cases by pools of standing water and occasionally by slowly flowing water.

This community is characterized by the diagnostic species group E. This group consists of species with low constancy values, including amongst others the robust, tall perennial Hyparrhenia dregeana, the hygrophyte Pycreus betschuanus and the evergreen, perennial shrub Gomphostigma virgatum. Other prominent and often dominant species include the graminoid Agrostis lachnantha, the sedge Mariscus congestus (species group G), the grass Eragrostis plana (species group I) and the weedy forb Conyza bonariensis (species group J) (Table 1). This community is related to the Fuirena pubescens-Mariscus congestus and Berkheya pinnatifida-Eragrostis plana Streambed communities by the presence of species group F (Table 1). Species of species groups G to J are often present. An average number of 23 species was recorded per sample plot.

6. Eragrostis curvula-Cyperus fastigiatus Riverbanks and streambanks

This community occurs on the banks of perennial rivers and streams characterized by relatively strongly flowing water (Figure 2). These banks consist partly of rocks and gravel, but are generally characterized by the Dundee Soil Form, consisting of stratified alluvium. The soils often reach a depth of more than 500 mm, with clay percentages varying from 15% to 20%. The relatively low clay content in some areas can be ascribed to the occurrences of layers of sand in the alluvium.

This community has no diagnostic species group and is characterized by the presence of widely distributed wetland species of species groups I and J (Table 1). The most conspicuous species include the tufted graminoids *Eragrostis plana* and *E. curvula*, with clumps of the reed *Phragmites australis* (species group I), often encountered growing in the watercourses. Other hygrophytes found in the water include *Cyperus fastigiatus*, *Hemarthria altissima* and *Persicaria attenuata* (species group J) (Table 1). The low species diversity is very noticeable with an average number of only 13 species recorded per sample plot.

7. *Senecio inaequidens*-*Cynodon transvaalensis* Pan Community

This is a transitional community, representing the peripheral zone of the pans where the vegetation of the drier surrounding communities and those found within these pans coincide. This community, however, is clearly visible and can easily be distinguished from the vegetation found deeper in the pans by its structural appearance. The erect vegetation of this community is in direct contrast to the creeping, carpetlike appearance of the vegetation encountered in the central parts of these pans. The typical soil type found here is the deep (> 500 mm), clayey (>35%) vertic Rensburg Form (Figures 2 & 3).

The only diagnostic species is the perennial shrublike forb *Senecio inaequidens* (species group K, Table 1) indicating the disturbed state of the vegetation. The rhizomatous couch grass, *Cynodon transvaalensis* (species group Q), is generally found in pans and may occur in the peripheral and central areas thereof. This community is distinguished from other pan communities by the presence of species group J. An average number of 7 species was recorded per sample plot.

8. Diplachne fusca-Cynodon transvaalensis Pan Community

This community is generally found in the central areas of pans and is the first to be submerged after good rains. The deep (> 500 mm), clayey (> 35%) Rensburg Soil Form is also encountered here, although few scattered rocks do occur (Figures 2 & 3). The trampling effect and grazing pressure exerted on this community by cattle and sheep are clearly recognizable.

The carpetlike appearance of this vegetation can be ascribed to the diagnostic perennial, rhizomatous swamp grass Diplachne fusca (species group L), and the widespread couch grass Cynodon transvaalensis. However, local differences do occur within this community with the procumbent forb Chenopodium sp. (species group M) sometimes covering relatively large areas (Table 1). Noteworthy is the exceptionally low species diversity with an average number of 3 species recorded per sample plot. This is a typical feature of pans, displaying a relatively homogeneous, though unique floristic composition under extreme environmental conditions.

9. Schoenoplectus sp.-Cynodon transvaalensis Pan Community

This community is also found in the central areas of pans and may under certain circumstances overlap slightly with community 8. The deep (> 500 mm), clayey (> 35%) vertic Rensburg Soil Form is encountered throughout these pans.

The only diagnostic species is the perennial hygrophyte Schoenoplectus sp. (species group N). This community is related to the two previously described pan communities by the presence of species group Q, containing a single species i.e. Cynodon transvaalensis (Table 1). Local differences are caused by the annual jungle rice Echinochloa colona (species group O) and a Panicum sp. (species group P), occurring as isolated patches within this pan community. These differences may be the result of the grazing strategy being applied since grazing gradients could clearly be observed. Again, the number of species recorded per sample plot was very low, ranging from 3 to 10 species. The wet conditions prevailing in the pans are probably causing the low species d·"ersity, being generally dominated by only a few species.

Ordination

The distribution of the relevés along the first and second axes of the ordination is presented in Figure 4. A clear separation of relevés on the first axis can be observed, following a moisture gradient. The three distinguishable groups cannot solely be ascribed to a single factor, but are the result of a combination of environmental variables. The occurrence of the first group (I) to the far left of the diagram can be explained by rocky conditions and a relatively high plant species diversity. The separation of this group from the intermediate group (II) can mainly be ascribed to the floristic composition, with the first group characterized by woody species. Although community 1 is found under drier conditions than the rest of the communities, the position of the former on the diagram can be ascribed to the soil type and soil depth it represents. The intermediate group (II) represents wet conditions with the substrate varying from rocks and gravel to deeper (300-500 mm) soils. A slightly lower species diversity is encountered here compared to that of the first group. The pan communities (III) to the far right of the diagram are clearly distinguished from the first two groups by the wetter prevailing conditions, deep (> 500 mm), clayey (> 35%) vertic soils and the extremely low species diversity encountered there. The first group represents the Leucosidea sericea-Schizostylis coccinea Wetland, and the second group represents communities 1, 3, 4, 5 and 6. The second axis could not be associated with any environmental variable to interpret the communities.

Seekoeivlei

The Seekoeivlei wetland habitat covers a large area, stretching from Memel northward up to the Transvaal border (20 km) and varying in width from 200 to 1 000 m (Land Type Survey Staff 1984). The Klip River is the main drainage line flowing through the vlei and is joined by several smaller non-perennial tributaries to join the Vaal River in the north. The riverbed may be as deep as 2 m at some places. Flooding of the vlei by the river can only take place after substantial rains. During the years of average rainfall the vlei is usually supplemented by run-off water. Under the present drought conditions, the only available water in the entire vlei is the standing pools in the river, directly north of Memel. Unfortunately, drainage of the vlei, annual burning and certain inappropriate management practices being applied by farmers (Van der Walt 1992) have also contributed to the large-scale degradation of this unique vlei area. No signs of a previously existing bird paradise (Van der Walt 1992) remained. Although no information exists on the vegetation of the vlei, it can be assumed that floristical changes have occurred since mankind has interfered in this ecosystem. Various parts of the vlei have already been changed into grasslands.

Huge specimens of the exotic tree Salix babylonica are found at various places along the Klip River. Other species found on the riverbanks include the weedy, annual forbs Bidens formosa, Hypochoeris radicata, Tagetes minuta and the exotic grass Pennisetum clandestinum, and also the indigenous grass species Bromus catharticus and Eragrostis planiculmis. Lower-lying areas are usually covered by dense stands of Phragmites australis and various Cyperus species, with the grass Echinochloa colona and the forb Conyza podocephala also present. Soils are the margalithic Arcadia, Rensburg and Champagne Forms, with the latter containing much organic material, indicating the biological productivity that must have taken place under wetter conditions.

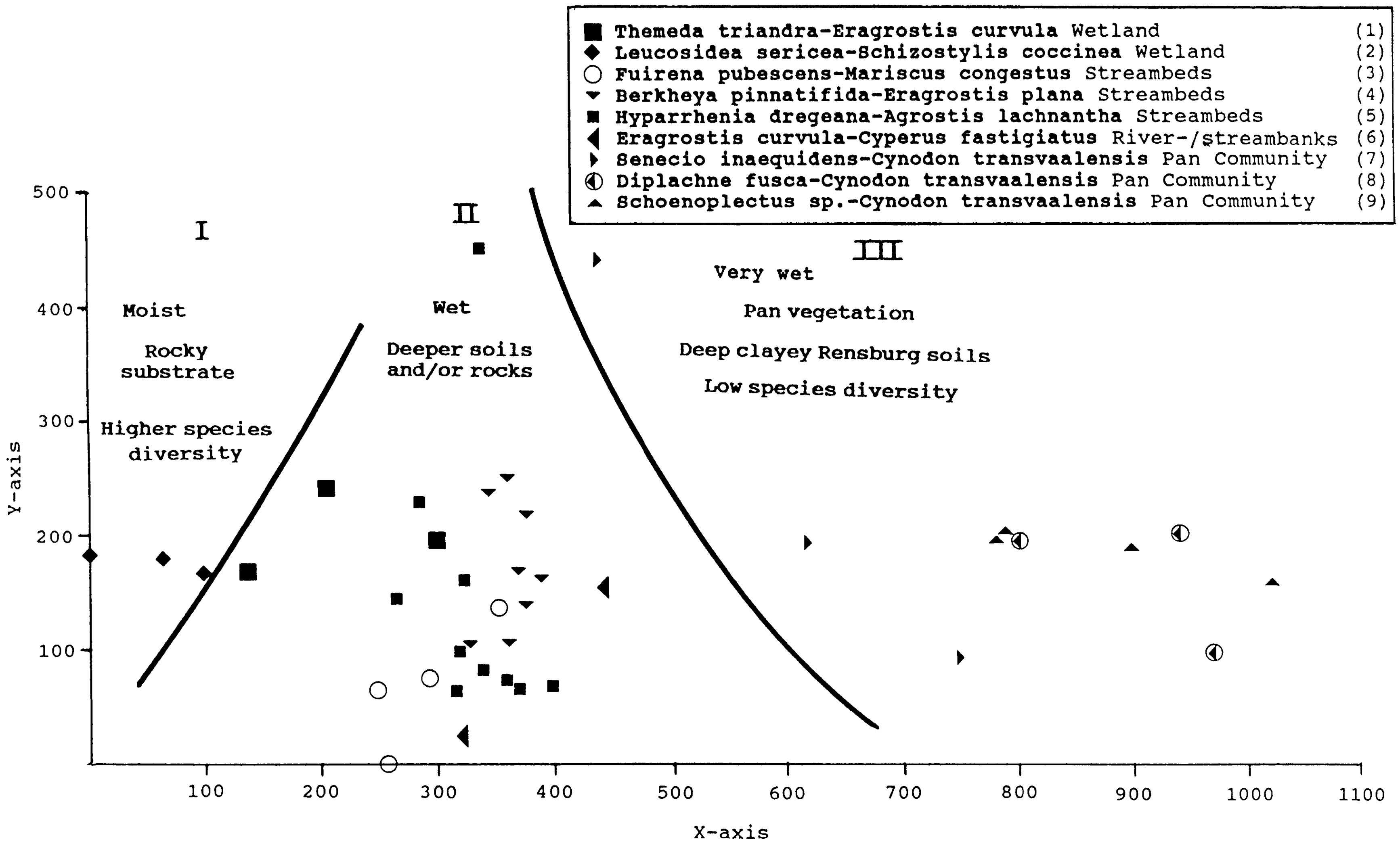

Figure 4. The DECORANA ordination of the wetland vegetation.

Higher-lying areas are mostly covered by grasses such as Eragrostis planiculmis, E. curvula, Cynodon sp. and forbs such as Rumex lanceolatus, Commelina africana and various Cyperus species. Areas in a seemingly more preserved state comprise species such as Phragmites australis, Eragrostis planiculmis, Andropogon appendiculatus, Panicum coloratum, various Cyperus species, Gladiolus eliottii, Helichrysum melanacme, Oenothera rosea, Hypoxis acuminata and Cephalaria pungens.

Detailed surveys during years of average to higher rainfall should reveal a clear picture of the floristic composition and the various plant communities to be found in the Seekoeivlei. It must be stressed, however, that without at least partial withdrawal of livestock and burning practices according to an ecologically based veld management plan, to enable recovery of the vegetation, plant surveys will not be successfull. The declaration of all the farms covered by the vlei as conservation areas, could be an efficient long-term solution for the restoration and preservation of this vlei. Negotiations between the Orange Free State Nature Conservation Branch and farmers are in progress to acquire more land and to establish a conservancy in the catchment area of the Klip River (Du Preez pers. comm.[1]).

CONCLUDING REMARKS

The nine plant communities identified within the wetlands are not strictly related to a specific environmental variable, but are rather the product of a combination of variables such as soil moisture, soil type and depth, clay contents and topography. However, the important role played by soil moisture is often clearly reflected by the type of vegetation occurring in a certain area. Although distinct, and characterized by diagnostic species groups, communities 3, 4 and 5 are floristically and

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ecologically related, as shown by species group F (Table 1) and by the largely similar habitat conditions of the streambeds. It is often found that different plant communities occur apparently under relatively similar conditions. Closer inspection of these conditions, however, reveal some differences in the habitat factors. Although the combination of different factors determines the floristic composition, the influence thereof is often overruled by the type of grazing management applied in a certain area. Furthermore, it should be emphasized that wetland communities are extremely dynamic, influenced by regular flooding, drought, and also by grazing of livestock. This could explain the low plant species diversity and the large number of annual weedy species present in the communities. The rapid changes in environment inhibit the establishment of many perennial species, but many of those that occur here are often unique and do not occur in the surrounding drier ecosystems.

Wetlands are considered as sensitive areas, but with the present management applied to most of these areas the future thereof seems bleak. These vleis contributed to the perennial flow of water in our river systems. However, many perennial rivers have changed now to the status of seasonal rivers and streams. Previously, the wetlands of the north-eastern Orange Free State and particularly the pans and vleis were important feeding grounds for many South African waterbirds (Van der Walt 1992). This picture has changed since and can only be reclaimed if these sensitive areas are managed according to sound ecological principles. This implies inter alia the delimitation of the different wetlands, implementation of ecologically sound veld management programmes, including the partial withdrawal of livestock and veld burning programmes, and the process of drainage being halted.

Further studies of the wetlands should make a contribution to a better understanding of these vital areas. Some information is presently being published on various wetlands in the grassland biome (Kooij 1990; Fuls, Bredenkamp & Van Rooyen 1992; Coetzee, Bredenkamp & Van Rooyen 1993). A phytosociological synthesis of these could create a basis for a first formal syntaxonomy on wetlands in the Grassland Biome of southern Africa.

OPSOMMING

'n Fitososiologiese opname van die vleilande van die Vrede-Memel-Warden-gebied, noordoostelike Oranje-Vrystaat, is uitgevoer. Relevés is in 44 gestratifiëerde ewekansig gekose monsterpersele saamgestel. 'n Voorlopige klassifikasie van die plantegroei met behulp van 'n TWINSPAN-analise is verder deur middel van Braun-Blanquetprosedures verfyn. Nege plantgemeenskappe is onderskei en hiërargies geklassifiseer, beskryf en ekologies geïnterpreteer. 'n Algemene beskrywing van die plantegroei van Seekoeivlei word ook gegee.

ACKNOWLEDGEMENTS

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CHAPTER 9

The conservation status of certain areas within the north-eastern Orange Free State

Introduction

The Grassland Biome is the third largest of the seven recognized biomes of southern Africa south of the 22^{o} S latitude, covering an area of about 343 216 km^2 or 16,5% of the subcontinent (Rutherford & Westfall 1986). Yet, this biome contains the greatest concentration of urban areas in southern Africa, including the large Pretoria-Witwatersrand-Vereeniging complex and smaller centres such as Pietermaritzburg and Bloemfontein. Furthermore, the Grassland Biome is the most important agricultural region regarding the production of beef, dairy, wool, timber and various important crops such as maize, sunflowers, wheat and sorghum (Mentis & Huntley 1982; Rutherford & Westfall 1986). The main economic mineral reserves found in this biome are gold, coal, diamonds, uranium and aluminium. Subsequently, large mining areas have been established in various parts of the grassland over the years.

Considering all the above-mentioned activities found in the Grassland Biome, it is clear that this biome is highly exploited. According to Edwards (1972), the land use pattern in the whole of South Africa was the following: urban areas cover 1,7%, nature reserves 2,4%, agriculture and forestry 86,7% and miscellaneous 9,1%. It is estimated that only 15% of the area of South Africa is available for cultivation with the arable area today nearing 13% (Edwards & Booysen 1972). This is an old estimation and it can be assumed that since then considerable changes have taken place. All reserves, including national parks, provincial nature reserves and wilderness areas, but excluding privately owned areas, account for 5,8% of the total surface area of southern Africa (Siegfried 1989). This figure is still far below the 10%, recommended by the IUCN (Anon. 1980). However, this is a relative figure and cannot be strictly applied to any country. In this respect, the 10% figure will have to be adjusted to suit the different environmental conditions of each and every country. Concern about the status of various habitats, plant communities and individual plant and animal species has prompted the Department of Environment Affairs to investigate the need and priority for conserving not only ecological sensitive areas, and certain areas displaying some kind of uniqueness and integrity, but also areas representative of typical grassland.

This chapter aims at identifying areas with a conservation potential. A discussion of such selected areas will be given, including motivations for the selection thereof.

Methods

The vegetation data of sample plots surveyed during the summer months of 1991 and 1991/1992 are used to identify potential areas for possible inclusion in the South African Natural Heritage Programme (Department of Environment Affairs n.d.) or other conservation strategies. At the time of the field surveys, attention was also given to the general condition of the veld. Further aspects which are taken into consideration are scenic values of specific areas, vegetation cover and plant species composition. The latter term includes species diversity and may also give an indication of rare species present in the areas concerned. Species richness is defined as the number of species present in an area within a community. Species diversity is expressed in terms of species richness and species evenness with the latter indicating the distribution of individuals among the species (Barbour, Burk & Pitts 1987). Biologically, diversity is the measure of population heterogeneity of a community. It must be stressed that veld in good condition often displays a relatively low diversity even though an increase in species richness is observed. This is due to the dominating effect of a few species, limiting the expansion of inferior species.

Although there were many areas in a good state of health or apparently representing undisturbed grassland, these were usually too small to ensure the viability and long-term survival thereof. These areas are not dealt with in this chapter. Only relatively large areas which could possibly be granted conservation status are indicated on the map (Figure 1). Due to the scale on which the vegetation surveys were conducted, the exact sizes of the relevant areas to be conserved are not indicated on the map. The ultimate sizes of such denoted areas can only be determined after more detailed studies of these areas.

A list of species declared as `protected plants' (Ordinances and Regulations of the Province of the Orange Free State 1971), is presented in Table 1.

Scientific names of taxa follow Gibbs Russell et al. (1985, 1987) and De Wet et al. (1989, 1990, 1991).

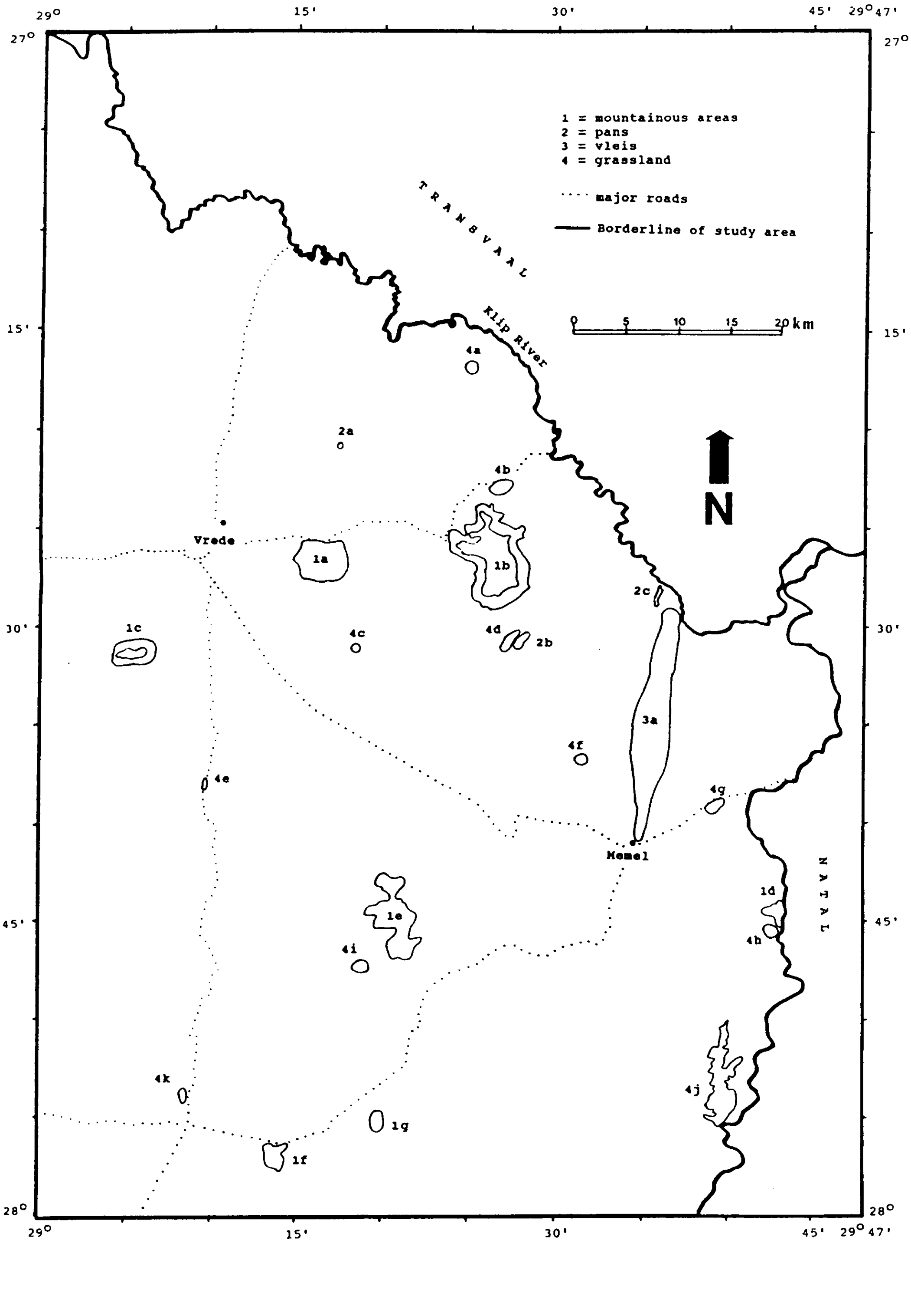

Figure 1. Map to indicate the different areas with a conservation potential. 1:a-g = mountainous areas; 2:a-c = pans; 3:a = vleis; 4:a-k = grassland.

Results and discussion

The areas to be considered for conservation are divided into four groups, namely the mountainous areas, pans, vleis and grassland.
The mountainous areas include crests and slopes of large, isolated koppies and mountains. Seven of these areas are identified for possible conservation and may to a great extent represent the vegetation types found throughout the mountain regions.
Although several pans occur in the study area, some of them are very small (100 m in diameter) and severely disturbed by grazing and trampling. Only three pans are proposed for conservation purposes. These three pans are of the largest (> 300 m in diameter) ones encountered in the study area and are better preserved than the smaller pans.
Only one vlei (Seekoeivlei) is identified as having high conservation priority and this needs urgent attention (see also Eckhardt et al. 1993a).
A total of eleven grassland areas is indicated on the map (Figure 1) which should be considered as potential conservation areas.

Classification

A classification of the areas is as follows:

1. Mountainous areas
   - 1a Rondehoekberg
   - 1b Gemsbokberg
   - 1c Bothasberge
   - 1d Kranskop
   - 1e Witkoppenberge
   - 1f Tafelkop
   - 1g Slopes at Farm Rusdal

2. Pans on the following farms:
   2a Judithslaagte
   2b Johanna
   2c Waaihoek

3. Vleis
   3a Seekoeivlei

4. Grasslands on the following farms:
   4a Langspruit
   4b Eksteensrust
   4c Onswoning
   4d Johanna
   4e Langverwag
   4f Goeiehoop
   4g Franshoek
   4h Maria
   4i Hermitage
   4j Welgelukt (Ad land type)
   4k Mooiplaas

Discussion of the areas

1. Mountainous areas

The mountainous areas are representative of the mountains found throughout the north-eastern Orange Free State. Isolated mesas (= flat-topped koppies/mountains) and butte (= conical hills) (Harmse 1983) occur in groups or are widely scattered on the flat to moderately undulating plains. The occurrence of such topographical shapes can be ascribed to the hard sedimentary sandstone and shale layers and/or vulcanic dolerite intrusions. Vertical rock cliffs are therefore frequently observed and display little or no vegetation cover. The vegetation is limited to the lower-lying parts of the slopes and is extremely dense in the ravines.

Nine plant communities were identified in the thicket and woodland vegetation of the slopes (Eckhardt *et al*. 1993b). These communities are dominated by shrub and tree specimens of *Leucosidea sericea* and various forb species adapted to shady conditions. Three grassland communities were identified which are exclusively restricted to slopes (Eckhardt *et al*. 1993c). Certain grassland communities of the plains and summits were also found on the slopes to a limited degree.

Each community with its own species composition and habitat factors represents a specific ecosystem. If survival of rare species in nature is to be ensured, it is important to conserve entire ecosystems rather than trying to protect individual species. The grassland communities of the slopes contain the highest percentage of protected species (Ordinances and Regulations of the Province of the Orange Free State 1971) found in the entire study area. Such plant species include *Zantedeschia albomaculata*, *Kniphofia linearifolia*, *Aloe greatheadii*, *A*. *ecklonis*, *Agapanthus campanulatus*, *Scilla nervosa*, *Eucomis autumnalis*, *Haemanthus humile*, *Dioscorea sylvatica*, *D*. *retusa*, *Schizostylis coccinea*, *Dierama medium*, *Gladiolus crassifolius*, *G*. *elliotii*, *G*. *sericeo-villosus*, *Gladiolus* sp., *E*. *clavaroides*, *Cussonia paniculata*, *Helichrysum adenocarpum*, *Helichrysum albo-brunneum*, *Helichrysum aureum* and *Helichrysum monticola* (Table 1). Most of the protected species encountered in the study area are limited to the mountainous areas. According to Hall *et al.* (1980), none of the above-mentioned species are classified into any one of the conservation status categories. Some of the species, however, listed by Hall *et al.* (1980) as being threatened, belong to the same genus of several of the above-listed species. It is important to note that little information exists presently on the conservation status of species of the Orange Free State. However, investigations into this aspect are in progress (Du Preez pers. comm.[1]). Concomitant with these investigations, special attention should also be given to endemism with the objective of identifying centres particularly rich in endemic species (see also Matthews et al. 1993). The mountainous areas represent centres of high species richness due to the heterogeneity in habitats. An average number of 32 species was recorded per sample plot.

Grey rhebok Pelea capreolus (Skinner & Smithers 1990) are very often found in mountainous areas. These antelopes are usually seen in small groups consisting of three to seven individuals. To protect these animals, it is inevitable to conserve their habitat.

The flat-topped koppie, marked 1f in Figure 1, needs to be mentioned (see also Eckhardt et al. 1993b). The crest of this koppie is the only area encountered to be in a pristine condition, which can be ascribed to the inaccessibility of this mesa. The vegetation is classified as Elionurus muticus-Themeda triandra Grassland which is a common community. The species richness of this mesa is relatively high but the diversity is somewhat lower due to a low value in species evenness. Due to similar habitat conditions prevailing on the Witkoppenberge (area 1e, Figure 1), it can be assumed that the vegetation on the latter mountains and those on the mesa were related in earlier times. Overgrazing and trampling by livestock have drastically changed the species composition of the Witkoppenberge since.

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Table 1. List of protected plant species and their families encountered in the study area (Ordinances and Regulations of the Province of the Orange Free State 1971). Names are updated according to Gibbs Russell et al. (1985, 1987) and De Wet et al. (1989, 1990, 1991).

Family	Species
MONOCOTYLEDONAE	
Araceae	Zantedeschia albomaculata (Hook.) Baill. ssp. albomaculata
Liliaceae	Kniphofia linearifolia Bak.
Liliaceae	Aloe greatheadii Schonl. var. davyana (Schonl.) Glen & Hardy
Liliaceae	Aloe ecklonis Salm-Dyck
Liliaceae	Aloe transvaalensis Kuntze
Liliaceae	Agapanthus campanulatus Leighton ssp. campanulatus
Liliaceae	Scilla nervosa (Burch.) Jessop
Liliaceae	Eucomis autumnalis (Mill.) Chitt. ssp. clavata (Bak.) Reyneke
Amaryllidaceae	Haemanthus humilis Jacq. ssp. humilis
Amaryllidaceae	Boophane disticha (L.F.) Herb.
Amaryllidaceae	Nerine angustifolia (Bak.) Bak.
Amaryllidaceae	Crinum bulbispermum (Burm. F.) Milne-Redh. & Schweick.
Dioscoreaceae	Dioscorea retusa Mast.
Dioscoreaceae	Dioscorea sylvatica (Kunth.) Eckl. var. sylvatica
Iridaceae	Schizostylis coccinea Backh. & Harv.
Iridaceae	Dierama medium N.E. Br. var. medium
Iridaceae	Gladiolus crassifolius Bak.
Iridaceae	Gladiolus elliotii Bak.
Iridaceae	Gladiolus sericeo-villosus Hook. f. forma sericeo-villosus
Iridaceae	Gladiolus sp.
DICOTYLEDONAE	
Fabaceae	Erythrina zeyheri Harv.
Euphorbiaceae	Euphorbia clavaroides Boiss. var. clavaroides
Araliaceae	Cussonia paniculata Eckl. & Zeyh.
Asteraceae	Helichrysum adenocarpum DC. ssp. adenocarpum
Asteraceae	Helichrysum albo-brunneum S. Moore
Asteraceae	Helichrysum aureum (Houtt.) Merr. var. monocephalum (DC.) Hilliard
Asteraceae	Helichrysum monticola Hilliard

2. Pans

From the various pans found in the study area, three pans (2a,b & c, Figure 1) have been identified for possible conservation (Figure 1). These are the largest of all the pans in the area and usually contain water for most of the year. Due to the prevailing drought in that part of the country, all the smaller pans dried up after the rainy season. It seems that these larger pans have a bigger vitality and therefore display a more natural vegetation cover. Noble & Hemens (1978) distinguished between six different types of pans which will not be discussed here. According to this classification system, the three pans mentioned above can be classified as grass pans. This means these pans are seasonal and dry up in the dry winter season except for a few perennial pools. The water is fresh and rich in nutrients during summer and may become slightly brackish in winter (Noble & Hemens 1978). The location of these larger pans with respect to the surrounding environment may play a crucial role in determining the condition of the pans. Pans with larger drainage areas tend to be holding water for longer periods of the year. These pans usually display a well-developed grass layer, which is dominated by a few species only.

Three different pan communities were distinguished, with the couch grass Cynodon transvaalensis as predominating species. These communities are restricted to the pans and are found nowhere else. Another prominent species is the halophytic swamp grass Diplachne fusca which is sometimes found along standing water pools (see also Eckhardt et al. 1993a). The limited number of species encountered in the pans is due to extreme prevailing conditions. The uniqueness of these pans can thus be ascribed to the harshness prevailing within the pans as well as the few species adapted to such environmental conditions. The flora of the pans attracts various insects and is also a source of nutrients for other small creatures like phyllopods, which in turn fall prey to various wading birds and other aquatic birds. These pans are often used by crowned cranes Balearica regulorum and blue cranes Anthropoides paradisea (Newman 1988) as places where they flock together. The drastic decline in the number of these majestic birds can mainly be ascribed to the destruction of their natural habitats, including pans, as well as the use of poison by the agricultural sector in the treatment of grain seed.

Due to the higher grazing capacity of pans with the vegetation being available and acceptable for longer periods of the year, farmers tend to overutilize these sensitive areas without realizing what irreparable damage they cause. Destruction of vegetation, compaction of soils and subsequent disturbance in the floral and faunal components on microscopical level are some of the results caused by overutilization.

3. Vleis

The single most important vlei in the whole study area which needs special conservation status is the well-known Seekoeivlei (area 3a, Figure 1) north of Memel. This vlei has been described by Eckhardt et al. (1993a) and will therefore not be discussed here in detail. It is a floodplain vlei (Noble & Hemens 1978), comprising the riverine area of the Klip River and a grassy floodplain on either side. The riverine area can be described as a reedbed marsh with the water level reaching slightly above soil level in the wet season. Due to the drought period of the past ten years, and especially the last two years (1990-1992), the Klip River has ceased to flow. The last flooding of the vlei took place two years ago, but all surface water has since disappeared.

No in depth studies have been conducted on the Seekoeivlei up to the present stage. A few sample surveyed directly north of Memel, give a superficial impression of the vegetation encountered in the vlei (Smit 1992). Two plant communities were distinguished, representing outer and inner zone vegetation respectively. Unfortunately, drainage of the vlei, annual burning and certain inappropriate management practices being applied by farmers (Van der Walt 1992) have also contributed to the large-scale degradation of this unique vlei area. Although various plant species occurring in the vlei, were listed by Eckhardt et al. (1993a), conditions in the vlei itself were not suitable to allow a classification of the vegetation. Protected species include *Nerine angustifolia*, *Crinum bulbispermum* and *Gladiolus crassifolius* (Table 1). Heavy utilization by livestock and frequent burning of the vegetation could lead to the disappearance of these species from the vlei.

During wetter years, waterfowl were abundant and even crowned cranes and blue cranes could be seen here (Van der Walt 1992). Compilation of a complete bird list for the vlei could possibly reveal scarcer species in need of protection.

If one considers the important functional role this vlei plays in the ecology of the area as well as the tourism potential it helds, this vlei should be ranked high on the priority list of areas in need of conservation. This vlei has not only a locally role to fulfil, but also plays a regulatory role in determining the quality and quantity of water carried off by the Vaal River and discharged ultimately into the Vaal Dam. This dam serves as a storage to supply water to the Pretoria-Witwatersrand-Vereeniging area.

4. Grassland

Eleven grassland areas have been identified (Figure 1), on the criteria of species composition and basal cover. These areas represent 10 different plant communities with most of them closely related to each other. The most important and conspicuous species is Themeda triandra, a highly palatable grass and very abundant in undisturbed climax grassland or well-managed veld (Van Oudtshoorn 1991). The eleven grassland areas were selected because it appears that they represent typical examples of "natural and relatively undisturbed" grassland. These areas display a relatively dense vegetation cover, mainly dominated by Themeda triandra. Although signs of utilization are visible, these are proof of ecologically sound management. Although well-preserved grassland may display a high species richness, the diversity is usually low due to the dominating effect of a few species such as Themeda triandra. In this study it was found however, that well-preserved grassland rather displayed a low species richness with an average number of 21 species per sample plot. Hemicryptophytes of the Poaceae are the characteristic life form of the Grassland Biome and tend to dominate other life forms (Rutherford & Westfall 1986).

The only protected plant species encountered in the grassland, were Boophane disticha, Erythrina zeyheri and various Helichrysum species (Table 1). There is a possibility that other protected species also occur in the grassland but were just not encountered during this survey.

The Botha's lark Spizocorys fringillaris is restricted to a small area of the Grassland Biome, which includes the moist grasslands of the north-eastern Orange Free State and south-eastern Transvaal (Brooke 1984; Newman 1988). The total population is estimated at 1 500 to 5 000 birds with less than 100 occurring in nature reserves (Siegfried 1992). The fact that breeding populations of the Botha's lark, blue crane, bald ibis Geronticus calvus and other birds, restricted to the grassland, are represented by less than 500 individuals in nature reserves, emphasizes the need that more areas within the Grassland Biome should be added to the South African nature reserve system (Siegfried 1992).

The grasslands and more specifically those of the north-eastern Orange Free State, the western parts of Natal and south-eastern Transvaal are home to the vulnerable giant girdled lizard, also called sungazer Cordylus giganteus (Van Wyk 1988). Although no occurrences of this lizard have as yet been recorded in the study area, there is always the possibility of undetected populations occurring somewhere in the area.

The area marked 4j (Figure 1) has been selected due to the limited occurrence of the land type Ad it represents within the study area. Although this land type is also found east of the escarpment, it occurs only on limited scale (Land Type Survey Staff 1984). This area represents typical short grassland on freely drained yellow soils (Land Type Survey Staff 1984) and displays a well-developed vegetation cover (Eckhardt et al. 1993c). This land type is only used for grazing purposes which confirms the statement made by Smit (1992) that this land type is almost inaccessible and totally undeveloped.

Concluding remarks

From Figure 1 it can be seen that altogether 22 areas were identified for possible conservation. These areas represent nine thicket and woodland communities and three grassland communities restricted to the slopes of mountainous areas, three pan communities, ten grassland communities of the flat and undulating

plains, and the Seekoeivlei ecosystem. It is important to note that these are potential conservation areas to be considered as South African Natural Heritage Sites.
Various criteria are to be considered before an area can be registered as a Heritage Site (Department of Environment Affairs n.d.). Therefore, more detailed ecological studies might be required to establish the need and priority for conserving these areas. The identified areas are selected only with reference to the north-eastern Orange Free State. Similar areas are likely to occur outside the study area as well.

Species composition of plant communities and habitat characteristics, were used as critera for identifying areas for conservational purposes. The approach followed by Ematek/CSIR, to determine vegetation conservation importance, is based on four criteria, namely rarity of community type, species richness, and the status of threatened and endemic species (Anon. 1993).
It is clear that plant communities are dynamic and may display changes in species composition. This may complicate the process of identifying conservation areas. However, grassland areas in good condition will not deteriorate during seasonal dry periods if excluded from grazing (Fuls & Bosch 1991). Heavily utilized grassland on the contrary, characterized by low ecological status species, will not be prevented from degradation if rested during a year of below-average rainfall. Veld in good condition is usually characterized by a high basal cover of high ecological status species. The resilience and stability of these species largely contribute to an increase in basal cover even during low and erratic rainfall, but only if excluded from grazing (Fuls & Bosch 1991). Years of below-average rainfall will therefore affect poor grassland more adversely than well-preserved grassland. This emphasizes the need of ecological sound management and veld resting especially during dry periods.

It was not possible at this stage to estimate the conservation value of the various plant communities in the study area. Although certain communities might be very restricted in their distribution, they could possibly be abundant in other parts of the north-eastern Orange Free State (see also Du Preez 1991). A phytosociological synthesis of the grasslands of the Orange Free State should most certainly reveal the scarcity of any specific community so that the conservation status (Hall et al. 1980) of such plant communities can be determined.

It is clear from the description of the various areas that the highest concentration of protected plant species is to be found in the mountainous areas. It can be assumed that most of the rarer species listed by Hall et al. (1980) will also occur in these areas. To protect these species, it is inevitable to conserve the mountainous areas which serve also as core areas of high species diversity. In contrast to the mountainous habitats the grassland communities display a generally lower species diversity. This does not implicate, however, that pristine grassland is floristically poor. In fact, grasslands are often more rich in endemic species than is Afromontane forest (Matthews et al. 1993). It is tragical enough that exactly grassland ecosystems, which are so threatened by ploughing and urban development, are considered as of little value. The free availability of grasslands for urban development and agricultural uses makes them very vulnerable. Only 1,12% of the Grassland Biome is conserved compared to the 8,5% of the Savanna and 16,69% of the Fynbos Biome (Rutherford & Westfall 1986). The two largest conserved areas are the Mkhomazi Wilderness Area and Giant's Castle Game Reserve, encompassing an area of 486 km^2 and 346 km^2 respectively. According to Siegfried (1989), it might be necessary to alter the existing system of nature reserves in order to conserve plant and animal associations that are under-represented in the current system. The imbalance in the distribution of nature reserves is confirmed by figures mentioned earlier, with the Grassland and Karoo Biomes represented relatively poorly. The protection of species-rich areas is considered as "the most efficient and cost-effective way to retain maximum biological diversity in the minimal area" (Scott et al. 1987). It is therefore considered uneconomical to protect large areas of low diversity if relatively smaller areas, representing maximum biological diversity, can be conserved instead.

It is not necessary to conserve large areas of grassland to halt the advancement of the Nama-Karoo into the Grassland Biome. Judicious management, based on ecological principles, could hamper the expansion of the Nama-Karoo, thereby safeguarding the Grassland Biome.

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CHAPTER 10

An analysis of the flora of the north-eastern Orange Free State

Introduction

The Grassland Biome is one of seven recognized biomes found in southern Africa (Rutherford & Westfall 1986). Hemicryptophytes of the Poaceae dominate the vegetation of this biome to such an extent that the entire Grassland Biome is described as being monolithic. Closer inspection via plant surveys, however, reveal a different picture, with many forb species actually present but hidden by the predominant grass layer. Indeed, grasslands are often characterized by a high species richness with many species endemic to it (see also Matthews et al. 1993). Fortunately, invasion by alien plant species is more restricted to water courses. Climatic conditions largely reduce the probability of exotic woody species invading the Grassland Biome. Abandoned fields are ideal places for exotic herbs to get established from where these can disperse into adjacent disturbed areas.
Many of the listed plants (Appendix 1), comprising mainly forbs as well as woody species, are especially derived from steep slopes and ravines, which are areas with a high species richness.

Methods

Specimens of all the species listed in Appendix 1 were collected during vegetation surveys from February to March of the years 1991 and 1992. Although some of the specimens were identified in the H.G.W.J. Schweickerdt Herbarium (PRU), most of them had to be identified by the National Botanic Institute in Pretoria.

The species list compiled follows Gibbs Russell et al. (1985 & 1987). The nomenclature and author names conform to that of Gibbs Russell et al. (1985 & 1987) and De Wet et al. (1989, 1990 & 1991). Plant species are arranged in alphabetical order within each genus. Naturalized exotic species (Gibbs Russell et al. 1985 & 1987), declared weeds and alien invader plants (Henderson et al. 1987) are marked with an asterisk (*) in Appendix 1 .

The relationships between the numbers of families, genera and species of the Pteridophyta, Monocotyledonae and Dicotyledonae are indicated in Table 1. A comparison of the flora of five different areas in the Grassland Biome is given in Table 2. In Table 3 the families with 10 and more species are indicated, while the genera with 5 and more species are listed in Table 4. Naturalized exotic species, declared weeds and alien invader plants, and their families are presented in Table 5.

Table 1. The relationship between the number of families, genera and species of the Pteridophyta, Monocotyledonae and Dicotyledonae in the north-eastern Orange Free State.

	Pteridophyta		Monocotyledonae		Dicotyledonae		
	No	% of total	No	% of total	No	% of total	Total
Families	8	10,00%	11	13,75%	61	76,25%	80
Genera	11	3,61%	93	30,49%	201	65,90%	305
Species	15	2,67%	162	28,88%	384	68,45%	561

Table 2. A floristic comparison of the north-eastern Orange Free State with various study areas in the Grassland Biome.

		Number of species							Number of:		
Region	Area (km²)	Pteridophyta		Monocotyledonae		Dicotyledonae		Total	Relevés	Acocks' Veld Types	Plant Communities described
		No	%	No	%	No	%				
North-western OFS (Kooij 1990)	11370	11	0,93	354	29,77	824	69,30	1189	204	4	42
Villiers-Grootvlei (Breytenbach 1991)	700	5	1,37	135	36,99	225	61,64	365	226	3	37
Newcastle-Memel-Chelmsford dam (Smit 1992)	1000	29	3,72	213	27,34	537	68,94	779	282	4	71
South-eastern Tvl Highveld Grasslands (Turner 1989)	1221	6	1,16	176	33,98	336	64,87	518	507	3	31
North-eastern OFS	5600	15	2,67	162	28,88	384	68,45	561	374	6	41

Results and discussion

Altogether 561 species representing 80 families and 305 genera, were recorded for the study area (Appendix 1). Of the total number of species, 29 or 5,2% represent naturalized exotics, declared weeds and alien invaders. These 29 species represent 12 families.

The results in Table 2 clearly indicate the differences in species numbers between the various areas. The size of an area does not closely correlate with the amount of species recorded. The heterogeneity of an area, however, directly affects the number of species, as substantiated by the case of the Newcastle-Memel-Chelmsford Dam area (Smit 1992). The large number of species recorded in the north-western Orange Free State can mainly be ascribed to the heterogeneous Vredefort Dome, with the rest of the study area being relatively homogeneous (Kooij 1990).

The three most strongly represented families are the Asteraceae, Poaceae and Fabaceae (Table 3). This supports the findings of Gibbs Russell (1987) that the three largest families in all biomes are those mentioned above, with the exception of the Poaceae in the Succulent Karoo and Fynbos. The largest family is not the Poaceae, but the Asteraceae which is, however, represented by less genera than the Poaceae. The two genera with the highest number of species are Helichrysum and Senecio (see also Du Preez 1991), followed by Eragrostis and Cyperus (Table 4).

Most of the exotic species are members of the Asteraceae, constituting 9 species or 31% of the total number of exotics (Table 5).

Acknowledgements

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Table 3. Most prominent families represented by 10 and more species.

Family	Genera	Species
Asteraceae	43	109
Poaceae	50	83
Fabaceae	16	39
Cyperaceae	13	29
Liliaceae	13	20
Lamiaceae	9	17
Scrophulariaceae	7	14
Euphorbiaceae	4	11
Rubiaceae	8	10

Table 4. Genera represented by 5 and more species.

Family	Genera	Species
Asteraceae	Helichrysum	26
Asteraceae	Senecio	18
Poaceae	Eragrostis	9
Cyperaceae	Cyperus	9
Fabaceae	Indigofera	8
Hypoxidaceae	Hypoxis	7
Scrophulariaceae	Sutera	7
Poaceae	Digitaria	6
Anacardiaceae	Rhus	6
Asteraceae	Berkheya	6
Fabaceae	Lotononis	5
Fabaceae	Argyrolobium	5
Fabaceae	Rhynchosia	5
Solanaceae	Solanum	5
Asteraceae	Cineraria	5

Table 5. List of naturalized exotics (Gibbs Russell et al. 1985, 1987), declared weeds (*) and alien invader plants (+) (Henderson et al. 1987).

Family		Species
MONOCOTYLEDONAE		
Poaceae		Paspalum dilatatum
Poaceae		Poa annua
Poaceae		Lolium perenne
DICOTYLEDONAE		
Salicaceae		Populus alba
Salicaceae		Salix babylonica
Chenopodiaceae		Chenopodium schraderianum
Amaranthaceae		Amaranthus hybridus
Amaranthaceae		Achyranthes aspera
Rosaceae		Pyracantha angustifolia
Fabaceae	+	Acacia dealbata
Fabaceae		Melilotus indica
Fabaceae		Trifolium pratense
Cactaceae	*	Opuntia ficus-indica
Onagraceae		Oenothera indecora
Onagraceae		Oenothera rosea
Onagraceae		Oenothera tetraptera
Solanaceae		Physalis viscosa
Solanaceae	*	Solanum elaeagnifolium
Solanaceae		Datura stramonium
Plantaginaceae		Plantago lanceolata
Asteraceae		Conyza albida
Asteraceae	*	Xanthium strumarium
Asteraceae		Zinnia peruviana
Asteraceae		Bidens formosa
Asteraceae		Tagetes minuta
Asteraceae	*	Cirsium vulgare
Asteraceae		Hypochoeris radicata
Asteraceae		Tragopogon dubius
Asteraceae		Taraxacum officinale

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CHAPTER 11

GENERAL DISCUSSION

The synecological study of the north-eastern Orange Free State successfully complied with the following main objectives:

- to identify and describe plant communities, and determine vegetation-cum-habitat relations; this coincides with the goals of the Grassland Biome Project (Mentis & Huntley 1982);
- to identify areas suitable for conservation purposes.

The results of this study will contribute to the syntaxonomical synthesis of the grasslands of the Orange Free State.

The application of the Braun-Blanquet method proved to be successfull in the identification, description and ecological interpretation of the various plant communities (see also Bezuidenhout 1988; Bredenkamp et al. 1989; Kooij 1990; Matthews 1991; Smit 1992). It was not always possible to relate the vegetation to certain environmental factors. Indeed, very often the results obtained by DECORANA (Hill 1979a) revealed no clear vegetation gradients. This can possibly be ascribed to the complexity of the interrelationship existing between different habitat factors. However, in most cases where vegetation gradients were observed, these could be associated with the following factors, namely soil type, soil depth, soil moisture and trophic regimes. The distribution of communities on the slopes was however, to a lesser degree determined by these factors. In this case the influence of aspect became more important. Although soils originate from geological formations, no direct relations could be detected between the latter and vegetation distribution.

It has been found that plant communities are not necessarily restricted to certain land types and terrain units. Very often the same plant community was found on different terrain units.

Such examples are the following: the Andropogon appendiculatus-Aristida junciformis Grassland of relatively wet areas is found on terrain units 1, 3 and 4; the Hermannia depressa-Tristachya leucothrix Grassland of relatively dry areas is found on terrain units 1 and 3; the Eragrostis curvula-Themeda triandra Dry Grassland of the flat and undulating plains and the Elionurus muticus-Themeda triandra Grassland of the flat plains are mainly found on terrain unit 1 but may also occur on terrain unit 2 under exceptional cases. The most dominant and common grass species are Themeda triandra, Eragrostis curvula, E. plana, Heteropogon contortus and Aristida junciformis, displaying high cover-abundance values virtually throughout the entire study area. These values are heavily weighted, overruling the importance of subordinate species. The fact that the same communities are often found on different terrain units is due to the high tolerances of the grass species mentioned above.

Altogether 41 plant communities were identified and described. The taxon names allocated to these communities are not formal since this study forms part of an overall syntaxonomic synthesis, and therefore names may change accordingly. The conservation status of these communities still needs to be assessed, but can only be done after a syntaxonomical synthesis of the grasslands of the entire Orange Free State has been completed. Nevertheless, an attempt has been made to identify areas suitable for conservation. This is dealt with under the next heading. The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity appears promising. The grazing capacities calculated for the five different grassland communities compare well to the overall grazing capacity for the north-eastern Orange Free State as recommended by the Resource Section of the Highveld Region (1991). Therefore, scientists should be encouraged to apply this technique more freely and test the reliability thereof.

The identification of conservation areas was conducted on a subjective basis, using species composition and habitat characteristics as criteria. However, the approach followed by Ematek/CSIR, which is based on four criteria (Anon. 1993), makes use of the Geographical Information System (GIS). One of the criteria is species richness, which is a key factor in the identification of conservation areas (Scott et al. 1987; Siegfried 1989). This is a more objective approach which appears to be promising, and the application thereof should therefore be considered for the future.

The results obtained by this study should not be used exclusively by scientists but must reach farmers and land owners too. Management programmes ought to be based on a planning frame work which in turn requires a detailed description of the vegetation. Well-preserved and sensitive areas should be taken into consideration for conservation purposes. Detailed studies on such areas should reveal the type of management to be applied in order to maintain the natural state and functions thereof.

SUMMARY

A synecological study of the vegetation of the north-eastern Orange Free State

by

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The study area is situated in the far north-eastern corner of the Orange Free State, i.e. between 29^{o} 00' and 29^{o} 47' E longitude and 27^{o} 00' and 28^{o} 00' S latitude, bordering on Transvaal and Natal. It covers a total surface area of 5 600 km^{2} and is characterized by a slightly to moderately undulating relief. The geology is relatively homogeneous, with sandstone and mudstone of the Beaufort Group making up more than 80% of the area. Six veld types and six land types are found within the entire study area.

The synecological study of the vegetation of the north-eastern Orange Free State includes the identification, classification and description of plant communities. The recognized vegetation units should serve as an aid in the compilation of ecological sound management programmes. Delimitation of management units should be

in accordance with vegetation units. This study forms part of a syntaxonomical synthesis of the Orange Free State and ultimately of the entire Grassland Biome.

The study area was stratified according to land types and terrain units. A total of 374 sample plots were distributed throughout the area on the basis of stratification units. Floristic and habitat data were recorded at each sample plot, using the Braun-Blanquet cover-abundance scale.

Data processing consisted of a TWINSPAN-classification and subsequent refinement by Braun-Blanquet procedures. The TWINSPAN-classification and subsequent refinement of the data of the Ea land type led to the recognition of nine plant communities. The data set, derived from the remaining two-thirds of the study area, was also subjected to TWINSPAN and refined by Braun-Blanquet procedures. This resulted in the recognition of six major plant communities, which were subsequently divided into four smaller data sets. These sets were again subjected to TWINSPAN and thereafter refined, resulting in the recognition of 32 plant communities which were ecologically interpreted.

The application of Braun-Blanquet data in the assessment of veld condition and grazing capacity was also tested. The Ecological Index Method was used to determine the veld condition and calculate the grazing capacity of five grassland communities within the Ea land type. The grazing capacities obtained compare well with the overall grazing capacity recommended for the north-eastern Orange Free State.

A total of 22 conservation areas were identified and described. These areas were identified on the criteria of species composition and habitat characteristics, and include mountains, grasslands, pans and a vlei.

OPSOMMING

'n Sinekologiese studie van die plantegroei van die noordoostelike Oranje-Vrystaat

deur

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Die studiegebied is in die verre noordoostelike hoek van die Oranje-Vrystaat geleë, dit wil sê tussen 29° 00' en 29° 47' O lengtegraad en 27° 00' en 28° 00' S breedtegraad, en grens teen Transvaal en Natal. Dit beslaan 'n totale oppervlakte van 5 600 km^2 en word gekenmerk deur 'n lig- tot matiggolwende reliëf. Die geologie is relatief homogeen waarvan sandsteen en moddersteen van die Beaufort Groep meer as 80% van die gebied uitmaak. Ses veldtipes en ses landtipes kom binne die hele studiegebied voor.

Die sinekologiese studie van die plantegroei van die noordoostelike Oranje-Vrystaat sluit die identifikasie, klassifisering en beskrywing van plantgemeenskappe in. Die erkende plantegroei-eenhede behoort as 'n hulpmiddel te dien in die samestelling van ekologiesgegronde bestuursprogramme. Afbakening van bestuurs-

eenhede behoort in ooreenstemming te wees met plantegroei-eenhede. Hierdie studie vorm deel van 'n sintaksonomiese sintese van die Oranje-Vrystaat en uiteindelik van die hele Grasveldbioom.

Die studiegebied is volgens landtipes en terreineenhede gestratifiseer. 'n Totaal van 374 persele is oor die hele gebied versprei en is op gestratifiseerde eenhede gebaseer. Floristiese en habitat data is by elke monsterperseel volgens die Braun-Blanquet bedekkings-sterktewaardes aangeteken.

Dataverwerking het uit 'n TWINSPAN-klassifikasie en 'n daaropvolgende verfyning deur middel van Braun-Blanquet-prosedures, bestaan. Die TWINSPAN-klassifikasie en daaropvolgende verfyning van die data van die Ea-landtipe het tot die erkenning van nege plantgemeenskappe gelei. Die datastel, wat afkomstig is van die oorblywende twee derdes van die studiegebied, is ook aan TWINSPAN onderwerp en verfyn deur Braun-Blanquet-prosedures. Dit het gelei tot die erkenning van ses hoofplantgemeenskappe, wat hierna verder verdeel is in vier kleiner datastelle. Hierdie stelle is weereens aan TWINSPAN onderwerp en daarna verfyn. Dit het gelei tot die erkenning van 32 plantgemeenskappe wat ekologies geïnterpreteer is.

Die aanwending van Braun-Blanquet-data vir die bepaling van veldtoestand en berekening van weikapasiteite is ook getoets. Die Ekologiese Indeks Metode is gebruik om die veldtoestand en weikapasiteit van vyf grasveldgemeenskappe binne die Ea-landtipe te bepaal. Die weikapasiteite wat verkry is, vergelyk goed met die algehele weikapasiteit wat vir die noordoostelike Oranje-Vrystaat aanbeveel word.

'n Totaal van 22 bewaringsgebiede is geïdentifiseer en beskryf. Hierdie gebiede is op grond van spesiesamestelling en habitateienskappe geïdentifiseer en sluit berge, grasvelde, panne en 'n vlei in.

APPENDIX 1. A checklist of the plant species of the north-eastern Orange Free State.

PTERIDOPHYTA

SELAGINELLACEAE

30 Selaginella Beauv.
S. caffrorum (Milde) Hieron.

EQUISETACEAE

50 Equisetum L.
E. ramosissimum Desf.

SCHIZAEACEAE

120 Mohria Swartz
M. caffrorum (L.) Desv. var. caffrorum
cf. M. caffrorum (L.) Desv. var. caffrorum

DENNSTAEDTIACEAE

260 Pteridium Scop.
P. aquilinum (L.) Kuhn

ADIANTACEAE

340 Cheilanthes Swartz
C. eckloniana (Kuntze) Mett.
C. hirta Swartz var. hirta
C. quadripinnata (Forssk.) Kuhn

360 Pellaea Link
P. calomelanos (Swartz) Link var. calomelanos

ASPLENIACEAE

520 Asplenium L.
A. aethiopicum (Burm.f.) Becherer
A. trichomanes L.

530 Ceterach DC.
C. cordatum (Thunb.) Desv.

ASPIDIACEAE

620 Dryopteris Adans.
D. inaequalis (Schlechtd.) Kuntze

650 Polystichum Roth
cf. P. sp.

BLECHNACEAE

690 Blechnum L.
B. australe L. var. australe

ANGIOSPERMAE

MONOCOTYLEDONAE

POACEAE

10 Ischaemum L.
I. fasciculatum Brongn.

21 Hemarthria R. Br.
H. altissima (Poir.) Stapf & C.E. Hubb.

28 Elionurus Kunth ex Willd.
E. muticus (Spreng.) Kunth

71 Andropogon L.
A. amethystinus Steud.
A. appendiculatus Nees
A. schirensis A. Rich.

72 Cymbopogon Spreng.
C. excavatus (Hochst.) Stapf ex Burtt Davy
C. plurinodis (Stapf) Stapf ex Burtt Davy

73 Hyparrhenia Anderss. ex Fourn.
H. dregeana (Nees) Stapf
H. hirta (L.) Stapf

73a Hyperthelia Clayton
H. dissoluta (Nees ex Steud.) Clayton

75 Monocymbium Stapf
M. ceresiiforme (Nees) Stapf

78 Trachypogon Nees
T. spicatus (L.f.) Kuntze

80 Heteropogon Pers.
H. contortus (L.) Roem. & Schult.

81 Diheteropogon Stapf
D. amplectens (Nees) Clayton
D. filifolius (Nees) Clayton

83 Themeda Forssk.
T. triandra Forssk.

89 Digitaria Haller
D. diagonalis (Nees) Stapf. var. diagonalis
D. eriantha Steud.
D. monodactyla (Nees) Stapf.
D. sanguinalis (L.) Scop.
D. ternata (A. Rich.) Stapf.
D. tricholaenoides Stapf.

94 Alloteropsis J.S. Presl
A. semialata (R. Br.) Hitch. ssp. semialata

104 Brachiaria Griseb.
B. eruciformis (J.E. Sm.) Griseb.
B. marlothii (Hack.) Stent
B. serrata (Thunb.) Stapf

107 Paspalum L.
* P. dilatatum Poir.
P. distichum L.

112 Echinochloa Beauv.
E. colona (L.) Link

116 Panicum L.
P. coloratum L. var. coloratum
P. ecklonii Nees
P. natalense Hochst.
P. sp.

128 Setaria Beauv.
S. nigrirostris (Nees) Dur. & Schinz
S. pallide-fusca (Schumach.) Stapf. & C.E. Hubb.
S. sphacelata (Schumach.) Moss var. torta (Stapf) Clayton

134 Melinis Beauv.
M. nerviglumis (Franch.) Zizka
M. repens (Willd.) Zizka ssp. repens

139 Pennisetum Rich.
P. clandestinum Chiov.
P. sphacelatum (Nees) Dur. & Schinz.

159 Leersia Swartz.
L. hexandra Swartz

163 Phalaris L.
P. arundinacea L.

173 Arundinella Raddi
A. nepalensis Trin.

174 Tristachya Nees
T. leucothrix Nees

192 Holcus L.
H. lanatus L.

197 Helictotrichon Bess. ex Schult.
H. turgidulum (Stapf) Schweick.

205 Pentaschistis Stapf
P. setifolia (Thunb.) McClean

214 Phragmites Trin.
P. australis (Cav.) Steud.

243 Agrostis L.
A. eriantha Hack. var. eriantha
A. lachnantha Nees var. lachnantha

262 Aristida L.
A. bipartita (Nees) Trin. & Rupr.
A. congesta Roem. & Schult. ssp. congesta
A. diffusa Trin. ssp. diffusa
A. junciformis Trin. & Rupr. ssp. junciformis

274 Tragus Haller
T. berteronianus Schult.

283 Sporobolus R. Br.
S. centrifugus (Trin.) Nees

286 Eragrostis Beauv.
E. caesia Stapf
E. capensis (Thunb.) Trin.
E. curvula (Schrad.) Nees
E. planiculmis Nees
E. gummiflua Nees
E. micrantha Hack.
E. plana Nees
E. planiculmis Nees
E. racemosa (Thunb.) Steud.

294 Microchloa R. Br.
M. caffra Nees

294a Rendlia Chiov.
R. altera (Rendle) Chiov.

294b Catalepis Stapf & Stent
C. gracilis Stapf & Stent

296 Cynodon Rich. ex Pers.

C. dactylon (L.) Pers.
C. transvaalensis Burtt Davy

298 Harpochloa Kunth
H. falx (L.f.) Kuntze

301 Chloris Swartz
C. virgata Swartz

345 Diplachne Beauv.
D. fusca (L.) Beauv. ex Roem. & Schult.

353 Trichoneura N.J. Anderss.
T. grandiglumis (Nees) Ekman var. grandiglumis

371 Fingerhuthia Nees
F. sesleriiformis Nees

374 Koeleria Pers.
K. capensis (Steud.) Nees

386 Melica L.
M. racemosa Thunb.

400 Stiburus Stapf
S. alopecuroides (Hack.) Stapf

407 Poa L.
* P. annua L.

417 Festuca L.
F. scabra Vahl

428 Bromus L.
B. catharticus Vahl

433 Lolium L.
* L. perenne L.

CYPERACEAE

459 Cyperus L.
C. albostriatus Schrad.
C. esculentus L.
C. fastigiatus Rottb.
C. longus L. var. longus
C. marginatus Thunb.
C. obtusiflorus Vahl var. obtusiflorus
cf. C. rigidifolius Steud.
C. rotundus L. ssp. rotundus var. rotundus
C. rupestris Kunth var. rupestris

459a Pycreus Beauv.
P. betschuanus (Boeck.) C.B. Cl.

459c Mariscus Gaertn.
M. capensis (Steud.) Schrad.
M. congestus (Vahl) C.B. Cl.

462 Kyllinga Rottb.
K. erecta Schumach.
K. pulchella Kunth

465 Ficinia Schrad.
F. sp.

467 Fuirena Rottb.
F. pubescens (Poir.) Kunth

468 Scirpus L.
S. burkei C.B. Cl.
S. falsus C.B. Cl.

468a Schoenoplectus Palla
S. decipiens (Nees) J. Raynal
cf. S. decipiens (Nees) J. Raynal
S. sp.

469 Eleocharis R. Br.
E. palustris R. Br.
E. sp.

471a Bulbostylis Kunth
B. humilis (Kunth) C.B. Cl.
B. oritrephes (Ridley) C.B. Cl. ssp. australis B.L. Burtt

471b Abildgaardia Vahl
A. ovata (Burm. F.) Kral

521 Schoenoxiphium Nees
S. rufum Nees

525 Carex L.
C. glomerabilis Krecz.
C. schlechteri Nelmes

ARACEAE

748 Zantedeschia Spreng.
Z. albomaculata (Hook.) Baill. ssp. albomaculata

COMMELINACEAE

896 Commelina L.
C. africana L. var. africana

904 Cyanotis D. Don
C. speciosa (L.F.) Hassk.

JUNCACEAE

936 Juncus L.
J. effusus L.
J. exsertus Buchen. ssp. exsertus
J. inflexus L.
J. punctorius L.f.

LILIACEAE

985b Trachyandra Kunth
T. saltii (Bak.) Oberm. var. saltii

989 Anthericum L.
A. cooperi Bak.
A. fasciculatum Bak.

1012 Eriospermum Jacq. ex Willd.
E. sp.

1024 Kniphofia Moench
K. linearifolia Bak.

1026 Aloe L.
A. greatheadii Schonl. var. davyana (Schonl.) Glen & Hardy
A. ecklonis Salm-Dyck
A. transvaalensis Kuntze

1046 Agapanthus L' Herit.
A. campanulatus Leighton ssp. campanulatus

1079 Albuca L.
A. shawii Bak.

1086 Scilla L.
S. nervosa (Burch.) Jessop

1088 Eucomis L' Herit.
E. autumnalis (Mill.) Chitt. ssp. clavata (Bak.) Reyneke

1090 Drimiopsis Lindl.
D. burkei Bak.

1090a Ledebouria Roth.
L. sp.

1113a Protasparagus Oberm.
P. laricinus (Burch.) Oberm.
P. setaceus (Kunth) Oberm.
P. virgatus (Bak.) Oberm.
P. sp.

1113b Myrsiphyllum Willd.
M. asparagoides (L.) Willd.
M. ramosissimum (Bak.) Oberm.

AMARYLLIDACEAE

1167 Haemanthus L.
H. humilis Jacq. ssp. humilis

1168 Boophane Herb.
B. disticha (L.f.) Herb.

1175 Nerine Herb.
N. angustifolia (Bak.) Bak.

1189 Crinum L.
C. bulbispermum (Burm. f.) Milne-Redh. & Schweick.

HYPOXIDACEAE

1230 Hypoxis L.
H. acuminata Bak.
H. argentea Harv. ex Bak. var. argentea
H. hemerocallidea Fisch. & Mey.
H. multiceps Buchinger ex Bak.
H. obtusa Burch. ex Edwards var. obtusa
H. rigidula Bak. var. rigidula
H. sp.

DIOSCOREACEAE

1252 Dioscorea L.
D. retusa Mast.
D. sylvatica (Kunth) Eckl. var. sylvatica

IRIDACEAE

1265 Moraea Mill.
M. brevistyla (Goldbl.) Goldbl.

1295 Aristea Ait.
A. montana Bak.

1299 Schizostylis Backh. & Harv.
S. coccinea Backh. & Harv.

1303 Dierama K. Koch
D. medium N.E. Br. var. medium

1311 Gladiolus L.
G. crassifolius Bak.
G. elliotii Bak.
G. sericeo-villosus Hook. f. forma sericeo-villosus
G. sp.

ORCHIDACEAE

1430 Satyrium Swartz
S. longicauda Lindl. var. longicauda

1434 Disa Berg.
D. versicolor Reichb. f.

DICOTYLEDONAE

SALICACEAE

1872 Populus L.
* P. alba L.

1873 Salix L.
* S. babylonica L.
S. mucronata Thunb.

MYRICACEAE

1874 Myrica L.
M. pilulifera Rendle

ULMACEAE

1898 Celtis L.
C. africana Burm. f.

URTICACEAE

2012 Forsskaolea L.
F. candida L.f. var. candida

SANTALACEAE

2108 Osyris L.
O. lanceolata Hochst. & Steud.

2118 Thesium L.
T. sp.

POLYGONACEAE

2195 Rumex L.
R. acetosella L. ssp. angiocarpus (Murb.) Murb.
R. lanceolatus Thunb.
R. sagittatus Thunb.

2201c Persicaria Mill.
P. lapathifolia (L.) S.F. Gray
P. serrulata (Lag.) Webb & Moq.
P. attenuata (R. Br.) Sojak ssp. africana K.L. Wilson

CHENOPODIACEAE

2223 Chenopodium L.
C. cristatum F. Muell.
* C. schraderianum Roem. & Schult.
C. sp.

AMARANTHACEAE

2299 Amaranthus L.
* A. hybridus L. ssp. hybridus var. hybridus

2312 Cyathula Blume
C. cylindrica Moq.
C. uncinulata (Schrad.) Schinz

2328 Achyranthes L.
* A. aspera L. var. aspera

2335 Alternanthera Forssk.
A. pungens H.B.K.

2338 Gomphrena L.
G. celosioides Mart.

AIZOACEAE

2379 Psammotropha Eckl. & Zeyh.
P. mucronata (Thunb.) Fenzl. var. mucronata

PHYTOLACCACEAE

2380 Phytolacca L.
P. heptandra Retz.

MESEMBRYANTHEMACEAE

2405.033 Delosperma N.E. Br.

D. herbeum (N.E. Br.) N.E. Br.
D. sp.

2405.105 Ruschia Schwant.
R. sp.

CARYOPHYLLACEAE

2467 Pollichia Ait.
P. campestris Ait.

2490 Silene L.
S. burchellii Otth. var. angustifolia Sond.
S. pilosellifolia Cham. & Schl.
S. undulata Ait.

2502 Dianthus L.
D. mooiensis F.N. Williams ssp. mooiensis var. mooiensis

RANUNCULACEAE

2542 Clematis L.
C. brachiata Thunb.
C. oweniae Harv.

2546 Ranunculus L.
R. multifidus Forssk.

2548 Thalictrum L.
T. rhynchocarpum Dill. & Rich.

PAPAVERACEAE

2853 Papaver L.
P. aculeatum Thunb.

BRASSICACEAE

2883 Lepidium L.
L. divaricatum (Burm.f.) DC. ssp. divaricatum (Ait.) Jonsell

2917 Sisymbrium L.
S. turczaninowii Sond.

2965 Rorippa Scop.
R. nudiuscula Thell.

CRASSULACEAE

3164 Cotyledon L.
C. orbiculata L. var. oblonga (Haw.) DC.

3166 Kalanchoe Adans.
K. paniculata Harv.

3168 Crassula L.
C. alba Forssk. var. alba
C. dependens H. Bol.
C. lanceolata (Eckl. & Zeyh.) Endl. ex Walp. ssp. transvaalensis (Kuntze) Toelken
C. setulosa Harv. var. setulosa

HAMAMELIDACEAE

3311 Trichocladus Pers.
cf. T. crinitus (Thunb.) Pers.

ROSACEAE

3333b Pyracantha M.J. Roemer
* P. angustifolia Schneid.

3353 Rubus L.
R. rigidus Sm. var. rigidus
R. sp.

3379 Leucosidea Eckl. & Zeyh.
L. sericea Eckl. & Zeyh.

3388 Cliffortia L.
C. linearifolia Eckl. & Zeyh.
C. nitidula (Engl.) R.E. & Th. Fries Jr. ssp. pilosa Weim.
C. sp.

FABACEAE

3446 Acacia Mill.
* A. dealbata Link

3607 Calpurnia E. Mey.
C. villosa Harv. var. intrusa (R. Br. ex Ait. f.) E. Mey.

3657 Lotononis (DC.) Eckl. & Zeyh.
L. calycina (E. Mey.) Benth.
L. eriantha Benth.
cf. L. laxa Eckl. & Zeyh.
L. procumbens H. Bol.
L. sp.

3669 Crotalaria L.
C. sp.

3673 Argyrolobium Eckl. & Zeyh.
A. humile Phill.
A. pauciflorum Eckl. & Zeyh.
cf. A. tuberosum Eckl. & Zeyh.
A. wilmsii Harms.
A. sp.

3688 Medicago L.
M. aschersoniana Urb.
M. lupulina L.

3689 Melilotus Mill.
M. alba Desr.
* M. indica (L.) All.

3690 Trifolium L.
T. africanum Ser. var. africanum
* T. pratense L. var. pratense

3702 Indigofera L.
cf. I. dregeana E. Mey.
I. frondosa N.E. Br.
I. hilaris Eckl. & Zeyh. Complex
cf. I. hilaris Eckl. & Zeyh. Complex
I. obscura N.E. Br.
cf. I. woodii H. Bol. var. woodii
cf. I. zeyheri Spreng. ex Eckl. & Zeyh.
I. sp.

3718 Tephrosia Pers.
T. capensis (Jacq.) Pers. var. capensis
T. semiglabra Sond.

3756 Lessertia DC.
L. stricta L. Bol.

3870 Erythrina L.
E. zeyheri Harv.

3897 Rhynchosia Lour.
R. adenodes Eckl. & Zeyh.
cf. R. capensis (Burm.) Schinz
R. totta (Thunb.) DC. var. totta
R. venulosa (Hiern) K. Schum.
R. sp.

3898 Eriosema (DC.) G. Don
cf. E. simulans C.H. Stirton

3905 Vigna Savi
V. vexillata (L.) A. Rich.

3910 Dolichos L.
D. falciformis E. Mey.

GERANIACEAE

3924 Geranium L.
G. schlechteri Kunth

3925 Monsonia L.
M. angustifolia E. Mey. ex A. Rich.
M. attenuata Harv.

3928 Pelargonium L'Herit.
P. bowkeri Harv.
P. luridum (Andr.) Sweet
P. sidoides DC.

OXALIDACEAE

3936 Oxalis L.
O. corniculata L.
O. obliquifolia Steud. ex Rich.
O. sp.

LINACEAE

3945 Linum L.
L. thunbergii Eckl. & Zeyh.

POLYGALACEAE

4273 Polygala L.
P. gymnoclada Macowan
P. hottentotta Presl.
P. rehmannii Chod.

EUPHORBIACEAE

4299 Phyllanthus L.
P. pentandrus Schumach. & Thonn.

4407 Acalypha L.
A. angustata Sond. var. glabra Sond.
A. glandulifolia Buchinger ex Meisn.
A. punctata Meisn.

4448 Clutia L.
C. affinis Sond.
C. hirsuta E. Mey. ex Sond. var. hirsuta
C. natalensis Bernh. ex Krauss
C. pulchella L. var. pulchella

4498 Euphorbia L.
E. chamaesyce L.
E. clavaroides Boiss. var. clavaroides
E. striata Thunb. var. striata
E. sp.

ANACARDIACEAE

4594 Rhus L.
R. dentata Thunb.
R. discolor E. Mey. ex Sond.
R. lucida L.
R. pallens Eckl. & Zeyh.
R. pyroides Burch. var. gracilis (Engl.) Burtt Davy
R. rigida Mill. var. dentata (Engl.) Moffatt

CELASTRACEAE

4626 Maytenus Molina
M. heterophylla (Eckl. & Zeyh.) N.K.B. Robson

MELIANTHACEAE

4854 Melianthus L.
M. dregeanus Sond. ssp. insignis (Kuntze) Tansley

RHAMNACEAE

4875 Rhamnus L.
R. prinoides L'Herit.

TILIACEAE

4957 Sparrmannia L.f.
S. ricinocarpa (Eckl. & Zeyh.) Kuntze

4966 Grewia L.
G. occidentalis L.

MALVACEAE

4987 Modiola Moench
M. caroliniana (L.) G. Don

5007 Pavonia Cav.
P. burchellii (DC.) R.A. Dyer

5013 Hibiscus L.
H. aethiopicus L. var. ovatus Harv.
H. microcarpus Garcke
H. trionum L.

STERCULIACEAE

5056 Hermannia L.
H. depressa N.E. Br.
H. geniculata Eckl. & Zeyh.
H. transvaalensis Schinz
cf. H. transvaalensis Schinz

CLUSIACEAE

5168 Hypericum L.
H. aethiopicum Thunb. ssp. sonderi (Bred.) N.K.B. Robson

FLACOURTIACEAE

5296 Kiggelaria L.
K. africana L.

5328 Dovyalis E. Mey. ex Arn.
D. zeyheri (Sond.) Warb.

CACTACEAE

5417 Opuntia Mill.
* O. ficus-indica (L.) Mill.

THYMELAEACEAE

5435 Gnidia L.
G. burchellii (Meisn.) Gilg
G. nodiflora Meisn.
G. gymnostachya (Meisn.) Gilg
G. kraussiana Meisn. var. kraussiana

5461 Passerina L.
P. sp.

LYTHRACEAE

5486 Nesaea Comm. ex Juss.
N. sagittifolia (Sond.) Koehne var. sagittifolia

ONAGRACEAE

5795 Epilobium L.
E. salignum Hausskn.

5804 Oenothera L.
* O. indecora Cambess. ssp. indecora
* O. rosea L'Herit. ex Ait.
* O. tetraptera Cav.

HALORAGACEAE

5836 Gunnera L.
G. perpensa L.

ARALIACEAE

5872 Cussonia Thunb.
C. paniculata Eckl. & Zeyh.

APIACEAE

5894 Centella L.
C. asiatica (L.) Urban

5922 Alepidea De la Roche
A. longifolia E. Mey. ssp. longifolia

5992 Heteromorpha Cham. & Schlechtd.
H. trifoliata (Wendl.) Eckl. & Zeyh.

5994 Bupleurum L.
B. mundtii Cham. & Schlechtd.

6004a Ciclospermum Lag.
C. leptophyllum (Pers.) Sprague

6033 Pimpinella L.
P. transvaalensis Wolff

6038 Sium L.
S. repandum Welw. ex Hiern

MYRSINACEAE

6313 Myrsine L.
M. africana L.

EBENACEAE

6404 Euclea Murray
E. crispa (Thunb.) Guerke ssp. crispa
E. undulata Thunb.

6406 Diospyros L.
D. austro-africana De Winter
D. lycioides Desf. ssp. lycioides
D. whyteana (Hiern) F. White

LOGANIACEAE

6470 Gomphostigma Turcz.

G. virgatum (L.f.) Baill.

6473 Buddleja L.
B. salviifolia (L.) Lam.

GENTIANACEAE

6481 Sebaea Soland. ex R. Br.
S. filiformis Schinz
S. grandis (E. Mey.) Steud.
S. leiostyla Gilg

6503 Chironia L.
C. palustris Burch. ssp. transvaalensis (Gilg) Verdoorn

ASCLEPIADACEAE

6777 Xysmalobium R. Br.
X. undulatum (L.) Ait. f.

6778a Aspidoglossum E. Mey.
A. cf. lamellatum (Schltr.) Kupicha

6791 Asclepias L.
A. adscendens (Schltr.) Schltr.
A. affinis Schltr.
A. fruticosa L.
A. sp.

6861 Sisyranthus E. Mey.
S. sp.

6870 Brachystelma R. Br.
B. pygmaeum (Schltr.) N.E. Br. ssp. flavidum (Schltr.) R.A. Dyer

6917 Pergularia L.
cf. P. daemia (Forssk.) Chiov. var. daemia

CONVOLVULACEAE

6972 Falkia L.f.
F. oblonga Bernh. ex Krauss

6993 Convolvulus L.
C. natalensis Bernh. apud Krauss var. transvaalensis (Schltr.) A. Meeuse
C. sagittatus Thunb. ssp. sagittatus var. sagittatus
C. thunbergii Roem. & Schult.

7003 Ipomoea L.
I. ommaneyi Rendle

7008 Turbina Rafin.
T. oblongata (E. Mey. ex Choizy) A. Meeuse

BORAGINACEAE

7064 Cynoglossum L.
C. enerve Turcz.
C. lanceolatum Forssk.

VERBENACEAE

7138 Verbena L.
V. brasiliensis Vell.

7144 Lantana L.
L. rugosa Thunb.

LAMIACEAE

7211 Ajuga L.
A. ophrydis Burch. ex Benth.

7264 Leonotis (Pers.) R. Br.
L. dysophylla Benth.
L. ocymifolia (Burm. f.) Iwarsson var. raineriana (Visiani) Iwarsson

7268 Leucas Burm. ex R. Br.
L. martinicensis (Jacq.) R. Br.

7281 Stachys L.
S. hyssopoides Burch. ex Benth.
S. kuntzei Guerke
S. natalensis Hochst. var. natalensis
S. sessilis Guerke

7290 Salvia L.
S. repens Burch. ex Benth. var. repens
S. runcinata L.f.
S. sisymbrifolia Skan

7328 Mentha L.
M. aquatica L.

7345 Aeollanthus Mart. ex K. Spreng.
A. buchnerianus Briq.

7350 Plectranthus L'Herit.
P. grallatus Briq.
P. hereroensis Engl.
P. madagascariensis (Pers.) Benth. var. ramosior Benth.

7350c Rabdosiella Codd
R. calycina (Benth.) Codd

SOLANACEAE

7400 Withania Pauquy
W. somnifera (L.) Dun.

7401 Physalis L.
* P. viscosa L.

7407 Solanum L.
* S. elaeagnifolium Cav.
S. incanum L.
S. panduriforme E. Mey.
S. retroflexum Dun.
S. supinum Dun.

7415 Datura L.
* D. stramonium L.

SCROPHULARIACEAE

7476 Nemesia Vent.
N. floribunda Lehm.

7477 Diclis Benth.
D. reptans Benth.

7493 Halleria L.
H. lucida L.

7517 Manulea L.
M. paniculata Benth.

7519 Sutera Roth
S. aurantiaca (Burch.) Hiern
S. crassicaulis (Benth.) Hiern
S. filicaulis (Benth.) Hiern
S. neglecta (Wood & Evans) Hiern
S. palustris Hiern
S. polelensis Hiern ssp. polelensis
S. pristisepala Hiern

7523 Zaluzianskya F.W. Schmidt
Z. microsiphon (Kuntze) K. Schum.
Z. schmitziae Hilliard & Burtt

7558 Limosella L.
L. grandiflora Benth.

SELAGINACEAE

7566 Hebenstretia L.
H. dura Choisy
H. comosa Hochst.

7568 Selago L.
S. galpinii Schltr.

7568a Walafrida E. Mey.
W. densiflora (Rolfe) Rolfe

SCROPHULARIACEAE

7579 Veronica L.
V. anagallis-aquatica L.

7597a Alectra Thunb.
A. basutica (Phill.) Melch.
A. sessiliflora (Vahl) Kuntze var. sessiliflora

7614 Graderia Benth.
G. scabra (L. f.) Benth.

7616 Sopubia Buch.-Ham. ex D. Don
S. cana Harv.

7625 Striga Lour.
S. bilabiata (Thunb.) Kuntze
S. elegans Benth.

ACANTHACEAE

7941 Chaetacanthus Nees
C. burchellii Nees
C. setiger (Pers.) Lindl.

7972 Crabbea Harv.
C. acaulis N.E. Br.
C. hirsuta Harv.
C. nana Nees

7980 Blepharis Juss.
B. subvolubilis C.B. Cl.

PLANTAGINACEAE

8116 Plantago L.
* P. lanceolata L.
P. virginica L.

RUBIACEAE

8136 Kohautia Cham. & Schlechtd.
K. amatymbica Eckl. & Zeyh.

8348 Pentanisia Harv.
P. angustifolia (Hochst.) Hochst.

8351b Pygmaeothamnus Robyns
P. chamaedendrum (Kuntze) Robyns var. chamaedendrum
P. chamaedendrum (Kuntze) Robyns var. setulosus Robyns

8352 Canthium Lam.
C. ciliatum (Klotzsch) Kuntze

8359 Pachystigma Hochst.
P. pygmaeum (Schltr.) Robyns

8438 Anthospermum L.
A. herbaceum L. f.
A. rigidum Eckl. & Zeyh. ssp. pumilum (Sond.) Puff

8486 Galium L.
G. capense Thunb. ssp. garipense (Sond.) Puff

8489 Rubia L.
R. horrida (Thunb.) Puff

DIPSACACEAE

8541 Cephalaria Roem. & Schult.
C. pungens Szabo
C. zeyheriana Szabo

8546 Scabiosa L.
S. columbaria L.

CUCURBITACEAE

8599 Cucumis L.
C. africanus L.f.
C. zeyheri Sond.

8628 Coccinia Wight & Arn.
C. hirtella Cogn.

CAMPANULACEAE

8668 Wahlenbergia Schrad. ex Roth
W. banksiana A. DC.
W. krebsii Cham. ssp. krebsii
W. squamifolia V. Brehm.

W. undulata (L.f.) A. DC.

LOBELIACEAE

8694 Lobelia L.
L. angolensis Engl. & Diels
L. flaccida (Presl.) A. DC. ssp. flaccida
L. vanreenensis (Kuntze) K. Schum.

8695 Monopsis Salisb.
M. decipiens (Sond.) Thulin

ASTERACEAE

8751 Vernonia Schreb.
V. hirsuta (DC.) Sch. Bip.
V. natalensis Sch. Bip.
V. oligocephala (DC.) Sch. Bip. ex Walp.

8900 Aster L.
A. bakeranus Burtt Davy ex C.A. Sm.

8919 Felicia Cass.
F. fascicularis DC.
F. muricata (Thunb.) Nees ssp. muricata
F. petiolata (Harv.) N.E. Br.

8925 Nidorella Cass.
N. anomala Steetz
N. hottentottica DC.
N. resedifolia DC. ssp. resedifolia

8926 Conyza Less.
* C. albida Spreng.
C. chilensis Spreng.
C. obscura DC.
C. podocephala DC.

8949 Denekia Thunb.
D. capensis Thunb.

8967 Ifloga Cass.
I. glomerata (Harv.) Schltr.

8992e Pseudognaphalium Kirp.
P. oligandrum (DC.) Hilliard & Burtt

9006 Helichrysum Mill.
H. adenocarpum DC. ssp. adenocarpum
H. albo-brunneum S. Moore
H. ammitophilum Hilliard
H. aureonitens Sch. Bip.

H. aureum (Houtt.) Merr. var. monocephalum (DC.) Hilliard
H. caespititium (DC.) Harv.
H. cephaloideum DC.
H. chionosphaerum DC.
H. coriaceum Harv.
H. dasycephalum O. Hoffm.
H. epapposum H. Bol.
cf. H. haygarthii H. Bol.
H. hypoleucum Harv.
H. melanacme DC.
H. miconiifolium DC.
H. monticola Hilliard
H. mundtii Harv.
H. nudifolium (L.) Less.
H. oreophilum Klatt
H. pallidum DC.
H. pilosellum (L.f.) Less.
H. psilolepis Harv.
H. rugulosum Less.
H. spiralepis Hilliard & Burtt
H. splendidum (Thunb.) Less.
H. umbraculigerum Less.

9037 Stoebe L.
S. vulgaris Levyns

9043 Metalasia R. Br.
M. densa (Lam.) Karis

9050 Relhania L'Herit Emend Bremer
R. acerosa (DC.) Bremer

9055 Athrixia Ker-Gawl.
A. elata Sond.

9059 Printzia Cass.
P. pyrifolia Less.

9078 Pulicaria Gaertn.
P. scabra (Thunb.) Druce

9090 Geigeria Griesselich
G. aspera Harv. var. aspera

9148 Xanthium L.
* X. strumarium L.

9155 Zinnia L.
* Z. peruviana (L.) L.

9237 Bidens L.
B. bipinnata L.
* B. formosa (Bonato) Sch. Bip.
B. pilosa L.

9246 Galinsoga Ruiz & Pav.
G. parviflora Cav.

9291 Schkuhria Roth
S. pinnata (Lam.) Cabr.

9311 Tagetes L.
* T. minuta L.

9351 Cotula L.
C. hispida (DC.) Harv.

9356 Schistostephium Less.
S. crataegifolium (DC.) Fenzl. ex Harv.

9358 Artemisia L.
A. afra Jacq. ex Willd.

9366b Oncosiphon Kallersjo
O. piluliferum (L.f.) Kallersjo

9406 Cineraria L.
C. alchemilloides DC.
C. aspera Thunb.
cf. C. geifolia (L.) L.
C. geraniifolia DC.
C. lyrata DC.

9411 Senecio L.
S. achilleifolius DC.
S. affinis DC.
S. anomalochrous Stapf
S. brevidentatus M.D. Henderson
S. coronatus (Thunb.) Harv.
S. erubescens Ait. var. crepidifolius DC.
S. glaberrimus DC.
S. harveianus Macowan
S. hieracioides DC.
S. inaequidens DC.
S. inornatus DC.
S. isatidioides Phill. & C.A. Sm.
S. laevigatus Thunb. var. integrifolius Harv.
S. lydenburgensis Hutch. & Burtt Davy
S. othonniflorus DC.
S. polyodon DC. var. polyodon
S. polyodon DC. var. subglaber (Kuntze) Hilliard & Burtt
S. subrubriflorus O. Hoffm.

9417 Euryops Cass.
E. laxus (Harv.) Burtt Davy

9426 Garuleum Cass.
G. woodii Schinz

9432 Arctotis L.
A. arctotoides (L.f.) O. Hoffm.

9432c Haplocarpha Less.
H. lyrata Harv.
H. scaposa Harv.

9434 Gazania Gaertn.
G. krebsiana Less. ssp. serrulata (DC.) Roessl.

9438 Berkheya Ehrh.
B. cirsiifolia (DC.) Roessl.
B. echinacea (Harv.) O. Hoffm. ex Burtt Davy ssp. echinacea
B. onopordifolia (DC.) O. Hoffm. ex Burtt Davy var. glabra Bohnen ex Roessl.
B. pinnatifida (Thunb.) Thell. ssp. stobaeoides (Harv.) Roessl.
B. radula (Harv.) De Wild.
B. setifera DC.

9462 Cirsium Mill. emend. Scop.
* C. vulgare (Savi) Ten.

9501 Dicoma Cass.
D. anomala Sond. ssp. anomala

9528 Gerbera L.
G. ambigua (Cass.) Sch. Bip.
G. piloselloides (L.) Cass.

9572 Hypochoeris L.
H. brasiliensis (Less.) Griseb.
H. radicata L.

9579 Tragopogon L.
* T. dubius Scop.

9592 Taraxacum Wiggers
* T. officinale Weber (Sens. Lat.)

9595 Sonchus L.
S. dregeanus DC.
S. wilmsii R.E. Fr.

9596 Lactuca L.
L. capensis Thunb.

9605 Crepis L.
C. hypochoeridea (DC.) Thell.

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